エチオピア国
エチオピア・カイゼン機構（EKI）

# エチオピア国
# 品質・生産性向上、競争力強化のためのカイゼン実施促進能力向上プロジェクト

## 別冊 II：成果品（研修教材）

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# 序　文

この教材は、中級レベルのカイゼン能力を身につける目的で開発されたものである。これから本書で勉強しようとする皆さんは、すでに基礎レベルのカイゼン技術を習得していることを前提として、テキストを編纂している。中級レベルのカイゼンでよく使用する手法や技術を中心に取り上げているが、ここで扱わなかった技術もたくさんある。これには、研修時間が短いという理由のほかに、せっかく時間をかけていろいろな技術をテキストで学んでも使う機会がなければ、すぐに忘れてしまうからでもある。

時間は、民族や種族、老若男女を問わず、みな平等に与えられている。一方、時間は保存ができず、その利用の仕方によっては人の100倍も1,000倍もの価値を生み出せる唯一無二の資源ともいえる。3カ月も経てば雲散霧消するものに再生産できない時間を費やすことは、Waste in timeの最たるものではないか。カイゼンコンサルタントであろうとする者は、個人にとって最も貴重な資源である時間のムダを看過してはならない。なぜならば、カイゼンの原点はムダ取りにあるからである。時間の重要性を伝えんとするあまり多言に過ぎたが、1点だけ強調しておく。それは個々の手法や技術の名称を使用目的と関連づけて覚えておくことである。その使い方の詳細は、必要になったときインターネットで簡単に調べることができる。そんなやり方で支障にならないか、と問われれば、問題ないと断言できる。現に日本人専門家のなかに、大学で学んだ技術だけで今日まで仕事をしてきた人は誰もいない。今日の我われがあるのは、大学を卒業したのちに仕事の必要性に応じて習得した技術がそのほとんどを占めているからである。

教材の中身を述べておこう。まず、重要なカイゼンシステムとして、3T、つまり、TQM、TPS、TPMがある。TQM（Total Quality Management）は品質の向上維持を基本思想としたカイゼンツールである。品質を落として生産性を上げる、質の悪い材料を使ってコストダウンを図る、といったことは真のカイゼンではない。カイゼンのOverall Goalは、「顧客満足の向上」にある。「顧客満足の向上」を実現するには「仕事の質の向上」を不断におこなう必要がある。「仕事の質の向上」には、製品の品質の向上・維持、顧客ニーズに適合した製品の市場導入、需要を創造することのできる製品開発、製品クレームに対し素早く的確な対応、修理サービスの充実、そしてこれらの業務を低コストでおこなえることなどを含む。このような意味での広義の「質」を第一のポリシーとするカイゼンでなければならない。

つぎにTPS（Toyota Production System）とは、日本の自動車メーカーのトヨタが20世紀の半ばに20年近くかけて開発した生産方式のことである。約1世紀前に開発され、長らく大量生産のパラダイムであったフォード生産方式が、今日では見直しがおこなわれTPSに移行している。その違いは、前者が作業の単純化、標準化をベースにした少品種大量生産にあるのに対し、後者は多品種少量をJust In Timeで生産すること、換言すれば必要なモノを、必要な量・時間・場所に供給できるように生産するシステムである。これにより、在庫を大量に抱え込むリスクを避ける一方で、需要の変動にも柔軟に対応できる。ここで使われているカイゼン手法にはほかにもたくさんある。大企業でもTPSをシステムとしてその全体を導入することは、難しいことが多い。その場合は、カイゼン効果は小さくなるが、部分的に導入してもよいだろう。

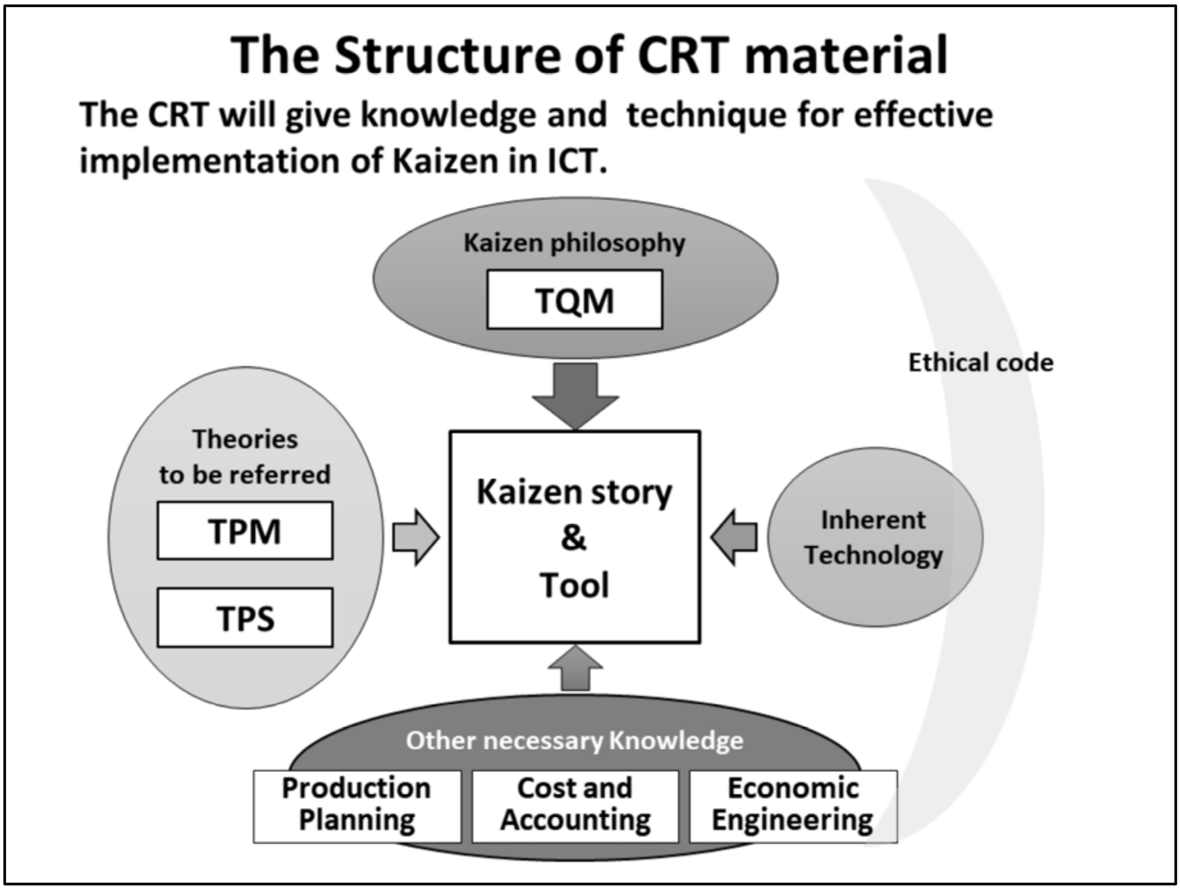
TPM（Total Productive Maintenance）については、これまでは機械の故障などはオペレーターの責任ではなくメンテナンス担当者の責任であった。これを製造のオペレーターやその他スタッフにも責任をもたすようにし、全員参加のメンテナンスを行う管理手法である。従来、人手を中心とした作業であった生産方式から機械生産に変わっていっている中で、メンテナンスの善し悪しが全体の生産性に影響するところが極めて大きい。開発途上国の中規模以下の工場では、中古の機械設備を使っているところが多い。故障の起こりやすい理由の1つがこれである。このような背景で、TPMの重要性がますます高まっている。

これら3Tの技術は業種を問わずどの産業にも導入可能である。また、IE（Industrial Engineering）も、作業の方法を動作分析し、時間測定により最も効率的な作業方法を導き出すツールである。このほかに、カイゼンのレベルが上がるにつれて、産業特有の固有技術の知識が必要となる。固有技術とは、溶接・塗装・鍛造・鋳造・縫製などの製造に関する技術である。カイゼンの主な技術である管理技術がサービス業、製造業、公的業務を問わないのに対し、固有技術の多くは使う業種が限定的であるという違いがある。

皆さんが、当教材を中級レベルに到達する梯子として十分に活用し、自己涵養に努め、クライアント企業から感謝され、さらにはエチオピアの発展に貢献するコンサルタントとして成長されることを我われプロジェクトのメンバーは心から期待している。

2020年7月

プロジェクト総括<br>杉本清次




**Framework of CRT material (Intermediate-level Kaizen)**

The framework of the material of CRT (Class Room Training) for Intermediate-level Kaizen is shown on the slide.

Intermediate-level Kaizen starts from understanding the company's mission, vision and policies followed by policy deployment. SWOT analysis is one of the key tools in this process. The TQM class provides a way to conduct this first process.

The next process in Kaizen follows the Kaizen story. The class of Intermediate-level Kaizen Story provides how to manage the process from setting a theme to comprehend the result. Some convenient and basic tools for conducting Kaizen are also reviewed in this class.

The classes of TPS and TPM provide key concepts and technologies essential for Intermediate-level Kaizen with the primary purpose of reducing MUDA (waste) in production.

The classes of Production Planning, Cost & Accounting and Economic Engineering also provide principles to solve problems and achieve tasks.

In addition to these knowledge and technologies (We call them as management technologies), inherent technology is essential, especially for Intermediate-level Kaizen. The class of Inherent Technology provides information on what it is and how to get it effectively.

Above all, Kaizen should be conducted in a faithful manner and the class of Ethical Code provides the necessary principles.

More detailed and theoretical explanations of TQM, TPS and TPM, and more detailed explanations of QC and IE tools are provided in the Kaizen Master Course and Basic-level Kaizen training respectively, apart from this CRT course.

Therefore, this CRT course focuses on providing ways to actually use these principles.

For the purpose of getting trainees to learn practical knowledge, we introduce case-method and case-study in each class.

The case-method is a teaching method in which multiple participants (trainees) derive answers (solutions) through a discussion-based analysis on actual cases. This method emphasizes on the participant's ability to think meticulously.

A case-study is a training process to acquire deep knowledge through case-based exercises. Since a case-study is an exercise, questions are inserted in the cases and the correct answers are also shown.

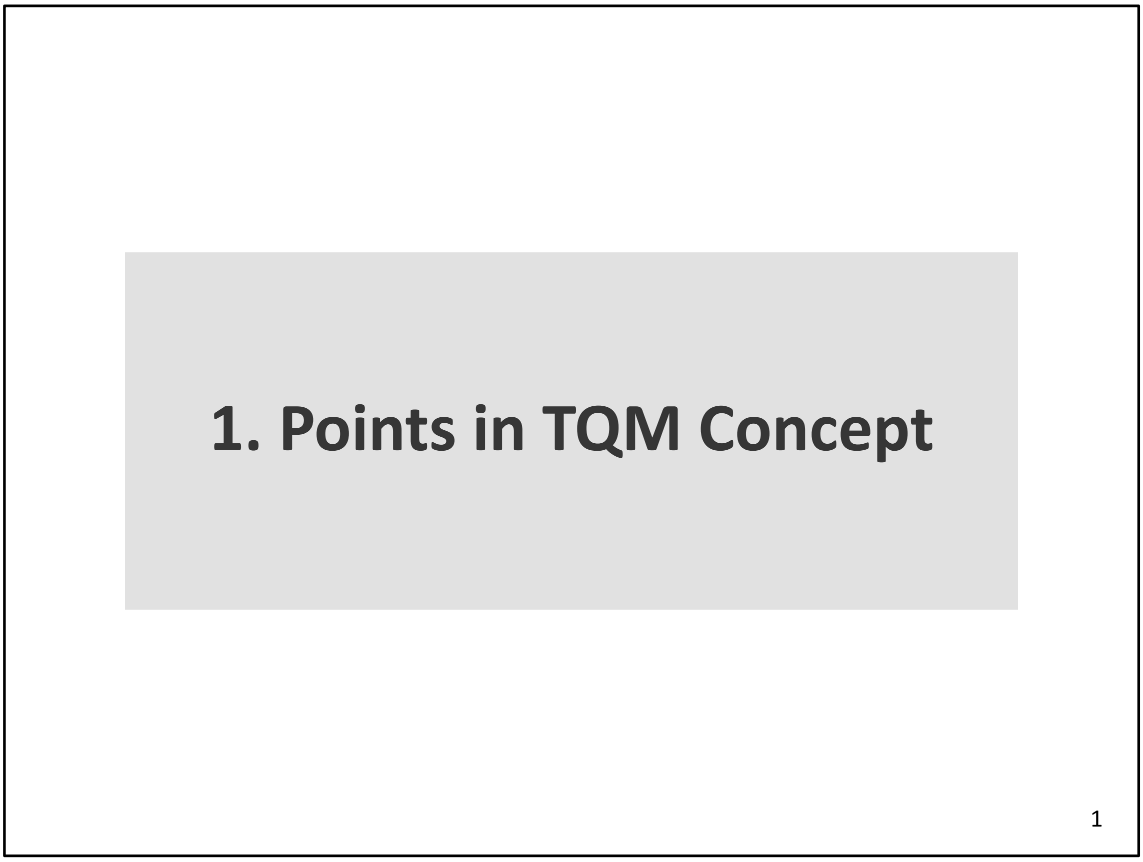
In general, questions and correct answers are not shown in the case-method, however as the trainees are not accustomed to this teaching method, questions and example answers are attached in the case-method materials of this CRT.

# 目　次

# 略語表

| Abbreviations | English |
| --- | --- |
| ATO | Assemble-to-order |
| BOM | Bill of Material |
| B/S | Balance Sheet |
| CBM | Condition-based maintenance |
| CFT | Cross Functional Team |
| CODP | Customer Order Decoupling Point |
| CRT | Class Room Training |
| ECRS | Eliminate, Combine, Rearrange, Simplify |
| EKI | Ethiopian Kaizen Institute |
| ETO | Engineer-to-order |
| IE | Industrial Engineering |
| ISO | International Organization for Standardization |
| JIPM | Japan Institute of Plant Maintenance |
| KPI | Key Performance Indicator |
| KPT | Kaizen Promotion Team |
| MRP | Material Requirement Planning |
| MTS | Make-to-stock |
| MTO | Make-to-order |
| OEE | Overall Equipment Effectiveness |
| PDCA | Plan, Do, Check, Action |
| P/L | Profit and Loss Statement |
| PM | Plant Maintenance |
| PM Analysis | Physical Phenomena Mechanism Analysis |
| PPM | Product Portfolio Management |
| QC | Quality Control |
| QCC | Quality Control Circle |
| QCD | Quality, Cost, Delivery |
| R&D | Research & Development |
| SWIP | Standard Work-in-process Stock |
| SWOT | Strengths, Weaknesses, Opportunities, Threats |
| TBM | Time-based maintenance |
| TPM | Total Productive Maintenance |
| TPS | Toyota Production System |
| TQC | Total Quality Control |
| TQM | Total Quality Management |
| TWI | Training within industry |
| WIP | Work in Progress |

TQM




**1. Points in TQM Concept**

- Management quality includes not only the quality of products, but also all the qualities of management, including the quality of business operations and the quality of managers and employees.
- In order to constantly improve these three qualities, it is necessary to maximize the capabilities of employees and emphasize independence. To that end, it is necessary to increase employee satisfaction and to improve the quality of management itself.

- Management quality has come to be recognized as truly determining the quality of products and services for customers.

  Then, new quality targets and measures that take into account the follow-up results will be created, and PDCA will make continuous improvements.

## Framework of TQM Introduction

**1.1 Purpose of TQM Activities**

**1.2 Company-wide Management of TQM**

**1.3 TQM Systematic Approach and Policy Deployment**

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### 1.1 Purpose of TQM Activities

It aims to provide products and services for customers' satisfaction.

### 1.2 Company-wide Management of TQM

TQM promotion organization under the president is organized.

The steering committee delegated authority leads the activity.

### 1.3 TQM Systematic Approach and Policy Deployment

Company's philosophy, vision and business policy are expressed. The roles are clarified for each department, or section as the subordinate organization. And they consider and execute the means as their roles to achieve the policy .

## 1.1 Purpose of TQM Activities

**(1) Market-oriented/ Market in**

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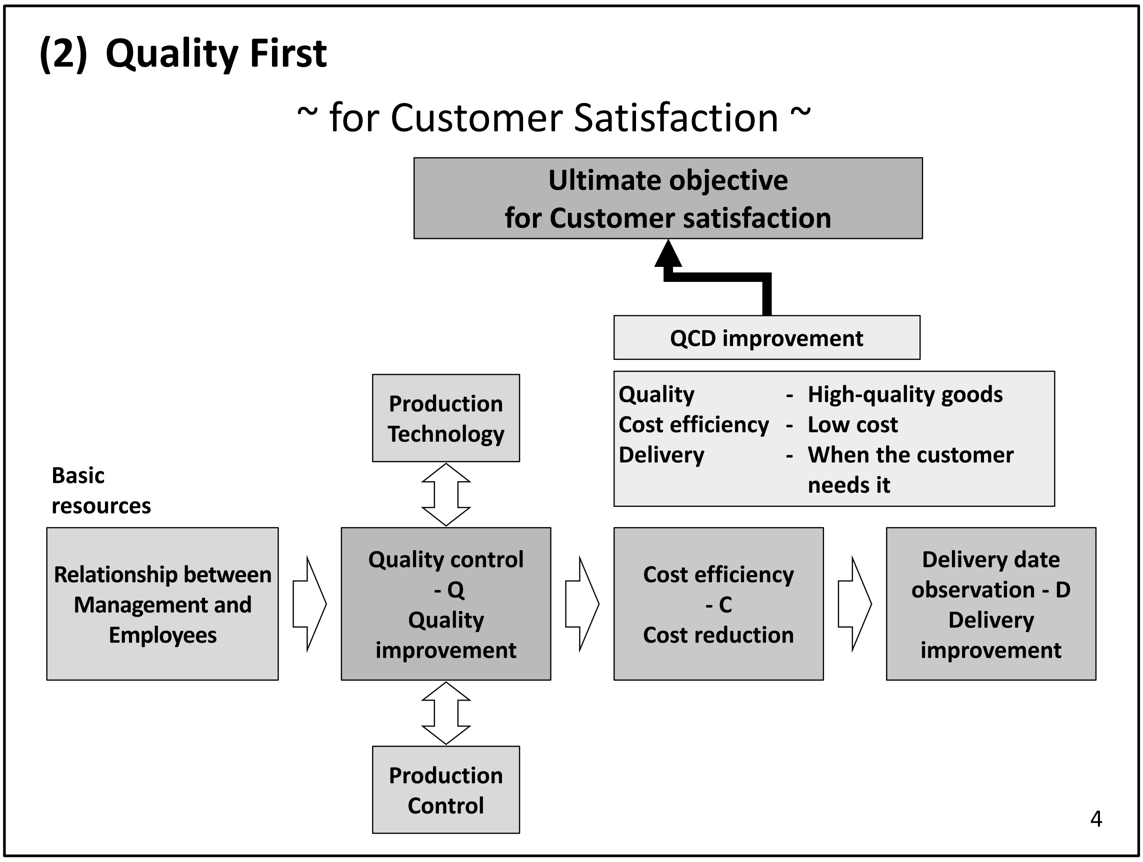
**1.1 Purpose of TQM Activities**

**Market-oriented means:**

**(1) Market-oriented/ Market in**

1) Goods and services that meet customers' needs
2) Provide at reasonable price
3) Together with gaining customer satisfaction, do business which makes it possible to secure a good profit for one's organization.




## (2) Quality First

The ultimate goal of TQM is in Customer Satisfaction, but it is sold to customers with the best quality and at the right price and delivered in a timely manner.

To that end, it is important for manufacturers to utilize efficiently the physical or human resources of companies and produce efficiently high-quality products at a low cost by making full use of sufficient production and management technologies.

## (3) Targets

1) **Products and Services**

2) **Process to make Products**

3) **Upgrading Employee's Capability**

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**(3) Targets**

TQM targets at three layers as the quality which gives the changing customer satisfaction.

1) Quality of the products and the services for customers
2) Quality of the process to make the products and give the services
3) Quality of developing process in upgrading the employee's capability to make the products and give the services

## 1.2 Company-wide Management of TQM

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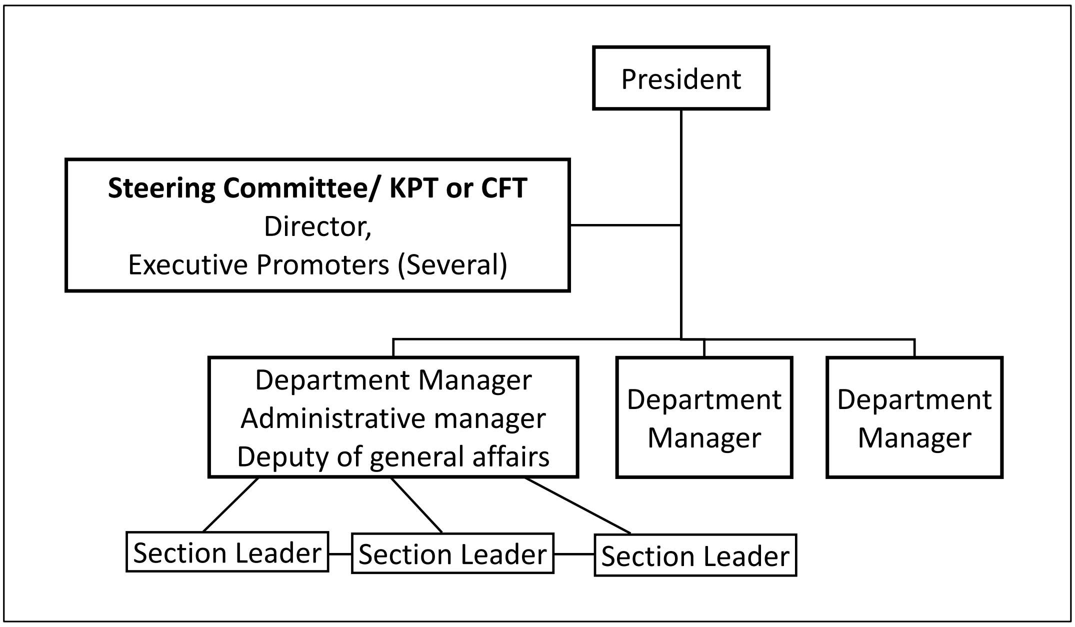
**1.2 Company-wide Management of TQM**

## (1) Company-wide Organization for TQM Promotion

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### (1) Company-wide Organization for TQM Promotion

In order to promote TQM activities, it is necessary to perform top-down by the president / top management. In practice, the Steering Committee/ KPT or CFT plays a central role by delegating the president's authority.

It is composed of Executive and Department Managers at the top of the division and several young employees. Executives and Managers will be asked for opinions and comments as the observer, and will direct and order the company department's subordinates to communicate company policies and review countermeasures. On the other hand, the young employees here are responsible for introducing and implementing TQM technology and managing the progress as Promotor.

In order to promote TQM activities, it is most effective that the top management, preferably the president himself, goes to the workplace and directly explains the management philosophy and the necessity of TQM activities to employees. Taking leadership by the top management is the key to improve management quality, and it is necessary to check policies and progress constantly .

## (2) TQM Preparation by Committee

| | |
|---|---|
| 1) Purpose of activities | Activities for foregoing departments as preparation for TQM development |
| 2) Members | The arrangement of promoters, Director, Executive, Administrative manager, Deputy of general affairs, Leader of group, Manager |
| 3) Activities | **Regular weekly meeting** (2 hours)<br>Discussion of activities and setup of the plan for one week |
| > Study how to develop TQM plan | **Monitoring** of the progress<br>Coaching by TQM promoter |
| > Declaration of TQM by directors | At the ceremony of the foundation |
| > Preparation of the development | TQM articles in the house organ, **TQM manual**,<br>Meetings for the **explanation** of TQM |

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**(2) TQM Preparation by Committee**

Make a list of the contents that the TQM Steering Committee must prepare.

## (3) Leadership of the Top Management

| | |
|---|---|
| 1) The **president** should be in charge of TQM promoter | Show his strong **will** |
| 2) He should give an instructional address to employees | Show his **enthusiasm** and decision |
| 3) He should inform **directly** his ideas and the future ideal status of company | Announce his **desirable** company's status |
| 4) He should have **enough communication** with TQM promoting members | Develop his ideas with the concrete **system** in the organization |

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**(3) Leadership of the Top Management**

Make a list of the necessary contents for top management to take leadership.

## (4) Activities Conducted by TQM Committee
(from the Top management to Departments and Sections)

Flow ↓

1) **Announcement** of Company's Policy
(Long & middle -term Plan and the Policy)
2) Direction of **drawing-up** the policy (Draft) by each department
3) Submission of **department policy** (Draft) to TQM promoter committee
4) **Diagnosis** of the policy (Draft) by the **director** of department
(Discussion by the director and TQM promoter's members )
5) Revision of the policy, and the order to make the renewal
6) Drawing up the **final policy** of department
7) Submission of the final policy to the **executive** in charge and the manager
8) Direction of **drawing-up** the policy (Draft) by each **section**
9) Drawing up the policy of each section
10) **Diagnosis** of the policy (Draft) by the executive in charge

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### (4) Activities Conducted by TQM Committee

The contents and the flow of activities conducted by TQM's Steering Committee are shown below.

## 1.3 TQM Systematic Approach and Policy Deployment

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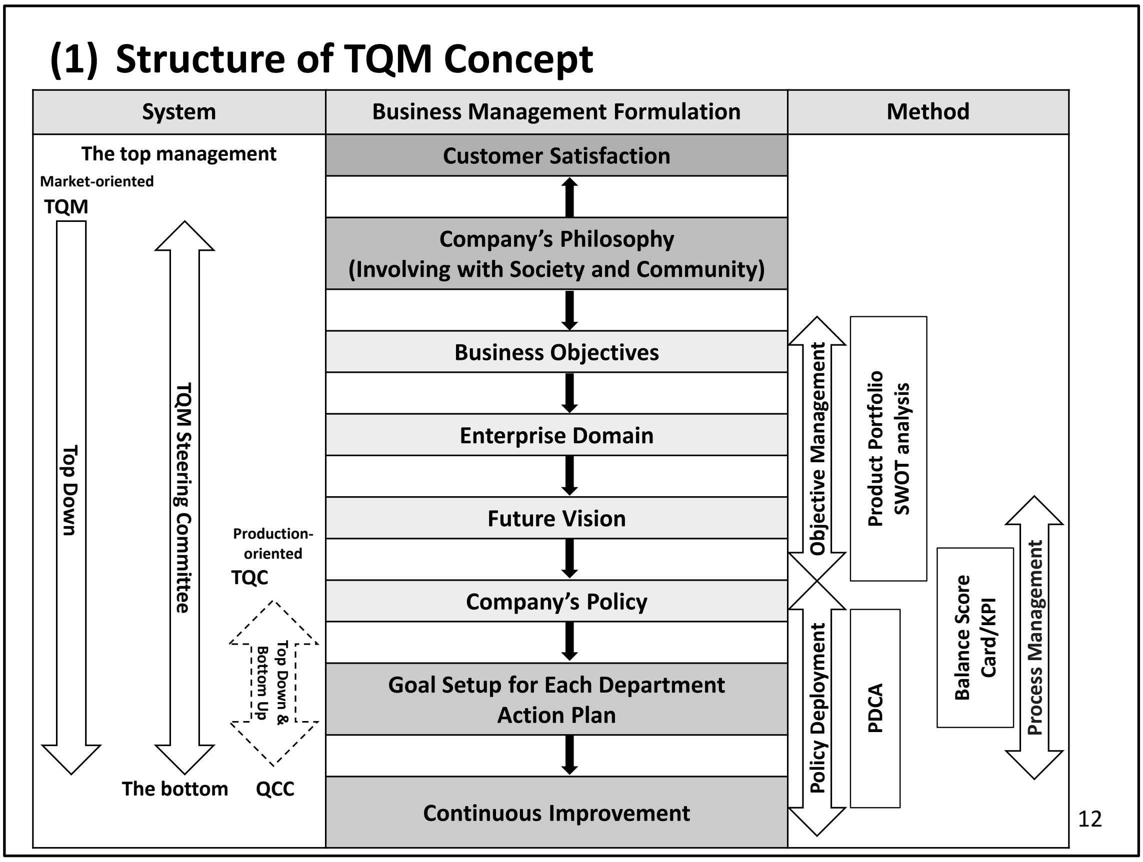
**1.3 TQM Systematic Approach and Policy Deployment**

When TQM is applied to a company organization, it is necessary to push the policy of top management strongly by top-down method. In other words, the policy of a company that has been studied and drafted by top management is understood from the top to the bottom, and it is required to proceed as a company-wide activity accordingly. In the following, we will introduce the necessary methods in the concept of TQM.




## (1) Structure of TQM Concept

First, before explaining the individual methods used in TQM, the overall structure of the TQM concept is shown. The goal of TQM written at the top of the Business Management Formulation is Customer Satisfaction, and the contents written below it are various management analyses to achieve the overall goal. Furthermore, the lower level is an execution path of the measures for Policy.

Also, System is written in the left column, TQM is top-down type, and the useful methods are written in the right column.

## (2) Management Strategy

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**(2) Management Strategy**

Strategy

~ Corporate strategy is the way to adapt its management upon purposes and resources to the business environment change from a broad perspective point of view ~

Tools for Strategy making

1) Enterprise Domain
2) SWOT Analysis
3) Product Portfolio Management(PPM）

## 1) Enterprise Domain

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**1) Enterprise Domain**

~ Enterprise domain defines what kind of business the company engages in now and what kind of business the company wants to go to further from the customers', the technology's and the function's points of view. ~

**Selection and focus**

Selection and Focus are based on Customers, Competitors and Company's Management Resources and Advantages of enterprise domain identification.

The focus on decision in concerns of the top management can be limited or expanded.

It can suggest what kind managerial resources should be accumulated. It can clarify the positioning in competitors.

## 2) SWOT Analysis

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**2) SWOT Analysis**

SWOT Analysis for making Competitive strategy

~ SWOT analysis is the tool to analyze Strength & Weakness of company, and Opportunity & Threat in business environment surrounding the company ~

## SWOT Analysis

| | |
|---|---|
| **S**trengths<br>S-1<br>S-2<br>S-3 | **W**eaknesses |
| **O**pportunities | **T**hreats |

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**SWOT Analysis**

SWOT analysis is for the pursuit of business opportunities.

The strategy formulation should be done by the parallel analysis on business environment and company‘s capability.

As usage, the strengths and weaknesses of the internal part of the company are firstly expressed in each category. It also clarifies opportunities and threats about the external environment surrounding the company.

## Cross SWOT Analysis

| | Strengths | Weaknesses |
|---|---|---|
| Opportunities | O*S-1<br>O*S-2<br>O*S-3 | O*W-1<br>O*W-2<br>O*W-3 |
| Threats | T*S-1<br>T*S-2<br>T*S-3 | T*W-1<br>T*W-2<br>T*W-3 |

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**Cross SWOT Analysis**

Next, a method called Cross SWOT will be described.

Using the strengths, weaknesses, opportunities and threats listed in the table above, you can further enhance your advantage by combining internal and external factors or turn them into opportunities by overcoming weak areas. These outputs are ideas that will be candidates for business policy.

The actual examples will be introduced in the Case Study.

# 3) Product Portfolio Management (PPM)

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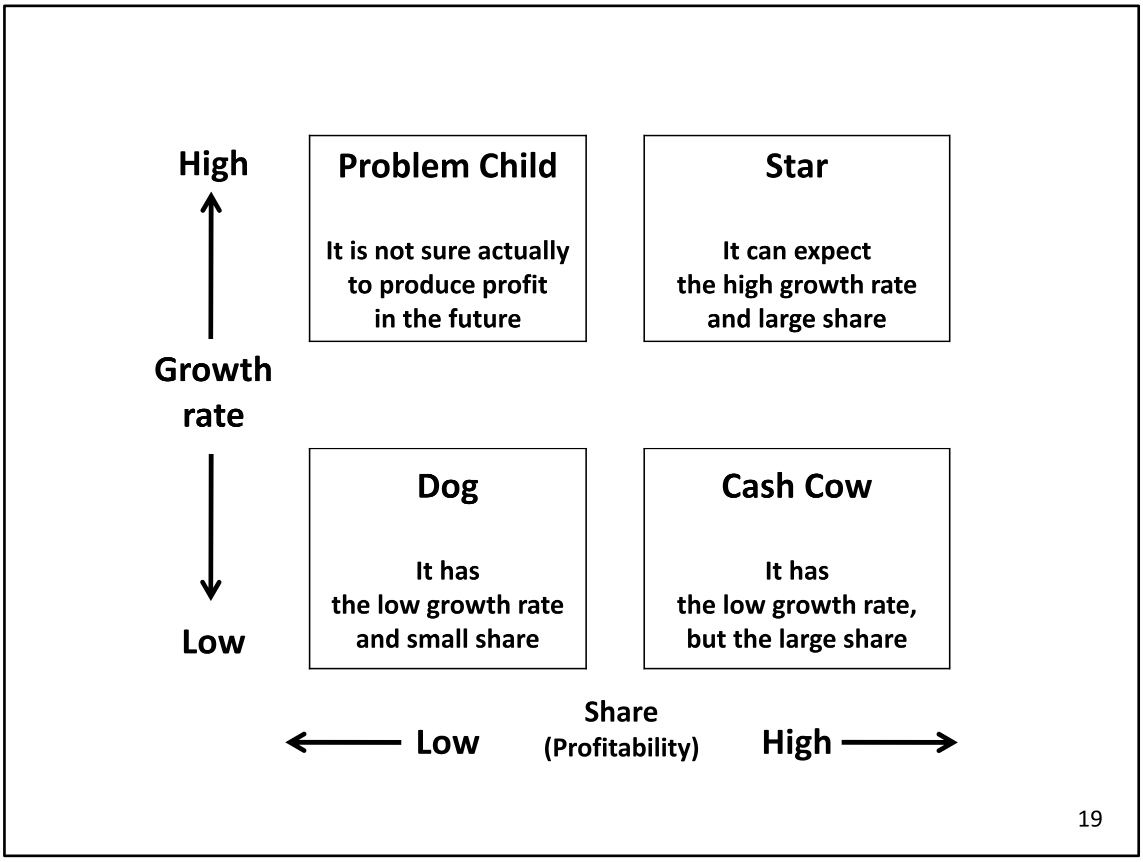
**3) Product Portfolio Management (PPM)**

~ Method to determine which product fields the company engages in ~

PPM is the tool for determining continuation or withdrawal of its business fields from the growth and the share in the market points of view.




In this PPM table, the vertical axis represents the growth potential of the company's products and businesses, and the horizontal axis represents the profitability of the products. Indicates whether it is positioned.

When thinking about a company's growth strategy, it is used to know the current state of the market and to understand how the company's products or businesses are positioned in relation to competitors in the future.

If the company is in Problem Child, it will become a Star in the near future and will be able to gain an advantage. On the other hand, if it is in the position of Dog, it is inferior, so profits are not expected, so it is better to withdraw the product or business immediately.

## (3) Systematic Policy Deployment

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### (3) Systematic Policy Deployment

Systematic Policy Deployment means that the company's policies and means are deployed from the top to the bottom of the company.

**1) Mission/ Philosophy**

The declaration of companies contributing to the society.

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**1) Mission/ Philosophy**

Entities above a certain size must have a corporate philosophy generally. The corporate philosophy is that the entity must not only pursue the profits of the company in order to survive in society, but also protect the health and life of employees and their families, and contribute to the community. It is also expected that large companies will consider contributing to the country and the world.

The top management should express the corporate philosophy, that is the ideas of business mission and the duty as producer and puts his/her decision-making and judgment into action.

Note: Corporate Philosophy prescribes the movement of organization and employees. (Code of Conduct).

## 2) Vision

- The future concrete figure which a company should aim for, and which is announced by the company to employees, customers and society.

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**2) Vision**

Corporate Vision refers to the most important medium- to long-term (5-10 years) business goals for a company to grow. And it is a business plan for the future by setting up activities to use management resources and systems within the enterprise.

(Note)

- The top management should decide the purpose of company.
- The top management should express his/her vision with the exact basic idea in the management.

**3) Company’s Business Policy**

The thing which is shown
to embody Vision.

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### 3) Company’s Business Policy

A business policy is a means that should be implemented in the near term (one to two years) among the several means that must be performed to achieve a company's vision. In addition, the means becomes a business policy of the department, and each department sets a directly related business policy as a goal of the department.

The simple expression is as follows.

Management Vision → Company’s Business Policy

> Purpose with Target as Company’s Business Policy
> Long & middle-term Plan

## (4) Policy Deployment

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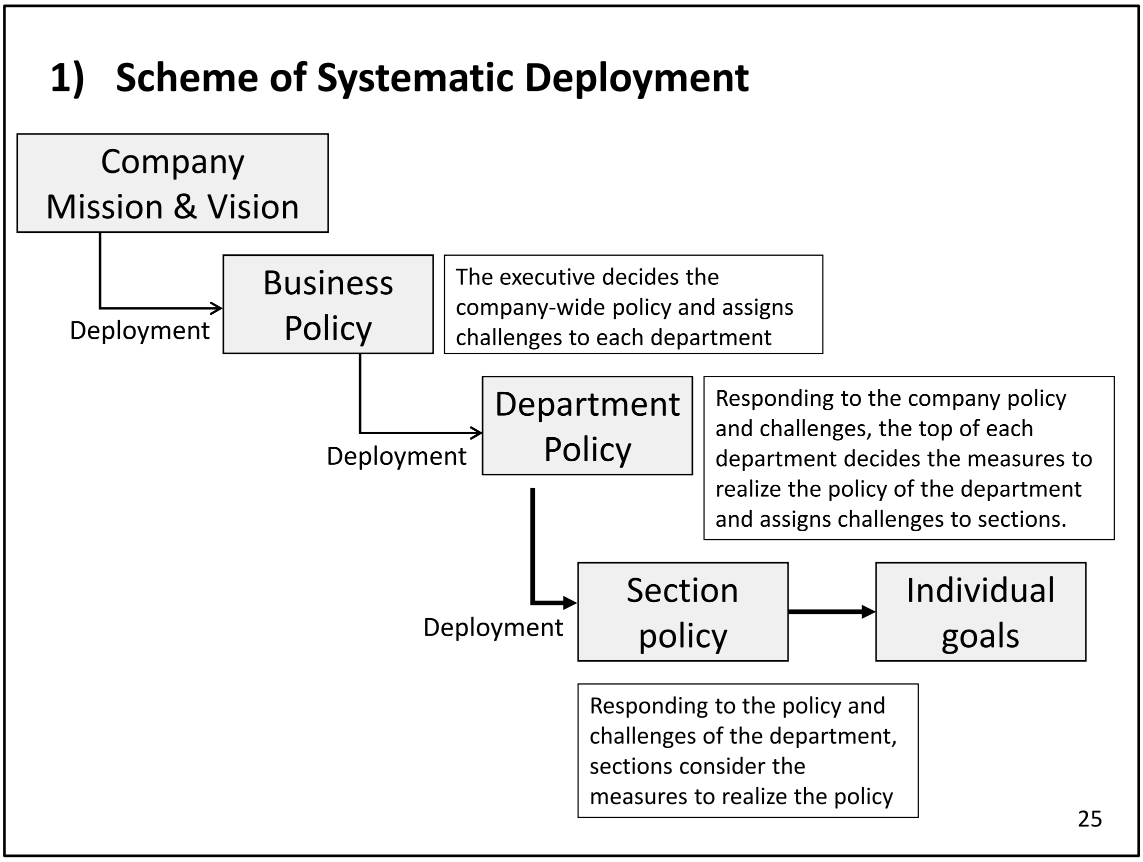
**(4) Policy Deployment**

Policy Deployment is where the top management of a company first thinks of a medium- to long-term business plan, and announces to the inside and outside of the company as a corporate vision to Stakeholders. In the Division or Department policy, it is shown how your department will contribute to the realization, that is, what can be done. At the same time, show the means to achieve it and clarify the deadline for its activities and schedule. And those contents are under Department

Each section that will be communicated to the section to which it belongs, and each section that will be able to receive the means for achieving the Department policy should make the Section policy and propose specific solutions and also activities and schedules. Clarify the deadline. This is a consistent process development.




**1) Scheme of Systematic Deployment**

Here, the systematical process of Policy Deployment is listed as a Scheme.

The formulated management plan will be executed. This is the concept to apply the company-wide target and plan to the operation divisions/sections.

First, the executive decides the major company-wide policies and targets in formulating the plan. The executive also assigns challenges to each department in order to realize the target.

The top of each department for which challenges are assigned considers how the department can achieve the company target.

The top of section also decides on the policy, target, and specific measures of the section. The supervisor of group considers how to achieve the challenges assigned with the schedule.

**Exp.**

## Company's Business Policy → Department Policy

⬇

| Middle-term Plan | | | | | |
|---|---|---|---|---|---|
| Production Plan | Sales Plan | R & D Plan | Purchase Plan | Personnel Plan | Financing Plan |

⬆

### Goal Setup

1. What is the target for products ?
2. What is the target for sales ?
3. Until when it should be achieved ?

### Action Plan

1. Measures
2. Steps
3. Schedule

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Department, Section, Group and specific activities for individuals propose and plan each Goal and how to achieve them for each level of Policy. In carrying out these activities, PDCA will accomplish the tasks or solve the problems.

In the same way, individuals think about policy/target/measures. These measures by sections and individuals will be compiled as the "action plan." This is used to manage progress of the plan during the period of the plan and problem solving.

Usually we confirm progress at the monthly progress meeting based on the action plan of the section. We also discuss the causes for non-achievement.

## 2) Points in Drawing up the Policy

1. Complete achievement of **important work**
2. Satisfaction of stockholders
3. **High goal**
4. Theme-up of importance to give the **impact**
5. Originality
6. Effectiveness
7. Intervention
8. Activation

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**2) Points in Drawing up the Policy**

Here are the main points when setting up policies at each level.

## 3) Framework of Screening Criteria for Japan Quality Award (1996)

1. Management **vision** and the **leadership**
2. Conception and correspondence of **customer/ market**
3. Drawing up and developing of **strategy**
4. **Human resource development** and learning environment
5. **Process** management
6. Commoditizing and applying of **information**
7. Achievement of **company-wide** activities
8. **Customer satisfaction**

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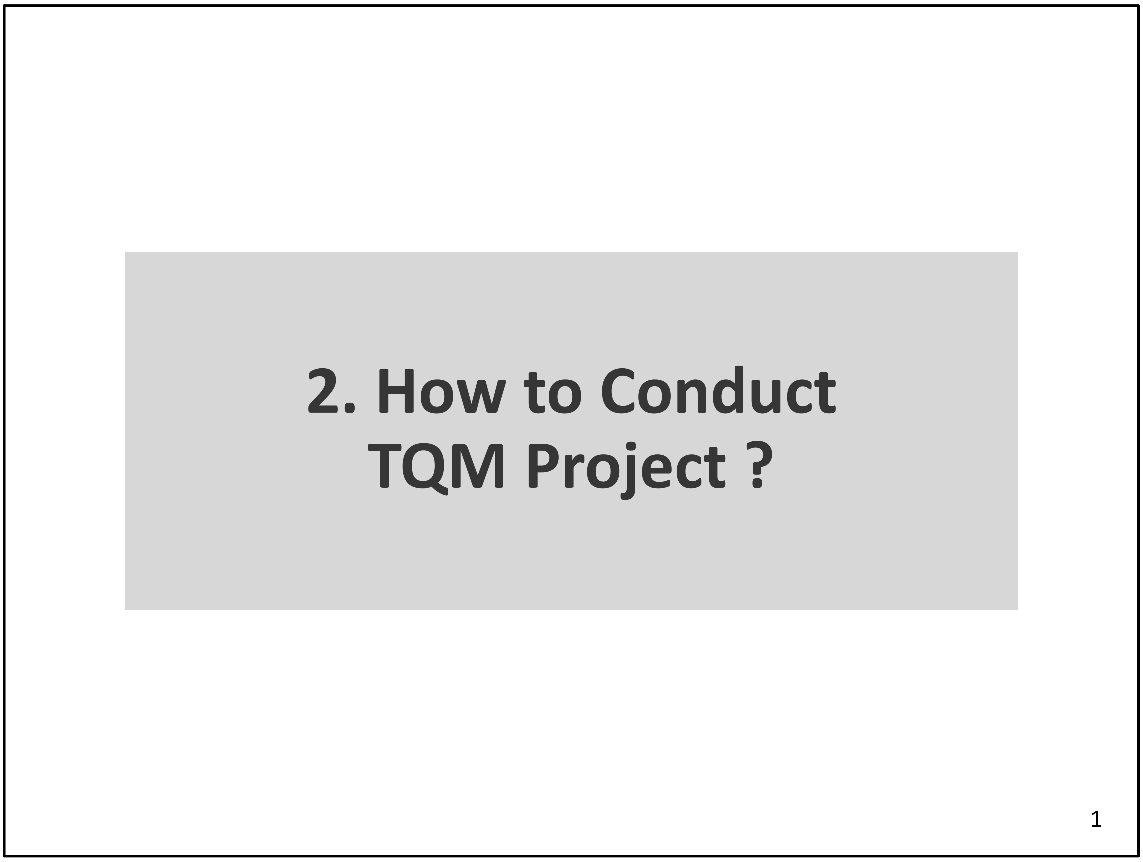
**3) Framework of Screening Criteria for Japan Quality Award (1996)**

Finally, Japan Quality Award evaluates the activities of companies that conducted TQM, and shows the evaluation criteria for giving awards to the companies that have achieved the best.




**2. How to Conduct TQM Project ?**

**2.1 Step-1 Organize Steering Committee to Conduct TQM Project**

**2.2 Step-2 Introduce TQM Technology**
~ to the top management and the engineers ~

(1) Explanation of Corporate Management Theory

(2) Explanation of how to conduct TQM

2

Please introduce the knowledge acquired in Points of TPM Concept to the top management and engineers of the company in the following order.

### 2.1 Step-1 Organize Steering Committee to Conduct TQM Project

Organize Steering Committee

(1) Prepare company-wide network as Steering Committee to promote TQM Activities
(2) Clarify the roles of Steering Committee
(3) Clarify the activities as TQM

### 2.2 Step-2 Introduce TQM Technology

TQM Technology

(1) Explanation of Corporate Management Theory
  1) Market-in/ Quality First
  2) Philosophy/mission and Vision
  3) Management Tools such as Domain, SWOT Analysis, and Product Portfolio
  4) Business Policy and the Deployment

(2) Explanation of how to conduct TQM
  1) Eight(8) Steps as described in this chapter

## 2.3 Step-3 Confirm Corporate Management
~ discussed by Steering Committee ~

(1) Identify corporate philosophy/ mission and vision

(2) Confirm with SWOT analysis whether Business Policy is appropriate

3

**2.3 Step-3 Confirm Corporate Management**

The following explains Corporate Management step by step.

First, please discuss Corporate Philosophy / Mission. If the company has already decided and raised it, listen to it and understand. If there is something that is difficult to understand or unnatural, please review and improve it.

Next, proceed to SWOT analysis.

## SWOT Analysis- A Step by Step Guide

| | |
|---|---|
| **Strengths** | Three questions to ask yourself to help in determining your strengths |
| **Weaknesses** | Three questions to ask yourself to help in determining your weaknesses |
| **Opportunities** | The opportunities refer to positive things that are out of your control<br>Three questions- |
| **Threats** | The threats refer to negative things that are out of your control<br>Three questions- |

4

**SWOT Analysis- A Step by Step Guide**

Again, use the knowledge gained from the Points of TPM Concept.

The following is the descriptions of what you, a consultant, should ask and what you should be aware of when specifying the content for each category.

Strengths

> What makes us unique and different from others?
> What people or customers praise us for?
> What gives us an advantage over others?

Weaknesses

> What can we improve on in our business or product?
> What do people or customers tell us for the necessity of our improvement?
> What are things we need to be avoiding?

Opportunities

> What are the technological trends that could give you an advantage?
> Are there any laws, policies or economic situations that work in your favor?
> Are there any events taking place that you can leverage (gain advantage)?

Threats

> What are technological trends that could disrupt or affect us negatively?
> Are there any laws, policies or economic situations that could impact us in a negative way?
> Are there any market financial risks that could be affecting us?

## How are the Results of a SWOT Analysis Used ?

A SWOT analysis is a subjective assessment of data that are organized into a four- dimensional SWOT matrix, similar to a basic two-heading list of pros and cons.

| | **Strengths**<br>**What the unit does very well internally** | **Weaknesses**<br>**Where functions are performed internally less than expected** |
|---|---|---|
| **Opportunities**<br>Potentially favorable external conditions for the unit | **S&O**:<br>Pursue opportunities that are a good fit with the program's strengths. | **W-O:**<br>Overcome weaknesses to pursue opportunities |
| **Threats**<br>Potentially unfavorable external conditions for the unit | **S-T**:<br>Identify the ways that the program can use its strengths to reduce its vulnerability to external threats. | **W-T**:<br>Establish a defensive plan to prevent the program's weaknesses from making it highly susceptible to external threats. |

5

**How are the Results of a SWOT Analysis Used ?**

To develop initiatives (strategies) that take into account the SWOT profile, unit members can translate the four lists into a matrix (see above) that associates strengths (maintain, build and leverage), Opportunities (prioritize and optimize), weaknesses (remedy), and Threats (counter) into actions that can be agreed and owned by the unit in SWOT

The detailed explanation here is omitted.

**2.4 Step-4 Break down Concrete Contents of Business Policy**
~ by KPT (Kaizen Promotion Team)/ Steering committee members ~

**2.5 Step-5 Deploy Business Policy to Departments**
~ by managers & engineers ~

**2.6 Step-6 Deploy Department's Policy to Sections, or Groups**
~ by managers & engineers ~

6

### 2.4 Step-4 Break down Concrete Contents of Business Policy

Proceed in the following order based on the knowledge that you have already acquired at the Points of TPM Concept and the Case Study CRT.

Step-4 Break down concrete contents of business policy

(1) Company's Super Goal, Means and the targets, etc.
(2) Scheduling of Long & Middle-term Activities as TQM

### 2.5 Step-5 Deploy Business Policy to Departments

(1) Set-up of the department's policy with the target to meet the company's business policy
(2) Make the annual plan as department activities

### 2.6 Step-6 Deploy Department's Policy to Sections, or Groups

(1) Set-up of the section's or group's policy with the target to meet the department's policy
(2) Make the annual plan as sections', or groups' activities

## 2.7 Step-7 Discuss on the Current Management
~ as section or group activities ~

## 2.8 Step-8 Propose the Means to Improve Management Issues
~ as section or group activities ~

7

Same as the comment on the previous page.

**2.7 Step-7 Discuss on the Current Management**

Identify the management issues in section or group activities to perform the department's policy and the target

Especially analyze the following issues;
- Sales and Profitability
- Product quality and Services for Customer Satisfaction
- Product Competitiveness such as Function and Design
- Price competitiveness such as Cost down and Productivity

**2.8 Step-8 Propose the Means to Improve Management Issues**

Discuss on the means to improve the managements regarding the following items

- Sales and Profitability ⇔ Ex. Expansion of Export
- Customer Satisfaction ⇔ Ex. Claims from customers
- Product Competitiveness ⇔ Ex. New Design or Function
- Price competitiveness ⇔ Ex. Cost down

# 3. TQM Implementation

1

**3. TQM Implementation**

The following are the examples of results obtained from the implementation of the methods used in TQM by companies.

## 3.1 Mission / Philosophy

**Example: Management Philosophy of Company**

2

### 3.1 Mission / Philosophy

**Example: Management Philosophy of Company**

First, some examples of corporate philosophy are introduced. Ethiopian companies often use the word “Mission”, but the meaning is almost the same. Either one is applicable.

**Example of  A-Company**

A-Company is insisting on contributing to the society through the superior technology of companies.

**B-Company**

**Management Philosophy**

B-Company expects employees who are engaged in industry devote themselves to work as their duty, and try to improve and upgrade the social life and contribute to the development of world culture.

4

**Example of B-Company**

B-Company advocates that employees work hard in the company to improve their confidence and contribute to the development of society.

## C-Company

### Corporate Philosophy

The history of C-Company was built up by innovation and challenge.

With the frontier spirit, each employee and the whole group continue to give the wide revolution which creates new values having social significance and brings big changes to the society to contribute the better future and happiness for clients, media, content holders, region, stakeholders and employees.

5

**Example of C-Company**

C-Company attaches great importance to employees' Frontier spirit and believes that the ideas they produce create social value. It expects it will bring happiness to customers, investors and employees.

3.2 Vision

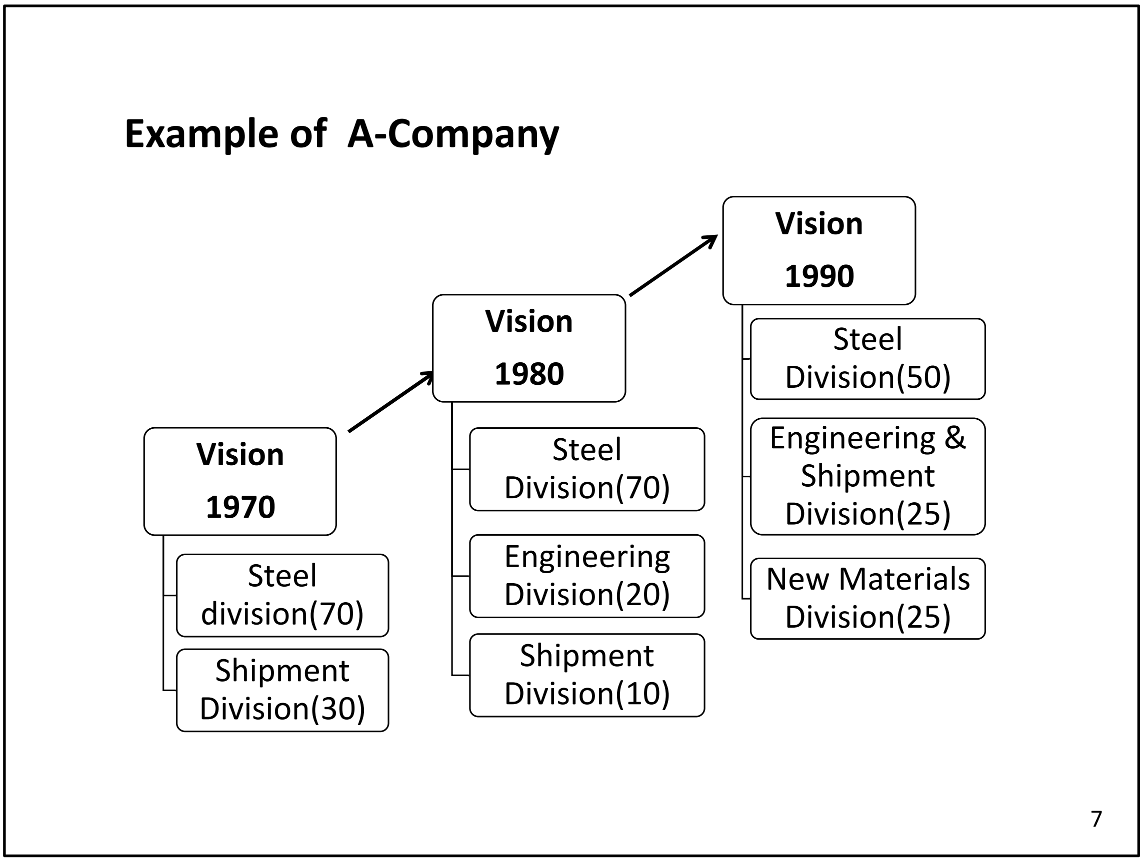
Examples of Corporate Vision

6

**3.2 Vision**

**Examples of Corporate Vision**

Next, I will introduce a Vision at a steel making company that I worked for long time ago.




**Example of A–Company**

A major Japanese steel production company manufactures steel and sells it to the automobile, heavy machinery, marine and civil engineering industries. When I joined the company in 1970, our company's Vision, which was shown, was to sell the products as a steel material and secures about 70% of revenue. On the other hand, in order to increase the sales volume of steel materials, our company made ships and sold them mainly overseas, so the profit from them was about 30%. When selling ships overseas, it was a common payment condition to settle in five to ten years on a dollar basis.

However, in 1980, the yen suddenly strengthened on the exchange rate of the dollar to yen, and the rate at the time of contract was extremely low compared to that of the time of settlement. Therefore, our company changed its Vision and reduced to 10% from 30 %, and instead brought the so-called new Engineering business up to 20% from 0%, which proceeded and sold steel for bridges and building construction.

In 1990, many steel companies in developing countries around the world started to emerge, and cheap steel materials for construction materials were on the market. Due to high labor costs, steel products in Japan have lost competitiveness and the production has dropped off. So our company created a new Vision again. That was to develop a new material to replace steel and respond to future business. It was expected that the new materials business would cover the decrease in revenue from sales of steel materials as a business by developing materials such as functional metals, semiconductors, and chemicals.

**3.3 SWOT Analysis to Produce Business Policies**

8

### 3.3 SWOT Analysis to Produce Business Policies

As a part of the JICA Kaizen project, the following introduces a case where trainees at EKI and engineers at the pilot company used SWOT Analysis to derive a Business Policy.

## An Example of a plastic products company implemented in the second batch of JICA Project

| External Environment | |
|---|---|
| Opportunity | Threat |
| 1. High population growth rate<br>2. Increasing growth rate<br>3. Increase demand for plastic package.<br>4. Preference for durable and environmental friendly at competitive price.<br>5. Technology accessibility eases to find market<br>6. Growing trend of agriculture, construction service and manufacturing sectors increase the demand for various types and size products.<br>7. Relatively cheaper labor cost<br>8. Availability of professional support service<br>9. Establishment of sector level institute | 1. Long delivery time of imported material<br>2. High amount of import from china and India<br>3. High inflation rate<br>4. Absence of quality inspection on imported similar products<br>5. Absence of formal training programs in the area of plastic industries<br>6. Insufficient services of financial institutions<br>7. Power interruptions<br>8. New entrants in the sector<br>9. High government emphasis on environmental issues<br>10. High tax rate on imported raw materials<br>11. The requirement to import using Ethiopian shipping lines alone |

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**An Example of a plastic products company implemented in the second batch of JICA Project**

This is the contents of each item obtained by EKI trainees discussing SWOT analysis together with CFT members of a plastic products company during the second batch of the JICA Project.

First, the external factors viewed from the company are classified into Opportunity and Threat, and the contents that are considered applicable are listed. The detailed description of each item is omitted.

## Contd.

| Internal Environment | |
|---|---|
| Strength | Weakness |
| 1. Large number of machines with diversified operation and products<br>2. Modification of some spare parts<br>3. qualified and experienced employees<br>4. Expansion of plant at Bishoftu<br>5. High management commitment and self-initiation<br>6. Good reputation about quality<br>7. Certified with ISO 90012008 and QMS | 1. High turnover of employees in technical field<br>2. Less focus on costing and market research activities<br>3. Most of machines are old<br>4. Frequent break down of a machine<br>5. Production flow is not conducive<br>6. High amount of waste and rework<br>7. Lack of sense of ownership<br>8. Products profitability is not assessed periodically<br>9. Lack of strategic linkage with existing customers<br>10. Lack of incentive and motivation scheme |

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Continued from previous page.

Similarly, they clarified strengths and weaknesses as the internal factors that the company have, organized and summarized them.

Here, the detailed explanation of each content is omitted.

## Cross SWOT Analysis

| | Opportunity | Threat |
|---|---|---|
| Strength | Large number of machines with diversified operation and products (S)<br>X<br>Increase demand for plastic package (O)<br>=<br>Increase Market share<br><br>Relatively cheaper labor cost(O)<br>X<br>qualified and experienced employees (S)<br>=<br>increasing labor productivity to produce in cost effective way<br><br>Expansion of plant at Bishoftu (S)<br>X<br>Growing trend of agriculture, construction service and manufacturing sectors (O)<br>=<br>Profit maximization through increasing sales amount | High amount of import from china and India(T)<br>X<br>Good reputation about quality (S)<br>=<br>Easily penetrate the market without high cost for market promotion<br><br>High tax rate on imported raw materials (T)<br>X<br>Large number of machines with diversified operation and products (S)<br>=<br>Increasing sales amount to compensate tax rate<br><br>Qualified and experienced employees (S)<br>X<br>High tax rate on imported raw materials (T)<br>=<br>Has potential to reduce defects and rework |

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**Cross SWOT Analysis**

Then use the SWOT items above to derive the results of the cross SWOT analysis. By multiplying the contents of Strength written on the left and the contents of Opportunity or Threat written at the top, each Business Policy can be derived. That is, these are candidates for some business policies.

## Contd.

| | Opportunity | Threat |
|---|---|---|
| Weakness | Availability of professional support service (O)<br>X<br>Frequent break down of a machine/ high downtime (W)<br>=<br>Reduce frequent breakdown and poor production flow<br><br>Growing trend for various types and size products(O)<br>X<br>Lack of strategic linkage with existing customers(W)<br>=<br>creating strong linkage with their customers having the high demand for plastic packages | New entrants in the sector (T)<br>X<br>High turnover of employees in technical field (W)<br>=<br>Installing incentive package for employees<br><br>High amount of import from china and India (T)<br>X<br>Less focus on costing and market research activities (W)<br>=<br>Finding ways for cost optimization |

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Continued from previous page. The technique is the same.

## Business Policies of a plastic products company

1. Institutional capacity enhancement
2. Increase market share and increase its sales and profitability by 3 folds
3. Enhancing human resources profile and management practice
4. Development and utilization of technology infrastructure
5. Enhancing productivity

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**Business Policies of a plastic products company**

As a result, several Business Policy proposals can be obtained, and the most important proposal as a company is selected from those proposals and set as the Business Policy from this fiscal year to the next fiscal year.

3.4 Policy Deployment

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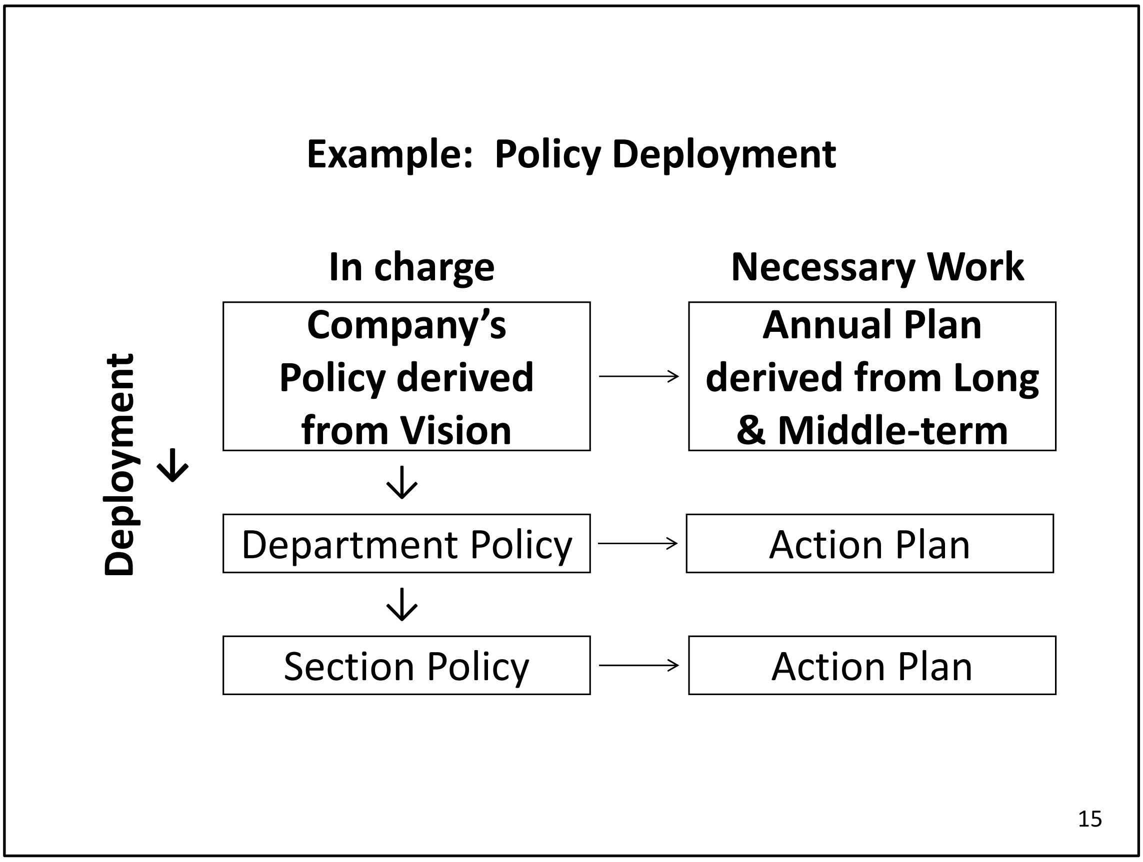
**3.4 Policy Deployment**

The following is an example of deploying a business policy from a company department level to a section level.




**Example: Policy Deployment**

This section uses a scheme to illustrate the deployment of policies in the enterprise.

In order to achieve the vision set by the company, several business policies are proposed along with an annual plan from the top of the company. These business policies are presented to departments, and when execution orders are issued, the departments then formulate departmental policies and annual plans. Similarly, when the policy at the top is presented to the sub-organization's Section and executed, the policy and annual plan for the Section are created. This is Policy Deployment.

## Example: Policies in each Hierarchy

| | Goal | Target | Means |
|---|---|---|---|
| **Company** | Annual Profit Up | 10 % | No Wastes |
| | Restructuring | 20% | Layoff |
| **Department** | Low Cost | 10 % Down | Min. Inventory |
| | | 10 % Down | Min. Expenses |
| **Section** ~Production Line~ | Reduction of Defects | <2% | Review of Operation Standard |
| | | | Visual Control |

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**Example: Policies in each Hierarchy**

Here, as an example, it is assumed that the business environment of the Japanese steel industry has deteriorated and that a certain steel company has proposed a restructuring of its business as a Business Policy.

Let's move on to deploying that policy. In order to achieve the company's business policy, ”Increase the profitability of the business”, the Department set its Policy of “Low Cost” as an own goal, plan how to achieve the goal, and schedule their execution. Then, the Production Line Section that receives the Department Policy sets the Policy as ” Reduction of Defects to 2% or less” together with the schedule.

The above table is an example of Goal, Target and Means.

<table>
<tr><th colspan="14">Department’s Policy Deployment</th></tr>
<tr><td colspan="4">Administration</td><td rowspan="5"></td><td colspan="4">Production</td><td rowspan="5"></td><td colspan="3">Design</td></tr>
<tr><td>Goal</td><td colspan="2">⟷</td><td>Means</td><td>Goal</td><td colspan="2">⟷</td><td>Means</td><td>Goal</td><td colspan="2">⟷</td></tr>
<tr><td rowspan="2">Low Cost</td><td>P</td><td>D</td><td rowspan="2">Min. Inventory & Min. Expenses</td><td rowspan="2">Low Cost</td><td>P</td><td>D</td><td rowspan="2">High Productivity & Min. Defects</td><td rowspan="2">Low Cost</td><td>P</td><td>D</td></tr>
<tr><td>A</td><td>C</td><td>A</td><td>C</td><td>A</td><td>C</td></tr>
</table>

⇩ **Policy Deployment**

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This Scheme shows that each Department plans Goal and Means to achieve its Policy and tries to realize it by PDCA.

The Department Policy is a means for the Company to achieve the Business Policy, and the means for the Department to achieve the Policy is the Section Policy of the subordinate organization.

## Action Plan of the Year
~ Production Department ~

| | Goal | Target | Means | Schedule | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
| **Adm.** | Low Cost | 50% | Min. Inventory | - - - - - - | | | |
| | | 70% | Min. Expenses | - - - - - - | - - - - - - | - - - - - - | - - - - - - |
| **Prod.** | Low Cost | 120% | High Productivity | - - - - - - | - - - - - - | - - - - - - | - - - - - - |
| | | <2% | Min. Defects | - - - - - - | - - - - - - | - - - - - - | - - - - - - |

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**Action Plan of the Year**

Show the action and schedule of the Administration and Production Department.

# INTERMEDIATE KAIZEN STORY

# Intermediate Kaizen Story

1

Intermediate Kaizen is performed according to Kaizen Story (QC story) by forming CFT (Cross Functional Team).

What is Intermediate Kaizen?

What is CFT?

After defining Intermediate Kaizen, we will learn about Intermediate Kaizen Story and supporting tools.

2

Intermediate Kaizen is performed most effectively when we use a proven procedure which is called “Kaizen story “(QC story).

In many cases, Intermediate Kaizen is performed by CFT (Cross Functional Team).

In this course we will learn Kaizen story and CFT.

Before that, we have to know what is intermediate Kaizen and what is CFT.

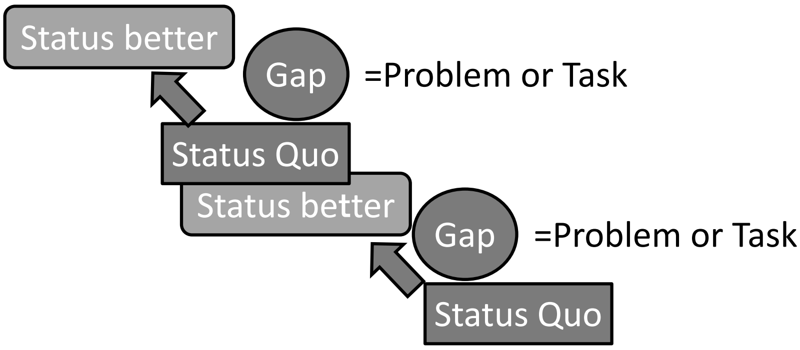
We will first define intermediate Kaizen and CFT, then learn the procedure to conduct intermediate Kaizen.

# Contents

# 1. Intermediate Kaizen & CFT

## 1.1 What is Kaizen ?

Continuous activities to make something better
Continuous activities to solve problems and or achieve tasks

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**1. Intermediate Kaizen & CFT**

**1.1 What is Kaizen ?**

Before all , what is Kaizen?

The original meaning of Kaizen is “change for the better”

Kaizen is “a Japanese business philosophy of continuous improvement of working practices, personal efficiency, etc.”

cite: Oxford Dictionary

We can call Kaizen as “Continuous activities to make something better” or “Continuous activities to solve problems and or achieve tasks”

The slide shows the Kaizen activities.

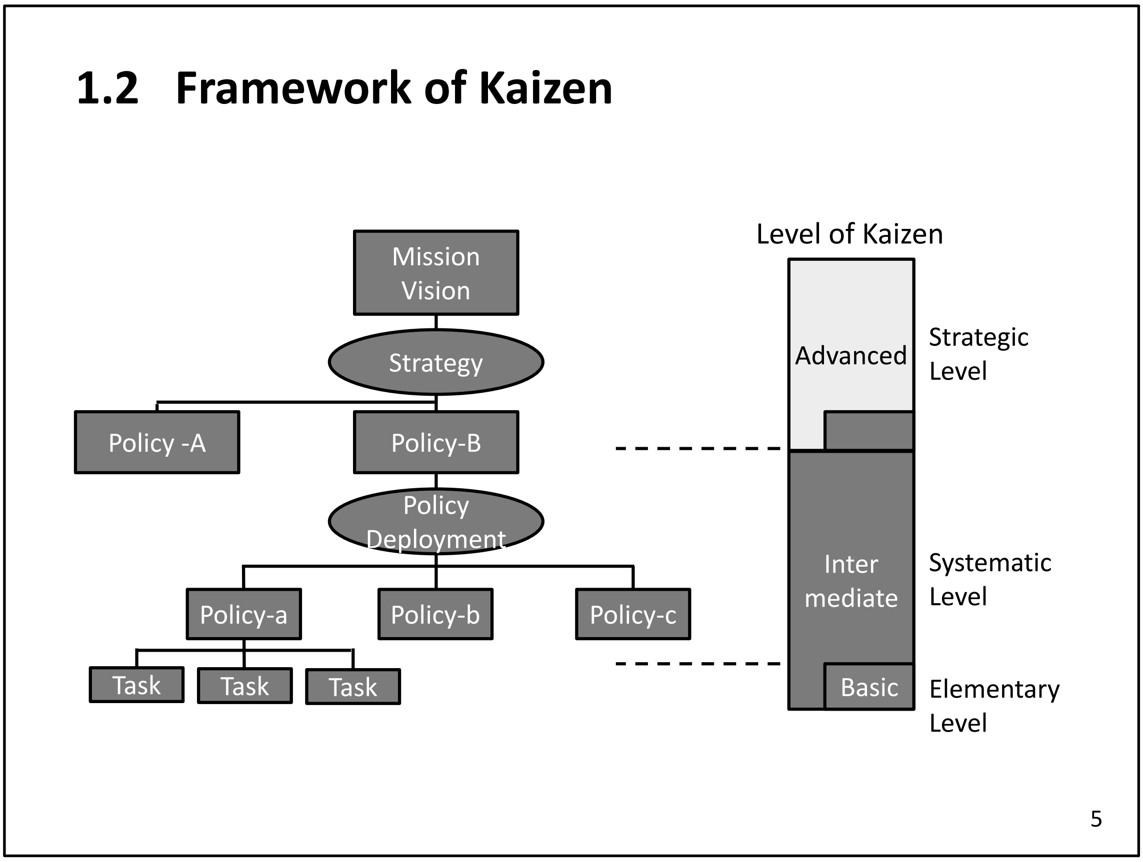
We start from the “status quo”

Sometimes the status quo has problem or is not the desired level or under the standard level . This means there is a gap between the standard level and the status quo.

We have to solve the problem or improve the situation and narrow the gap.

Once the problem is solved and the gap is filled , then there may appear new field for improvement.

Thus Kaizen has no end.




**1.2 Framework of Kaizen**

There are three levels of kaizen

1. **Strategic level:**

Company or organization has its mission, vison and policy (Business policy)

Here, the mission is a statement regarding its value and contribution to the society.

Vision is a blue print of the company for long term and policy is a guideline/set of principles which guide and govern its action.

Strategy or strategic mind is mandatory for the top management to develop policy from mission and vision.

This strategy is often called as competitive strategy because a company or an organization should consider its position in market (domain).

We sometimes use the word "plan". What is the difference between policy and plan.

Policy: Policies are the guidelines/set of principles which guide the concerned authority in its course of action

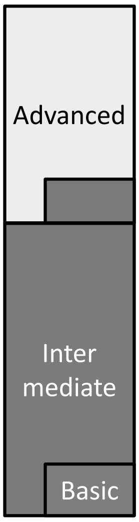
Plan: Plan is a roadmap to achieve the goal in coming 3years or 5years.

According to company policies each division will set their policies and tasks. Task is a piece of work assigned or to be done for achieving some goal shown by policy. Policies and tasks are divided and assigned to sections, groups and individuals

We call this process as "policy deployment process " and is explained in our curriculum "TQM" more in detail

In the intermediate Kaizen, normally we start from reviewing company policy and policy deployment.

## 1.3 Features of each Kaizen Level




| | Knowledge & tool | Characteristics | Stakeholders |
|---|---|---|---|
| Strategic Level | Competitive strategy<br>Domain<br>SWOT<br>Marketing | Innovative<br>Strategic<br>Global | Competitors<br>Those in Supply chain |
| Systematic Level | TQM<br>TPM<br>TPS<br>New 7QC tools<br>7QC tools<br>IE<br>Cost management<br>Production Planning | Creative<br>Task achieving<br>Problem solving<br>Top down | Customers<br>Divisions<br>Departments<br>Sections |
| Elementary Level | 7QC tools<br>IE | Bottom-up<br>Analytical | Section<br>Group/ Circle |

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### 1.3 Features of each Kaizen Level

Kaizen will be divided into Basic, Intermediate, and Advanced.

Basic level can be called elementary level. Intermediate level and Advanced level can be called Systematic level and Strategic level respectively.

The slide shows the knowledge & tools, characteristics, and stakeholders of each level of Kaizen.

## 1.4 What is I-KPT ?

What is KPT ?
=> Kaizen Promotion Team
(QC circle)

What is I-KPT ?
=> Intermediate Kaizen
Promotion Team
(KPT that can solve higher level problems
and tasks which require participants of
different sections or divisions
Same as “CFT” (Cross function Team)

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**1.4 What is I-KPT ?**

Before explaining CFT, KPT will be explained.

KPT is an abbreviation for “Kaizen Promotion Team” and is synonymous with Japanese QC circles.

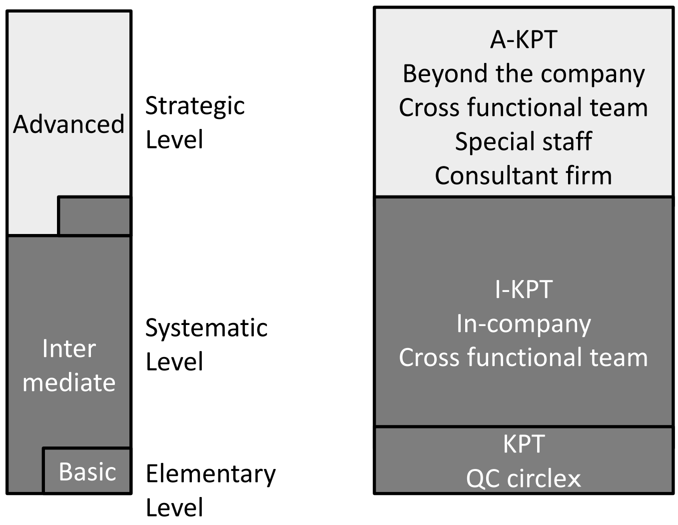
This is based on the naming of Mr. Getafun, the first director of EKI.

Whereas KPT or QC circles are usually made up of members of one department, section, or group, CFT is made up of members from different organizations.

This is because Intermediate Kaizen usually deals with problems and tasks that span multiple organizations and participate of members from multiple organizations is required for the solving.

Instead of the name “CFT”, “I-KPT” (Intermediate Kaizen Promotion Team) is also used in EKI.

## 1.5 KPTs by the Level of Problem and Task

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### 1.5 KPTs by the Level of Problem and Task

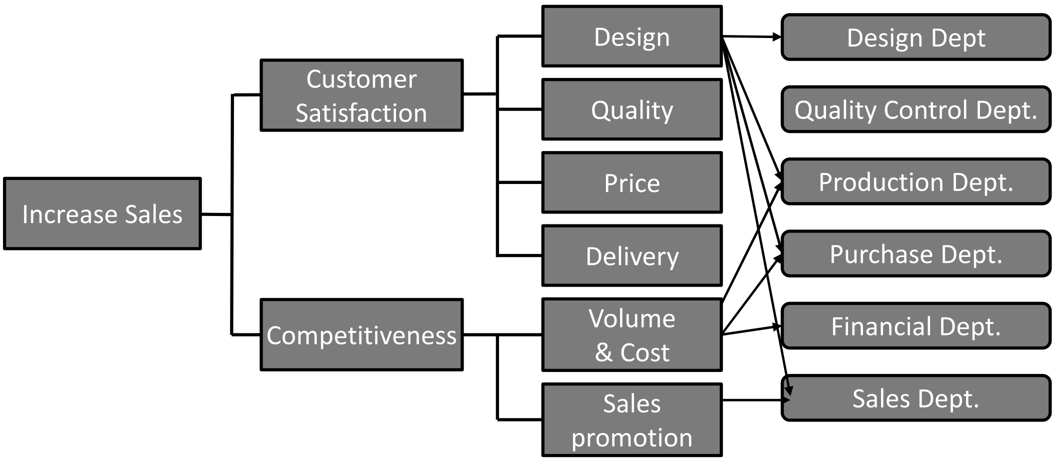
Kaizen is divided into Basic, Intermediate, and Advanced, and the corresponding team structure changes accordingly.

Basic level kaizen is usually resolved by a team (KPT or QC circle) selected from one section or group.

Intermediate Kaizen is resolved by a team of people selected from several related departments.

Advanced level is resolved by the team including external consultants in sometimes.

# 1.6 Example of Policy and Concerned Organization (CFT Configuration)

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**1.6 Example of Policy and Concerned Organization (CFT Configuration)**

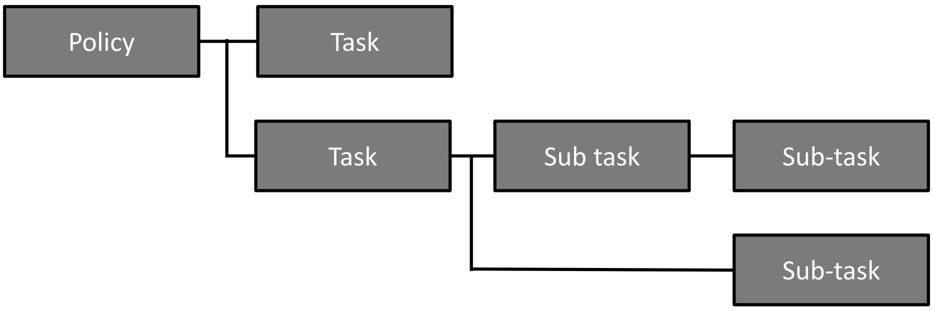
When policy is set to improve sales, customer satisfaction can be considered as a measure to achieve the policy. In addition, there are competitors in the market, so competitiveness against other companies should be considered. As the parameters to improve customer satisfaction ,there are Design, Quality, Price, Delivery and other factors

When design improvement is selected as a kaizen theme, the department concerned is not only the design department. Participation of production and purchase department are required . Participation of the sales department is also essential to check whether it is acceptable to customers.

In order to win the competition with other companies, it may be necessary to secure production volume besides the design and quality that satisfy customers. In that case, participation of finance and procurement department is necessary.

## 1.7 Policy- Task- Subtask

(Policy-Task-Sub task)




The target of Kaizen can be the tasks drawn from policy and sometimes sub-tasks drawn from tasks

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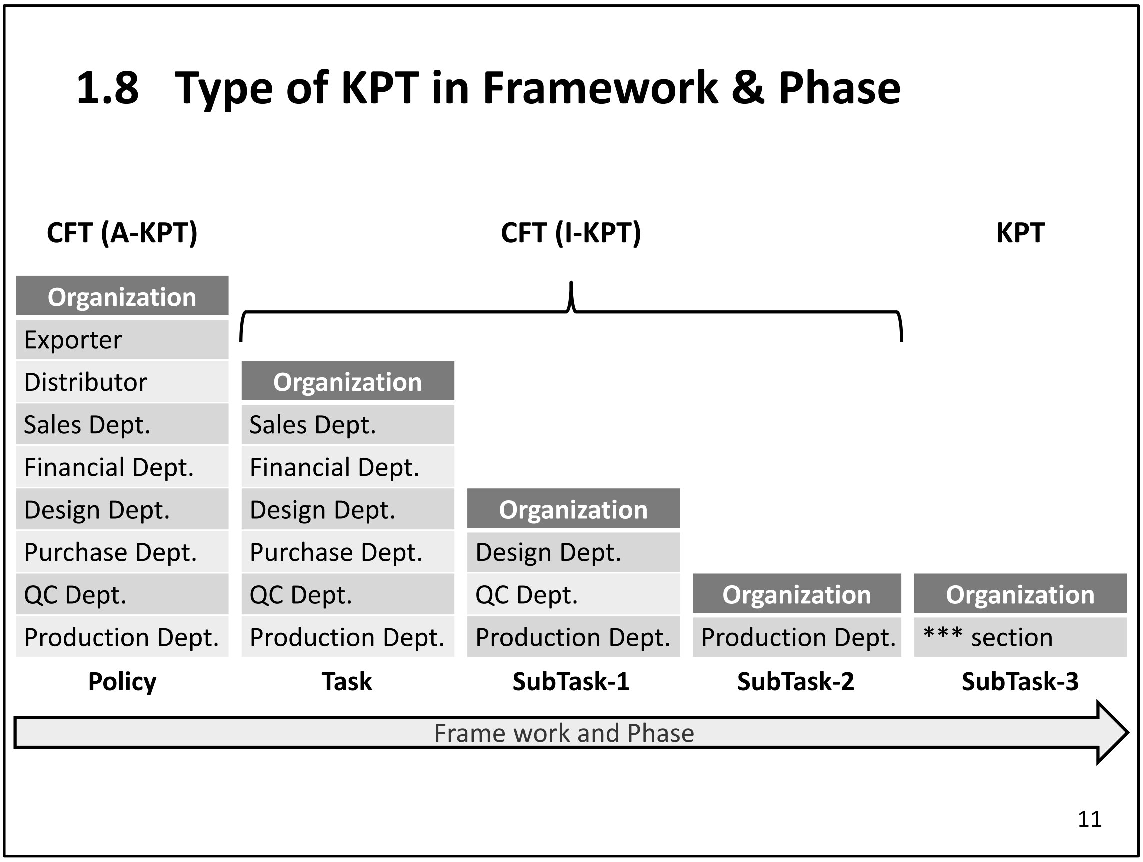
### 1.7 Policy-Task-Subtask

As already explained, Task is a piece of work assigned or to be done for achieving some goal shown by policy.

Kaizen activity is sometimes to achieve the policy direct and sometimes to achieve the tasks which link to policy

Tasks can be divided into sub-task which links to upper task.




## 1.8 Type of KPT in Framework and Phase

Depending on your goals (policies, tasks, subtasks), you can form a large KPT (CFT) consisting of members from many departments or form a small KPT consisting only of members of one section or group.

# 1.9 Difference between Basic/ Intermediate Kaizen

| | Basic Kaizen | Intermediate Kaizen |
|---|---|---|
| Company Policy | | Policy Deployment |
| Theme selection | Work place | Along with the company policy |
| Kaizen Story | Problem Solving | Problem Solving<br>Task Achievement |
| Tool | 5S<br>7QC tools<br>IE | 7QC tools, New 7QC tools<br>Advanced IE<br>TQM, TPS, TPM,<br>Cost Management<br>Inherent technology |
| Organization | KPT<br>Autonomous | I-KPT<br>More organized |

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**1.9 Difference between Basic/ Intermediate Kaizen**

This table shows the difference between the Basic Kaizen and Intermediate Kaizen in terms of Kaizen process, tool and organization.

# 2. Intermediate Kaizen Stories

## 2.1 Two Types Kaizen Stories (QC Story)

- I-KPT (QCC, CFT) will solve their problems along the "Kaizen Story" ( "QC story" ).
- Kaizen Story shows the steps to solve the problem or to achieve the task
- There are two types of Kaizen Stories.

**Problem Solving** & **Task Achieving**

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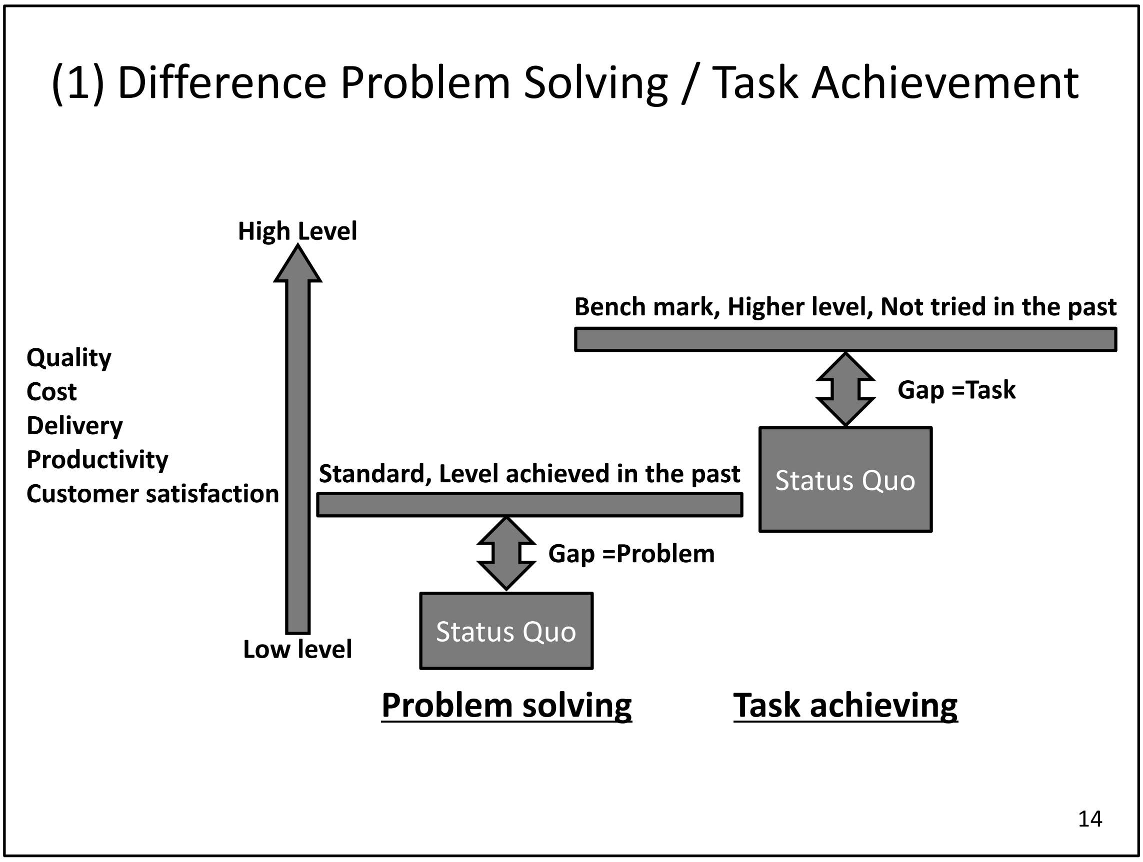
## 2. Intermediate Kaizen Stories

### 2.1 Two Types Kaizen Stories (QC Story)

QC Story was originally developed as a guide to make effective presentations of QC (Kaizen) achievement. But at the same time, it is also used as a standard procedure for performing QC (Kaizen) activities.

There are two types of Kaizen Stories Problem solving and Task achievement.

But please note that we normally can not perform kaizen exactly same order as the Kaizen story whether the problem solving or task achieving.




**(1) Difference Problem Solving / Task Achievement**

There are two types of Kaizen stories, Problem solving (PS) and Task achieving (TA)

In general, PS is said as a method to fill the Gap between the Status Quo and some standard level or the level which was once achieved at the company in the past.

TA is said to fill the gap between the Benchmark, higher level which has not been achieved at the company in the past.

TA can be said as an activity to realize the policy and PS can be said to solve the problems at Genba.

However in Intermediate Kaizen, even though the PS, the activity and the goal should align with the policy.

(2) Points of Problem Solving & Task Achieving

**Problem solving**

- In approaching, **find the root cause** which brings the problem is most important

**Task Achieving**

- In approaching, **create the ideas** as countermeasures which realize the ideal state is most important

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**(2) Points of Problem Solving & Task Achieving**

In the approach in Kaizen, PS approach normally put most importance on finding the root cause and TA put most importance on creating idea for solution.

That is because PS approach is normally used when there is problem but no one knows the causes and TA approach is mainly used when the causes are clear but the solution is not known.

## (3) Table of Differences

| “Task-Achievement” type Kaizen | “Problem-Solving” type Kaizen |
|---|---|
| ● To achieve an objective (task) that has not accomplished in the past.<br>● Seeking for benchmark from other companies or overseas enterprises and attempting to make own enterprise’s achievement closer to it.<br>● Innovative idea is necessary to design effective plan.<br>● It takes longer period of time to accomplish the task.<br>● Large number of persons and related departments of the enterprise are involved.<br>● The gap between task and current status is wide in general. | ● To fill the gap (problem) against the set objective.<br>● To fill the gap between the best standard that an enterprise accomplished in the past and the current situation.<br>● It is important to investigate the true cause of the problem.<br>● It can be accomplished in short time of period.<br>● Small number of persons and related departments of the enterprise are involved.<br>● The gap between the set objective and current status is not so wide. |

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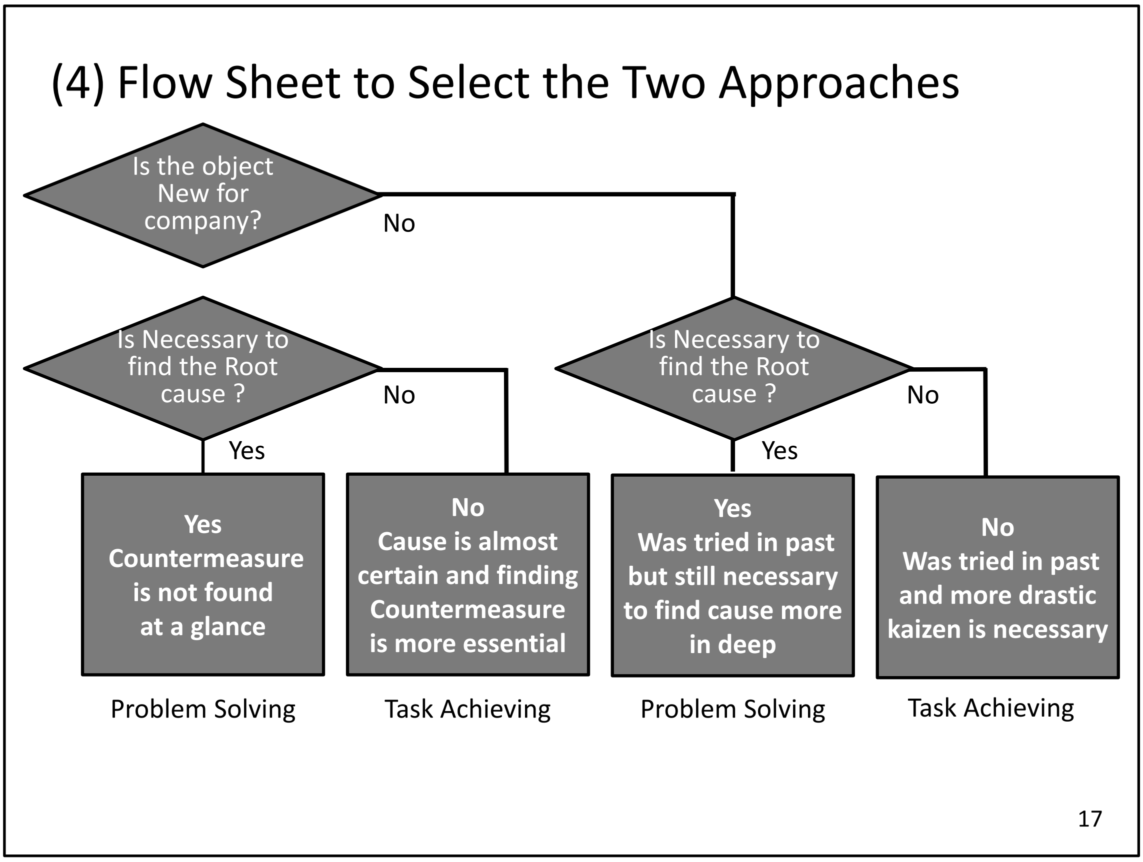
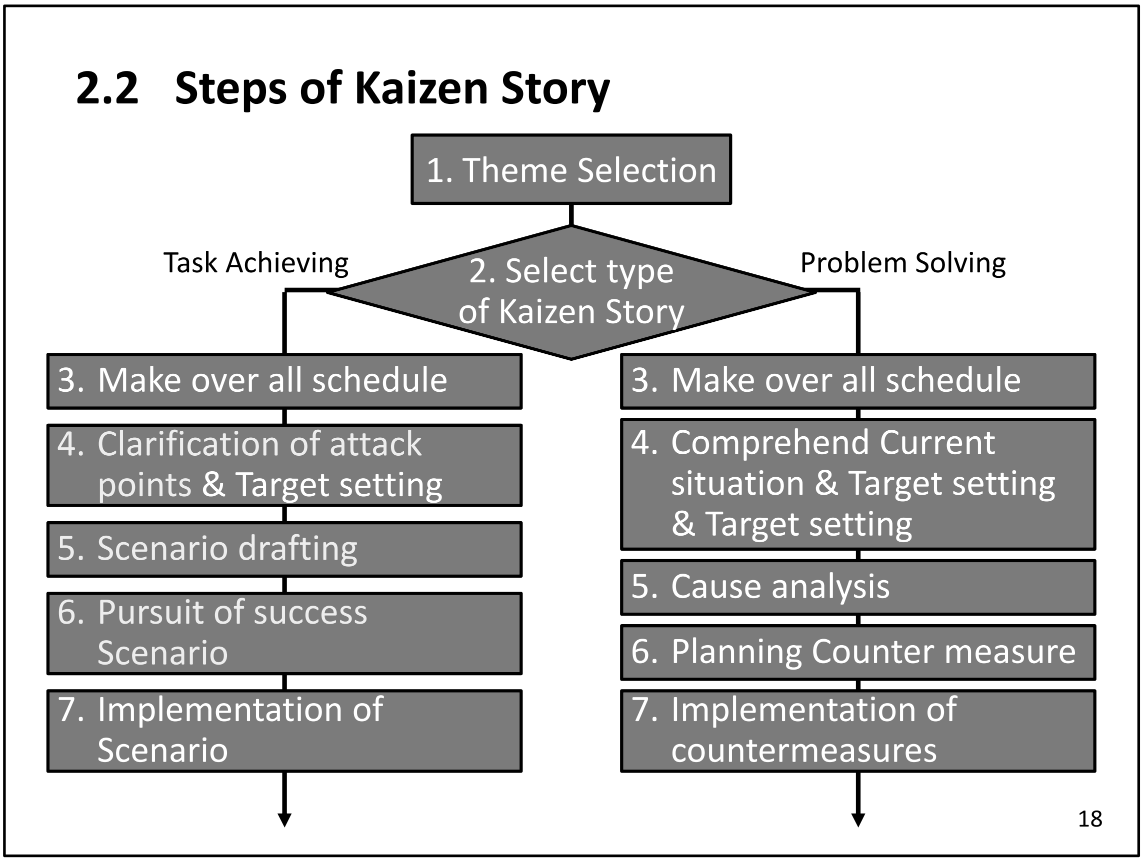
**(3) Table of Differences**

This table will help to select the PS approach or TA approach.




**(4) Flow Sheet to Select the Two Approaches**

This flow sheet may help to select the PS approach and TA approach.




**2.2 Steps of Kaizen Story**

The Kaizen Story (QC Story) sums up the necessary steps for proceeding Kaizen in ICT. At the same time, it is the index that is used when trainees and CFT members present their achievements in the middle and at the end of project. It is originally called the QC Story, however, in addition to quality, these steps are also used for resolving problems concerning productivity, cost, and delivery.

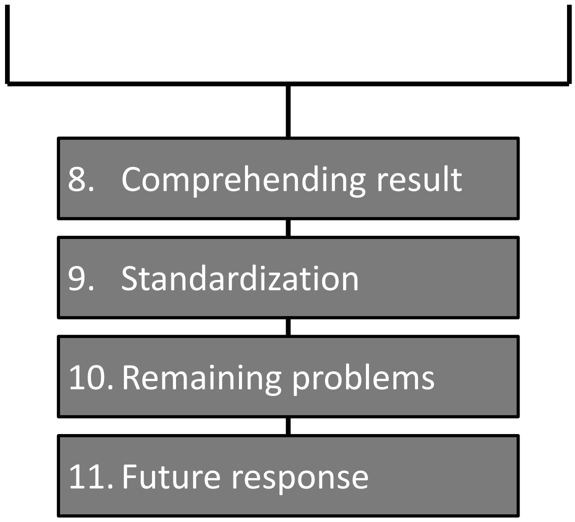
So we call the procedure as “Kaizen Story”

Kaizen story is applied both the Task achieving and Problem solving approach.

The advantage of following the QC Story is to promote projects in the manner of scientific and logical approach.

At the same time, by using Kaizen story as a standard process , mutual understanding among persons concerned become easy.

## Cont.

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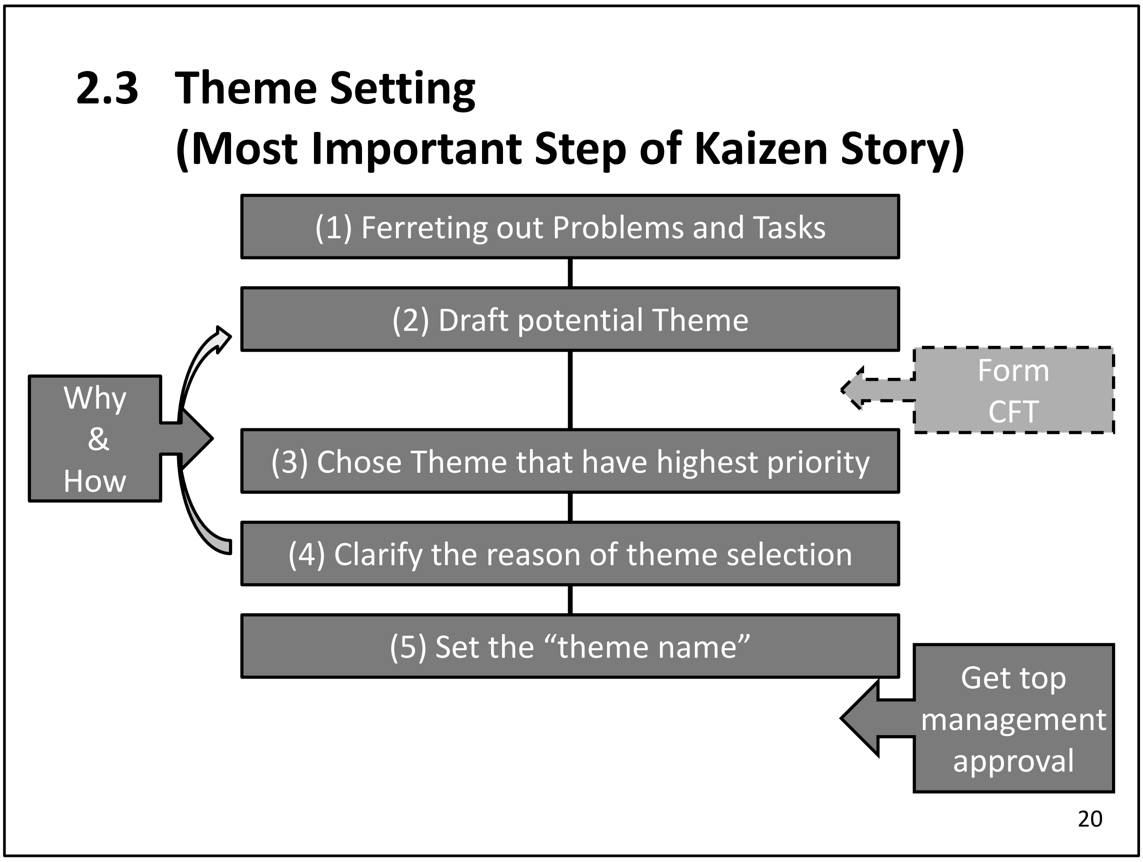
Here, the Kaizen Story is composed of 11 steps.

When you use the story as the table of contents of presentation, there would be Preface and Profile of company before these 11 steps.

Introduction of CFT members also would be added for the presentation.




**2.3 Theme Setting**

The first step is theme setting. This step is one of the most important steps in Kaizen Story.

The success and failure depends on selection of theme.

## (1) Ferreting out Problems and Tasks

1. Check the vison and policy of the company
2. Study the business environment of the company
3. Visit the “Genba” and try to find out something strange
   (MUDA mind, IE mind and QC mind may help in this phase)
4. Interview the management, Kaizen office

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**(1) Ferreting out Problems and Tasks**

For setting good theme, ferreting out the problem and task is the first and most important step.

## (2) Draft Potential Theme

1. Not limit to one
2. Typical categories of Theme are shown in Fig. 2-1 & Table 2-1

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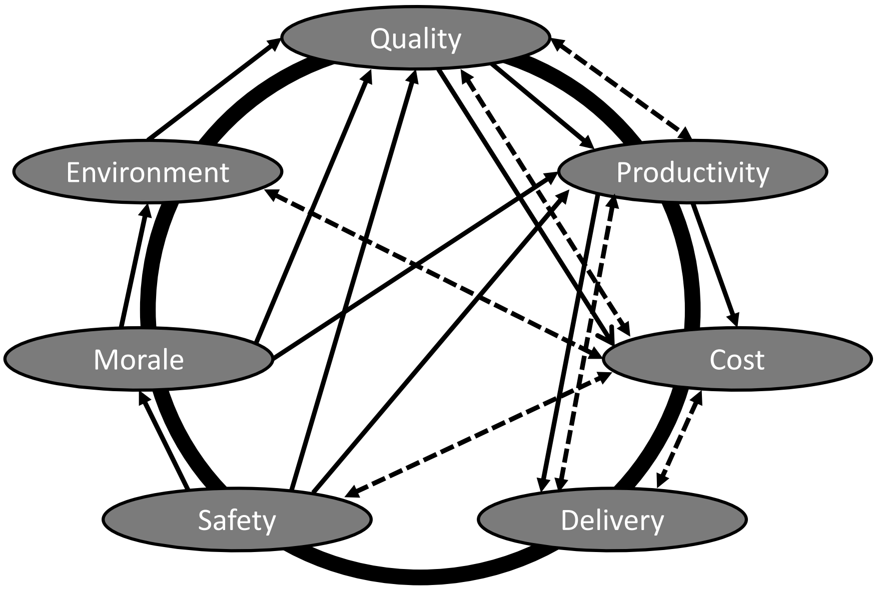
**(2) Draft Potential Theme**

It is recommended to list up several themes before selecting one.

Flexible mind is also required in this process.

According to the Kaizen story, comprehending current situation/ clarification of attack points come after theme setting. But in actual Kaizen, some part of comprehending current situation/clarification of attack points come during the theme finding process.

Fig. 2-1 Typical Categories of Theme

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## Table 2-1 Problem/Task Finding Check sheet

| | Check Point | What concerns you |
|---|---|---|
| Q | What are the problems and tasks on quality | |
| C | What are the problems and tasks on cost | |
| D | What are the problems and tasks on delivery time | |
| P | What are the problems and tasks on productivity | |
| S | What are the problems and tasks on safety | |
| M | What are the problems and tasks on moral | |
| E | What are the problems and tasks on environment | |

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**Problem/Task Finding Check Sheet**

When you visit Genba, It is recommended to have some check points in your mind.

By looking Genba without having such mind, you may not able to find any problem.

## (3) Example of Theme in Line with Company Policy

- Increase production volume of by ****
- Increase sales by ***
- Increase productivity by***
- Improve product quality
- Reduce customer complain by***
- Develop new variety of products

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**(3) Example of Theme in Line with Company Policy**

Typical theme in line with company policy are shown.

# (4) Formulate Appropriate CFT

1. Ask the managers to select appropriate personnel for Kaizen
2. The leader is better to be selected from the Department or Section which has biggest relation with the theme

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**(4) Formulation of Appropriate CFT**

CFT is to be formulated after or in between the selection of the theme.

Appropriate selection of leader and members is most important for steering the CFT.

Official formulation of CFT is better after setting theme, however provisional members have been selected during the process of finding theme.

To get good theme it is mandatory to grasp current situation quickly and precisely. To do so, you need some key members before the formulation of formal CFT

## (5) Choose Theme that have Highest Priority

1. Decide on evaluation items and narrow down the theme based on the items.
   Refer to Table 2-2 for example
2. Discuss with the managers of the company on the narrowed down theme and get consensus that it is the priority item and decide the theme finally
3. Review the theme by Why and How

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**(5) Choose Theme that have Highest Priority**

It is common that several potential themes become candidate.

Theme should be selected finally after getting consensus of top management.

It is recommended to make sure the reason of selection by means of Why and How.

Company's demand should be largest priority.

## Table 2-2 Example of Evaluation Sheet of Theme

| Evaluation items / Problems and tasks | Necessity | | | | KPT Capability | | Overall evaluation | Priority to table |
|---|---|---|---|---|---|---|---|---|
| | Importance | Urgency | Feasible for tackling | Upper Policy | Is the timing right? | Is the work possible to cope with ourselves? | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

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**Example of Evaluation Sheet of Theme**

The theme should be selected considering necessity and capability.

## (6) Set the "Theme Name"

- Put appropriate name which shows the purpose of Kaizen
- The name should clearly shows "What" and "How"
- The name should not limit the means

" Increasing sales of ladies' clothes by 20%" ○
" Increasing sales of ladies' clothes by campaign" △
" Increase sales" ×

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**(6) Set the "Theme Name"**

The important thing when deciding on a theme name is that the theme name correctly conveys the contents of kaizen.

It is necessary to identify the Kaizen area specifically.

It is recommended not to limit the way (How) by the naming.

## Key Points at Theme Selection

- Theme selection is a key for successful consulting work specially for ICT training.
- The most important at this phase is grasp the situation wide and by fact
- Along with the data collection KKD is also important (K: experience, K: feeling, D: courage)
- Don’t rely on the QC tools too much, rely on your thinking power

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**Key Points at Theme Selection**

Total period of ICT is 6months or 7months.

We have to get result in this short period.

It normally takes 2 or 3 months for implementation, so theme setting should be done in first 1 or 1.5 months.

The time is limited but the success of ICT depends mainly getting good theme so we should be careful.

Most important thing is grasp the fact and think on the fact.

Don’t forget to use your own head rather than using many tools .

## (7) Useful Tools at Theme Setting

- At the phase of theme setting, It is important to gather and analyze data quickly and appropriately.
- Useful tools at this phase are;

**Check sheet**

**Pareto diagram**

**Tree Diagram**

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**(7) Useful Tools at Theme Setting**

At the theme setting phase, to think logically and statistically based on fact and data is most important.

There are QC tools which help thinking logically and statistically.

Appropriate use of such QC tools is recommended but using tool itself is not the purpose.

# 2.4 Make over all Schedule

## Decide Kaizen overall activity plan and roll-sharing

Work break down

Kaizen overall activity plan

| Activity item | Person in charge | Schedule | | | | | |
|---|---|---|---|---|---|---|---|
| | | Jan. | Feb. | Mar. | Apr. | May | Jun. |
| Study current plant layout | Samson | ▪▪▪▶ | | | | | |
| Study process flow | Selamawit | ▪▪▪▶ | | | | | |
| Investigate MUDA | Fetene | ▪▪▪▶ | | | | | |

Plan ▪▪▪▪▪▪▪▪▪▶ Actual performance ⟶

Decide schedule

Decide roll sharing

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**2.4 Make over all Schedule**

The third steps is the planning of Kaizen activities. In the previous steps, the Kaizen theme was set and the deadline for achieving the target was decided. Now it is necessary to define the activities and make schedule.

The Kaizen activity plan specifies three items. First are the activity items needed in order to achieve the target. Taking a simple example, let's assume that the theme is to reducing defect in sewing line. First of all CFT should receive some training of Kaizen story where the CFT members are educated about how to gather and analyze data. Next, comprehending current situation and cause analysis are conducted where brainstorming, Why-Why analysis and other tools are uesed by CFT members. Next activities are the countermeasures setting, implementation and comprehending the result.

The next item is deciding person in charge of each activity item. And the third item is the scheduling of each item. The scheduled start and completion dates for each item are entered onto a Gantt chart.

## 2.5 Comprehending Current Situation/ Clarification of Attack Points

### (1) Comprehending Current Situation

**After analyzing current situation of problems based on data, define the problem points and decide objectives**

- Clear up the current situation through brainstorming and cause and effect diagram.
- Comprehending current situation is done quantitatively through observation.
- Gather stratified data and graph it.
- Comprehend variability of data.
- Set objectives (what, how many, how much, by when).

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**2.5 Comprehending Current Situation/ Clarification of Attack Points**

**(1) Comprehending Current Situation**

Next step in Problem solving is comprehending current situation. The problem situation is gauged, analyzed and defined based on data. In addition to this analysis, the Kaizen target is set in this step. The target clearly defines what should be improved, by how much, and by when. This series of tasks is referred to as comprehending the current situation. This is an extremely important step in order for Kaizen to produce results.

Comprehending the current situation can be easily confused with the later step of cause analysis. There are two types of analysis in the Kaizen approach, i.e. results-oriented analysis and cause-oriented analysis. Results-oriented analysis is concerned with the current situation. Let's take the case of a traffic accident. One car has crashed with another. What kinds of cars were they? When and where did they crash? What was the extent of injuries? How badly damaged were the cars? In this way, results-oriented analysis entails comprehending the conditions of the accident. Put another way, results-oriented analysis entails comprehending conditions using 5W1H with the Why omitted. On the other hand, cause-oriented analysis entails analyzing the causes that brought about the accident. For example, it asks if the accident was caused by lack of attention of the drivers, slippage, falling asleep at the wheel and so on. It is analysis of Why.

For the comprehending the current situation, Results-oriented analysis is most required.

## Check Sheet

[Example] Number of Defects in Leather Shoe

| | Feb/1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Leather defect | // | /// | // | /// | // | /// | // | /// | 20 |
| Wrong centering | / | // | // | // | // | // | // | // | 15 |
| Stitching problem | / | / | / | // | / | / | / | // | 10 |
| Back part wrinkle | | / | | // | | | / | / | 5 |
| Leather scratch | | / | | / | / | | | | 3 |

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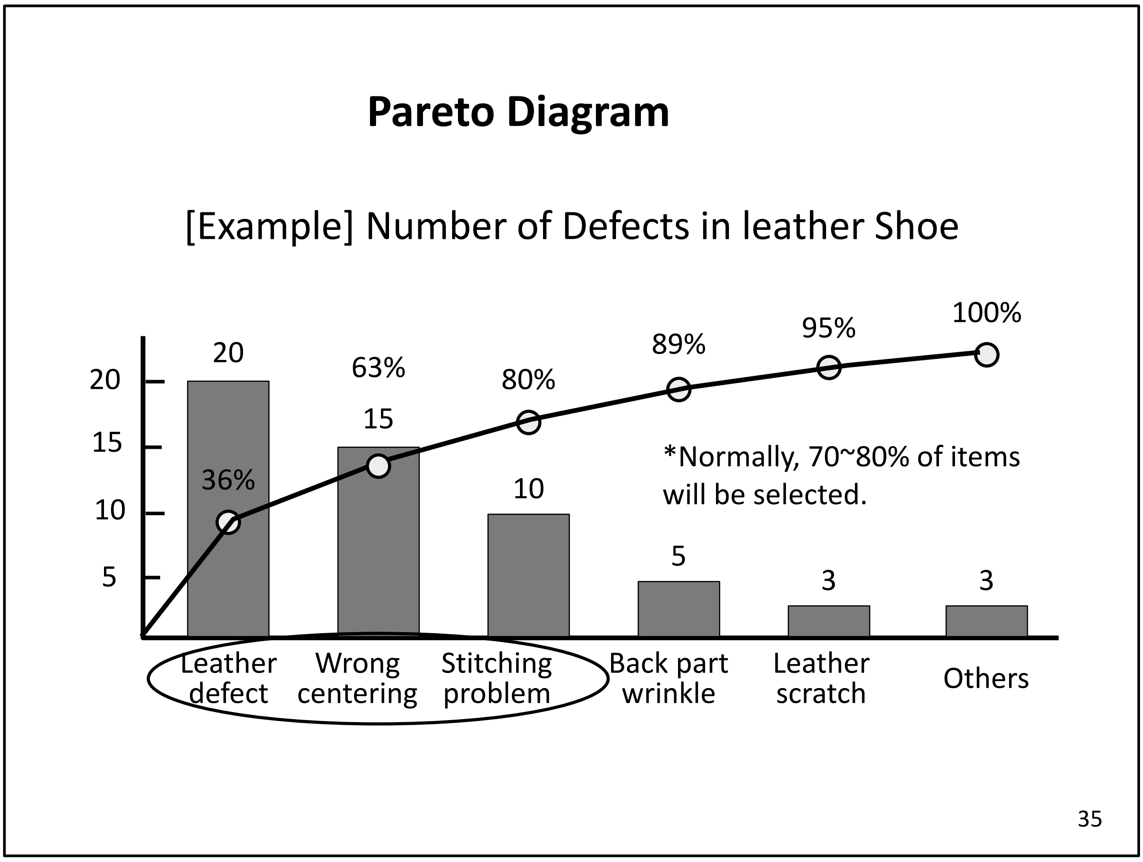
**Check Sheet**

For the comprehending current situation , fact finding by data is most important and check sheet is often used to record the occurrence.




**Pareto Diagram**

Pareto diagram is effective to select the point to tackle with

## (2) Clarification of Attack Points

**Before generating idea for better, grasping the current situation and knowing GAP between the current and goal**

- Grasp the current situation by data and observation .
- Compare the current situation with the best practice
- Use internet to find best practice

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**(2) Clarification of Attack Points**

In case of Task achieving (TA), next step is clarification of attack points. This step is similar to comprehending current situation in Problem solving. The actual situation should be gauged, analyzed and defined based on data. Then target should be decided according to benchmark, company policy etc.

The target clearly defines what should be achieved by how much, and by when. This series of tasks is an extremely important step as well as in the Problem solving approach.

## Example: Attack Points Selection Sheet

| Characteristic | | Desired level | Current level | Gap | Attack points | Effect | Obstacle | Adopt |
|---|---|---|---|---|---|---|---|---|
| Parameter | Product time | 0.8 Hr/piece | 1.0 Hr/piece | 0.2Hr/piece | | | | |
| Method | Man | Keep | 14 | No | Precondition | - | - | - |
| | Machine | No break down | down time: 5Hr. /Month. | No big gap | - | - | - | - |
| | | Good operation ability | No problem | No | - | - | - | - |
| | Method | No Muda | Complicated layout Long moving distance | 50m | Reduce moving distance | 0.1Hr | cost | ○ |
| | | | Waiting time : average 0.2Hr/Hr/operator | 0.1Hr | Reduce staying time of WIP and parts | 0.1Hr | | ○ |
| | Environment | Sorted and Set work space | Many storage area for WIP and | 50 sqm | - | - | - | - |
| | | Safe | Narrow aisle, High shelf | Unsafe | Wide aisle | - | | - |

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### Attack Points Selection Sheet

It is convenient to use list to define the attack points.

# 2.6 Cause Analysis/ Scenario Drafting

## (1) Cause Analysis

**Investigate root causes which induce problems**

- Pick out causes from problems through brain-storming.
- Focus on causes supposed to be important through cause and effect diagram and why-why analysis.
- Confirm important causes with data (fact).

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**2.6 Cause Analysis/Scenario Drafting**

**(1) Cause Analysis**

Step 5 in Problem solving approach is Cause Analysis. Here, we try to comprehend the conditions surrounding the problem from as many angles as possible. Opinions are gathered through brainstorming and so on to determine the influencing factors. These opinions are then structured into a cause and effect diagram.

Cause and effect diagram is also used to help extracting opinions. Categorizing the causes to 4M(Man, Machine, Material and Method) is most commonly used.

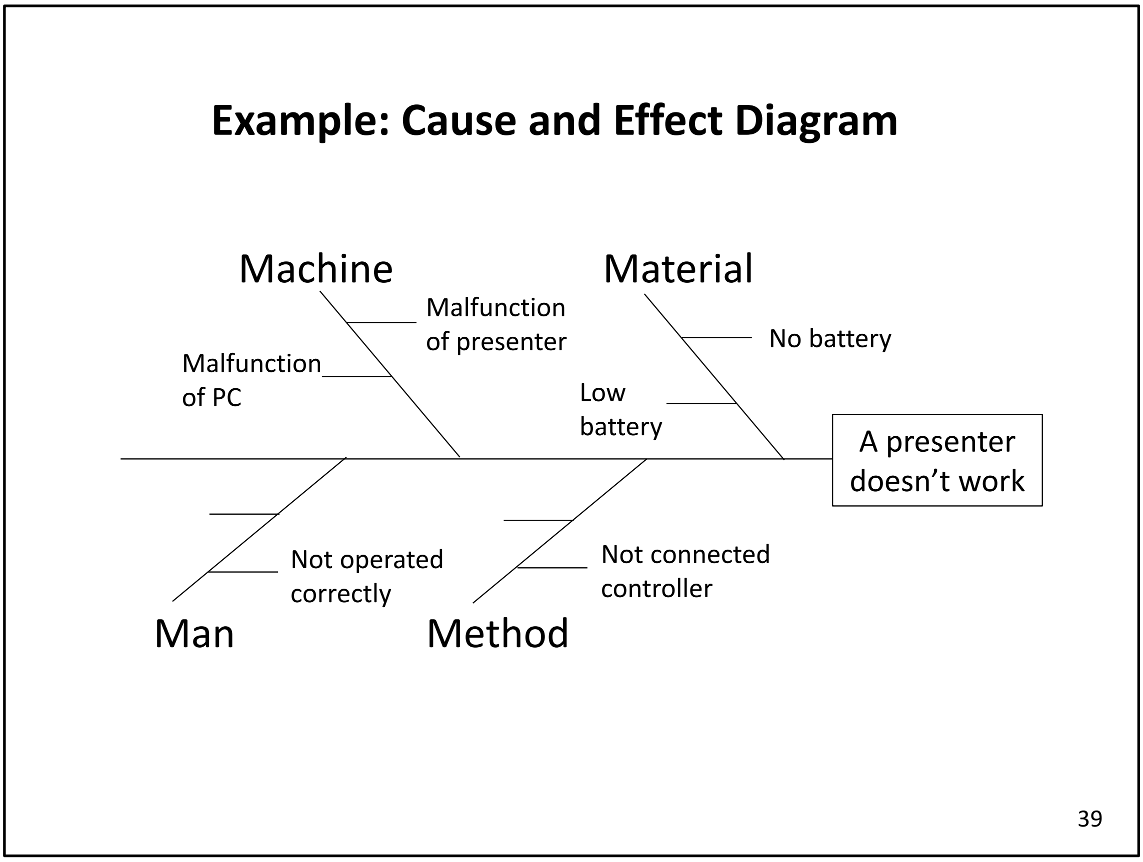
For example, let's assume that a KPT identified a problem on a laser pointer with controller of PC which can't feed and/or back the slide in the presentation even though pushing the button switch. Why doesn't it work? Comprehending the situation is what this step is about. Numerous potential causes come to mind, for example, battery is done or becomes weak, USB adaptor not inserted to PC, pushed incorrect button switch, breakdown of laser pointer and so on. The cause and effect diagram displays these causes in a structured style.

However, the cause and effect diagram is a qualitative analysis technique. It presents numerous potential causes of the problem, but it does not show which factor is most likely.

So, It becomes necessary to investigate the factor more in detail with quantitative data.

Thus, cause and effect diagram can show potential causes but can't show the root cause.

Why-Why analysis is often used for analyzing and finding root cause from the cause and effect diagram.




**Example: Cause and Effect Diagram**

## Example: Why-Why Analysis

<table>
<tr><th>Problem</th><th>why 1</th><th>why 2</th><th>why 3</th><th>why 4</th><th>why 5</th></tr>
<tr><td rowspan="4">Too much consume of material in Bedding</td><td rowspan="2">Increment of OD of bedded cable</td><td>Lack of proper die and tips selection</td><td>Lack of skill</td><td></td><td></td></tr>
<tr><td>Using larger diameter</td><td>Unavailability of proper die and tips</td><td></td><td></td></tr>
<tr><td rowspan="2">Unevenness of bedding</td><td rowspan="2">Incompatibility of line speed with RPM</td><td>Standard speed is not shown to operator</td><td>Lack of standard & manual</td><td></td></tr>
<tr><td>Operator negligence</td><td>Lack of motivation</td><td></td></tr>
<tr><td rowspan="2">To big strand diameter in Assembly</td><td rowspan="2">Increase laid up diameter</td><td rowspan="2">Tension variation</td><td>ware out of each drum break</td><td></td><td></td></tr>
<tr><td>lack of proper adjustment</td><td>Proper adjustment way is not shown to operator</td><td>Lack of standard & manual</td></tr>
</table>

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**Example: Why-Why Analysis**

Try several Whys till arriving root causes

## (2) Scenario Drafting

**Generate ideas which contribute achieving the target**

- Use Brain-storming method .
- Narrow down the ideas to several categories.
- Consider the effect.

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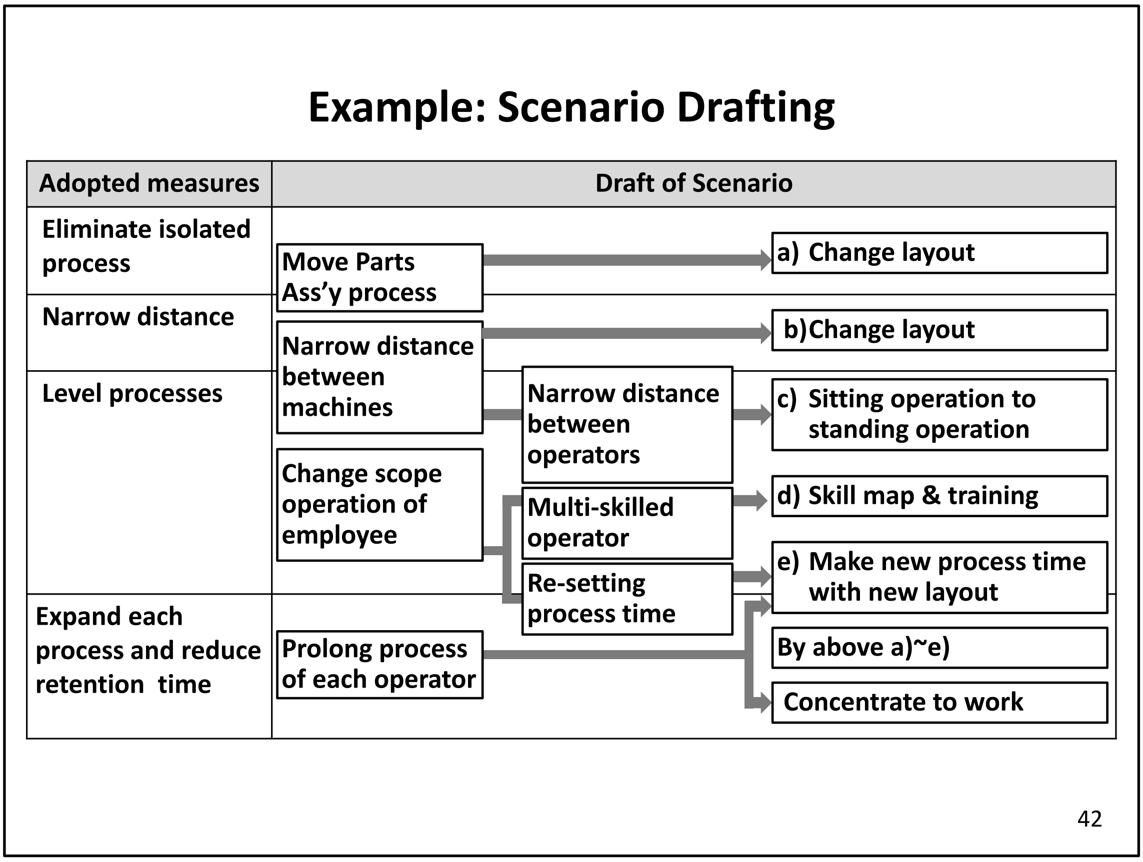
**(2) Scenario Drafting**

In case of Task achieving, next step is Scenario drafting. Here, we try to generate ideas which contribute achieving the goal or target.

Brainstorming is effective in this step.

Scenario drafting becomes easier if we grasp the current situation and the gap between the ideal figure.

Creative mind is most required.




**Example: Scenario Drafting**

In the scenario drafting process, CFT first try to come up with many ideas.

Then for these selected ideas, list up detailed method.

## 2.7 Planning of Countermeasures/ Pursuit of Success Scenario

(1) Planning of Countermeasures

**Planning and implementation of countermeasures which take away root causes**

- Generate countermeasures by confirmed root causes.
- Focus on countermeasures to be implemented.
- Create an action plan for preferential countermeasures.
- Implement the action plan.

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**2.7 Planning of Countermeasures/ Pursuit of Success Scenario**

**(1) Planning of Countermeasures**

Step 6 is the planning of countermeasures for the Problem solving and Pursuit of success scenario for the Task achieving.

Planning countermeasures can be divided into results-oriented measures and cause-oriented measures. Let's assume that nonconforming products have suddenly increased. In order to prevent nonconformities from reaching customers, for the time being inspections of final products are reinforced to prevent nonconformities from getting out. This is a results-oriented measure. It is an emergency measure aimed at stopping nonconformities reaching customers.

However, although results-oriented measures stop nonconforming products from leaving the plant, they do not reduce the actual occurrence of nonconformities. For this, it is necessary to conduct cause-oriented measures. The measures dealt with in the kaizen Story are basically cause-oriented measures aimed at either eliminating the cause of the problem or mitigating the effects of the cause.

## Example: Countermeasure

| Problem | AREA | Root causes | Countermeasure |
|---|---|---|---|
| **Increment of Pvc consumption over unit length** | Assembly process | Tension problem | Adjusting break of 1600 and changing belt of 1250 to disk break |
| | | | Substituting old breaks with new one |
| | | | Use extension wire to keep the last tension of each cable |
| | | | Conducting experience sharing with in operators |
| | | | Adjusting travers during insulation process |
| | Bedding process | Increment of OD | Provide training how to select appropriate die and tips |
| | | | Provide training how to use die and tips keeping center |
| | | | Purchase die and tips having frequent order |
| | | Incompatibility of line speed with RPM | Preparing operation manual |

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**Example: Countermeasure**

Once you find root cause, you will find the countermeasures relatively easily.

# (2) Pursuit of Success Scenario

**Planning and implementation of countermeasures which achieve the task and not give second effects**

- Study the draft into detail and rigid scenario.
- Prioritize the effect and feasibility .
- Consider the obstacle and side effect

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**(2) Pursuit of Success Scenario**

Step 6 in the Task achieving is the Pursuit of success scenario.

Drafted scenarios are to be studied from effect, feasibility and secondary effect.

In this process, drafts are narrowed down into a most effective and realistic scenario.

## Example: Pursuit of Success Scenario
## – Check Obstacle and Secondary Effect -

| Candidate Scenario | Obstacle<br>Secondary effect | Counter measure | Decision |
|---|---|---|---|
| a) Change layout | Stop operation<br>Budget | Convince management by EE | Go |
| b) Change layout | Stop operation<br>Budget | Convince management by EE | Go |
| c) Sitting operation to standing operation | Physical Fatigue | Adjust height of work table | Go |
| d) Skill map & training | New process time with new layout | | Go |
| e) New process time with new layout | Mindset of operator | Meeting and award | Go |
| f) Concentrate to work process | Need operator for parts supply | Assign one operator | Go |

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**Example: Pursuit of Success Scenario**

Scenarios are then checked whether some obstacles and or sub effect exist.

Final Scenario checked through these processes will be implemented.

## 2.8 Implementation of Countermeasures/ Success Scenario

**Implementation will be done according to detail action plan under the consensus of management, CFT and operators**

- Assign appropriately the responsible personnel.
- Make action plan to show What, Why, When, Where, Who, How

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**2.8 Implementation of Countermeasures/ Success Scenario**

Once the countermeasures are planned, they are then executed. Here, caution needs to be exercised concerning two points, i.e. are the measures being executed as planned, and how long have they been executed for? First, when executing measures, modified work methods should be notified to the related persons, and checks should be conducted to make sure that the measures are being properly executed. If attention is not paid, workers may revert to their old methods. Certainly, adopting new methods entails some difficulty. In such cases, it might be necessary to modify the method to better suit reality.

Another point requiring care concerns for how long the new method should be tried. It is rare for improvements to immediately produce results. Particularly in cases of Kaizen that includes improvement of manual tasks, results may temporarily decline compared to before the measures. However, if the improvement plan is appropriate, results will eventually appear and results will surpass the conditions that existed before Kaizen. Another point concerns for how long to follow up the results of implementing improvement measures. The higher the level of task, the longer it takes for results to appear. Whether it be one week or one month, it is necessary to decide the length of the period for assessing results.

It is useful to make table of countermeasure implementation plan which shows "What, Why, Who, Where, When and How (5W1H)"

## Implementation Action Plan

| What should be | Why it should be done? | How should it be done? | Where should it be done? | Who should be | When should be done |
|---|---|---|---|---|---|
| **Adjusting break of each drum** | Adjusting break | Changing ware out disk | Assembly machine 1600 | - Technique | Feb.13-18 |
| | Improving tension capacity | Changing belt to break system | Assembly machine 1250 | - Technique | Feb.13-30 |
| **Use extension wire at the end of each cable** | Twisting and keeping tension of the last cable | Fixing exterior cable at the end of the cable | Assembly machine /1250 and 1600/ | - CFT and trainee | Feb. 13-20 |

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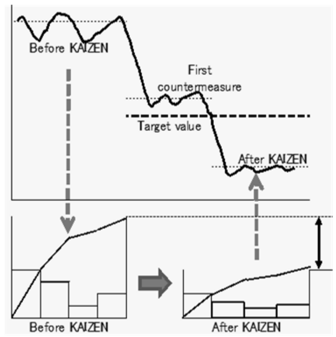
**Implementation Action Plan**

# 2.9 Comprehending Results

**Comprehend results and compare them with target**

- Compare quantitative performance with target value.
- Comprehend ripple effect.
- Comprehend qualitative effect.

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## 2.9 Comprehending Results

Step 8 entails comparing results against target values and gauging the ripple effect. It is necessary to gauge results quantitatively. Results cannot be defined by general terms such as “work has become easier” or “operators have become more animated” and so on. It is necessary to comprehend in quantitative terms, for example, productivity has increased by a certain percentage, material traffic lines have been shortened by 40%, attendance rate has increased from 92% to 96%, and so on. The meaning of results can be comprehended by comparing conditions before and after Kaizen or comparing against the Kaizen targets. Moreover, rather than simply showing numerical figures, a stronger impression can be imparted through expressing by a line graph and so on.

# 2.10 Standardization & Training

**Standardize effective countermeasures and settle good results**

- Standardize effective countermeasures.
- Register the standard.
- Train related workers to sustain the standard.
- Confirm results.

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### 2.10 Standardization & Training

Step 9 is standardization and training. The measures that were effective are standardized in order to permanently embed the effects. It is not necessary to standardize all countermeasures, only the effective ones. However, standardization does not guarantee embedding of the effects. It is necessary to train operators to perform work according to the standards, and to have a system for recognizing work that does not follow the standard. For example, the line supervisor can perform frequent checking of the work method.

Standardization is and training are necessary for embedding Kaizen and so it is normally done after the time frame of ICT.

# 2.11 Remaining Problems

**Reflect on good aspects and bad aspects in Kaizen activity and clear up remaining problems**

- Reflect on gap between plan and performance.
- Reflect on activity by each step.
- Collect up remaining problems.

| Step | Good aspect | Bad aspect |
|---|---|---|
| Selection of KAIZEN subject | | |
| Grasp of current situation | | |
| Activity planning | | |
| Cause analysis | | |
| Grasp of results | | |

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## 2.11 Remaining Problems

Step 10 entails reflecting on good aspects and bad aspects in Kaizen activity and clearing up remaining problems. For this purpose, as is shown in the slide, the good aspects and bad aspects are tabulated for each Kaizen procedure, and the remaining problems are clarified. These problems become the theme for the next step of future Kaizen activity planning.

## 2.12 Future Planning

**Study on how to make use of reflection for future activity**

- Use the reflection for the next Kaizen activity.
- Come up remaining problems for the next Kaizen subject.
- Prepare future Kaizen plan.

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**2.12 Future Planning**

The final step entails compiling the plan for the next Kaizen theme. This plan is based on the review that was conducted in the previous step. Concrete examination is carried out to determine how to take advantage of the good aspects and how to improve things so that the bad aspects are not repeated. Also, remaining themes are sorted and designated as candidate themes. After that, the specific schedule is compiled. Simply stating theme names is not enough for future planning.

## Key Points for Good Kaizen

- To know the situation Quo
- To set the theme adequately
- To know the Problem or Task in deep
- To use Tools appropriately, but not to rely on tools too much

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**Key Points for Good Kaizen**

Several key points are shown in the table.

You must practice several times until you will find your own way good to promote Kaizen. Kaizen story is not theory but an accumulation of practice so you are requested to have your own method. Thus, customization of Kaizen story is important.

# Useful 7-QC Tools in Kaizen Story

| 7 QC tools / Step in QC story | Graph | | | | | Cause and effect diagram | Preto chart | Stratification | Check sheet | Histgram | Scatter diagram | Control chart |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bar graph | Line graph | Pie chart | Band chart | Rader chart | | | | | | | |
| 1. Preface | ◎ | | | | | | | ● | | | ◎ | |
| 2. Selection of subject | ● | ● | ◎ | | ◎ | ◎ | ● | ● | | | | |
| 3. Grasp of current situation | ● | ● | ◎ | ◎ | | | ● | ● | ● | ◎ | | |
| 4. Activity planning | | | | | | | | ● | | | | |
| 5. Analysis of root causes | ● | ● | ◎ | ◎ | | ● | ◎ | ● | ● | ● | | |
| 6. Countermeasure planning | | | | | | ◎ | | ● | | | | |
| 7. Grasp of results | ● | ● | ◎ | ◎ | ◎ | | ◎ | ● | ● | ● | | ◎ |
| 8. Standardization & training | ● | ● | ◎ | ◎ | | | | ● | | | | ● |
| 9. Remaining problems | | | | | ● | | | ● | | | | |
| 10. Future planning | | | | | | | | ● | | | | |

* ●: Very useful ◎: Commonly used

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**Useful 7-QC Tools in Kaizen Story**

There are some useful tools which are used along Kaizen story.

7QC tools are most often used.

This table shows the Kaizen step and typical 7QC tools used in each step but please note that this table doesn’t mean you have to use these tools or you can’t use other tools.

# REVIEW OF KAIZEN TOOL

## QC TOOL

# Review of Kaizen Tool
# QC Tool

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**Review of Kaizen Tool: QC Tool**

There are many useful tools to be applied along with Kaizen Story such as 7QC tools, New 7QC tools, IE .

QC tools are essential for analyzing the Status Quo (comprehending current situation and/or clarification of attack point)

We will review QC tools first

# Contents

1. 7 QC Tool
2. New 7 QC Tool

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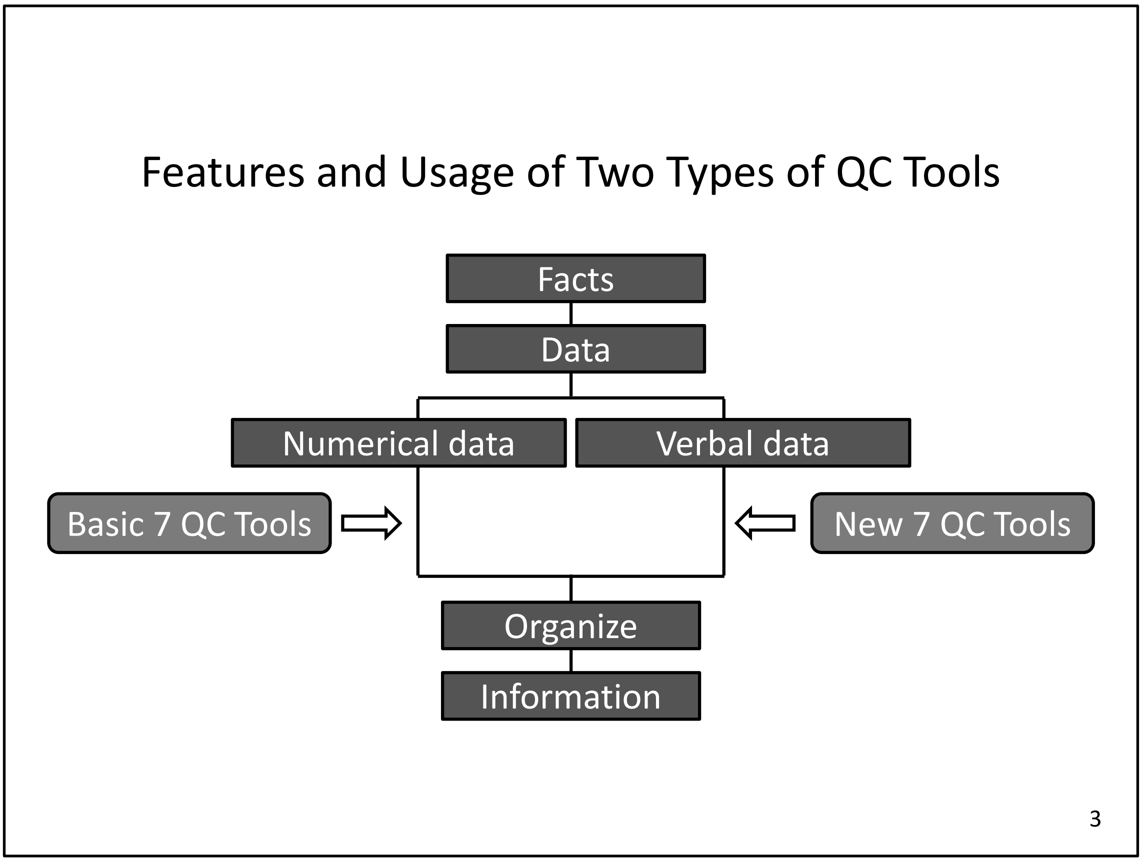


**Features and Usage of Two Types of QC Tools**

Basic 7 QC tools and New 7 QC tools are both effective to comprehend actual situation and clarify attack points.

Basic 7 QC tools are numerical annalistic tool and New 7 QC tools are to categorize the phenomenon logically and to make it easier to understand.

# 1. 7 QC Tool

1.1 Check Sheet
1.2 Pareto Diagram
1.3 Histogram
1.4 Stratification
1.5 Scatter Diagram
1.6 Line Graph/ Control Chart
1.7 Cause and Effect Diagram

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**1. Review of 7 QC Tool**

Basic 7 tools are effective for data analysis, process control, and quality improvement and most of them are based on statistical methods

## 1.1 Check Sheet

[Example] Number of Defects in Leather Shoe

| | Feb/1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Leather defect | // | /// | // | /// | // | /// | // | /// | 20 |
| Wrong centering | / | // | // | // | // | // | // | // | 15 |
| Stitching problem | / | / | / | // | / | / | / | // | 10 |
| Back part wrinkle | | / | | // | | | / | / | 5 |
| Leather scratch | | / | | / | / | | | | 3 |
| Others | / | | / | / | | | | | 3 |

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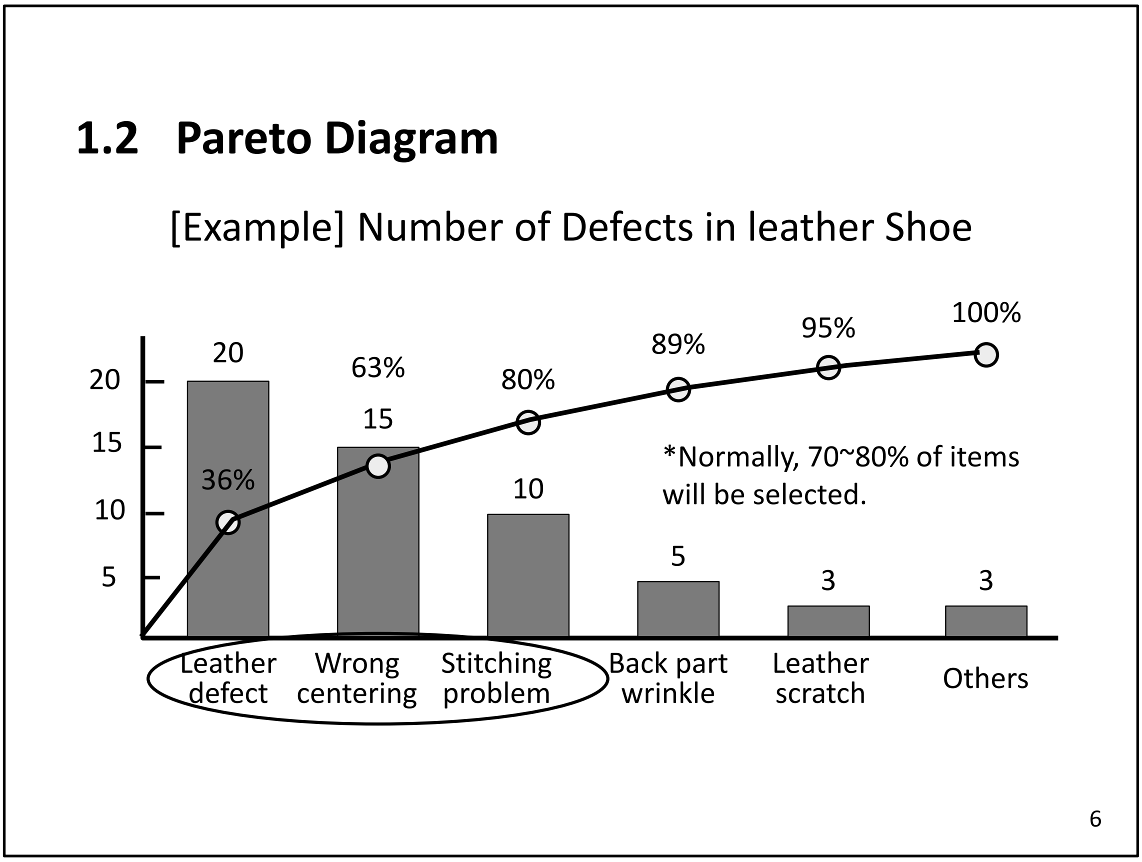
### 1.1 Check Sheet

The first of the basic seven tools is the check sheet. Check sheet is often and commonly used In order to show the phenomenon in numerical data. The example above is to grasp the occurrence of defect in shoe manufacturing.

The type of defect is shown In the left hand column and the numbers of the defects by the type are checked on a day-by-day basis.

Check sheets are often used when collecting the data required for Pareto charts and histograms.




### 1.2 Pareto Diagram

The second of the basic 7QC Tools is the Pareto chart. A Pareto chart collects data on problems that are happening on-site, such as defects, complaints or accidents, and categorizes them by phenomenon and cause, then arranges them in descending order in terms of the number of defective units or financial losses incurred, and represents those sizes on a bar chart.

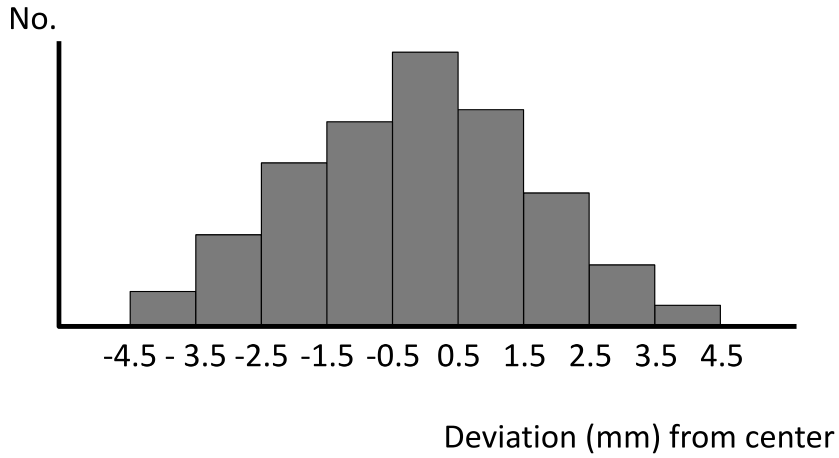
This image shows the number of defects in shoe manufacturing gathered by the check list.

The bar chart is arranged from left to right in descending order of number of defects. The horizontal axis represents each phenomenon. The line chart takes the total of the bar chart as 100％, and displays the % of the total for each bar; here it is showing that the three phenomena of “leather defect”, “wrong centering” and “stitching problem” account for 80% of defects. The last phenomenon is “other,” which accounts for a number of small phenomena. In this case, even though the total of “other” is larger than “leather scratch” it is a rule that it always comes last.

Normally first two or three phenomenon covers 70% to 80% of the phenomenon and so we can select only these two or three out of many phenomenon as effective to select the point to tackle with.

## 1.3 Histogram

[Example] Normal distribution Defects and others

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**1.3 Histogram**

Next comes the third tool, histogram. Even if a product is created via the same process, by the same worker, using the same method, with the same materials and on the same machine, there will be slight differences in the quality of the item produced; for example, in length, weight, or color.

A histogram takes data acquired by measuring quality characteristics, categorizes it into certain ranges and then creates a bar chart showing the number of cases within each range. This image shows the number of cases for each 1millimeter range of diameter data for round poles. There are 9 different sections. When organizing this kind of data, it is normal for the largest number of cases to be clustered around a certain value, with the percentage of cases decreasing the further away from that value you go. A bell contour style is normal. This means that the group of products has normal distribution.

A histogram has three roles. First, it allows us to know what kind of form the distribution is taking. Second, it allows us to know what kind of variance there is around what kind of center point in the data. Third, it allows us to know how many cases there are that fall outside of specifications.

## How to Make Histogram

1. Gather data (n=50 ~ 200)
2. Find maximum (L) and minimum (S), calculate range (L-S)
3. Calculate number of range (Sqr. n)
4. Decide width of range ( (L-S)/ Sqr. N
5. Excel can create histogram

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Exercise

Example Outer dimension of plastic pipe

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**Exercise: Example Outer Dimension of Plastic Pipe**

We will learn how to make histogram using an example.

A plastic manufacturer makes pipes by extruder.

The outer diameter should be in certain tolerance.

So, QC people measured the outer diameter by a scale.

## Measured Result

| No. | Diameter mm |
|---|---|
| 1 | 202 |
| 2 | 171 |
| 3 | 208 |
| 4 | 160 |
| 5 | 199 |
| 6 | 189 |
| 7 | 180 |
| 8 | 189 |
| 9 | 172 |
| 10 | 182 |

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**Exercise: Example Outer Dimension of Plastic Pipe**

QC people measured the actual diameter of pipes 10 times and got the result in mm as shown in the table.

Answer

## Sorted Result

| Diameter mm |
|---|
| 160 |
| 171 |
| 172 |
| 180 |
| 182 |
| 189 |
| 189 |
| 199 |
| 202 |
| 208 |
| Average 185.2 |
| S Deviate 14.3 |

| From | To | No. |
|---|---|---|
| 160 | 176 | 3 |
| 176 | 192 | 4 |
| 192 | 208 | 3 |
| | | |
| | | |
| Total | | 10 |

| From | To | No. |
|---|---|---|
| 160 | 172 | 2 |
| 172 | 184 | 3 |
| 184 | 196 | 2 |
| 196 | 208 | 3 |
| | | |
| Total | | 10 |

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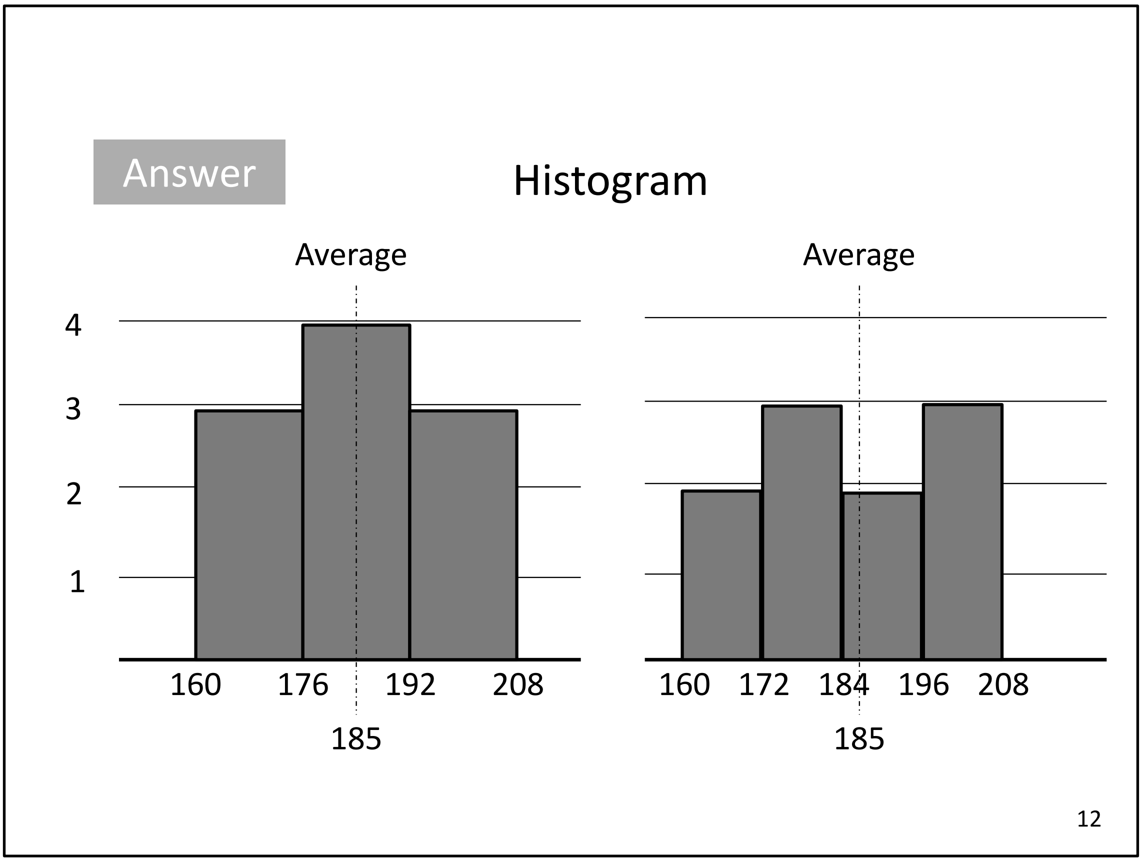
**Exercise: Example Outer Dimension of Plastic Pipe**

After gathering the data, they are sorted in ascending manner.

As the maximum data is 208mm and minimum data is 160mm, the range is 48 (208-160=48).

Sqr. Of 10 (No. of data) is around 3 ~ 4, so the scale of range is 16 and 12 respectively.




**Histogram**

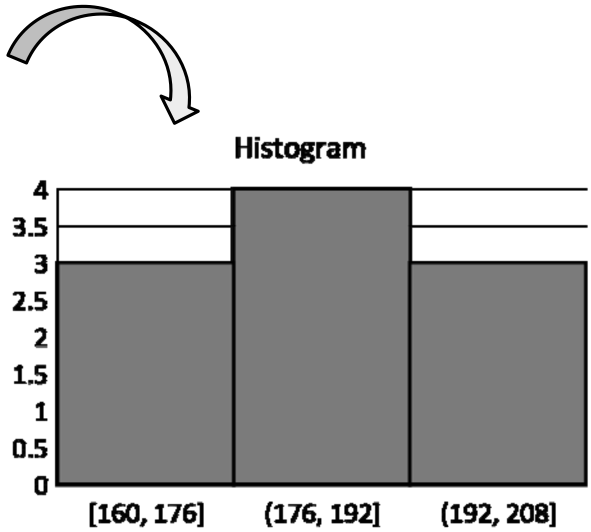
Two histograms are shown.

The number of range of the left is 3 and the right is 4 respectively.

As the Sqrt. of range is nearly 3, the left graph is deemed as correct figure.

## Histogram by Using Excel

| No. | Diameter mm |
|---|---|
| 1 | 202 |
| 2 | 171 |
| 3 | 208 |
| 4 | 160 |
| 5 | 199 |
| 6 | 189 |
| 7 | 180 |
| 8 | 189 |
| 9 | 172 |
| 10 | 182 |

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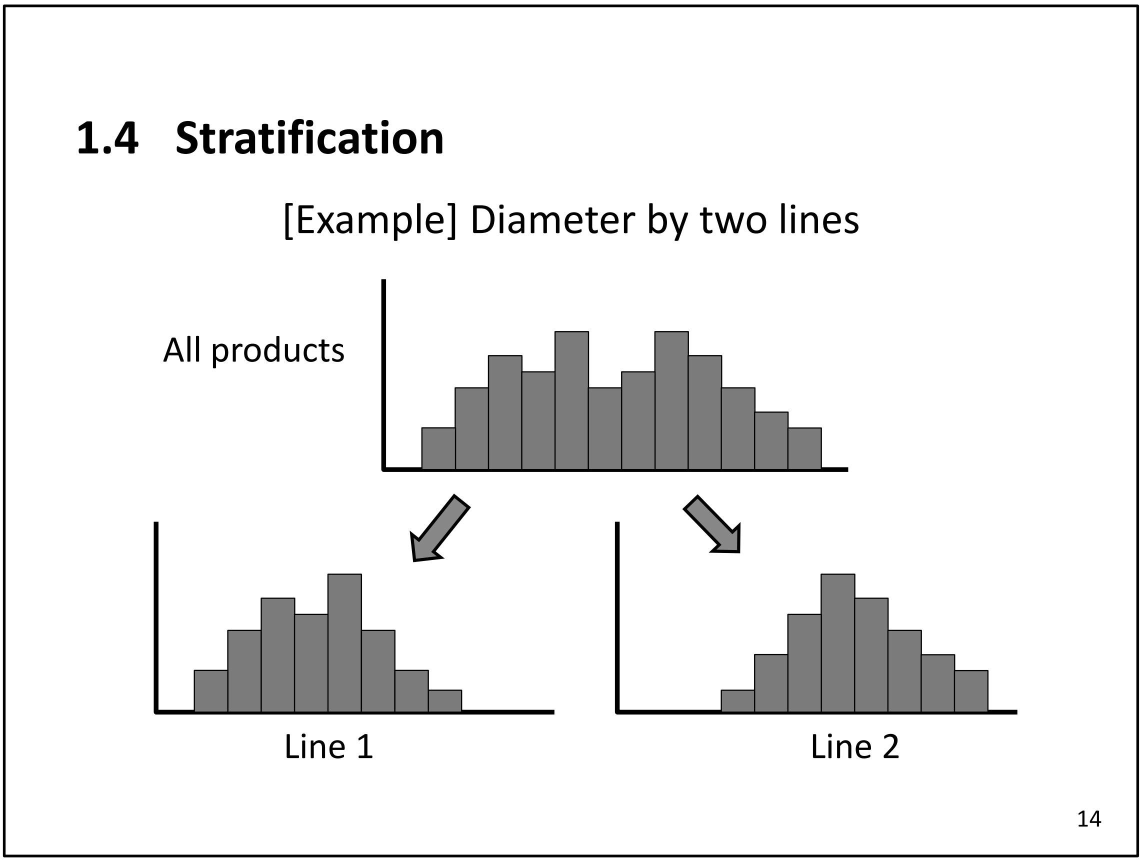
**Histogram by Using Excel**

Histogram can be made by using Excel.

Histogram graph is able to drawn by “Graph” function of Excel directly from the raw data when you decide the No. of range.

Average and standard deviation are calculated by using “Analysis” function of Excel.




**1.4 Stratification**

Stratification is a technique to separate the whole data by characteristics found in data.

For example, assuming that the individual productivity of workers in a sewing department are gathered and presented on a histogram like the upper graph in the slide. If this department has two line, Line1 and Line2, it will be worthwhile to separate the data in two groups (Line1 and Line2) and make histograms and check if there are something different.

Even though these two lines are making same product and using same machine, there may be some difference caused by some other factors like workers' morale and/or skill.

From the histogram of Line 1, if the workers are doing same job but with different machine, we can make further stratification of Line1 by machine they use.

In this way, stratification is an extremely effective tool in terms of determining target (possible cause) to solve in regard to the workers' skill and/or morale, machine, raw materials and so on.

Exercise

| No. | Diameter mm | Line |
|---|---|---|
| 1 | 202 | L1 |
| 2 | 171 | L2 |
| 3 | 208 | L1 |
| 4 | 160 | L2 |
| 5 | 199 | L1 |
| 6 | 189 | L1 |
| 7 | 180 | L2 |
| 8 | 189 | L1 |
| 9 | 172 | L2 |
| 10 | 182 | L2 |
| 11 | 184 | L1 |
| 12 | 188 | L2 |
| 13 | 200 | L1 |
| 14 | 202 | L2 |
| 15 | 190 | L1 |
| 16 | 166 | L2 |
| 17 | 180 | L1 |
| 18 | 182 | L2 |

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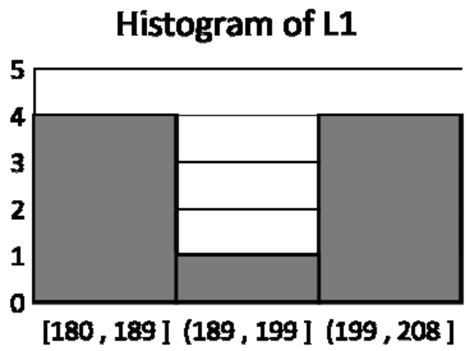
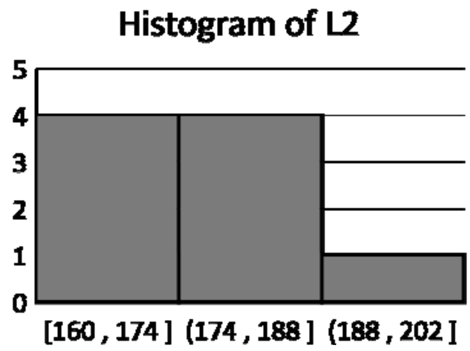
Answer

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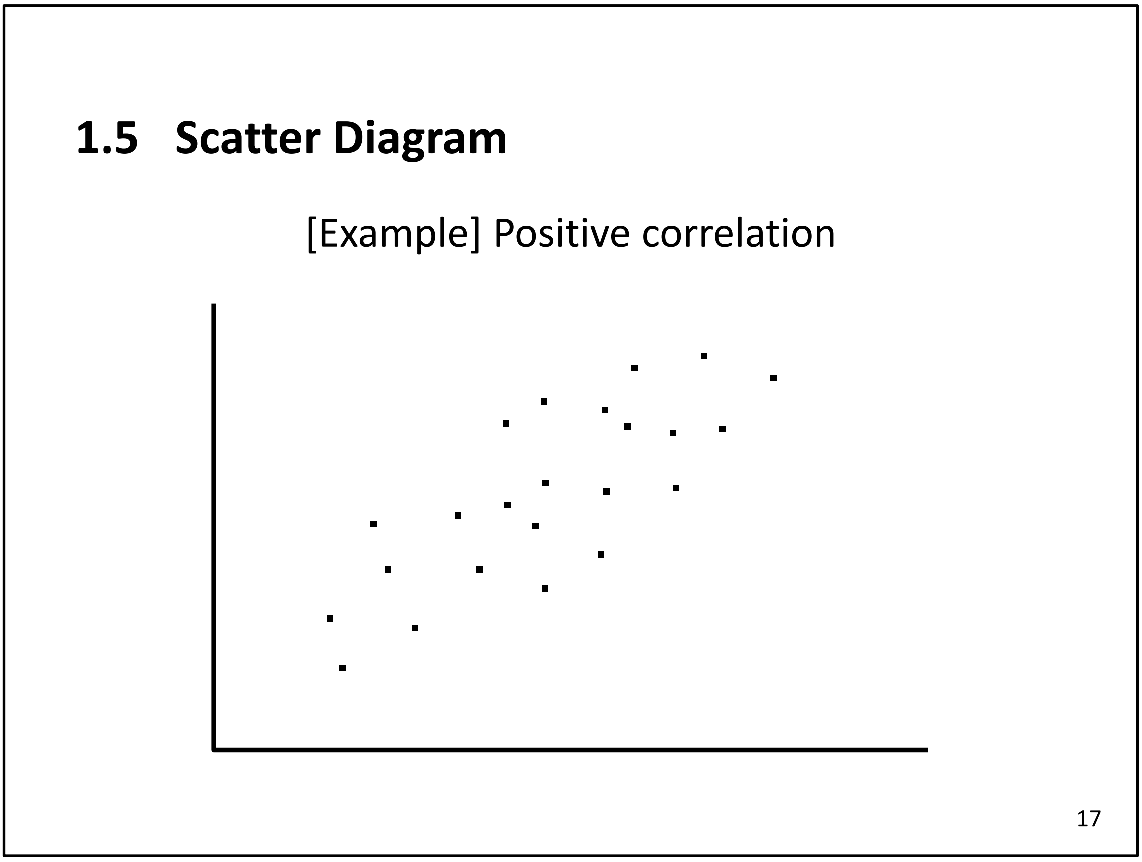
**Stratification**

The result of stratification is shown in the slide above.

There are significant difference between the two lines.

The shape of L1 histogram is far from normal distribution curve.

That means there are something irregular especially in Line 1.




### 1.5 Scatter Diagram

A scatter diagram is a figure representing paired data in dots on a sheet of graph paper.

A scatter diagram can tell us relationships of paired data clearly. It is often used to see relationships between the characteristics and factors.

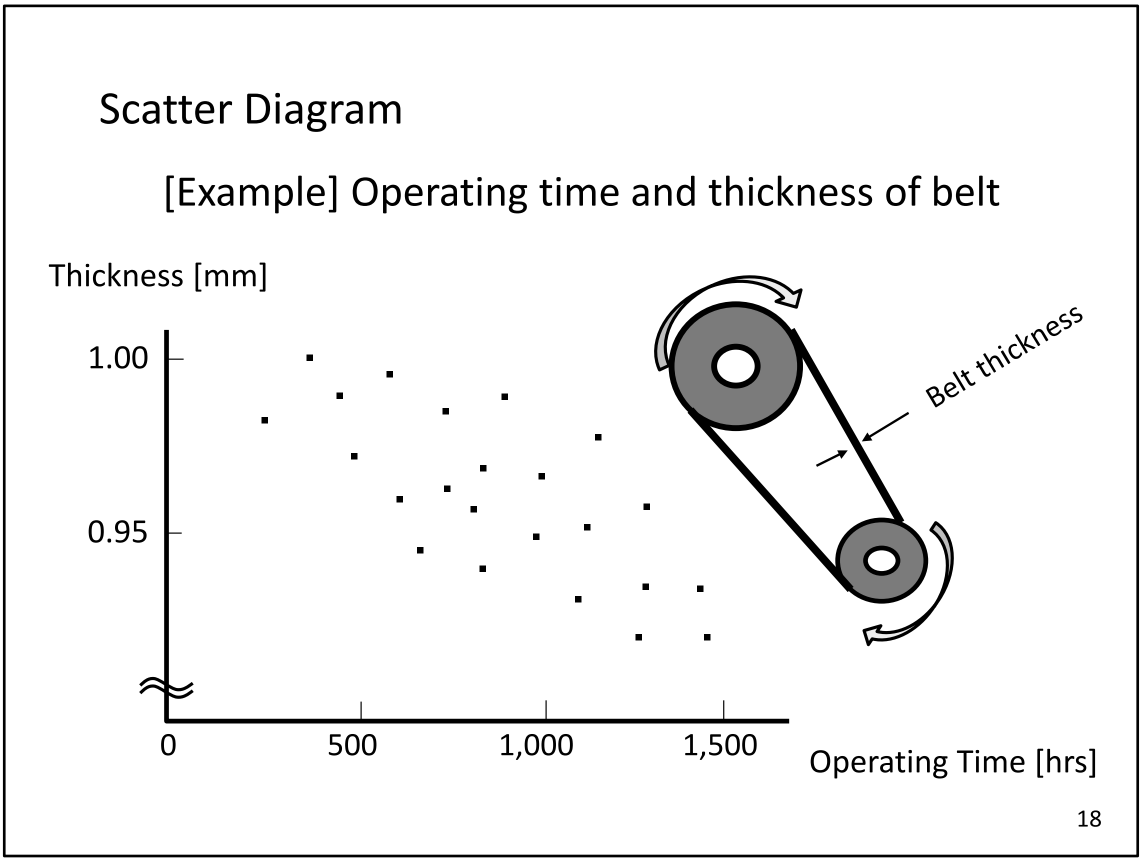
For example, the scatter diagram in the slide displays the relationship between height ad weight of men.

X-axis shows the height and Y-axis shows the weight. Normally these data have correlation. When the height becomes bigger the weight becomes heavier.

This is called there is a positive correlation.

There is other scatter diagram which falls to the right. As characteristic value A increase, characteristic value B falls. This is called a negative correlation.

When creating a scatter diagram by hand you must plot both sets of characteristic values where they meet, which takes quite a lot of time, but nowadays if you use Excel then a computer can quickly create a simple scatter diagram.




**Scatter Diagram**

This slide shows an example of negative correlation.

When the operation time increase the thickness of belt which drives the pulley decrease because of the wear caused by friction.

## Coefficient of Correlation

To know about correlation between 2 types of data, use "Coefficient of Correlation (r)".

$$r = \frac{\sum_{i=1}^{n} (x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}}$$

Or "CORREL" function of excel

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**Coefficient of Correlation**

This is a formula for evaluating the strength of correlation.

It conducts evaluation based on the absolute total of differences between the average value and each data.

This calculation can be done by using function of Excel "CORREL"

The plot chart and trend line can also be created by Graph function of Excel.

Coefficient of Correlation

Indication for strength of correlation

| Coefficient of Correlation | Strength of Correlation |
|---|---|
| $0.7 < \|r\|$ | Correlating strongly |
| $0.4 < \|r\| \leqq 0.7$ | Correlating |
| $0.2 < \|r\| \leqq 0.4$ | Correlating weakly |
| $\|r\| \leqq 0.2$ | No correlation |

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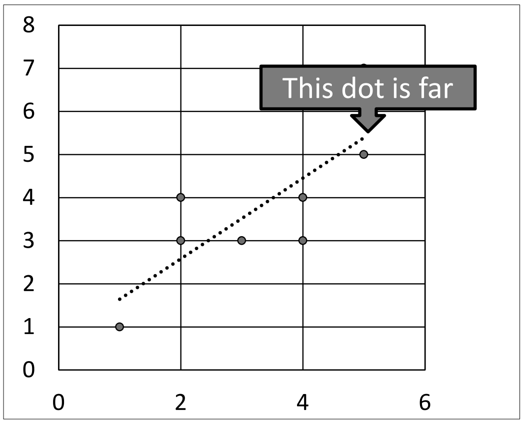
**Coefficient of Correlation**

As a result of calculation, there is deemed to be no correlation if the obtained coefficient is 0.2 or less, a weak correlation if it is between 0.2 and 0.4, a correlation if it is between 0.4 and 0.7, and a strong correlation if it is more than 0.7.

## Create Scatter Diagram and Coefficient of Correlation

| No. | Xi | Yi | CORREL |
|---|---|---|---|
| 1 | 1 | 1 | 0.79 |
| 2 | 2 | 3 | |
| 3 | 4 | 3 | |
| 4 | 5 | 7 | |
| 5 | 2 | 4 | |
| 6 | 4 | 4 | |
| 7 | 5 | 5 | |
| 8 | 3 | 3 | |

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**Create Scatter Diagram and Coefficient of Correlation**

This slide shows the result of creating scatter diagram for 10 data which have value Xi and Yi.

You can make it in manual or by Excel. By Excel function “CORREL” you can get coefficient value.

In this case, coefficient value is 0.79 and it shows that Xi and Yi have strong correlation.

If we put out one dot which is extremely far from the trend line, we can get stronger coefficient.

## Scatter Diagram Spurious Correlation

Q : An CFT thinks that failures increase Mo. to Fr. How can this idea be evaluated?

| Date | Failure | Date | Failure |
|---|---|---|---|
| 1 (Mo) | 1.3% | 15 (Mo) | 0.9% |
| 2 (Tu) | 0.9% | 16 (Tu) | 0.9% |
| 3 (We) | 1.2% | 17 (We) | 1.3% |
| 4 (Th) | 1.9% | 18 (Th) | 1.4% |
| 5 (Fr) | 1.8% | 19 (Fr) | 2.4% |
| 8 (Mo) | 1.0% | 22 (Mo) | 1.1% |
| 9 (Tu) | 1.4% | 23 (Tu) | 1.3% |
| 10 (We) | 1.1% | 24 (We) | 1.8% |
| 11 (Th) | 2.2% | 25 (Th) | 2.2% |
| 12 (Fr) | 2.6% | 26 (Fr) | 2.4% |

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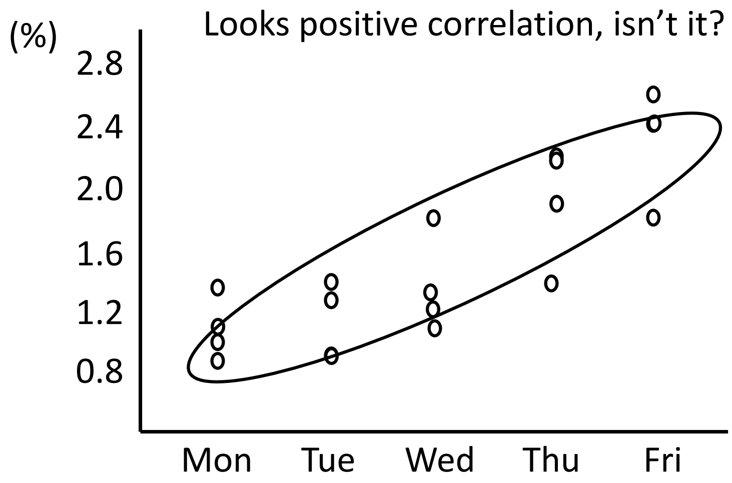
**Scatter Diagram Spurious Correlation**

On seeing that failure rates differ according to the day of the week, a certain KPT decided to gather a month's data.

How should the relationship between day of the week and failure rate be evaluated?

## Scatter Diagram Spurious Correlation

A : ① Make Scatter Diagram
② Check Correlation

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**Scatter Diagram Spurious Correlation**

This slide shows the scatter diagram based on the data in the table.

At first sight, it looks like there is a positive correlation.

Scatter Diagram Spurious Correlation

A : Add production quantity information.

| Date | Prod. qty. | Failure | Date | Prod. qty. | Failure |
|---|---|---|---|---|---|
| 1 (Mo) | 1,400 | 1.3% | 15 (Mo) | 1,500 | 0.9% |
| 2 (Tu) | 1,200 | 0.9% | 16 (Tu) | 1,400 | 0.9% |
| 3 (We) | 1,500 | 1.2% | 17 (We) | 1,900 | 1.3% |
| 4 (Th) | 2,000 | 1.9% | 18 (Th) | 1,800 | 1.4% |
| 5 (Fr) | 2,100 | 1.8% | 19 (Fr) | 2,200 | 2.4% |
| 8 (Mo) | 1,300 | 1.0% | 22 (Mo) | 1,700 | 1.1% |
| 9 (Tu) | 1,600 | 1.4% | 23 (Tu) | 1,600 | 1.3% |
| 10 (We) | 1,600 | 1.1% | 24 (We) | 1,800 | 1.8% |
| 11 (Th) | 1,900 | 2.2% | 25 (Th) | 2,100 | 2.2% |
| 12 (Fr) | 2,400 | 2.6% | 26 (Fr) | 2,600 | 2.4% |

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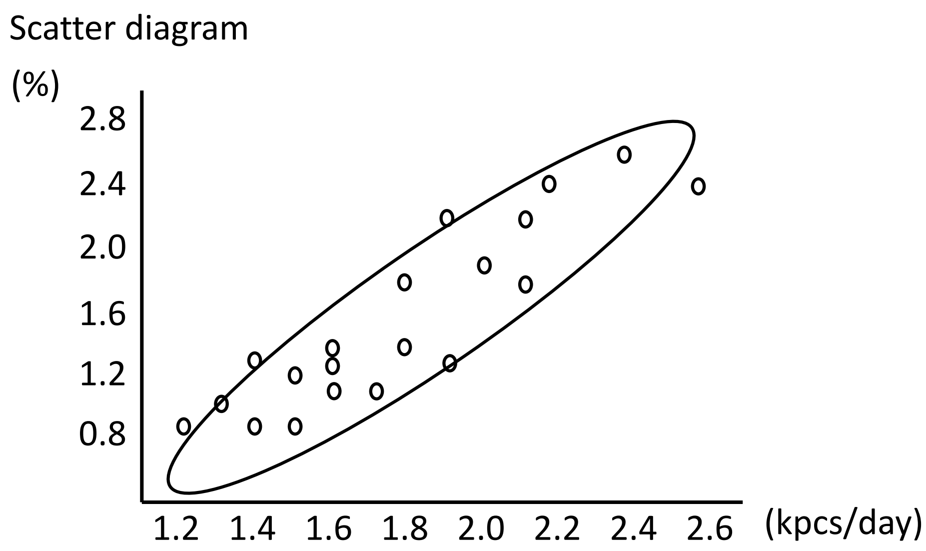
**Scatter Diagram Spurious Correlation**

On the same table, production quantity information is added.

Scatter Diagram Spurious Correlation

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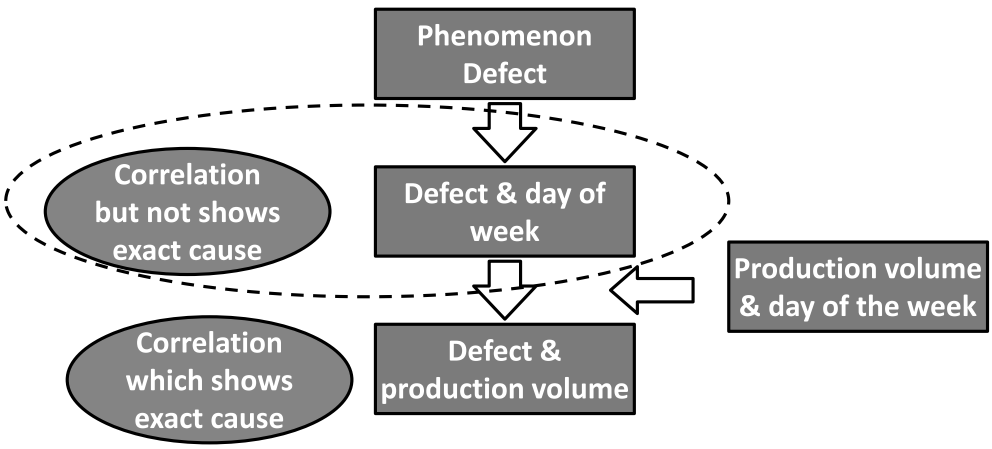
**Scatter Diagram Spurious Correlation**

Plotting the relationship between production quantity and failure rate gives the result shown as this slide.

## Spurious Correlation
## Meaning of Spurious Correlation

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**Meaning of Spurious Correlation**

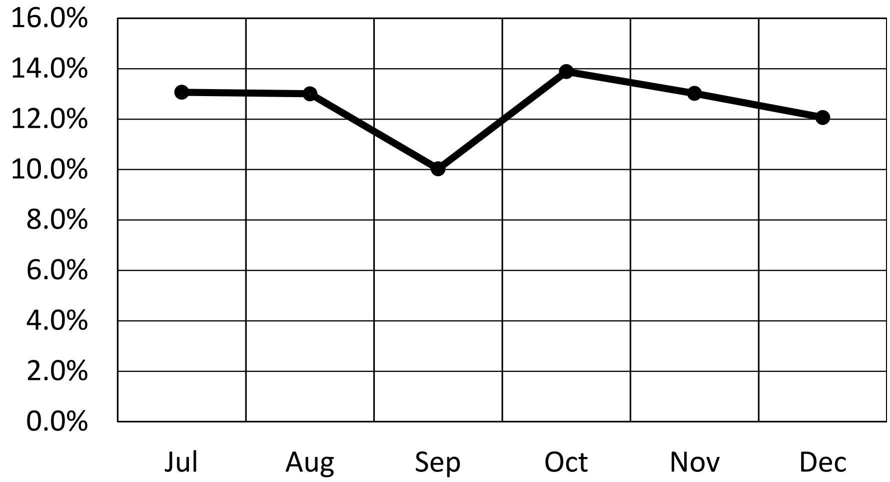
The relationship between day of the week and failure rate is a false correlation that is known as a spurious correlation.

When examining correlations, it is necessary to carefully investigate whether a correlation is spurious or not.

Correct cause analysis is not borne from the spurious correlation.

# 1.6 Line Graph/ Control Chart

Line graph [Example] Defect rate

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**1.6 Line Graph/ Control Chart**

## Control Chart

$\bar{x}$ and R chart

Used for valuing the process controls include length, weight, hours, strength, degree of purity.

1) Select data:
   create an inspection lot (k), select 4 or 5 samples (n) from each lot, and measure the quality characteristic value

2) Calculate average value x, and range R

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**Control Chart**

When we analyze data we need to see both average and variance.

If there is volatility problem in quality, the problem consists of two factors; that is bias of average and variance of data.

The control chart also known as Shewhart charts shows these two factors visually and help finding problems.

Example Outer dimension of plastic pipe

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**Example: Outer Dimension of Plastic Pipe**

Here, we show an example ow to create control chart.

Assuming the outer diameters of plastic pipes fluctuate, and customer complain about that.

## Example

| Lot | n1 | n2 | n3 | n4 | n5 |
|---|---|---|---|---|---|
| 1 | 202.0 | 188.6 | 179.3 | 136.0 | 134.5 |
| 2 | 171.4 | 181.9 | 150.5 | 193.5 | 147.2 |
| 3 | 207.7 | 198.1 | 174.4 | 195.3 | 160.4 |
| 4 | 161.8 | 171.5 | 184.4 | 125.6 | 202.3 |
| 5 | 199.1 | 217.2 | 148.6 | 191.8 | 142.3 |
| 6 | 189.2 | 138.3 | 173.4 | 165.4 | 262.0 |
| 7 | 180.2 | 148.8 | 158.1 | 136.1 | 218.5 |
| 8 | 189.4 | 193.6 | 146.0 | 166.5 | 218.5 |
| 9 | 172.1 | 199.9 | 193.4 | 192.0 | 218.5 |
| 10 | 181.7 | 190.2 | 177.7 | 145.6 | 218.5 |

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**Example: Outer Dimension of Plastic Pipe**

The table shows data of outer diameter of plastic pipes.

Assuming 400 pipes are produced continuously by a machine per day.

First thing we do is to decide the lot size, here lot size is decided as 10.

So, each lot has 40 pieces of pipes.

From each lot, 5 samples (n1.n2.n3.n4.n5) are taken and measured. The results are put in the table.

## Calculation

| n | A2 | D3 | D4 |
|---|---|---|---|
| 2 | 1.880 | 0 | 3.267 |
| 3 | 1.023 | 0 | 2.574 |
| 4 | 0.729 | 0 | 2.282 |
| 5 | 0.577 | 0 | 2.114 |
| 6 | 0.483 | 0 | 2.004 |
| 7 | 0.419 | 0.076 | 1.924 |
| 8 | 0.373 | 0.136 | 1.846 |
| 9 | 0.337 | 0.184 | 1.816 |
| 10 | 0.308 | 0.223 | 1.777 |

**X**

UCL=X barbar + $A_2$Rbar
LCL=X barbar - $A_2$Rbar

**R**

UCL=D4Rbar
LCL=D3Rbar

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**Calculation**

The upper and lower limit of control chart are given by the formula in the slide.

Here, coefficient A2 , D3 , D4 are given from the table where n is the sample size.

# Calculation Result

| n | n1 | n2 | n3 | n4 | n5 | Average | Range | X bar | | | R bar | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | X | R | LCL | CL | UCL | LCL | CL | UCL |
| 1 | 202.0 | 188.6 | 179.3 | 136.0 | 134.5 | 168.1 | 67.5 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 2 | 171.4 | 181.9 | 150.5 | 193.5 | 147.2 | 168.9 | 46.3 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 3 | 207.7 | 198.1 | 174.4 | 195.3 | 160.4 | 187.2 | 47.3 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 4 | 161.8 | 171.5 | 184.4 | 125.6 | 202.3 | 169.1 | 76.7 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 5 | 199.1 | 217.2 | 148.6 | 191.8 | 142.3 | 179.8 | 74.9 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 6 | 189.2 | 138.3 | 173.4 | 165.4 | 262.0 | 185.7 | 123.7 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 7 | 180.2 | 148.8 | 158.1 | 136.1 | 218.5 | 168.3 | 82.4 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 8 | 189.4 | 193.6 | 146.0 | 166.5 | 218.5 | 182.8 | 72.5 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 9 | 172.1 | 199.9 | 193.4 | 192.0 | 218.5 | 195.2 | 46.4 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| 10 | 181.7 | 190.2 | 177.7 | 145.6 | 218.5 | 182.7 | 72.9 | 137.8 | 178.8 | 219.8 | 0 | 71.1 | 150.2 |
| | | | | | | 178.8 | 71.1 | | | | | | |
| | | | | | | X bar | R bar | | | | | | |

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**Calculation Result**

Calculation results are shown in the table.

Here, X (average) is a simple average of 5 samples of each lot.

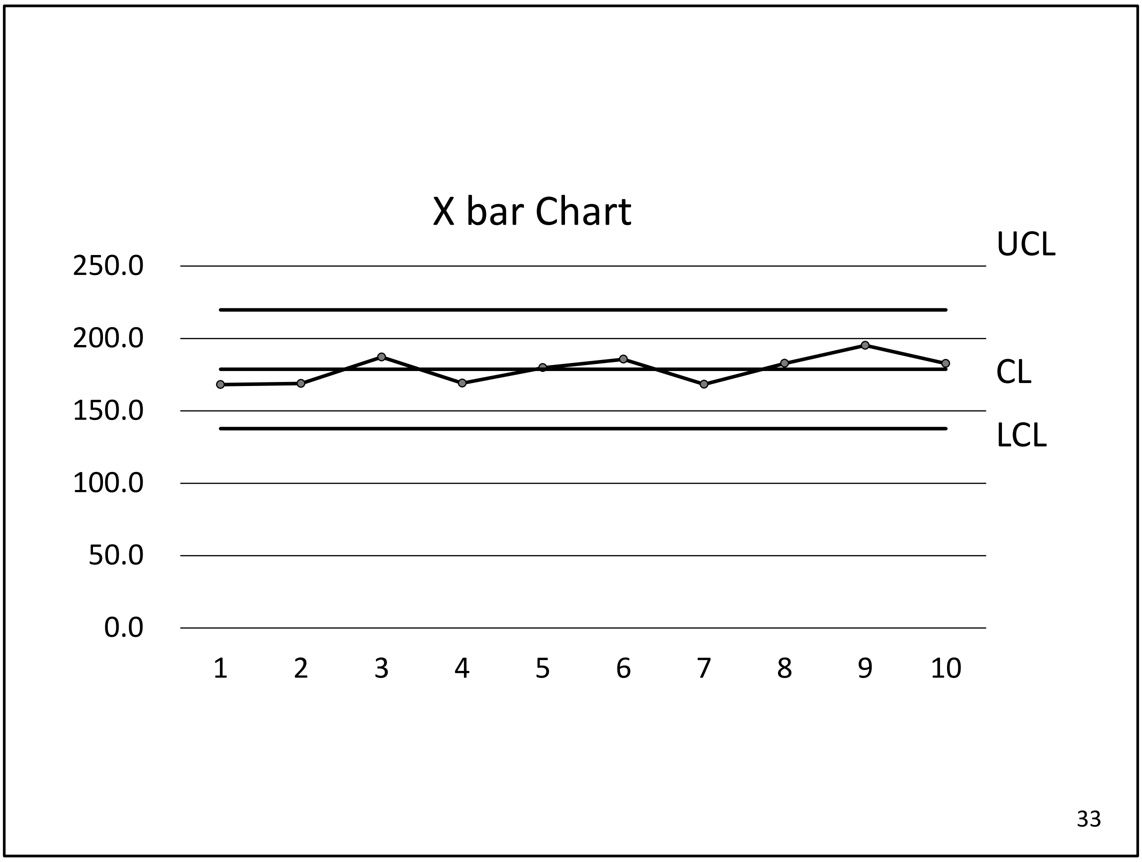
For instance, the first column of X= (202.0+188.6+179.3+136.0+134.5)/5=168.1

R (Range) is a subtraction of Max and Min of each lot.

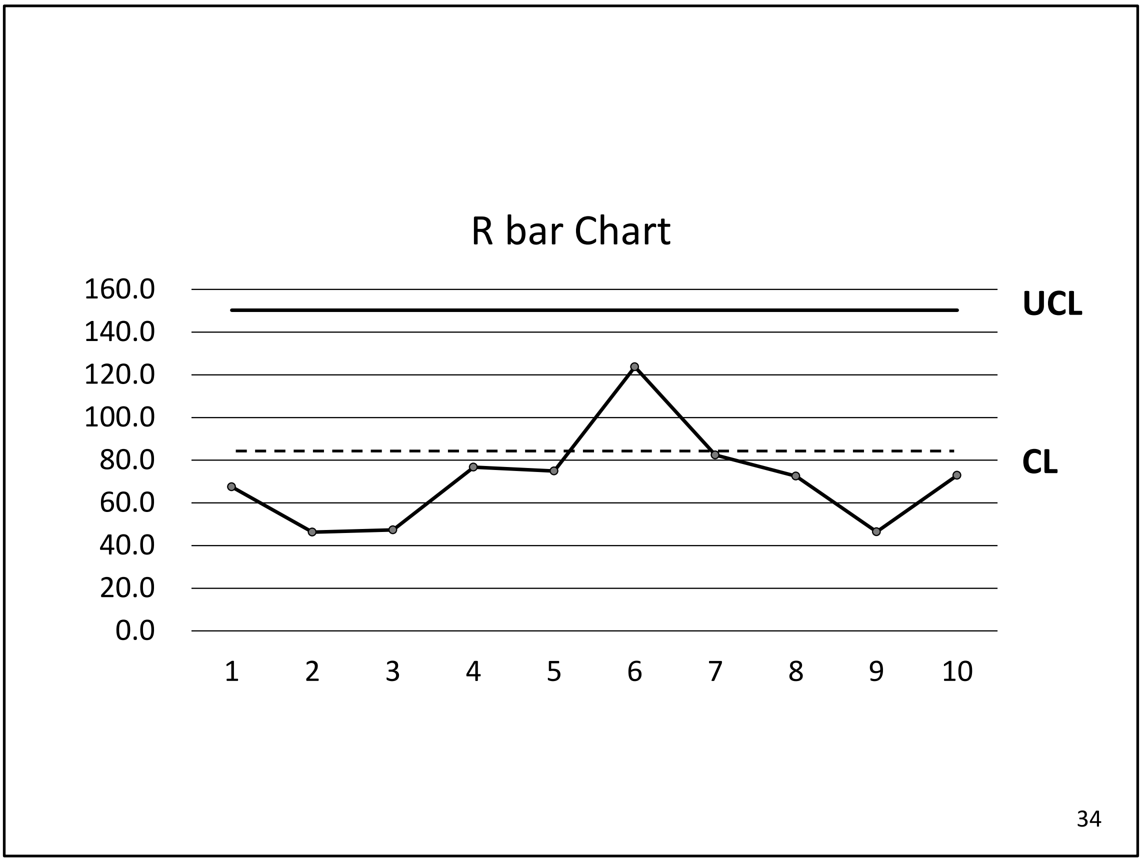
So, the first column of Range R= (202.0-134.5)=67.5

The X bar and R bar of the lowest column are both the average of all X and R respectively.

CL means the center (average), LCL means the lower limit and UCL means upper limit of control respectively.


X bar Chart
UCL
CL
LCL
250.0
200.0
150.0
100.0
50.0
0.0
1
2
3
4
5
6
7
8
9
10
33

**X bar Chart**


R bar Chart
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1
2
3
4
5
6
7
8
9
10
UCL
CL
34

**R bar Chart**

## How to Check Control Chart

| No. | Naming | Perspective | Action |
|---|---|---|---|
| 1 | Out of control | Dot of average or deviation is out of control limit. | Because of indicating abnormal, investigate its causes and develop preventive measures |
| 2 | Continuous 7 or more dots | Continuous 9 or more dots on one side of central line | Necessary to survey due to strong possibility of technical problems |
| 3 | Dots close to limitation | 2 dots among continuous 3 dots exit two third far from control limit. | Indicate the variability in process increases. Caution needed. |
| 4 | Biased dots | Dots links upward or downward and indicates cyclic nature. | Survey is needed because of strong possibility of problem in process control. |
| 5 | Stable statue | No.1 to No.4 do not exist among continues 25 dots. | Confirm sustainability |

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**How to Check Control Chart**

Everything is not necessarily okay even if the mean values and variance values plotted on a control chart fall within the control limits. Looking at exactly where the plotted points fall can allow problems that may occur in the future to be identified.

Five ways in which data can be read from a control chart are shown in the slide.

The first is when a mean value of variance has appeared outside the control limits. In this case the cause must be immediately analyzed and steps taken to prevent this happening again.

The second is when, while the mean values are inside the control limits, they continue for 7 points either along the top or along the bottom. In this case a technical problem can be predicted.

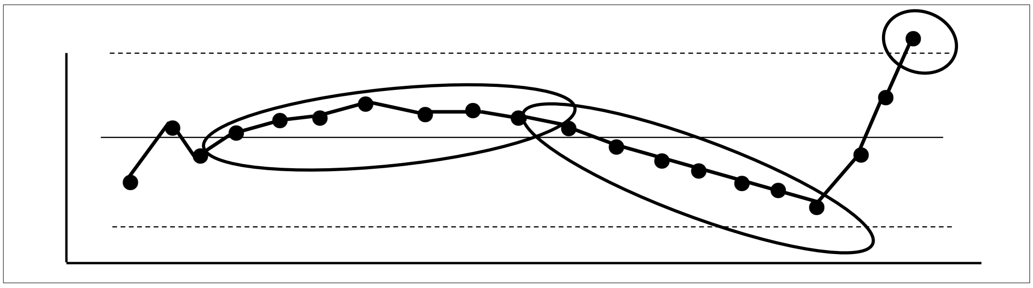
The third is when, between the limit and mean values, two out of three points are close to the limit value. This predicts that there is variance in processing.

The fourth is when periodicity can be confirmed in the way the points appear. This predicts that there is a problem with process control.

The fifth is when any symptoms other than those above are seen. It can be determined that the process is stable.

## How to Check Control Chart

when all points of each lot are within the control limit line, the manufacturing process is thought to maintain in the state of statistical control but even though there are some other points to check.



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**How to Check Control Chart**

As explained, even if all the mean values and variance values plotted on a control chart fall within the control limits, looking at exactly where the plotted points fall shows problems that may occur in the future.

This slide shows , for example, seven consecutive points are all going up or all going down and are assumed to be a problem. In such a case, the way of working should be changed, and the tools and machines should be changed because they might be worn down.

## Types of Control Chart

| Type | | Target |
|---|---|---|
| **$\overline{X}$-R control chart** | Measurable | Length, weight, time, etc. |
| **P control chart** | Countable | Defective ratio<br>(in the case of uneven size of sample) |
| **nP control chart** | Countable | Defective number<br>(in the case of even size of sample) |
| **C control chart** | Countable | Defective number<br>(in the case of even size of sample unit) |
| **u control chart** | Countable | Defective number<br>(in the case of uneven size of sample unit) |

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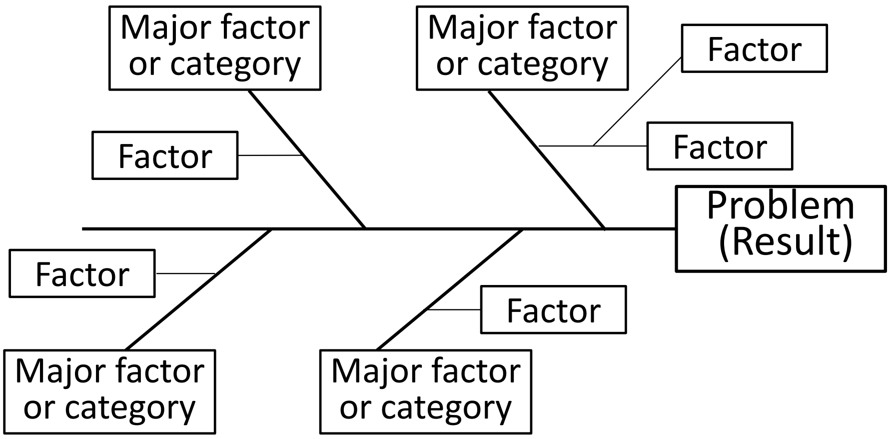
**Types of Control Chart**

The X-R control chart can be used when the characteristic values are things like weight or length, that can be measured, but it cannot be used for countable numbers, such as the number of defective items. It is important to remember this point.

Under such circumstances, one of the four control charts shown in this chart are used.

## 1.7 Cause and Effect Diagram

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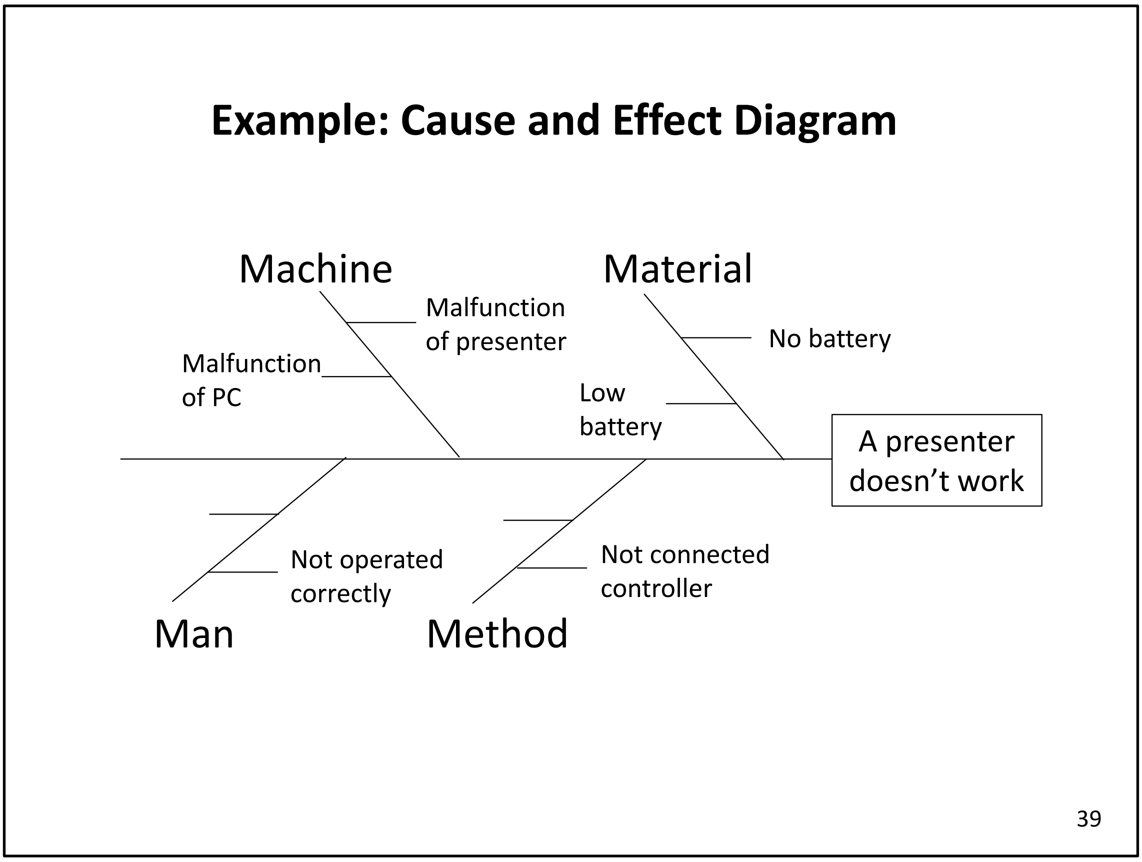
### 1.7 Cause and Effect Diagram

A cause and effect diagram was created by Dr. Kaoru Ishikawa called the Japanese father of quality management.

A cause and effect diagram arranges the relationship between problems and the causes believed to be behind them in a fish-bone style diagram. The effects, that is the problems, are placed on the right side, and the causes are then filled in, comprised of the primary causes and those causes that comprise the primary causes. Therefore, if the primary causes are the large bones, the lower level causes are the medium sized bones, and the causes below those are represented by the small bones.

A cause and effect diagram can be used not only in problem analysis, but also when creating countermeasures. In this case the targets should be entered on the right side, and detailed countermeasures for the large bones, medium bones and small bones developed.




**Example: Cause and Effect Diagram**

This slide shows a Cause and effect diagram to find the causes of the problem "A presenter doesn't work".

This presenter has such functions as feeding forward and back the PPT slides.

The presenter is powered by battery and connected to PC by inserting USB.

In this case, CFT member enumerated possible causes by categories Man, Machine, Material, and Method.

Please take note that the causes (factors) are the possible cause and are not certain which is the real cause.

So, Cause and effect diagram is the start of cause analysis but not the end and not show the Root cause.

## Cause and Effect Diagram

**Application**

To find problems, gather opinions from related persons for improvement, analyze causes supposed to have the biggest impact and evaluate results after improvement.

**Category and target**

1. Cause and effect diagram for cause investigation

   Take up a problem for characteristic item, sort systematically its causes and describe themes in order according to big borne, medium born and small borne.

2. Cause and effect diagram for investigation of countermeasures

   For resolution of the problem, take up countermeasures in order.

**Point to remember**

Cause and effect diagram is more effective when used in combination with other tools.

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**Cause and Effect Diagram**

Next are a few points of caution when using cause and effect diagrams. First, and this is somewhat dependent on what kind of situation you are using it in, but cause and effect diagrams are generally suited to when you are performing an investigation of the causes of problems and development of countermeasures without leaving or missing anything out, and furthermore when not working alone, but completing the task through discussion with lots of other people. As mentioned above there are two types of cause and effect diagram, one for when investigating causes and one for when investigating countermeasures.

As another note of caution for when using them, this method alone will not resolve problems or propose countermeasures, and it will be more effective if used in conjunction with others from the seven tools, such as Pareto charts and stratification.

# 2. New 7 QC Tool

2.1 Affinity Diagram
2.2 Relations Diagram
2.3 Tree Diagram
2.4 Matrix Diagram
2.5 Arrow Diagram
2.6 Process Decision Program Chart
2.7 Matrix Data Analysis

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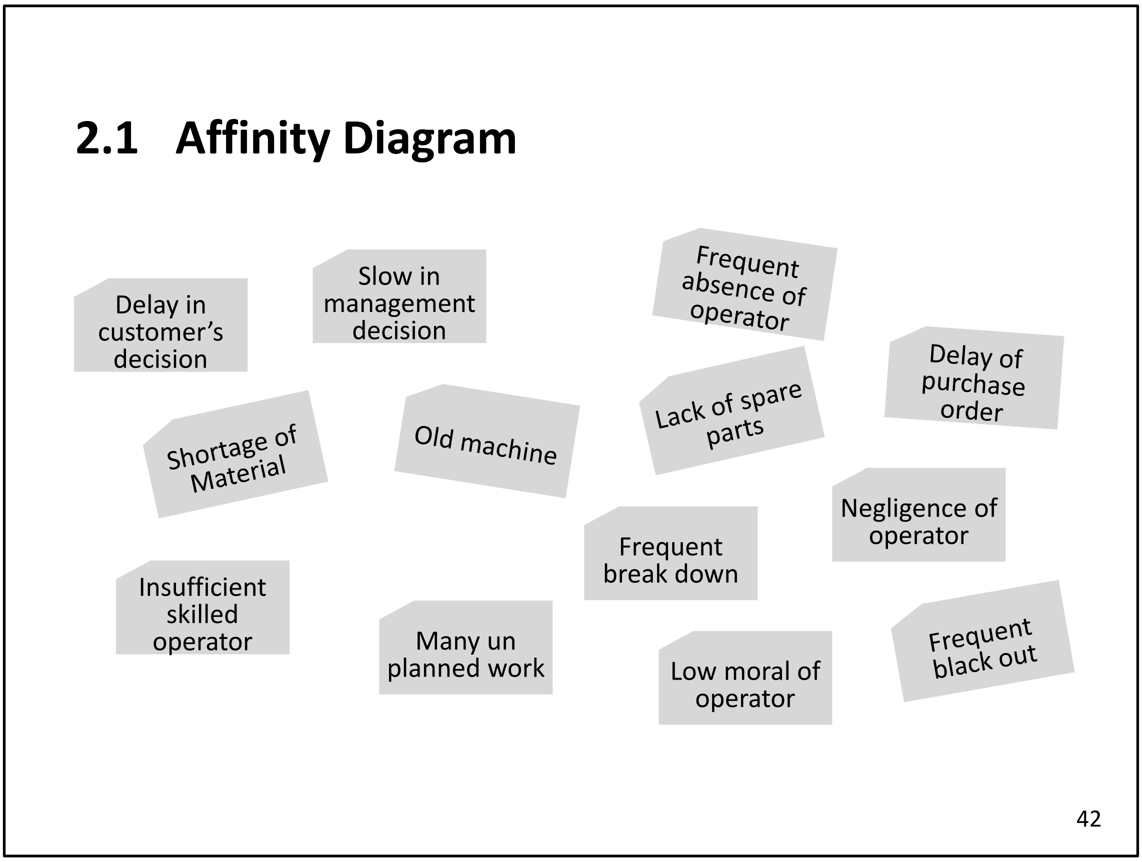
**2. Review of New 7 QC Tool**

New 7 QC tools were developed to organize verbal data diagrammatically. They are also called Seven Management and Planning Tools

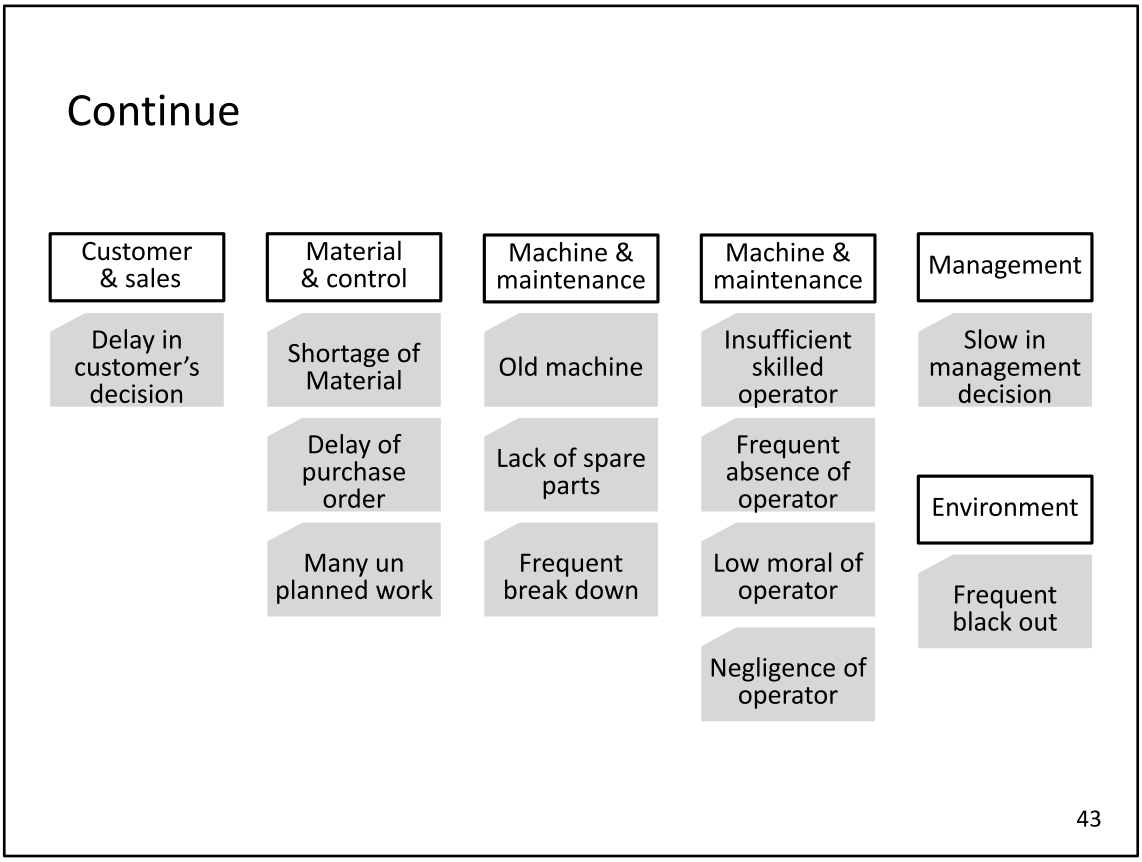



**2.1 Affinity Diagram**

The affinity diagram is used to organize ideas and data.

The term affinity diagram was devised by Jiro Kawakita in the 1960sand is sometimes referred to as the KJ Method.

The tool is commonly used within project management and allows large numbers of ideas stemming from brainstorming to be sorted into groups, based on their natural relationships, for review and analysis. It is also frequently used in contextual inquiry as a way to organize notes and insights from field interviews. It can also be used for organizing other freeform comments, such as open-ended survey responses, support call logs, or other qualitative data.

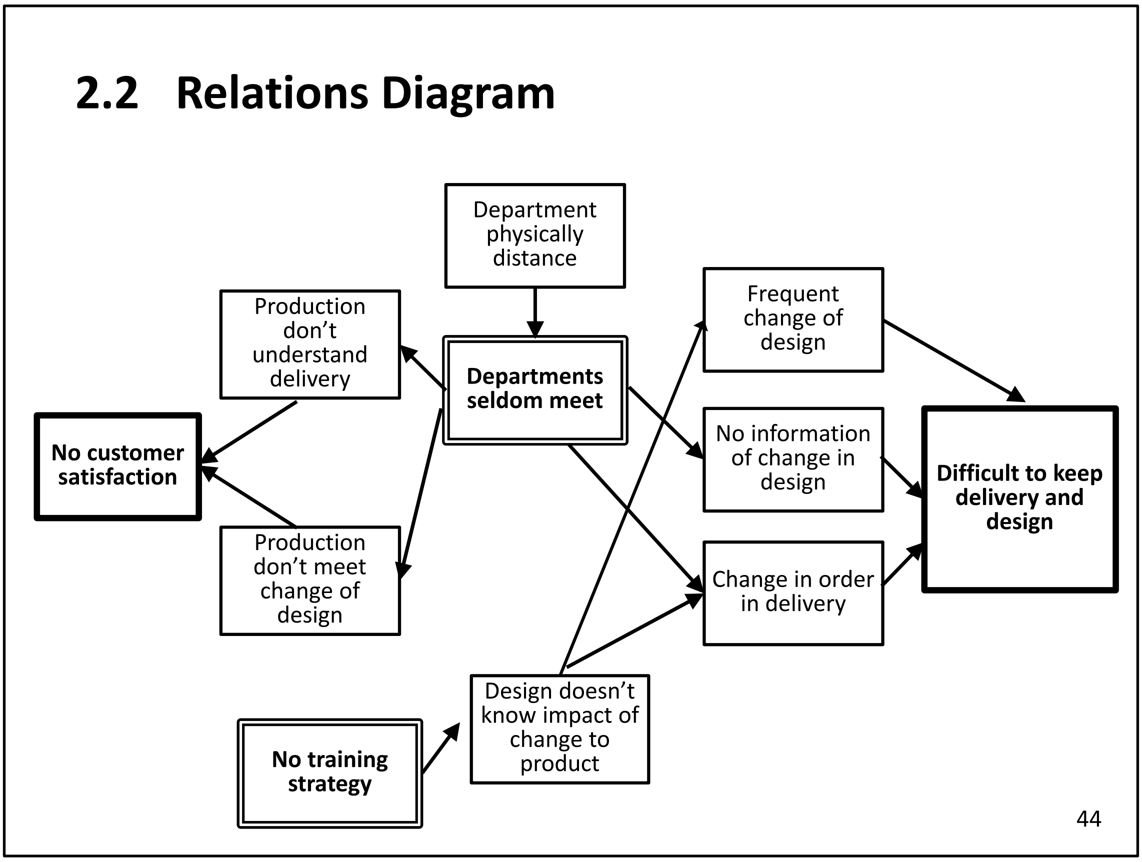



**The affinity diagram organizes ideas with following steps:**

1) Record each idea on cards or notes.
2) Look for ideas that seem to be related.
3) Sort cards into groups until all cards have been used.

Once the cards have been sorted into groups the team may sort large clusters into subgroups for easier management and analysis. Once completed, the affinity diagram may be used to create a cause and effect diagram.

In many cases, the best results tend to be achieved when the activity is completed by a CFT. The process requires becoming deeply immersed in the data, which has benefits beyond the tangible deliverables.




**2.2 Relations Diagram**

Relations Diagrams are drawn to show all the different relationships between factors, areas, or processes. Why are they worthwhile? Because they make it easy to pick out the factors in a situation which are driving many of the other symptoms or factors.

In Kaizen, it is worthwhile at the initial stage to select real problem and/or task which should be tacked with.

Example is shown above:

There are many problem related to customer satisfaction in a company which produces industrial cabinets.

For the sales and design department biggest problem was dissatisfaction caused by delay in delivery and un-match of design. They were continually irritated by the production department, who doesn't keep the delivery and/or doesn't follow the requested design.

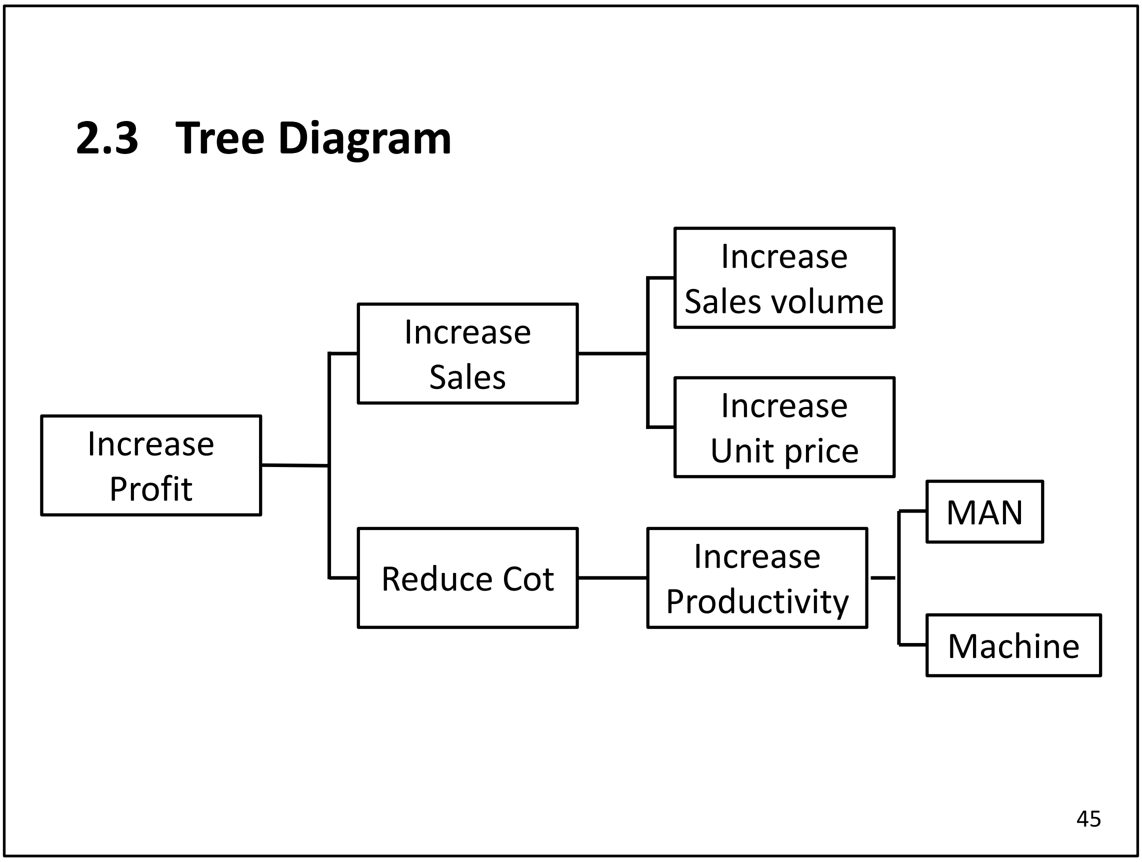
For the production department, on the other hand, the problem was the difficulty of keeping delivery and design.

They were irritated by frequent change of design and delivery order.

To solve this problem, two members from each department met to try and find the key causes of this problem. Initially they could not agree, and so decided to use a cause-effect Relations Diagram to try and work from their two problems in towards common causes that could be addressed. They defined the problems as (a) production doesn't follow changes in design, and (b) designs are impractical to build in production

In the next meeting, they put the problem cards on either side of the work area and started Brainstorming. Initially, each department naturally focused on their each grievance area. However, working together, they soon started to find common areas. Their mutual understanding further improved when they started to add causal links, and they were surprised how easily they agreed on the final key causes. Their diagram is shown in the slide. As result, two countermeasures were proposed.

1) Have close meeting among saces, design and production department.
2) Provide training for the design people to understand the process of production.




**2.3 Tree Diagram**

Tree diagram is a tool that depicts the hierarchy of tasks and subtasks needed to complete and objective. The tree diagram starts with one item that branches into two or more, each of which branch into two or more, and so on. The finished diagram bears a resemblance to a tree, with a trunk and multiple branches.

It is used to break down broad categories into finer and finer levels of detail. Developing the tree diagram helps you move your thinking step by step from generalities to specifics.

It is useful when;

Analyzing processes in detail
Probing for the root cause of a problem
Evaluating implementation issues for several potential solutions

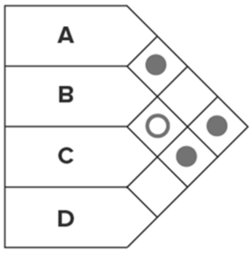
When you make tree diagram, first develop a statement of the goal, project, plan, problem, or whatever is being studied. Write it at the top (for a vertical tree) or far left (for a horizontal tree) of your work surface.

Ask a question that will lead you to the next level of detail. For example:

For a goal, action plan, or work breakdown structure, ask: "What tasks must be done to accomplish this?" or "How can this be accomplished?"

For root-cause analysis, ask: "What causes this?" or "Why does this happen?"

# 2.4 Matrix Diagram




| | Taste | Volume | Temperature |
|---|---|---|---|
| **Putting water** | | | ○ |
| **Boiling kettle** | | ◎ | |
| **Adding coffee** | ◎ | | |
| **Adding sugar** | ○ | | |
| **Adding milk** | ○ | | ○ |

**Roof shape Matrix Diagram**

**L shape Matrix Diagram**

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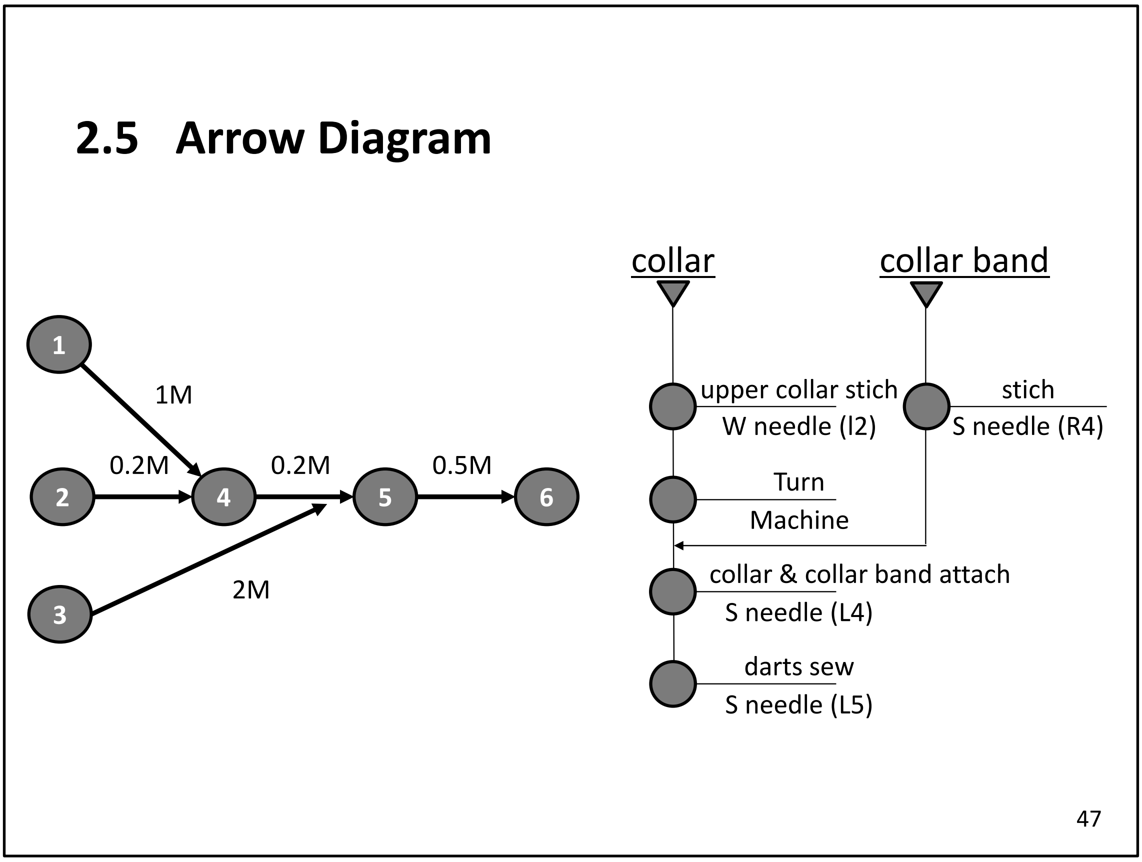
**2.4 Matrix Diagram**

Matrix Diagram shows the relationship between items. At each intersection, a relationship is either absent or present. It then gives information about the relationship, such as its strength, the roles played by various individuals or measurements. It can be shaped differently depending on how many groups must be compared.

There are many forms.

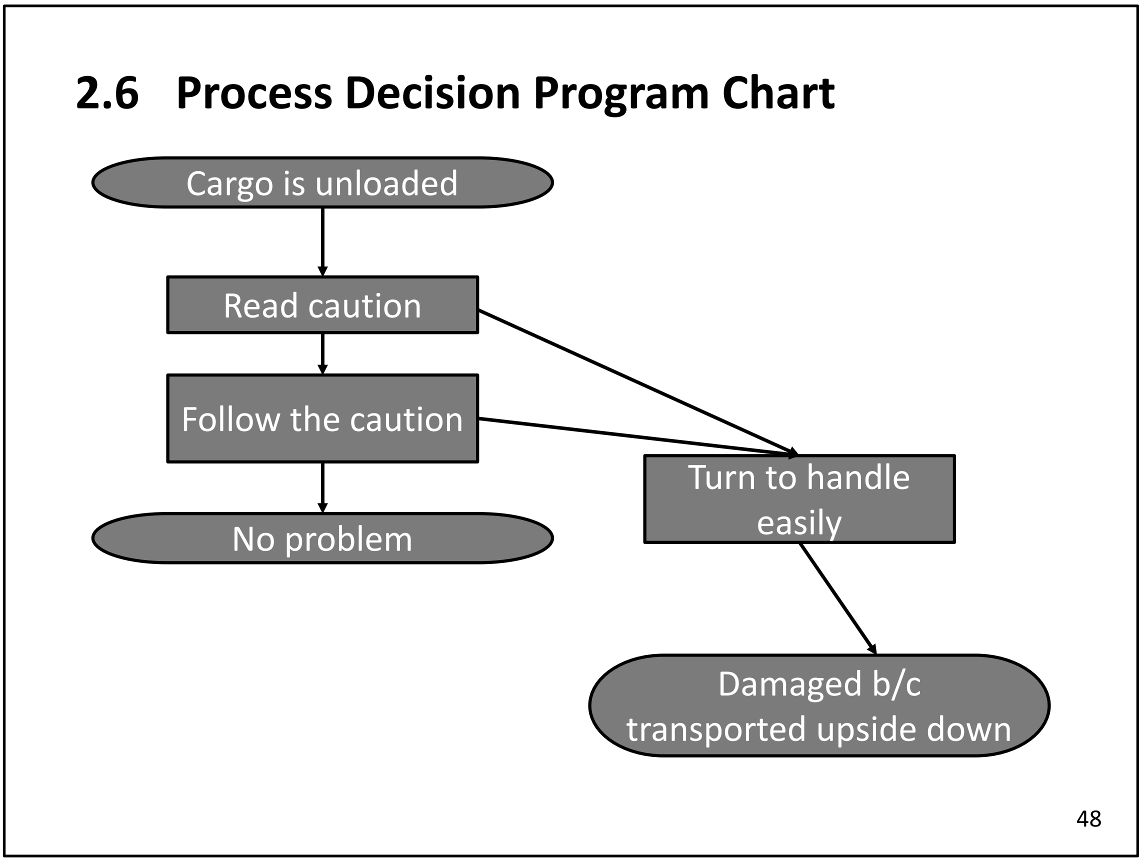
Roof Shaped Matrix Diagram and L Shaped Matrix Diagram are the typical ones.

Matrix diagrams help project managers visualize and evaluate those complex relationships so they can make better decisions and keep projects on track.




**2.5 Arrow Diagram**

Arrow diagram is defined as a process diagramming tool used to determine optimal sequence of events, and their interconnectivity. It is used for scheduling and to determine the critical path through nodes. The arrow diagramming method shows the required order of tasks in a project or process, the best schedule for the entire project, and potential scheduling and resource problems and their solutions. The arrow diagram lets you calculate the "critical path" of the project—the flow of critical steps where delays can affect the timing of the entire project and where addition of resources can speed up the project.




**2.6 Process Decision Program Chart**

Process Decision Program Chart (PDPC) is a technique designed to help prepare contingency plans. The emphasis of the PDPC is to identify the consequential impact of failure on activity plans and create appropriate contingency plans to limit risks.

The slide shows operations and risks after unloading a cargo.

Assuming that cargo is damaged if putted on upside down.

Caution label is put on the cargo to avoid the damage but there remain risks which consequently cause damage.

The PDPC is similar to the failure mode and effects analysis (FMEA) in that both identify risks, consequences of failure, and contingency actions. The FMEA adds prioritized risk levels through rating relative risk for each potential failure point.

## 2.7 Matrix Data Analysis

**Feature:**

- Matrix data analysis is the only quantitative data analysis method in New QC Method.
- Matrix data analysis is equivalent to "principal component analysis" of multivariate analysis.

**Purpose:**

- For "extracting what it should be“
- For "understanding the current situation“
- For "pursuing the cause“
- For "confirming the effect".

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**2.7 Matrix Data Analysis**

Matrix data analysis is the only quantitative data analysis method, while other methods of the new QC seven tools are analysis of qualitative information such as language data. Matrix data analysis is equivalent to "principal component analysis" of multivariate analysis.

Matrix data analysis can be used in all cases, such as "extracting what it should be", "understanding the current situation", "pursuing the cause", and "confirming the effect".

## Example Matrix Data Analysis

We gathered data of products A to H by parameters and evaluated.
(Highest:5, Lowest: 1)
By using Matrix diagram analysis, we can know the tendency of quality control, relationship among the parameters

| Product type | Parameter A (Strength) | Parameter B (Visual) | Parameter C (Durability) | Parameter D (Cost) |
|---|---|---|---|---|
| A | 5 | 3 | 4 | 2 |
| B | 4 | 4 | 3 | 3 |
| C | 5 | 2 | 4 | 3 |
| D | 5 | 4 | 5 | 1 |
| E | 3 | 5 | 3 | 3 |
| F | 3 | 3 | 3 | 5 |
| G | 3 | 5 | 2 | 4 |
| H | 4 | 4 | 4 | 4 |

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**Example: Matrix Data Analysis**

This slide show an example of Matrix data.

We gathered data of products A to H by parameters and put number 5 (Highest ) to 1 (lowest) after evaluation.

Each parameters were evaluated but how we can know the total evaluation point?

If we know the preference of the customers to these products A to H, we like to know the relation between some total parameter and the customer preference.

In such a case, the Matrix data analysis gives you one combined parameter (new parameter)

# REVIEW OF KAIZEN TOOL

# IE TOOL

# Review of Kaizen Tool
# IE Tool

1

**Review of Kaizen Tool: IE Tool**

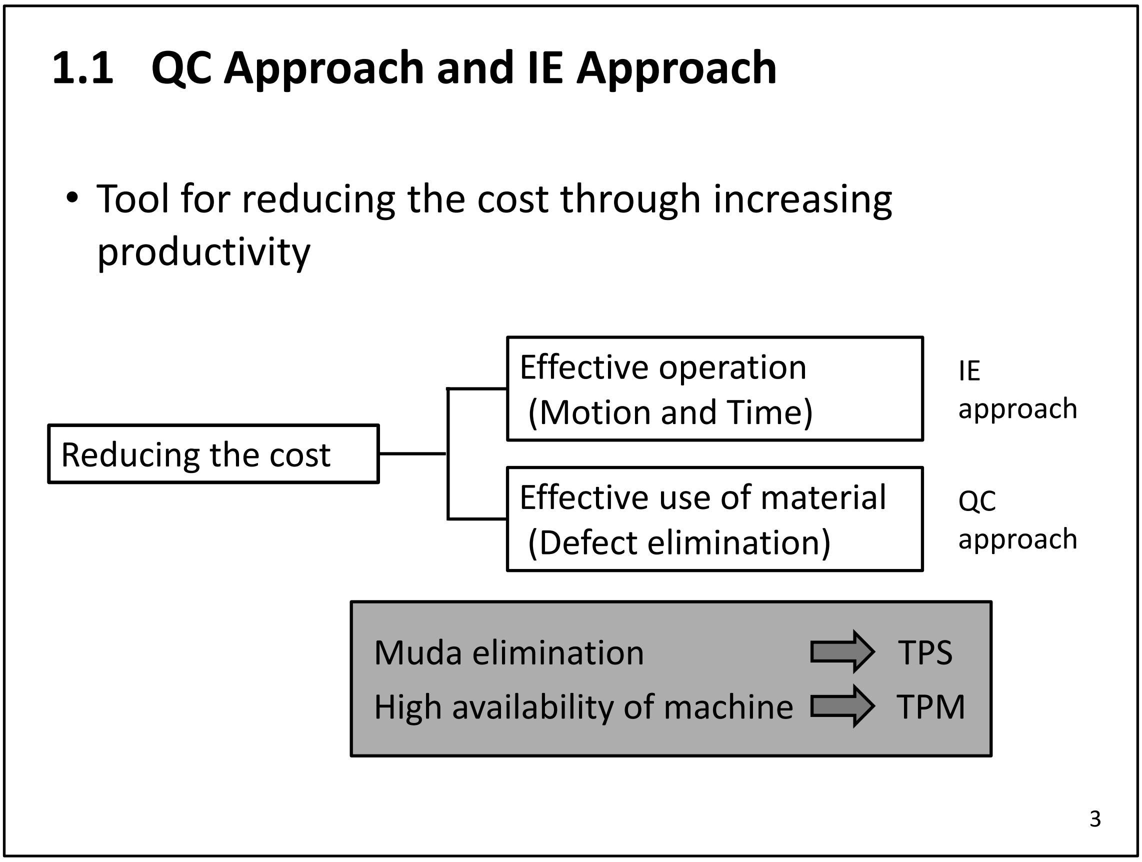
IE tools is a set of conventional tool for Kaizen and its class is provided in Basic Kaizen , but it is also used in the Intermediate Kaizen so often.

So, review of IE is presented here.

Only the briefing and key knowledge are shown in this class. Please refer Basic Kaizen manual for detail.

# 1. IE in Kaizen

2




**1.1 QC Approach and IE Approach**

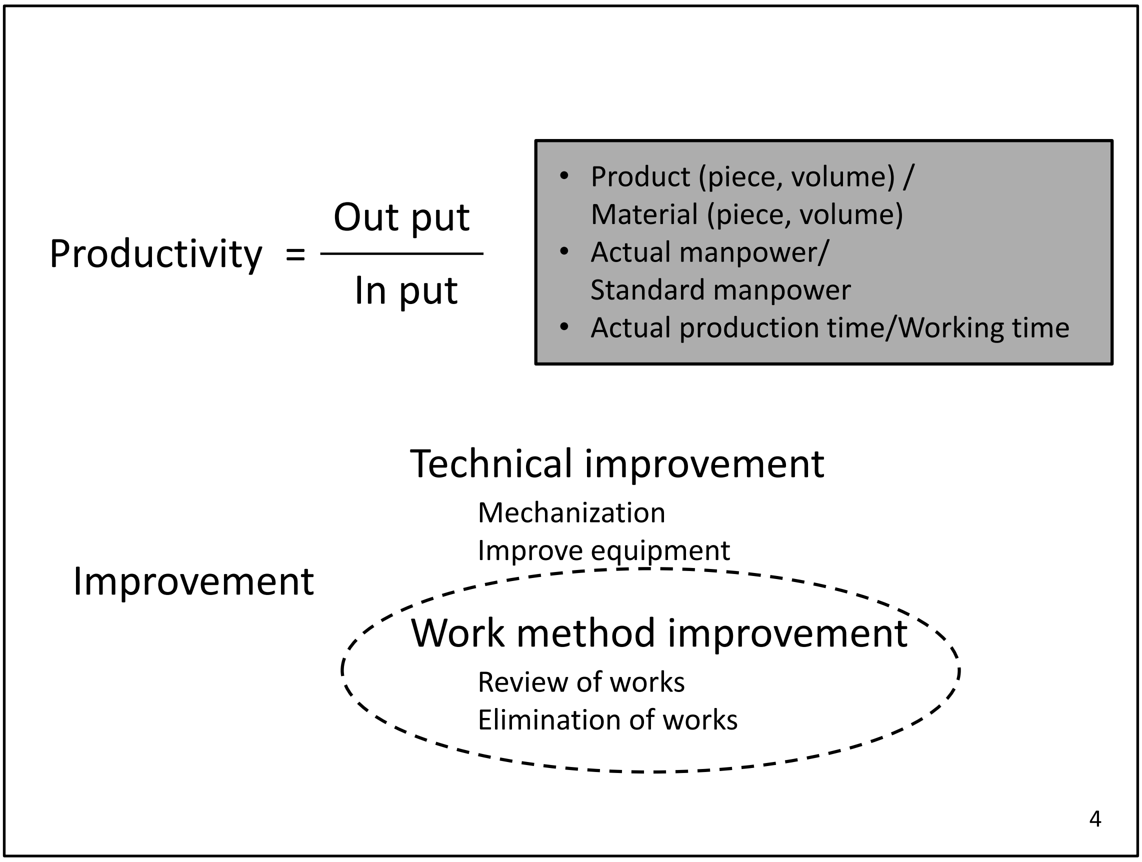
QC and IE are both used for Kaizen.

IE is most useful for making the operation effective or in other word elimination of Muda of process, motion and time.

So, IE contribute mainly reducing cost and delivery by reducing Muda.

QC, on the other hand, is to contribute improving quality by statistical measurement and systematic cause finding.

Nowadays, TPS (Toyota Production System) and TPM (Total Productive Maintenance ) can be called as advanced system of IE

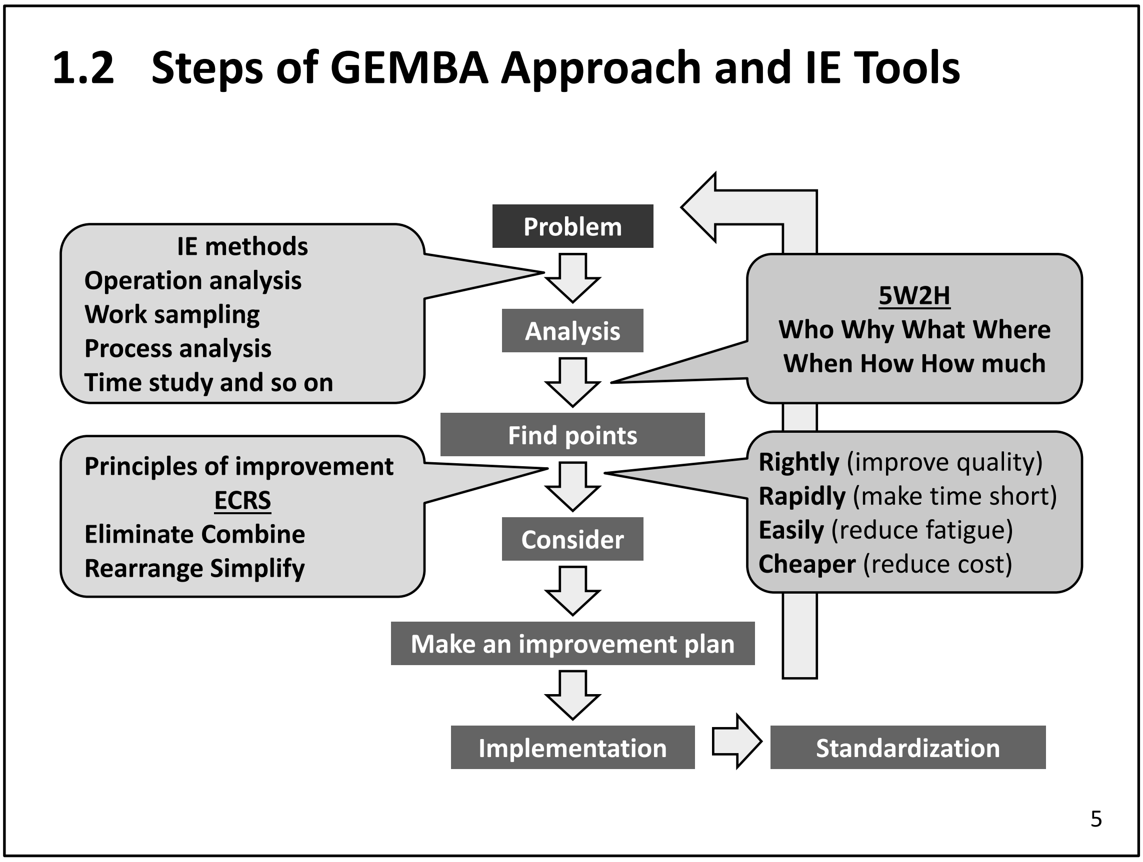



**Productivity and IE**

One definition of productivity is the ration of Out-put over In-put .

There are two ways to improve productivity, one is technical (mechanical) improvement and the other is work method improvement.

IE is mainly a set of tools for work method improvement.




### 1.2 Steps of GEMBA Approach and IE Tools

In the process of KAIZEN story, IE methods such as Operation analysis, Time study are mainly used for comprehending current situation.

In the process of analysis, 5W2H is an effective tool.

ECRS provide view points for improvement.

**Steps of the GEMBA approach**

This slide shows the procedure of the GEMBA approach (realistic approach which we take).

In Kaizen, we call this as Kaizen story, as already mentioned.

It identifies the problem(s) and or task(s) that should be resolved first. As the problem/task means the deviation between the standard (ideal state) and the current state, it is easy to identify the problem(s)/task(s) when standardization is made and benchmarking is shown.

The next step is an analysis to explore cause(s) that bring(s) about the gap. Many analytical methods are prepared in IE, including the analysis by 5W2H which is simple but useful for qualitative analytical purposes.

Once gaps and causes are identified, their countermeasures and scenarios are formulated. The law of motion economy and ECRS are well known as ideas that can be used here. ECRS is the combination of initials from elimination, combination, rearrangement, and simplification. What should be considered first in the order is the elimination. When you cannot make the elimination absolutely, what you should consider next is the combination. Considerations should be given to whether or not two works can be done at one time.

The next step is the implementation of measures. Work methods after improvements should be standardized, when measures become effective. Its order is as shown in the slide, but it can rarely be progressing smoothly like this in practice. Because various pitfalls lurk in the middle of these steps, including measures formulated on the basis of erroneous root causes, measures that are correct but not thoroughly implemented, or the case in which operators set back original methods after surprised to see that the productivity falls down temporarily after the countermeasures are implemented, the situation is often in a back-and-forth condition.

## 1.3 5W2H

1. **Why do they do it ?** (purpose/ performance/ reason)
   Is it necessary for them to do it absolutely ?
2. **What are they doing it ?** (objective/scope)
   Is it possible for them to eliminate the operation (process)?
3. **Where do they have to do it ?** (position/route/direction)
   Is it possible for them to change operation procedure?
   Is it possible for them to do it together with other processes?
4. **When do they do it ?** (hour/ day/ time)
5. **Who do they do it ?** (operator/ machinery)
6. **How do they do it ?** (procedure/ method)
7. **How much does it cost ?** (unit price/sum)
   Do you have any idea to do it more easily?

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**1.3 5W2H**

Three typical concepts that provide perspectives useful when utilizing IE methods are introduced.

The first concept is 5W2H.

5W2H is composed directly from the initials of characters shown in the figure. It is good to use 5W2H as a check point to discover improvement points. It is easy to readily find challenges by looking at work sites from the viewpoint of 5W2H instead of looking vaguely at onsite works.

So , it is recommended to have 5W2H thinking mind as a check sheet in your hand or in your head when you visit Gemba.

## 1.4 3S

### 3S is the second concept which is the basis of IE thinking way

| Item | Hint | Example |
|---|---|---|
| 1. Simplification | ① Simplify the structure of mechanism<br>② Simplify methods<br>③ Reduce the amount of parts | ① Use simple tools<br>② Reduce operating spots<br>③ Combine two parts into one part |
| 2. Standardization | ① Integrate methods<br>② Integrate styles<br>③ Provide the standard | ① The standard time is set.<br>② The procedure is set. |
| 3.Specialization | ① Limited items<br>② Share jobs<br>③ Put similar jobs together | ① Specialization for equipment, jigs and tools<br>② Divide jobs into specialization (conveyer, inspection) |

Taylor : He improved operation methods to require fair work volume and normal work volume per day

Gilbreth : He found the best way of motion (Therblig), He got the result of required time.

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**1.4 3S**

The next to be introduced is 3S.

3S is the combination of initials from simplification, standardization, and specialization. For example, simplification is to improve the productivity by facilitating works through simplifying their mechanisms or reducing parts. Standardization is to define a work method so that the same result can be obtained from anybody's works. Specialization is a method of improving the productivity by improving jigs and tools or decomposing and specializing works. While 5W2H has the viewpoint of finding problems, 3S is intended to show the direction of Kaizen.

# 1.5 ECRS

**The concept of ECRS is similar to that of 53S and ECRS clarifies on-going problems to suggest how to improve them.**

**Eliminate**:
Consider whether or not it is possible **to eliminate the process and operation.**

**Combine**:
Consider whether or not it is possible to **combine more than two processes into one process.**

**Rearrange**:
Consider whether or not it is possible to **rearrange process/ procedure.**

**Simplify**:
Consider whether or not it is possible to **simplify the process and operation**

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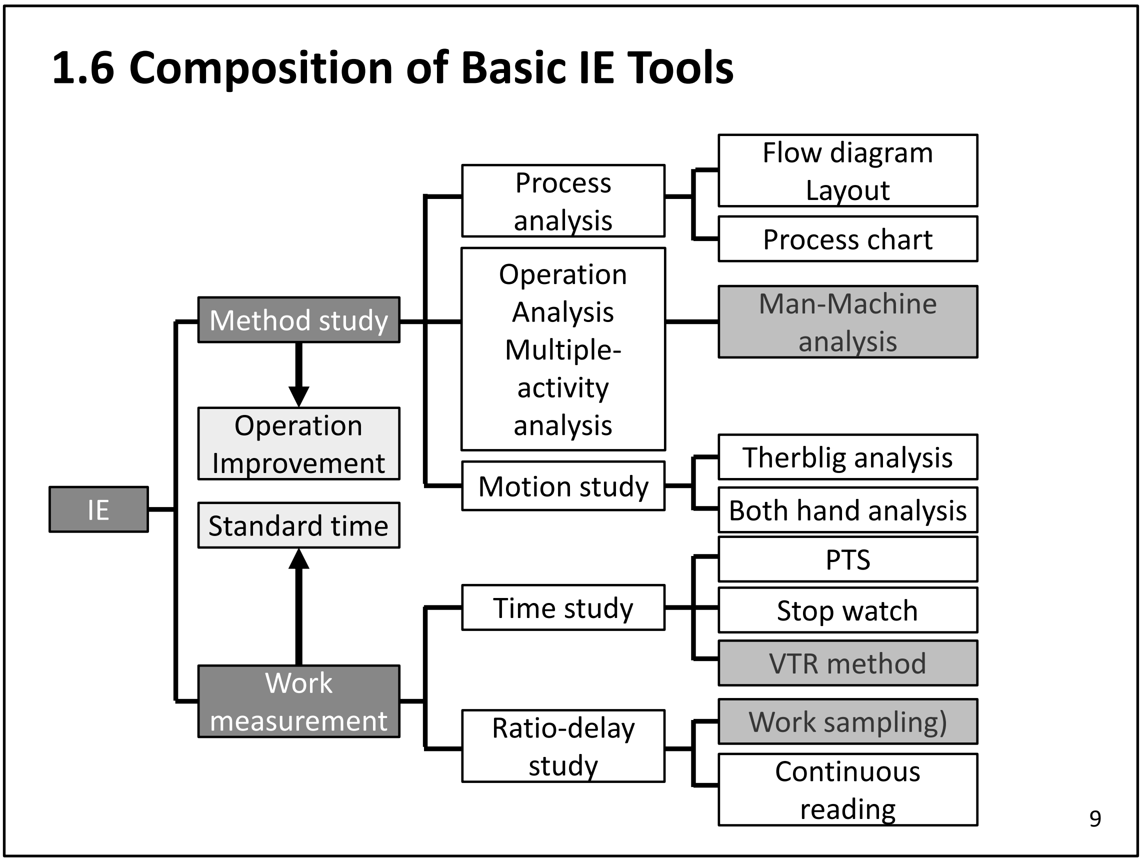
## 1.5 ECRS

ECRS is also the combination of initial letters taken from names of respective items. It also provides a hint indicating the direction of Kaizen such as 3S described previously. Firstly, you should think of eliminations. You consider whether or not you should surely do works and refrain from doing them if not necessary. If it is assumed that these works are absolutely essential, you should assemble or combine two works to be done into one work or perform them while changing their order. If they are not still less successful, then you should think of simplifying the works.




**1.6 Composition of Basic IE Tools**

IE is composed of two elements, one is Method study and the other is Work measurement.

Method study has its root in Therblig analysis of Frank Bunker Gilbreth who categorized the elements of human motion into 18 basic elements called therbligs. The work measurement has its root in Frederick W. Taylor who deemed work deserving of systematic observation and study.

Motion study and work measurement together contribute to productivity improvement by improvement of operation and setting most refined standard time

# 2. Method Study

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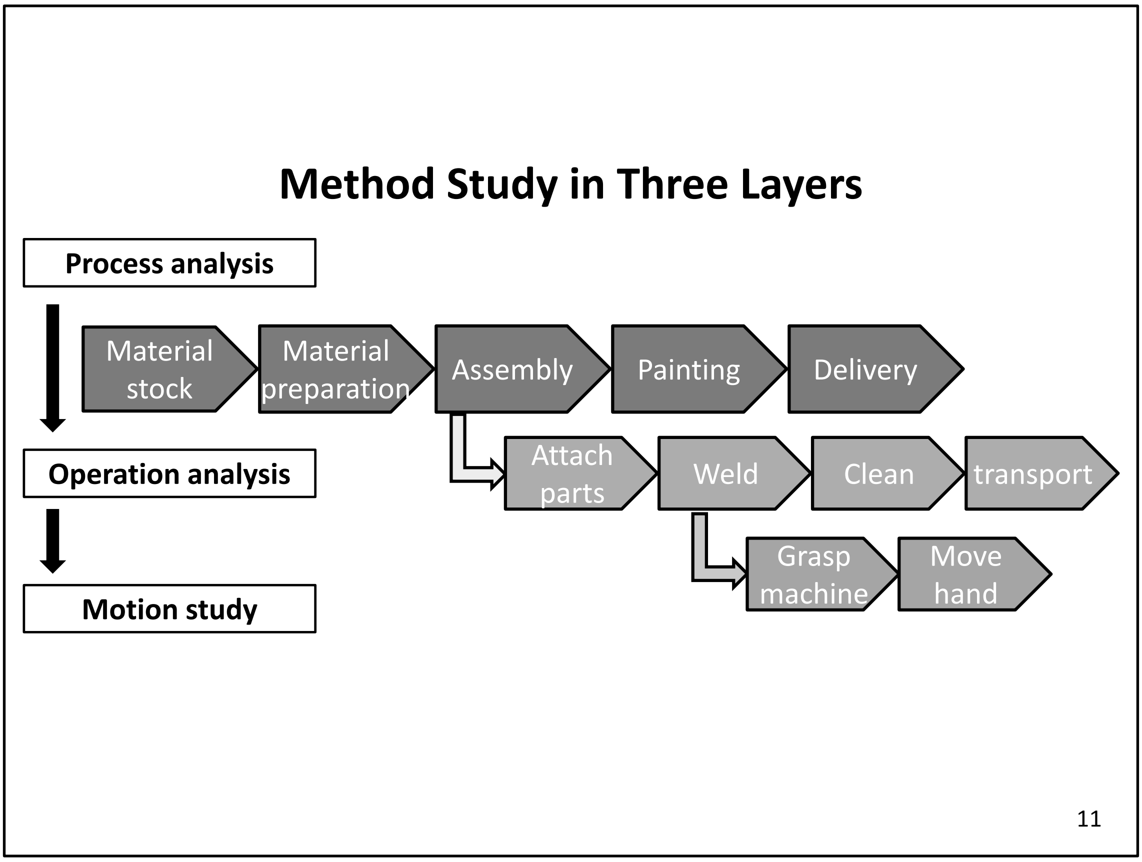
**2. Method Study**

Method study is a series of study of motion and/or process and its aim is simplify and eliminate Muda.

This study is very useful to grasp the actual situation.




**Method Study in Three Layers**

Method study is divided into three layers, process, operation and motion.

Process analysis is the first layer and it shows main flow of activity like production.

For example, steel structure production process start from material stock then proceed to material preparation such as cutting and sand blasting , assembly of cut parts, painting and delivery at the end. This is a principal process and to visualize the process by flow chart help understand the whole process.

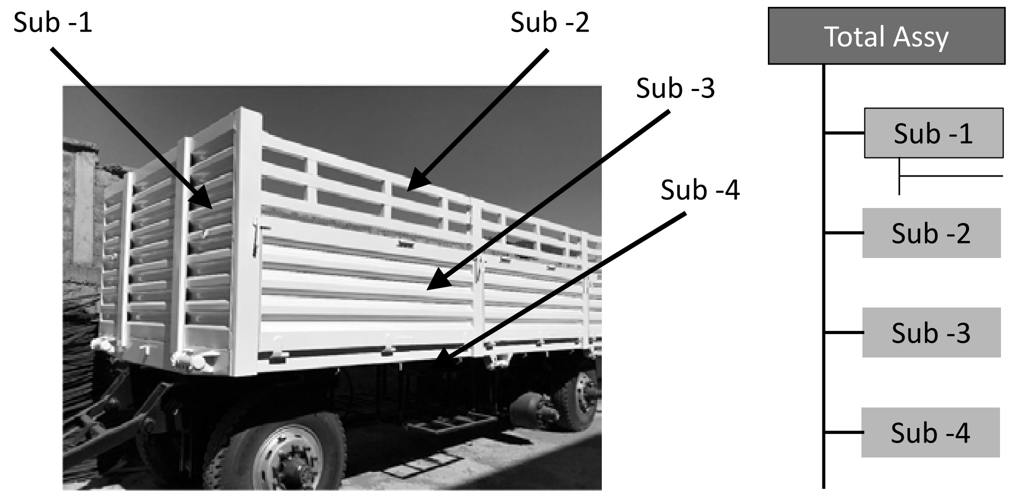
Second layer is operation analysis. For example, in the assembly process, there are several smaller processes such as attaching the parts, welding, cleaning and transport to next process.

Third layer is close to motion analysis. For example, welding process is divided in operator's several motions such as grasping the machine (torch), move hand etc.

Thus, we can understand the processes from whole to individual.

**Example**

## 1st step- to Know BOM

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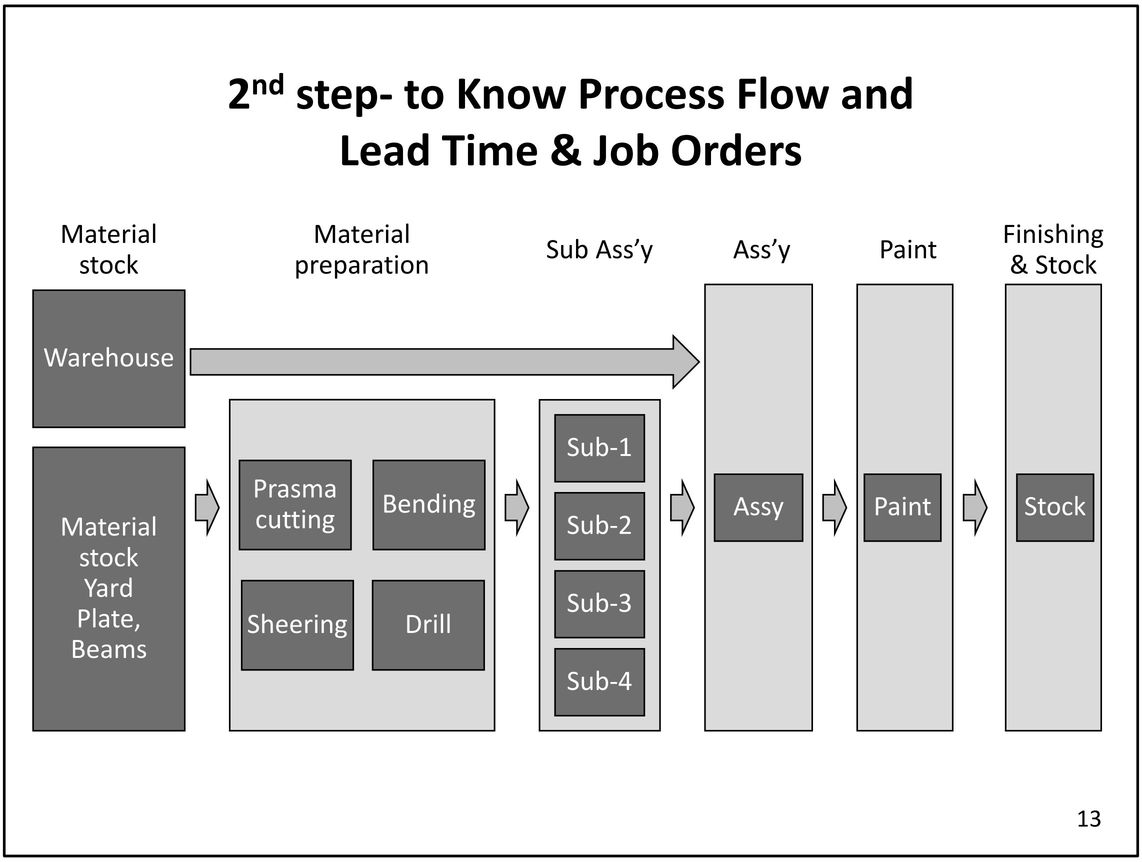
**Process Analysis and BOM**

Process analysis becomes easier if we have BOM (Bill Of Material) of product.




We can analyze process by many types of process flow sheet .

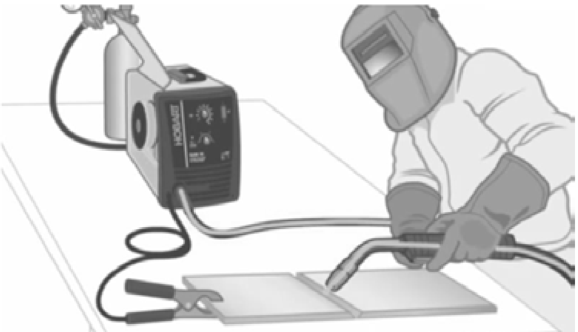
Flow sheet which shows simply the process.

Flow sheet which shows process with layout.

Flow sheet which shows process and time to be taken.

VSM (Value stream mapping) is one advanced figure of process flow diagram

## Motion Study



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**Motion Study**

The movement of welder is a target of the motion study.

Here, very detailed motions similar to those described in Thirblig can be measured.

# 2.1 Process Analysis

1) Flow Diagram (Layout)

Convenient to show the process
in different place
e.g. Chemical Plant , Food plant,
Metal fabrication shop

2) Process Chart

Convenient to show the process in line
e.g. Sewing line

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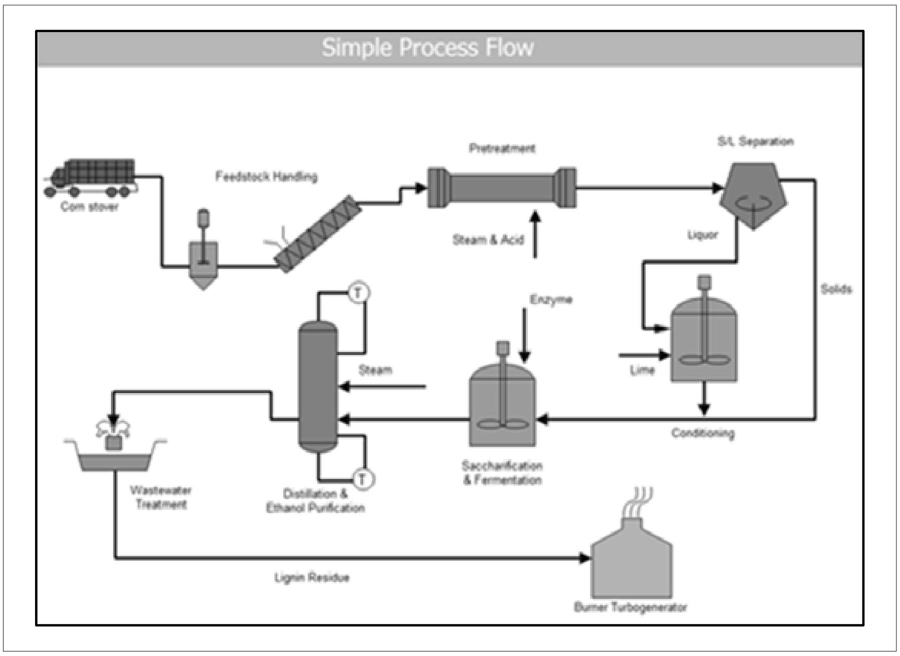
**2.1 Process Analysis**

Many types of diagrams and charts are used for process analysis such as Flow diagram, Process chart.

Not only showing the processes, layout, process time are able to shown in the diagram and chart.

Process analysis is the first thing to be don to proceed Kaizen, especially to grasp the current situation.

Example: Flow Diagram with Layout

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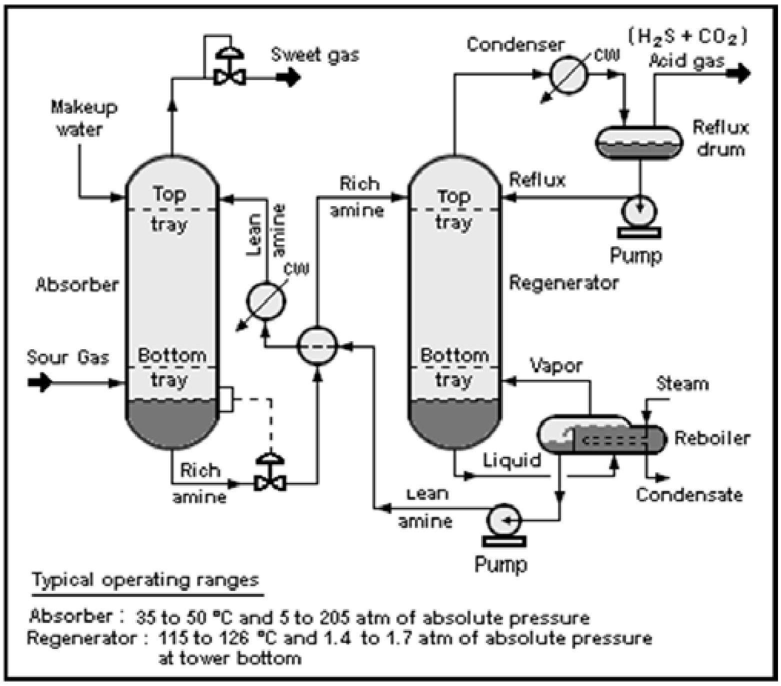
**Example: Flow Diagram with Layout**

This example is a flow diagram of a chemical plant.

We can easily understand the process, shape of machine and layout.

By visiting Gemba with this diagram, we can understand the situation easily.

## Example: Flow Diagram with Symbol

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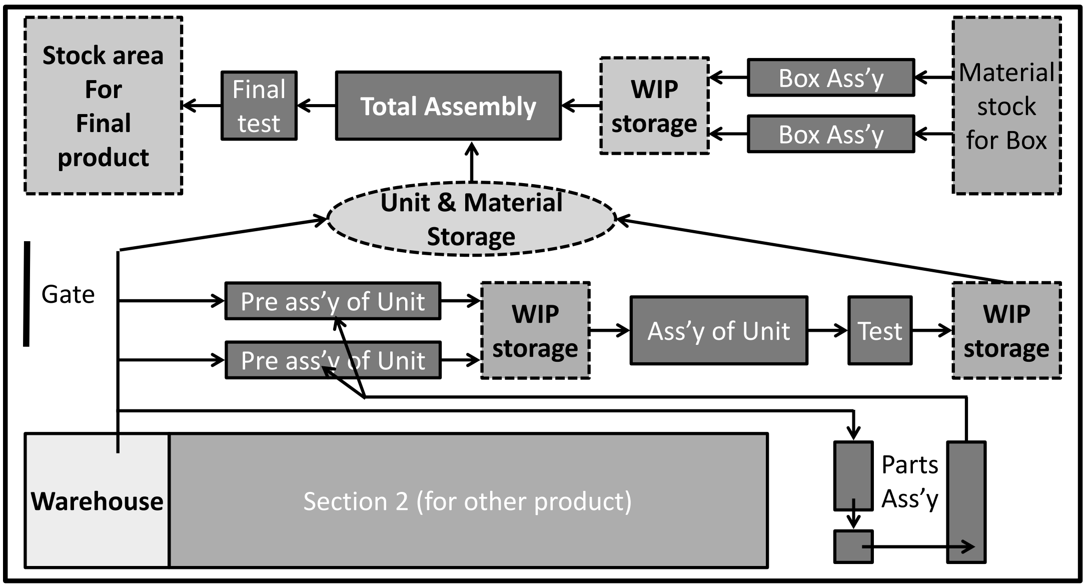
**Example: Flow Diagram with Symbol**

This example shows flow diagram of a chemical plant where symbols corresponding to pump, valve and so on are used.

Important parameters like pressure, water level, temperature can be put in this diagram.

## Example: Flow Diagram which Shows Layout and the Material Flow

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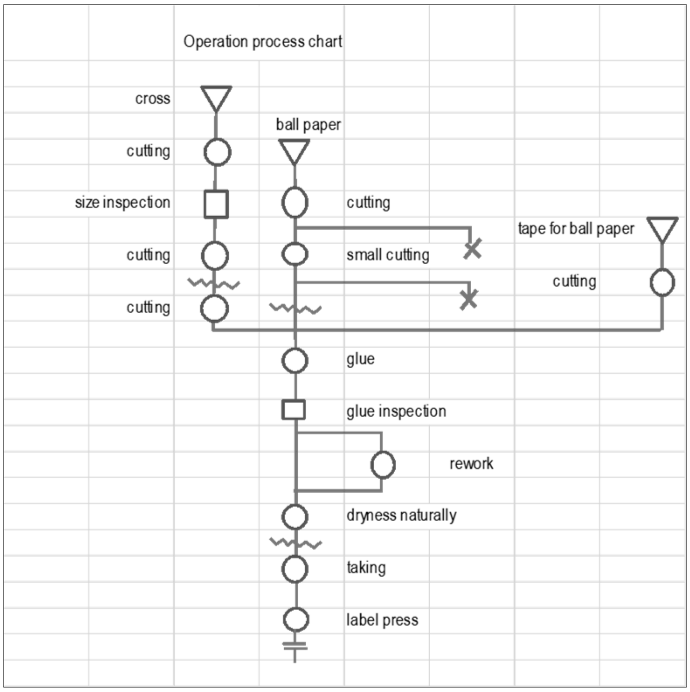
**Example: Flow Diagram which Shows Layout and the Material Flow**

This diagram shows the layout and the material flow from which we can know loss of transportation and others.

## Example: Flow Process Chart

To simply show the sequence of operation

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**Example: Flow Process Chart**

Process flow chart is often used to simply show the process sequence.

It is convenient to show the sequence and order of production.

In the process where more than one flow of processes exist, such plural flows are written together. Furniture or metal assembly products have this kind of process chart. It is the case in which after many parts are processed separately, those parts are assembled into a product. On the other hand, there is also a double-line process chart in the reverse case. In the sugar industry, for example, sugar cane is invested as a raw material to produce sugar and molasses as a by-product. Molasses are further processed into alcohol.

If you draw in this manner, it is possible to understand the flow of manufacturing processes well and easily determine how several raw materials are involved in product processing and assembly.

## Example: Single Linear Flow Process Chart

| Distance (m) | Time (min) | Process chart | Contents of Process |
|---|---|---|---|
| | | ▽ | **warehouse** |
| **15** | 0.85 | ○ | **to line top by forklift** |
| | 125.00 | ▽ | **on the pallet** |
| **1** | 0.05 | ○ | **The material are moved to the machine by the hand.** |
| | 1.00 | ○ | **cutting edge by miling machine** |
| **3** | 0.20 | ○ | **automatic transportation by conveyor** |
| | 1.00 | ○ | **cutting shaft roughly by leather machine** |
| **3** | 0.20 | ○ | **automatic transportation by conveyor** |
| | 1.50 | ○ | **finishing shaft roughly by leather machine** |
| **3** | **0.20** | ○ | **automatic transportation by conveyor** |

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**Example: Single Linear Flow Process Chart**

Single linear Flow Process Chart is often used for line production such as sewing line of garment and/or shoe production where the layout is not so complicated.

Here, lead time for each process and distance between processes are shown.

# Example : Flow Process Chart Using Symbols

To analyze the MUDAs

FLOW PROCESS CHART — ~~MAN~~/MATERIAL/~~EQUIPMENT~~ TYPE

| CHART No. 1 SHEET No. 1 OF 1 | SUMMARY | | | |
|---|---|---|---|---|
| | ACTIVITY | PRESENT | PROPOSED | SAVING |
| Subject charted: *Used bus engines*<br>ACTIVITY: *Stripping, cleaning and degreasing prior to inspection* | OPERATION ○<br>TRANSPORT ⇨<br>DELAY D<br>INSPECTION □<br>STORAGE ▽ | 4<br>21<br>3<br>1<br>1 | | |
| METHOD: PRESENT/~~PROPOSED~~ | DISTANCE (m) | 237.5 | | |
| LOCATION: *Degreasing Shop* | TIME *(man-min)* | — | — | — |
| OPERATIVE(S): CLOCK Nos. 1234, 571 | COST<br>LABOUR<br>MATERIAL | —<br>—<br>— | | |
| CHARTED BY:<br>APPROVED BY: DATE: | TOTAL | — | — | — |

| DESCRIPTION | QTY. | DISTANCE (m) | TIME (min) | ○ | ⇨ | D | □ | ▽ | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| *Stored in old-engine store* | | | | | | | | | |
| *Engine picked up* | | | | | | | | | *Electric crane* |
| *Transported to next crane* | | 24 | | | | | | | " " |
| *Unloaded to floor* | | | | | | | | | |
| *Picked up* | | | | | | | | | " " |
| *Transported to stripping bay* | | 30 | | | | | | | " " |
| *Unloaded to floor* | | | | | | | | | |
| *Engine stripped* | | | | | | | | | |
| *Main components cleaned and laid out* | | | | | | | | | |
| *Components inspected for wear; inspection report written* | | | | | | | | | |
| *Parts carried to degreasing basket* | | 3 | | | | | | | |

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**Example : Flow Process Chart Using Symbols**

This example is a flow process chart with symbols.

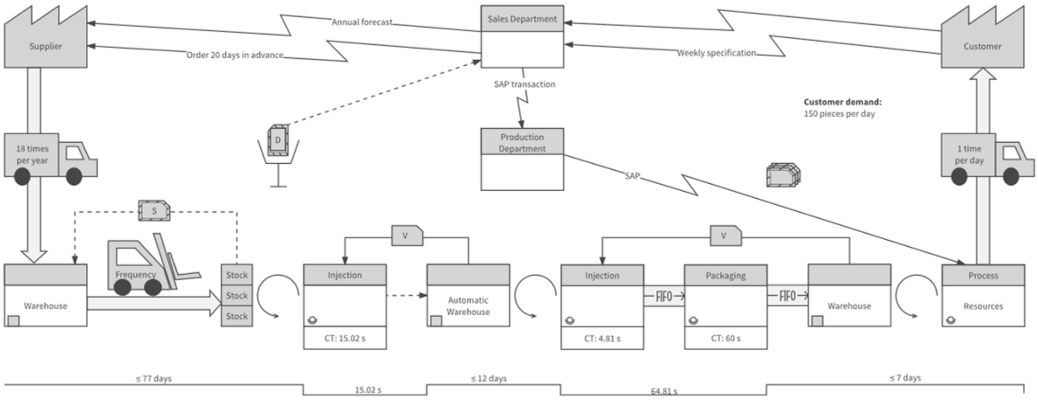
It is convenient to find Muda in process especially in line production with relatively short process time like sewing.

(Normally in sewing line, each processing time doesn't exceed a minute but number of process is bigger than 20 and to improve some seconds of each step leads to big improvement)

It is not so recommended in the process where each process time is long as more than a hour and number of process is small.

## Example: Value Stream Mapping

Process chart which shows process of product and information and each time

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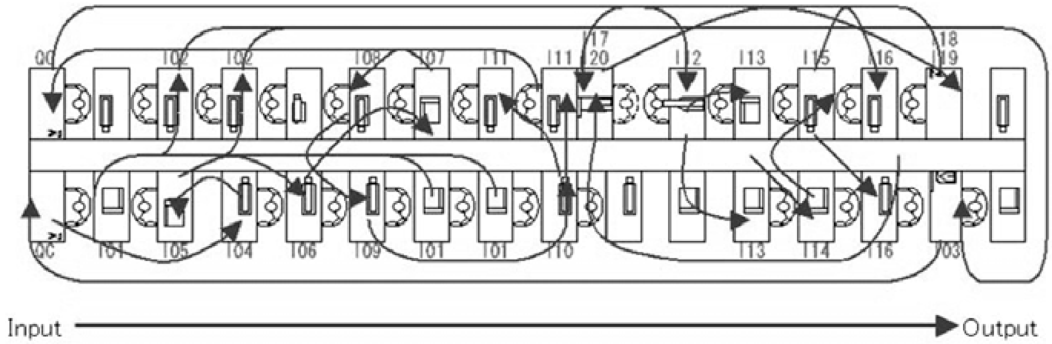
**Example: Value Stream Mapping**

VSM (Value Stream Mapping ) is also one type of process flow chart which shows flow of material, information and process time.

## Example: Improvement of Flow Diagram

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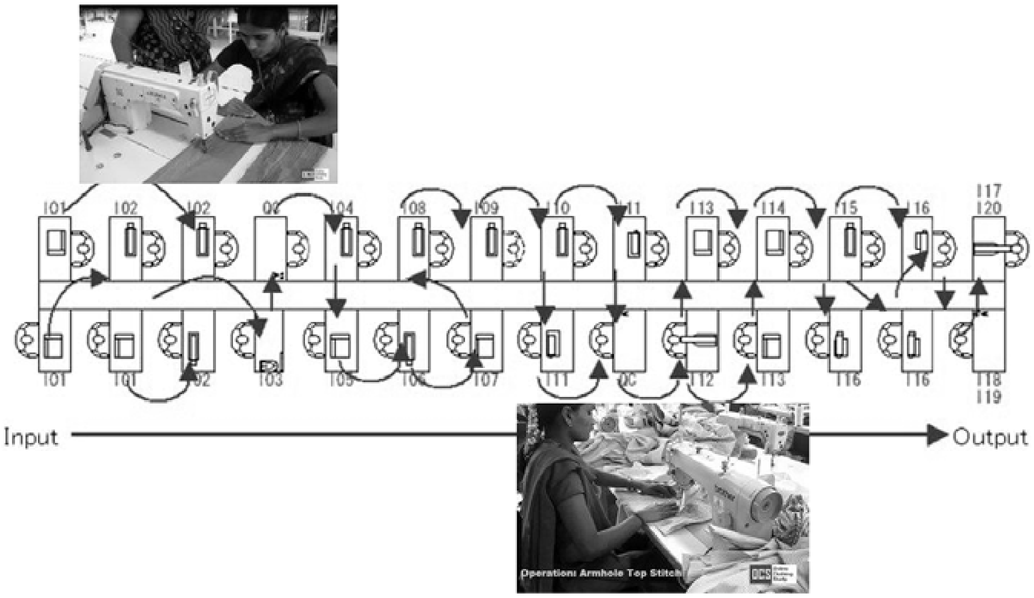
**Example: Improvement of Flow Diagram**

This slide shows a flow diagram of sewing line.

You can see how the lines are complexed.

## Improved Flow Diagram

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**Improved Flow Diagram**

By changing the machine position, we can make the flow lies simple.

# 2.2 Operation Analysis (Multiple-Activity Analysis)

Man-Machine Analysis

Man-Man Analysis

Use mainly for some group work

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**2.2 Operation Analysis (Multiple-Activity Analysis)**

Multiple-activity analysis is an analysis method using operational timing chart between multi-activity, like man – man or man-machine. This method is used to know the loss of multiple-activity Multi-activity analysis is an analysis performed between multiple activities .

There are Man-Machine analysis which analyze the process consisted with several machines and operators and Man-Man analysis which is analyze the process consisted with several operators.

The finishing process in sugar factory,

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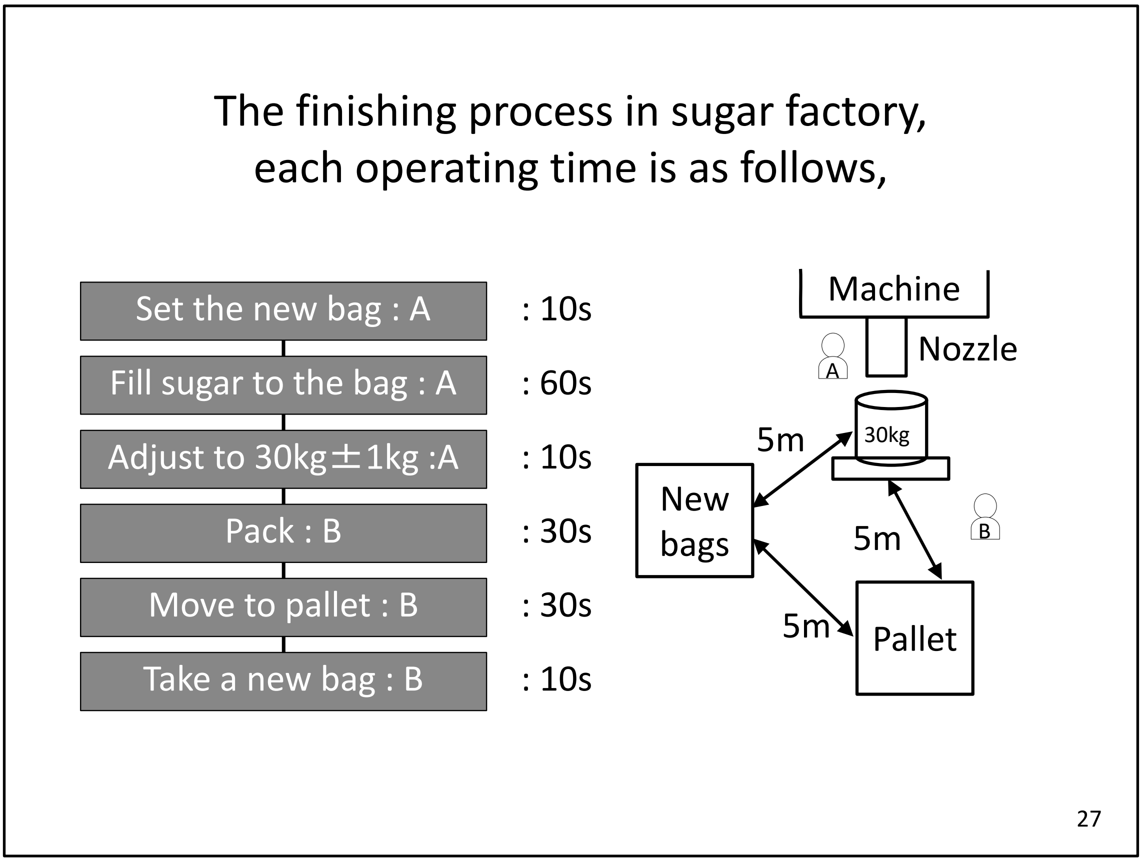
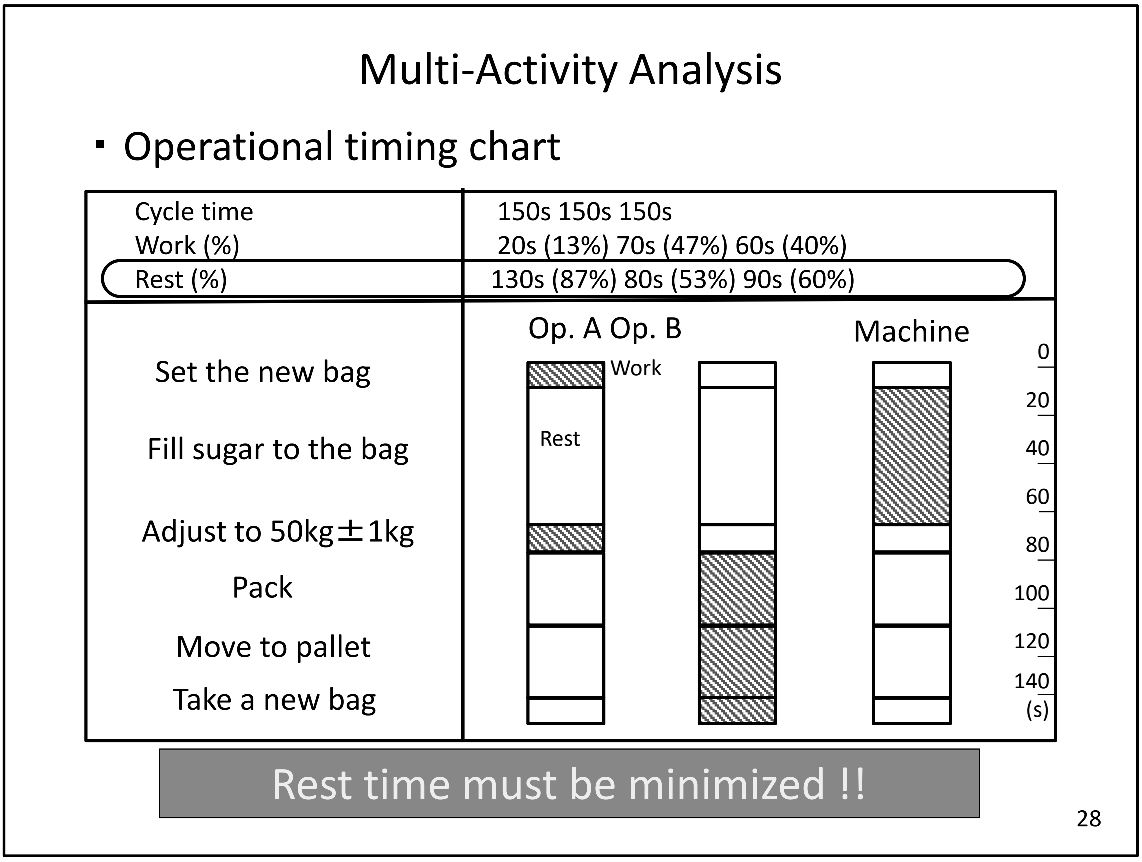
Let’s consider the finishing process in a sugar factory.




In the finishing process, each operating time is as follows.

It takes 10 seconds to set an empty bag under the nozzle, 60 seconds to fill the bag with sugar, 10 seconds to adjust the weight to 30kg±1kg, 30 seconds to seal the bag, 30 seconds to move the bag to the pallet, and 10 seconds to take a new bag.

Operator A performs the bag setting work, nozzle opening and adjustment work, while Operator B seals the bags, moves the bags to the pallet and takes the new bags.




The goal of multi-activity analysis is to clarify and minimize the non-operating (rest) time.

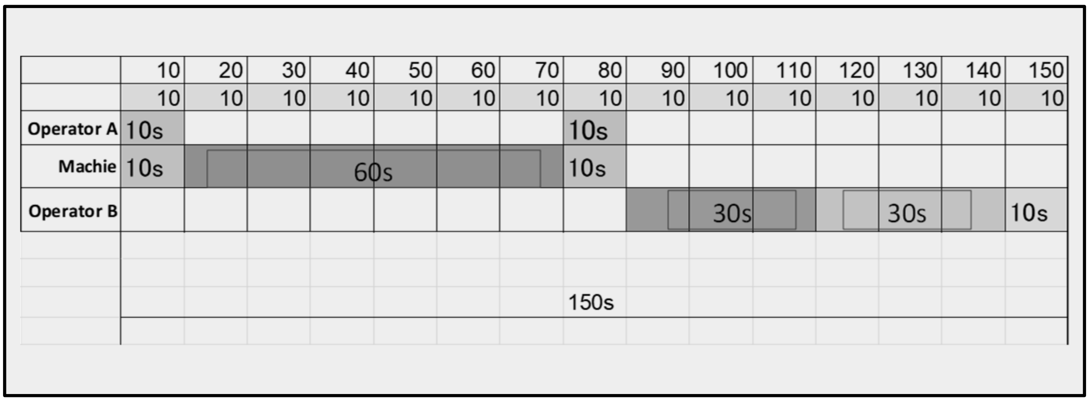
To do so, we should make Operational timing chart of man and machine individually.

The slide shows the cycle time, work (operation) time, rest time and their percentages.

From this chart we can know that the work time ratio of Operator A is only 13% (rest time is 87%) and that of Machine is only 40 % (rest time is 60%).

It shows there are a lot of Muda in this process and shows there are big room for Kaizen.

## Operational Timing

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**Operational Timing**

This slide shows a operational timing chart (horizontal type).

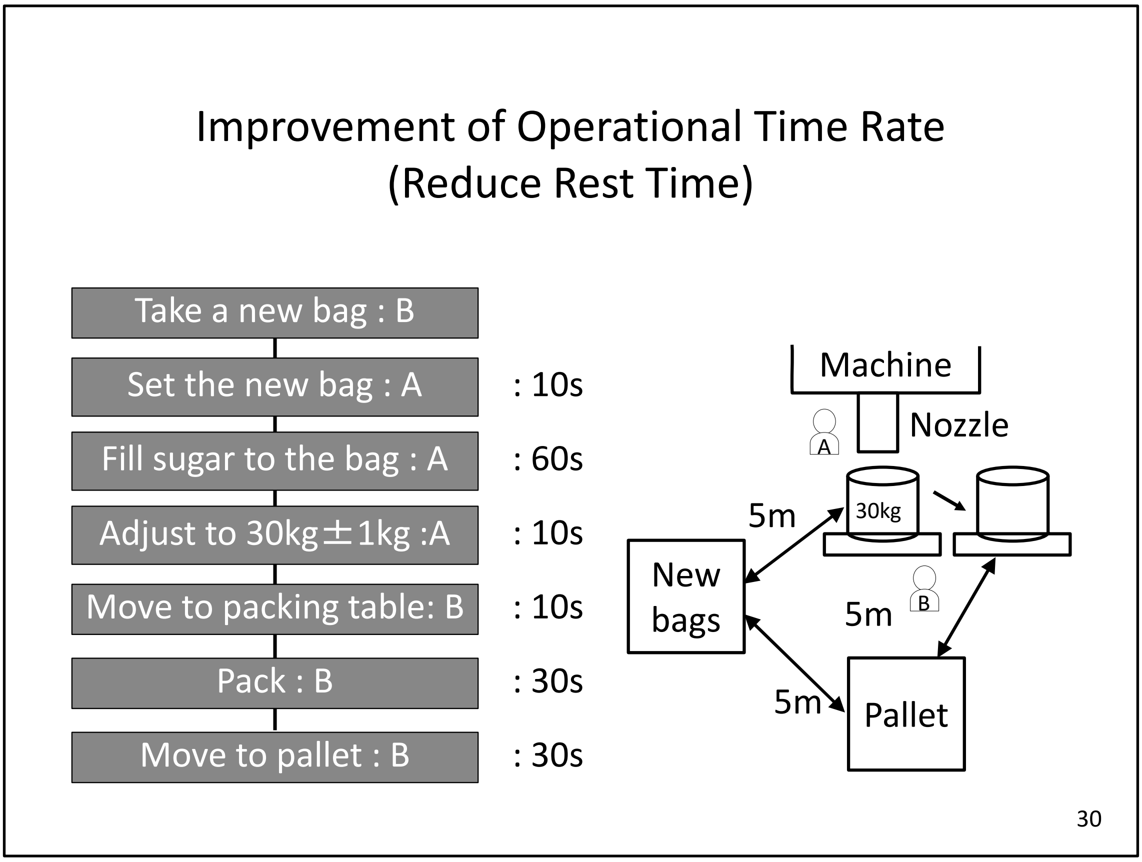
In the first 10 seconds, operator A sets a new bag on the machine. So, Operator A has work and machine is oqqupied however Operator B has nothing to do.

After 10 seconds machine start o work for 60 seconds.

After 70 seconds (10s+60s), Operator A works for adjusting 1kg and machine B is occupied.

After 80 seconds ( 10s;60s+10s),Operator B starts to work for packing (30s) and moving to palette (30s), and taking a new bag (10s).

After that new cycle starts. So the total cycle time to complete one sugar packing is 150 seconds.




**Improvement of Operational Time Rate (Reduce Rest Time)**

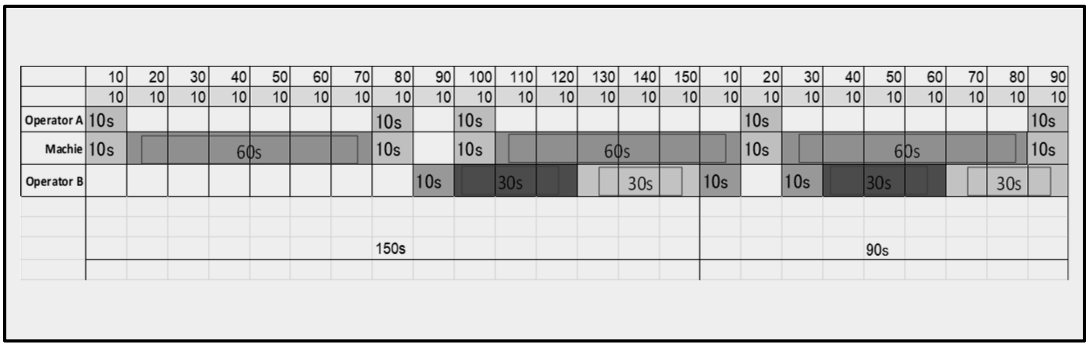
We can see typical Kaizen's mindset in Multi activity analysis.

The problem of current procedure is two actions (filling and packing) are done on one table.

If we prepare a new table on which only packing work is done by operator B, setting and filling work for next bag are able to be started by operator A immediately.

Only by adding simple table, Muda is reduced and consequently productivity becomes bigger.

# Improvement of Operational Time Rate
# (Reduce Rest Time)

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**Improvement of Operational Time Rate (Reduce Rest Time)**

It takes 150s for the first bag even if new table is added but takes only 90s for the second bag and the later.

## 2.3 Motion Study

To focus the movement of body and eyes
To analyze the process in more detail
Motion mind : there are difference of motion along with the difference of morale

A work is made up of many motions. The motion study is the method for breaking down the work at the motion level, eliminating motions having Muda (Waste), Mura (Inconsistency), and Muri (Unreasonableness)

Use mainly improve the one operator's work

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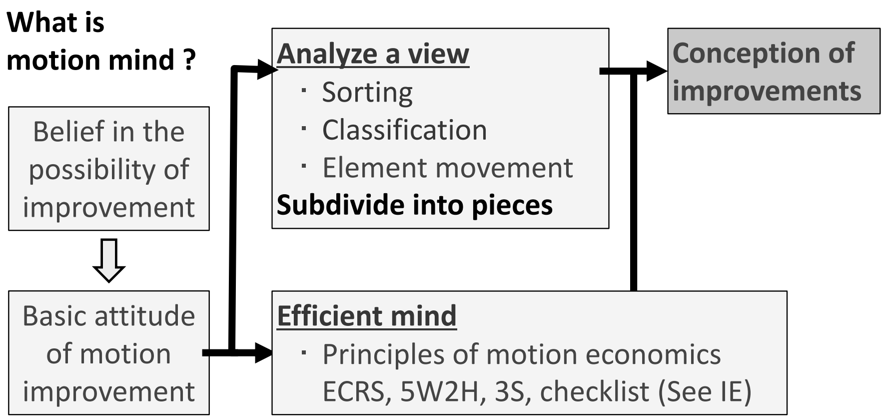
### 2.3 Motion Study

The productivity improvement can be achieved by the introduction of a high-performance machine and the elimination of unnecessary works or motions. The improvement of productivity by Kaizen focuses on the thorough elimination of useless motions.

A work is made up of many motions. The motion study is the method for breaking down the work at the motion level, eliminating motions having Muda (Waste), Mura (Inconsistency), and Muri (Unreasonableness), determining procedures and methods of essential motions, considering the placement of appropriate tools and jigs, and building a reasonable work.

## Motion Mind

**Have a keen awareness of problems in daily work and judge the quality of motions using detailed observations and considering the procedures and methods of motions.**

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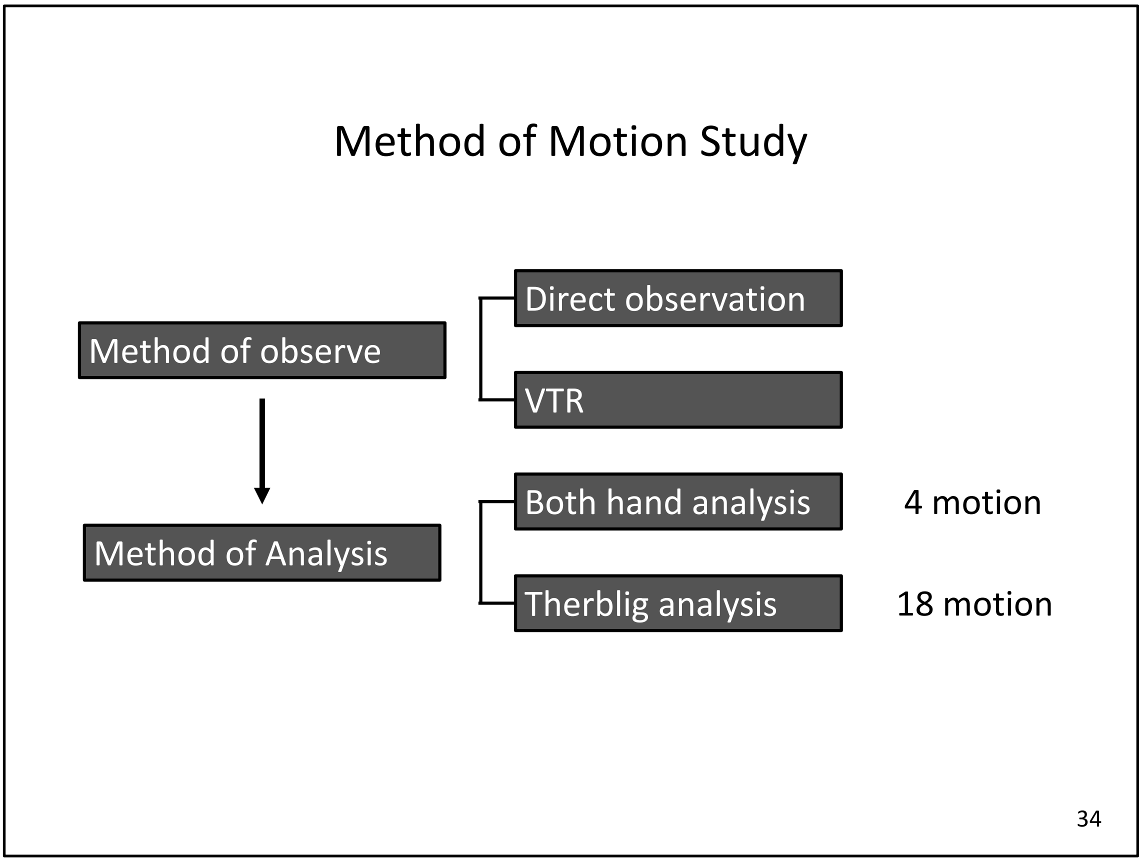
**Motion Mind**

In order to find out waste lurking in motions for their improvement (Kaizen), it is important to acquire a sense of discovering and overcoming problems for the improvements against motions on a daily basis. This is referred to as the awareness of motions (Motion Mind). In other words, it means that you have the awareness of problems with your daily work, observe it in minute detail, judge good or bad motions, and consider the better sequence and methods of motions.

The biggest point in the motion study is to observe things from the viewpoint of the motion mind. Moreover, the motion mind itself is a fundamental philosophy that strikes through all approaches to IE, which lays the foundation of solving larger problems in the manner of IE by acquiring groundings in distinguishing necessary and unnecessary elements and thus disallowing even a little waste at the micro stage of work such as motions.



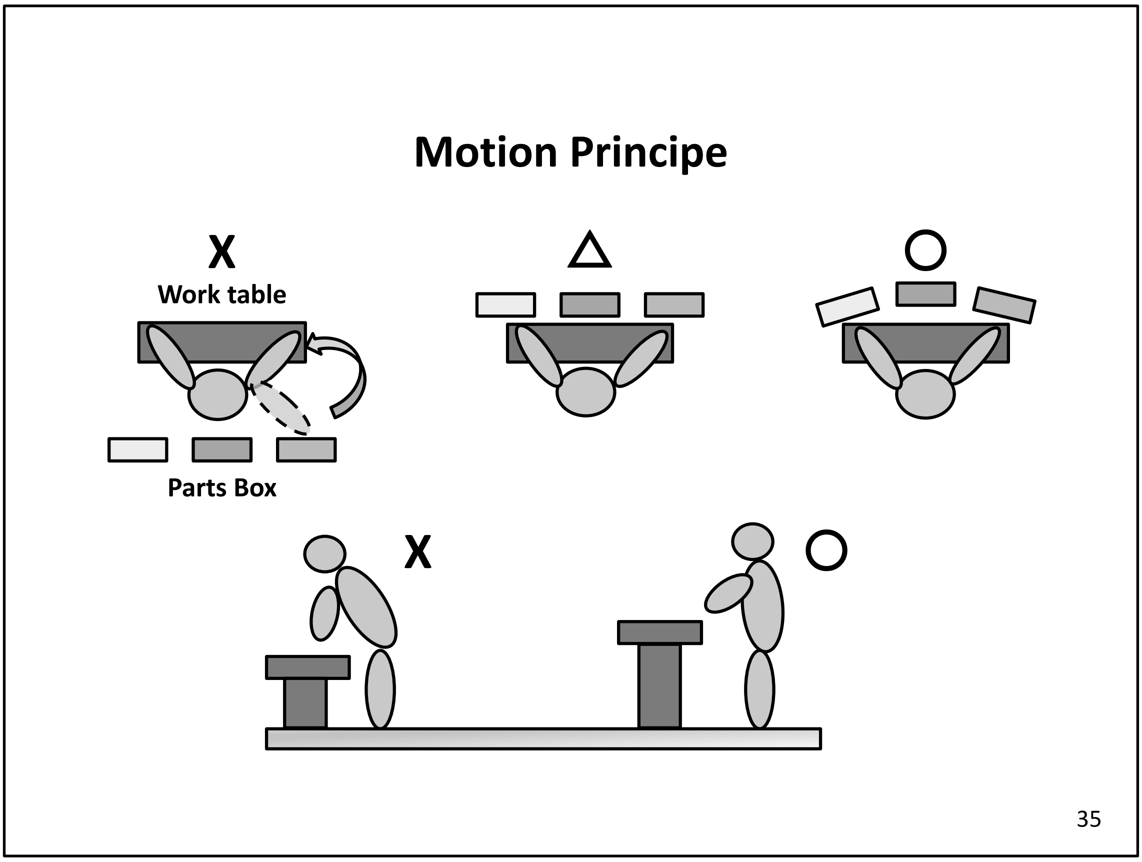

**Method of Motion Study**

Techniques of the motion study include the method by visual observation and the analytical method with a film or a video.

Categories of methodological classification as viewed from targets of the motion study include the element work analysis, both-hand work analysis, Therblig analysis.

Detail of analysis method like Both-hand analysis and the Therblig analysis are not explained in this class.

Please refer the Basic Kaizen manual when you need.




**Motion Principe**

This slide shows how an operator’s motion becomes rational (Fast and not tired)

# 3. Work Measurement

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**3. Work Measurement**

Work measurement is a set of tools to record and analyze the time of processes.

## 3.1 Time Study

- Time study entails dividing work into certain units, measuring the time required, improving the work method and system, conducting design, and performing standardization.
- Mainly used for analyzing the one operation (operator)

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### 3.1 Time Study

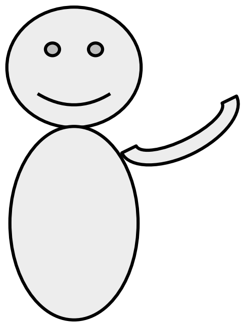
Time study entails dividing work into certain units, measuring the time required and then improving the work method and system.

## (1) PTS (Pre-determined –Time Standards)

- Predetermined Time Study

Standard timetable ⇨ Analyze the motion ⇨ Get standard time to make some work

| Type of Motion | Standard time |
|---|---|
| Raise hand | 0.5s |
| Turn hand | 1.0s |
| | |
| | |
| | |
| | |
| | |



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**(1) PTS (Pre-determined –Time Standards)**

PTS is an abbreviation of Predetermined Time Study or Standard and is a work measurement technique whereby times established for basic human motions classified according to the nature of the motion and the conditions.

PTS systems offer a number of advantages over stop watch time study.

1. With PTS one time is indicated for a given motion, irrespective of where such a motion is performed.
2. Timing by direct observation and rating can sometimes lead to inconsistency. A PTS system avoids both rating and direct observation and hence can lead to more consistency in setting standard times.
3. Since the times for the various operations can be derived from standard time tables, it is possible to define the standard time for a given operation even before production begins and often while the process is still at the design stage.

PTS is particularly useful for very short repetitive time cycles such as assembly work in the electronics industry.

**Steps:**

- Break the operation into basic movements
- Give standard time for each movements considering the conditions (distance, weight, difficulty etc.)

**Benefit:**

- Understand the movements in detail
- Improve the movements by changing the conditions

**Disadvantage:**

- Too detail

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## Typical Types of PTS

- WF (Work Factor method)
- MTM (Methods Time Measurement method)
- MODAPTS (Modula Arrangement of PTS method)

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(2) Stopwatch

Observe the work and record the process and time

1) For Cyclic-work

   Make record sheet which list work elements
   Put the measured time on the sheet

2) For non Cyclic-work

   Observe and measure the process and its time at the same time

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**(2) Stopwatch**

These days, VTRs are better used than stopwatches

## (3) VTR (Video Tape Recording)


Most convenient method

- Take video of work (Process)
- Analyze the motion and time
- Often used for Line Balancing

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**(3) VTR**

VTR is most convenient method for time recording now.

We can observe and record the work process and time at the same time.

## 3.2 Ratio- Delay Study

- This study is to know the ratio of the delay time and working time to the total time of an activity.

Continuous reading

Observe one worker continuously and record the time of several motion

Work Sampling

This is done by random (irregular) time observation of the workers

Estimate statically how much time is spent in what motion

Mainly used for improving group work e.g. Sewing line

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**3.2 Ratio- Delay Study**

Ratio-delay study is used to search for causes of lowering operation rates for making Kaizen in raising them as well as to set the standard time and grasp loads.

For example, the Ratio-delay study includes the followings;

1) Machine stop due to the trouble
2) Analysis of various “Waiting” (Waiting for materials, Waiting for parts, Waiting for jigs and tools etc.)
3) Work stop by the physiological reason
4) Machine stop or work stop for set-up
5) Machine stop for tool exchange

There are two types of measuring methods. One is Continuous reading and the other is Work sampling method.

Continuous reading method is to observe and analyze the operation status of a worker or machinery in succession all day long.

## (1) Work Sampling Method


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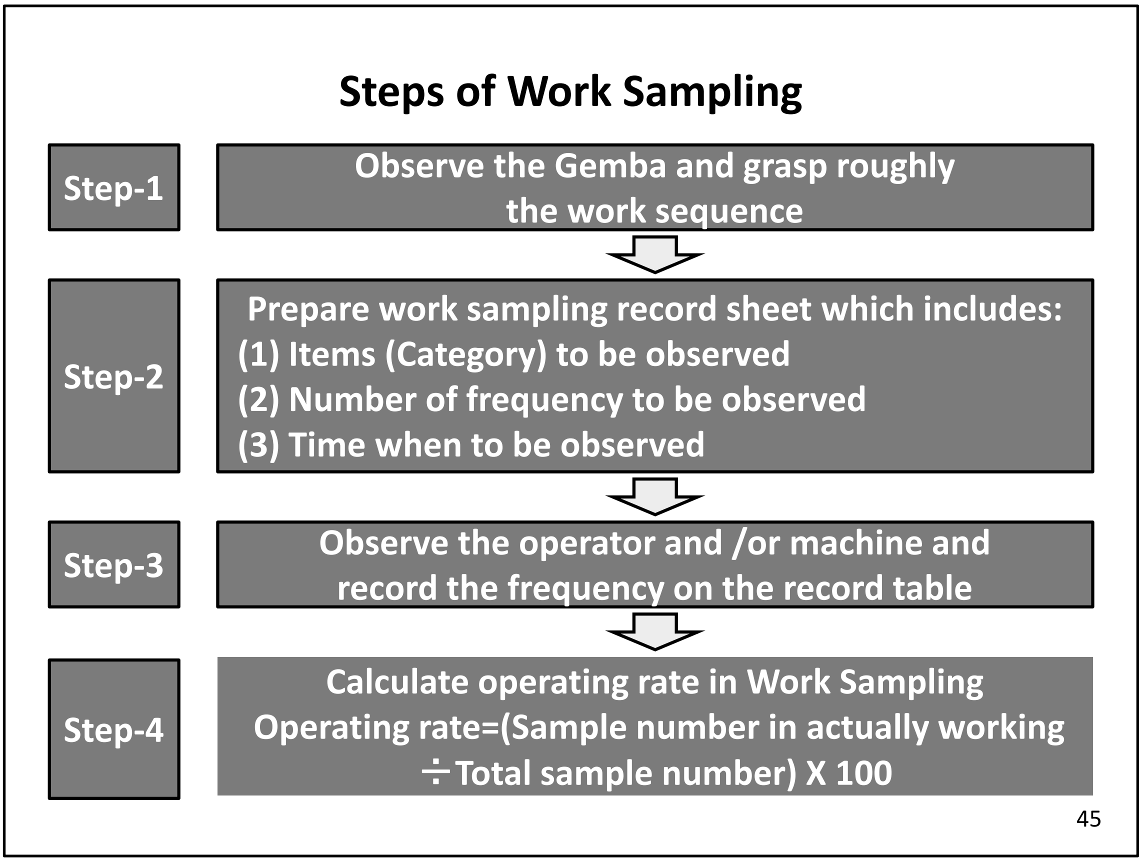
**(1) Work Sampling Method**

The method to observe and analyze the operation status of worker or machinery by momentarily observing the frequency for a long time according to the classification of an action.

For example, When observing the operation situation and checking it 30 times a day, if a worker is observed working 27 of 30 times, calculated as 27÷30=0.9. The rate of utilization is 90%.

Work sampling is a work measurement method that estimates the proportion of time employee utilizes in performing assigned jobs/tasks.

The methodology uses random observations of actual worker’s activity and is dependent on the laws of probability.




**Steps of Work Sampling**

Steps to work sampling is described in the slide.

## Step-1 Observe the Gemba and Grasp Roughly the Work Sequence and Decide the Purpose of Work Sampling

1. **Ratio-delay studies.**
   Worker's allowances are determined by calculating the percentage of time an employee spends in unavoidable delays.
2. **Percentage of utilization of equipment.**
   The technique is used to determine the actual utilization of machinery and other equipment.
3. **Determining labor standards.**
   The technique is useful in determining work standards for various tasks by rating the employee's performance.
4. **Evaluating an employee's performance.**
   A performance standard can be calculated utilizing the work sampling procedure and resulting standards.

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**Step-1 Observe the Gemba and Grasp Roughly the Work Sequence and Decide the Purpose of Work Sampling**

Before starting to use work sampling, we should observe the Gemba and decide the purpose of sampling.

One of them is the operation analysis (Ratio-delay studies). The margin time can be obtained by calculating the proportion of time arising from employees' inevitable physiological desire and fatigue as well as managerial reasons such as meetings in the total time.

The second is the equipment utilization rate. The work sampling is used when determining actual operation rates of machinery and equipment.

The third is to use the work sampling in determining working standards for various tasks by rating employees' actual time as well.

The fourth is to use the work sampling in evaluating employees' work performances.

## Step-2　Prepare Work Sampling Record Sheet

### a) Item to be Observed (Example: Garment Sewing Line)

| Category | Behavior | Description |
|---|---|---|
| Operation | Main operation | Sewing, , Ironing |
| | Associated operation | Picking up, Placing, Fitting, Cutting the thread |
| Work allowance | Condition arrangement | Adjust tension of thread, Check temperature of iron |
| | Product arrangement | Preparing material, Check quantity |
| | Thread replacement | Replace needle thread and bobbin thread |
| | Trouble | Replace broken needle, Malfunction of machine |
| Workshop allowance | Preliminary | Periodical maintenance, Education, Meeting |
| | Transport | Transferring products & material |
| | Waiting | Waiting for materials |
| No operation | Fatigue | Take rest in addition to predetermined rest time |
| | Physiological needs | Going to washroom, Drink water |
| | Negligence | Chatting, Absence |

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**Step-2　Prepare Work Sampling Record Sheet**

**a) Item to be Observed (Example: Garment Sewing Line)**

## Recording Sheet Example

Work Sampling table Left Line Right Lline

Observing Date: Observing time: 8:30 Observer:

| PRC No. | Process name | Main work | | | | Preparation | | | | | Reserved time | | | | | Non-operating | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mark | Attach (Fitting) | Sew | Others | Material picking | Material checking | Thread replace | Transportation | Others | Re- threading | Repair machine defect | Waiting | Cleaning | Others | Rest | Chat | others |
| 1 | | V | | | | | | | | | | | | | | | | |
| 2 | | | V | | | | | | | | | | | | | | | |
| 3 | | V | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | V | | | |
| 5 | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | |

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**Recording Sheet Example**

This is a sample of recording sheet of work sampling.

Vertical column show the operator to be observed and horizontal column show the category of work.

The time of observation and the name of observed line are to be recorded.

## b) Number of Frequency to be Observed (Sample Size)

- The sample size is dependent on the desired level of statistical confidence and accuracy.
- Normally, the acceptable level of confidence is 95% with the accuracy level of ± 5%.
- The following formula determines the actual sample size necessary for a work

**The necessary sample size (in the case of 95% confidence)**
**$N=4\ p\ (1-p)\ /\ e^2$**

p= estimation of the number of times that are spent in an activity
1-p= estimation of the number of times that are not spent in an activity
e= absolute accuracy

- Higher confidence level or higher accuracy level will increase the required sample size.
- The 95% confidence level and ± 5% accuracy level mean that the results of 95 times of work sampling executed 100 times will be within ±5% of accuracy error margin.

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**b) Number of Frequency to be Observed (Sample Size)**

We should decide the number of frequency to be observed, which is so called as "Sample size"

To decide the sample size, we should tentatively decide the rate of main work by preliminary work sampling or simple assumption.

Then we should calculate necessary observation frequency by statistical method.

Confidence limit is decided first. 95% is usually used as a certain confidence limit.

The formula: N=4p(1-p)/e2 listed in the slide aims to determine what number of sampling is required in the work sampling

The required number of sampling N becomes larger as the temporary operation rate p is closer to 0.5(50%), while the former decreases when the latter is closer to 0 or 1, as can be seen from the formula. In addition, the required number of samples is larger when the absolute accuracy is higher.

Let's assume the tentatively decided main work percentage as 60% and absolute accuracy is 5%.

The required number of samples with the confidence limit of 95 % is determined as 4X0.6x(1-0.6)/0.052=384

When a workplace you like to apply work sampling has 20 employees, if you observe 20 times in a day, the number of observations becomes 400 which is bigger than 384.

Now what you should memorize here is the expression of N=4p (1-p)/e2.

Meanwhile, some books that introduce the work sampling method include a quick reference chart in which N can be found immediately from p and e, and thus the calculation is not necessary when using it.

In addition, for your reference, the "4" in the formula means (1.96)2 , where 1.96 gives range of 95% in normal distribution.

## c) Determination of Observation Hours

- It is necessary in the “Work Sampling method” to determine observation hours at random.
- Random hours are usually determined based on a “Random Time Table”.
- There are various kinds of “ Random Time Table”. One of the tables is shown on the next slide.
- As for this “Random Time Table,” 40 times of “hour” are written by unit of one minute for about ten hours from 0:00 to 9:59.
- As for two sets of numerical values in two columns, the sequence No.(1-40) is written on the left column and the hour is written in the right column.

Example of Random Timetable (A part of the Random Timetable)

| 1 | | 2 | | 3 | | 4 | | 5 | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Hour | No. | Hour | No. | Hour | No. | Hour | No. | Hour |
| 40 | 0.05 | 13 | 0.26 | 11 | 0.25 | 17 | 0.14 | 19 | 0.11 |
| 1 | 09 | 8 | 48 | 8 | 34 | 10 | 37 | 16 | 39 |
| 16 | 12 | 23 | 58 | 2 | 52 | 39 | 44 | 10 | 53 |
| 9 | 16 | 2 | 1.46 | 40 | 1.13 | 19 | 48 | 32 | 1.11 |
| 21 | 33 | 17 | 48 | 16 | 23 | 12 | 50 | 28 | 30 |
| 29 | 37 | 37 | 2.10 | 4 | 30 | 31 | 1.05 | 20 | 51 |
| 15 | 38 | 30 | 25 | 15 | 34 | 20 | 18 | 18 | 55 |
| 32 | 54 | 24 | 40 | 27 | 37 | 4 | 44 | 3 | 2.01 |
| 8 | 1.12 | 9 | 46 | 25 | 58 | 30 | 2.12 | 25 | 14 |
| 36 | 26 | 29 | 56 | 9 | 2.27 | 14 | 23 | 24 | 20 |
| 38 | 35 | 22 | 57 | 19 | 36 | 13 | 45 | 27 | 21 |
| 5 | 36 | 11 | 59 | 30 | 48 | 16 | 50 | 6 | 46 |

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### c) Determination of Observation Hours

Work sampling is based on a statistical theory, and that theory assumes that the sampling is performed at random. For example, suppose that one worker cuts timber in 50 seconds, and does the setting by replacing wood with the next one in 10 seconds. One cycle is equal to 60 seconds. If this worker is observed and observation data are aggregated every one or two minutes, it means that the worker always cuts timbers or performs the setup change at all times. This is because the cycle of works and that of observations are synchronized. In order to know the exact work ratio, it is necessary to perform observations in order not to be synchronized. Therefore, the observations should be conducted randomly.

A random number (time) table is used for this purpose. This table is arranged in order that time to be observed becomes at random. The table in the slide is a part of the random number table regarding time.

When the observed work is not cyclic and or only rough measurement is required, constant pitch observation could be applied.

Random Time table(1) — 40 times for 10 hours

| 1 | | 2 | | 3 | | 4 | | 5 | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Hour | No. | Hour | No. | Hour | No. | Hour | No. | Hour |
| 40 | 0.05 | 13 | 0.26 | 11 | 0.25 | 17 | 0.14 | 19 | 0.11 |
| 1 | 09 | 8 | 48 | 8 | 34 | 10 | 37 | 16 | 39 |
| 16 | 12 | 23 | 58 | 2 | 52 | 39 | 44 | 10 | 53 |
| 9 | 16 | 2 | 1.46 | 40 | 1.13 | 19 | 48 | 32 | 1.11 |
| 21 | 33 | 17 | 48 | 16 | 23 | 12 | 50 | 28 | 30 |
| 29 | 37 | 37 | 2.10 | 4 | 30 | 31 | 1.05 | 20 | 51 |
| 15 | 38 | 30 | 25 | 15 | 34 | 20 | 18 | 18 | 55 |
| 32 | 54 | 24 | 40 | 27 | 37 | 4 | 44 | 3 | 2.01 |
| 8 | 1.12 | 9 | 46 | 25 | 58 | 30 | 2.12 | 25 | 14 |
| 36 | 26 | 29 | 56 | 9 | 2.27 | 14 | 23 | 24 | 20 |
| 38 | 35 | 22 | 57 | 19 | 36 | 13 | 45 | 27 | 21 |
| 5 | 36 | 11 | 59 | 30 | 48 | 16 | 50 | 6 | 46 |
| 27 | 59 | 36 | 3.09 | 22 | 3.02 | 36 | 3.07 | 29 | 3.10 |
| 22 | 2.29 | 7 | 25 | 28 | 15 | 15 | 16 | 38 | 42 |
| 18 | 3.00 | 39 | 47 | 1 | 35 | 27 | 23 | 23 | 4.00 |
| 39 | 37 | 15 | 57 | 29 | 4.03 | 26 | 30 | 1 | 10 |
| 2 | 4.04 | 18 | 4.26 | 17 | 16 | 5 | 39 | 33 | 14 |
| 28 | 08 | 27 | 28 | 20 | 20 | 21 | 4.08 | 7 | 34 |
| 26 | 15 | 40 | 33 | 23 | 35 | 37 | 17 | 8 | 49 |
| 4 | 40 | 34 | 45 | 31 | 42 | 35 | 38 | 21 | 57 |
| 6 | 5.02 | 1 | 58 | 7 | 5.02 | 32 | 5.12 | 22 | 5.08 |
| 31 | 07 | 38 | 5.12 | 36 | 07 | 40 | 22 | 5 | 32 |
| 30 | 21 | 4 | 35 | 35 | 21 | 3 | 35 | 15 | 34 |
| 14 | 29 | 3 | 6.08 | 21 | 29 | 24 | 6.02 | 26 | 58 |
| 23 | 41 | 19 | 18 | 26 | 41 | 38 | 07 | 2 | 6.21 |
| 11 | 6.24 | 26 | 26 | 13 | 6.15 | 22 | 34 | 11 | 43 |
| 7 | 38 | 31 | 39 | 12 | 29 | 23 | 57 | 34 | 44 |
| 25 | 7.00 | 33 | 41 | 37 | 35 | 2 | 7.01 | 17 | 7.08 |
| 3 | 10 | 25 | 49 | 5 | 41 | 33 | 10 | 37 | 20 |
| 24 | 22 | 16 | 51 | 6 | 55 | 28 | 22 | 4 | 31 |
| 17 | 32 | 14 | 7.02 | 14 | 7.32 | 8 | 30 | 40 | 34 |
| 37 | 46 | 5 | 08 | 32 | 49 | 34 | 46 | 36 | 8.11 |
| 12 | 51 | 21 | 8.00 | 18 | 8.05 | 7 | 52 | 31 | 17 |
| 33 | 8.16 | 20 | 05 | 38 | 25 | 11 | 8.02 | 13 | 27 |
| 19 | 27 | 10 | 19 | 24 | 45 | 25 | 16 | 35 | 34 |
| 34 | 36 | 6 | 40 | 39 | 57 | 18 | 41 | 39 | 41 |
| 35 | 46 | 32 | 49 | 10 | 9.02 | 1 | 9.09 | 30 | 44 |
| 20 | 9.04 | 28 | 9.06 | 33 | 21 | 6 | 29 | 9 | 9.00 |
| 10 | 23 | 12 | 34 | 34 | 30 | 29 | 33 | 14 | 06 |
| 13 | 45 | 35 | 53 | 3 | 34 | 9 | 55 | 12 | 33 |

Random Time table(2) — 40 times for 10 hours

| 6 | | 7 | | 8 | | 9 | | 10 | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Hour | No. | Hour | No. | Hour | No. | Hour | No. | Hour |
| 36 | 0.02 | 31 | 0.08 | 5 | 0.05 | 12 | 0.41 | 31 | 0.11 |
| 9 | 08 | 20 | 11 | 11 | 17 | 18 | 1.00 | 25 | 14 |
| 24 | 28 | 3 | 41 | 38 | 28 | 4 | 15 | 33 | 26 |
| 13 | 31 | 38 | 44 | 34 | 42 | 37 | 24 | 37 | 29 |
| 10 | 1.04 | 14 | 53 | 15 | 43 | 22 | 57 | 29 | 38 |
| 30 | 15 | 4 | 1.00 | 13 | 1.01 | 5 | 2.11 | 12 | 53 |
| 26 | 41 | 9 | 24 | 39 | 20 | 20 | 16 | 9 | 1.30 |
| 28 | 2.01 | 34 | 42 | 27 | 35 | 24 | 28 | 14 | 45 |
| 5 | 40 | 30 | 54 | 17 | 49 | 16 | 30 | 5 | 2.22 |
| 22 | 51 | 37 | 2.13 | 37 | 59 | 28 | 47 | 24 | 33 |
| 35 | 3.05 | 12 | 22 | 2 | 2.08 | 31 | 52 | 17 | 3.16 |
| 1 | 16 | 18 | 33 | 19 | 12 | 32 | 54 | 35 | 25 |
| 23 | 40 | 8 | 47 | 4 | 23 | 11 | 3.05 | 20 | 29 |
| 7 | 41 | 1 | 3.01 | 22 | 36 | 1 | 08 | 3 | 58 |
| 14 | 4.09 | 26 | 09 | 35 | 45 | 15 | 22 | 11 | 4.02 |
| 38 | 17 | 35 | 36 | 6 | 3.20 | 9 | 35 | 1 | 25 |
| 16 | 21 | 5 | 54 | 9 | 29 | 26 | 54 | 36 | 30 |
| 19 | 27 | 23 | 59 | 25 | 32 | 23 | 4.24 | 16 | 34 |
| 4 | 42 | 32 | 4.05 | 31 | 45 | 35 | 55 | 10 | 51 |
| 32 | 57 | 17 | 34 | 29 | 4.39 | 8 | 5.06 | 27 | 5.05 |
| 17 | 5.28 | 27 | 54 | 18 | 57 | 19 | 27 | 2 | 12 |
| 27 | 35 | 22 | 58 | 40 | 5.12 | 40 | 35 | 7 | 22 |
| 12 | 58 | 33 | 5.05 | 21 | 52 | 10 | 58 | 30 | 28 |
| 20 | 6.13 | 13 | 28 | 33 | 6.02 | 36 | 6.24 | 32 | 46 |
| 6 | 33 | 16 | 32 | 30 | 34 | 7 | 39 | 23 | 6.04 |
| 25 | 45 | 39 | 36 | 12 | 39 | 33 | 57 | 18 | 16 |
| 34 | 7.04 | 7 | 54 | 23 | 41 | 25 | 7.01 | 40 | 25 |
| 2 | 12 | 29 | 6.04 | 7 | 49 | 30 | 06 | 28 | 36 |
| 18 | 30 | 36 | 36 | 36 | 7.13 | 21 | 20 | 4 | 52 |
| 31 | 42 | 10 | 57 | 3 | 50 | 3 | 48 | 15 | 7.24 |
| 29 | 8.09 | 19 | 7.04 | 28 | 8.06 | 14 | 8.02 | 13 | 46 |
| 8 | 11 | 21 | 46 | 14 | 25 | 34 | 11 | 21 | 8.10 |
| 21 | 30 | 15 | 50 | 24 | 32 | 17 | 31 | 34 | 20 |
| 37 | 43 | 24 | 8.11 | 20 | 49 | 39 | 54 | 26 | 33 |
| 40 | 49 | 40 | 20 | 32 | 52 | 2 | 9.07 | 19 | 34 |
| 11 | 56 | 6 | 31 | 10 | 9.06 | 38 | 15 | 39 | 52 |
| 39 | 59 | 11 | 9.14 | 26 | 09 | 27 | 20 | 6 | 9.05 |
| 3 | 9.05 | 28 | 26 | 8 | 33 | 13 | 27 | 22 | 26 |
| 15 | 28 | 2 | 35 | 1 | 45 | 6 | 38 | 38 | 33 |
| 33 | 48 | 25 | 58 | 16 | 53 | 29 | 54 | 8 | 53 |

Source: "Basics of IE" by Akihisa FUJITA(published by Kogakusha)

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## Random Time Table

The random number table shown in this slide is the same as that shown earlier, but its range of display is wider.

## Step-3 Observe the Operator and /or Machine and Record the Frequency on the Record Table

| | | | | | |
|---|---|---|---|---|---|
| Operation name | Assembly | Department | | Observed by | |
| Operator | 10 persons | Section | | Date | |
| Equipment | | Group | | | |

| Classification | | Main Work | | | | | Peparation | | | Reserve time | | | | | Non-operating | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time / Item | | Mark | Attach | Sew | Iron | Others | Material picking | Transportation | Others | Change needle | Repair machine defect | Waiting | Cleaning | Others | Rest | Chat | others | |
| 1 | 8:30 | | 5 | | 3 | | | | | | | | | | | | | |
| 2 | 8:45 | | | | | | | | | | | | | | | | | |
| 3 | 9:00 | | | | | | | | | | | | | | | | | |
| 4 | 10:00 | | | | | | | | | | | | | | | | | |
| 5 | 10:30 | | | | | | | | | | | | | | | | | |
| 6 | 11:00 | | | | | | | | | | | | | | | | | |
| 7 | 11:30 | | | | | | | | | | | | | | | | | |
| 8 | 12:00 | | | | | | | | | | | | | | | | | |
| 9 | 12:30 | | | | | | | | | | | | | | | | | |
| 10 | 13:00 | | | | | | | | | | | | | | | | | |
| 11 | 13:30 | | | | | | | | | | | | | | | | | |
| 12 | 14:00 | | | | | | | | | | | | | | | | | |
| 13 | 14:30 | | | | | | | | | | | | | | | | | |
| 14 | 15:00 | | | | | | | | | | | | | | | | | |
| 15 | 15:30 | | | | | | | | | | | | | | | | | |
| 16 | 16:00 | | | | | | | | | | | | | | | | | |
| 17 | 16:30 | | | | | | | | | | | | | | | | | |
| 18 | 17:30 | | | | | | | | | | | | | | | | | |

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**Step-3 Observe the Operator and /or Machine and Record the Frequency on the Record Table**

Sheet for work sampling

This sheet shows the summary sheet of individual check sheet.

## Step-4 Calculate Operating Rate in Work Sampling

| Classification | Main Work | | | | | Preparation | | | Reserve time | | | | | Non-operating | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time / Item | Mark | Attach | Stich | Iron | Others | Material picking | Transportation | Others | Change needle | Repair machine defect | Waiting | Cleaning | Others | Rest | Chat | others | |
| Count No. | 16 | 16 | 32 | 8 | 8 | 16 | 8 | 4 | 8 | 6 | 16 | 4 | 4 | 8 | 8 | 8 | 170 |
| % (A) | 9.4 % | 9.4 % | 18.8 % | 4.7 % | 4.7 % | 9.4 % | 4.7 % | 2.4 % | 4.7 % | 3.5 % | 9.4 % | 2.4 % | 2.4 % | 4.7 % | 4.7 % | 4.7 % | 100 % |
| | 20.0 % | 20.0 % | 40.0 % | 10.0 % | 10.0 % | | | | | | | | | | | | |
| % (B) | | | | | | 17.8 % | 8.9 % | 4.4 % | 8.9 % | 6.7 % | 17.8 % | 4.4 % | 4.4 % | 8.9 % | 8.9 % | 8.9 % | 100 % |
| % © | 47.1% | | | | | 16.5% | | | 22.4% | | | | | 14.1% | | | 100 % |

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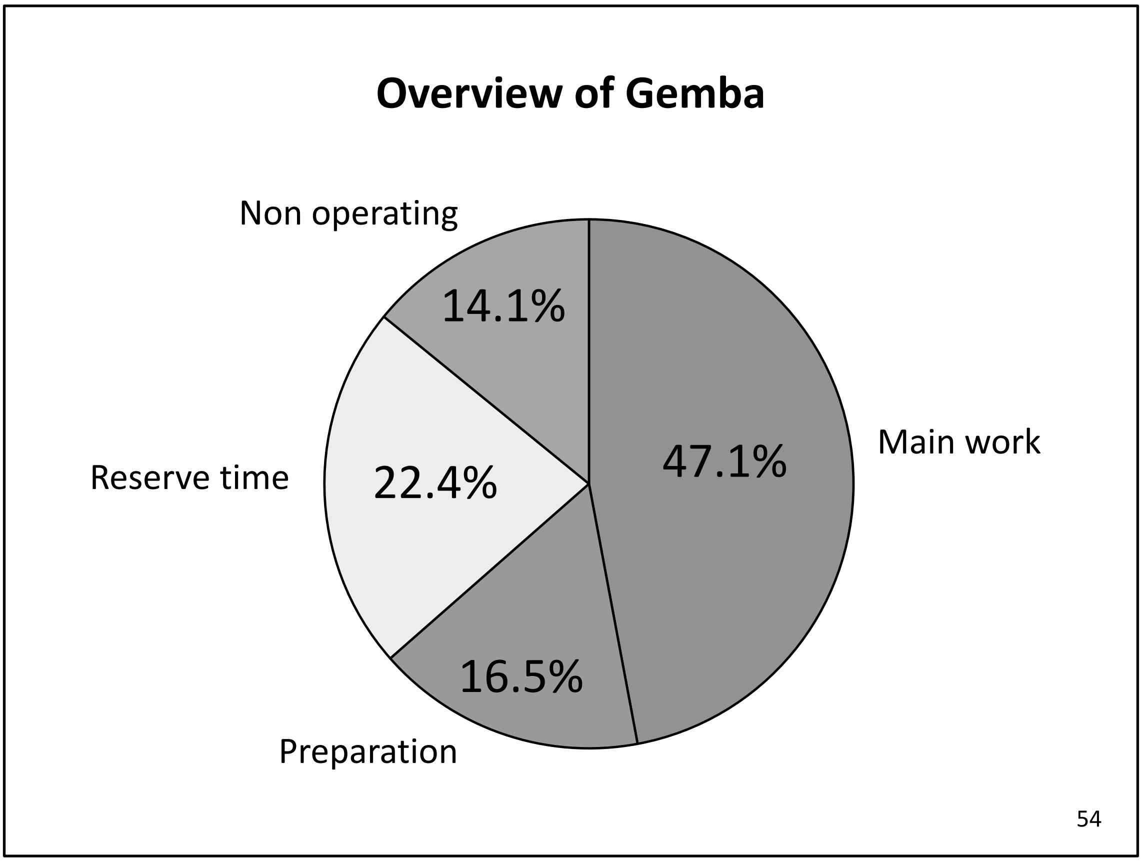
**Step-4 Calculate Operating Rate in Work Sampling**

**Result of Work Sampling**

By gathering the check sheet we generate summary sheet which shows the percentage of op the category of work.




**Overview of Gemba**

Finally the result of work sampling is shown by some graph like pie chart.

From the graph we can know the Nuda visually .

# 4. Line Balance

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## 4. Line Balance

The line balance analysis is a technique for improving productivity, in which the process analysis and the time study are utilized. Optimization of lines is a very important task, because a large amount of waste is generated if a load on each process in a line is not.

## Example of Time Study

| Process No. | Name of work | SAM |
|---|---|---|
| 1 | Set front & backs & mark neck for collar | 0.636 |
| 2 | Shoulder attach | 0.977 |
| 3 | shoulder top stich | 0.561 |
| 4 | Sleeve attach | 1.391 |
| 5 | Topstich Armhole | 0.709 |
| 6 | Side seam | 0.841 |
| 7 | Collar attach | 0.948 |
| 8 | Collar close & I serrt label | 0.780 |
| 9 | Cuff attach & close | 1.382 |
| 10 | Bottom Hem | 0.926 |

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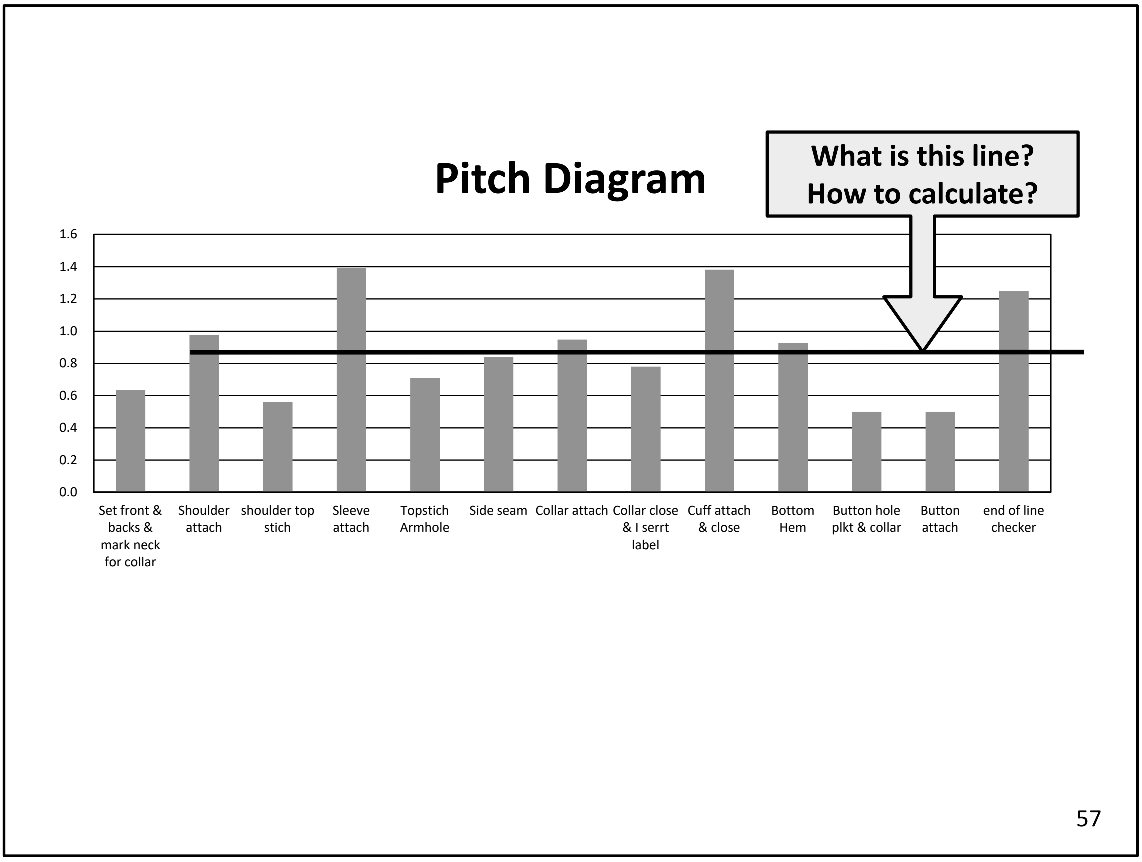
**Example of Time Study**

Line balance analysis stats from observing Gemba, analyze the process and measure the time.

Example is a timetable of a production of a shirt which shows process name and SAM (Standard Allowed Minute)

Standard allowed minute (SAM) means how much time is required to make one complete garment including allowances. SAM is used to measure the task or work content of a garment. This term is widely used by industrial engineers and production people in the garment manufacturing industry.




**Pitch Diagram**

In order to see the quality of the line balance, we measure the work time by process and show the time by process in a bar graph, as shown in the figure. We call such a graph as a ”pitch diagram”.

The horizontal line shows the average time of all the processes.

## Calculation of the Line Balance

Line Balance Efficiency =

$$\frac{\text{Total of net time for each process X100}}{\text{Operation time of longest process} \times \text{Number of process}}$$

Balance loss ratio = 100-Line Balance Efficiency

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**Calculation of the Line Balance**

Let us introduce two indices to assess the extent of the line balance. One of them is the line-balance efficiency, and another is the balanced loss ratio.

The line-balance efficiency is the value obtained by dividing the sum of adding up the work time of each process by the work time of the bottleneck process consuming the most time x number of processes. The balance loss ratio is the ratio of loss time and calculated as 100% - Line balane efficiency (%).

How much should the line-balance efficiency be sufficient? Ideally it should be 100%, but such a situation is not possible in reality. It is said as a reference that the creation of a line is meaningful, if the line-balance efficiency reaches 85 percent or more. If it is 80%, there is a need to improve the line balance. If you cannot improve it any more, you should consider a production system other than the line production system.

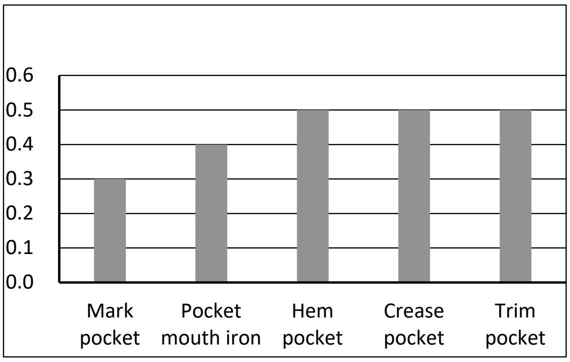
The cell production system is premised on the presence of skilled workers as one worker is responsible for plural processes, and there are many cases in which the productivity increases by 40 % or more by changing from the line production to this system.

Case-1

$$\textbf{Line balance efficiency} = \frac{\Sigma \text{ each process time X 100}}{\text{Longest process time X Number of processes}}$$

$$= \frac{(0.3+0.4+0.5+0.5+0.5) \times 100}{0.5 \text{ X } 7} = 88\%$$

| process No. | Name of work | Time (Min.) | Operator |
|---|---|---|---|
| 1 | Mark pocket | 0.3 | 1 |
| 2 | Pocket mouth iron | 0.4 | 1 |
| 3 | Hem pocket | 0.5 | 1 |
| 4 | Crease pocket | 0.5 | 1 |
| 5 | Trim pocket | 0.5 | 1 |
| | Total | 2.2 | 7 |

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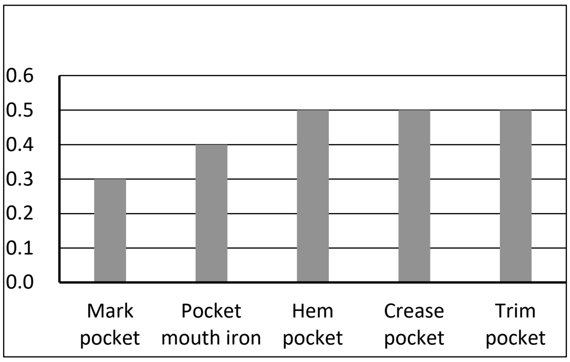
Line Balance Efficiency Calculation

Case-2

**Line balance efficiency** $= \dfrac{(0.3+0.4+0.5+0.5+0.5) \times 100}{0.5 \times 7} = 63\%$

| process No. | Name of work | Time (Min.) | Operator |
|---|---|---|---|
| 1 | Mark pocket | 0.3 | 2 |
| 2 | Pocket mouth iron | 0.4 | 2 |
| 3 | Hem pocket | 0.5 | 1 |
| 4 | Crease pocket | 0.5 | 1 |
| 5 | Trim pocket | 0.5 | 1 |
| | Total | 2.2 | 7 |

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Calculation of Line balance efficiency in case there are more than one operator in one process.

In this case , No. of operator should be considered in the denominator

## How to Improve Line Balance (IE Approach)

Eliminate bottlenecks from the line

1) Divide works and allocate some of them to other processes
2) Shuffle operators
3) Reduce cycle time using works aids & attachment
4) Improve workstation layout & improve methods
5) Increase the capability of the machine
6) Do extra work at bottleneck operations

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**How to Improve Line Balance (IE Approach)**

There are several methods of time savings for processes consuming much time.

Divide work: Divide works of a long-time process and add some of the divided works to other processes.

Shuffle: If operator's skill differ and it causes the process time longer, put skilled operator in the longest process.

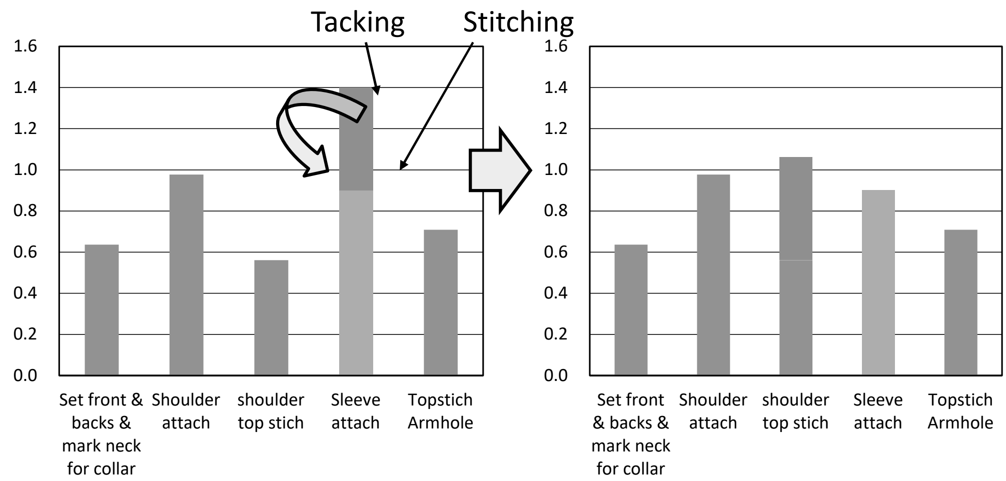
Use of machine and or some work aids : It can reduce the process time

Improve layout & method: If transportation time cause long process time, change layout to reduce the bottleneck time

Increase the capability of machine: Make appropriate maintenance to increase work speed

Extra work: Not so much recommended

## Example : Divide Works and Allocate some of them to other Processes




**Pitch time improve : 1.4s →1.1s (21% improve)**

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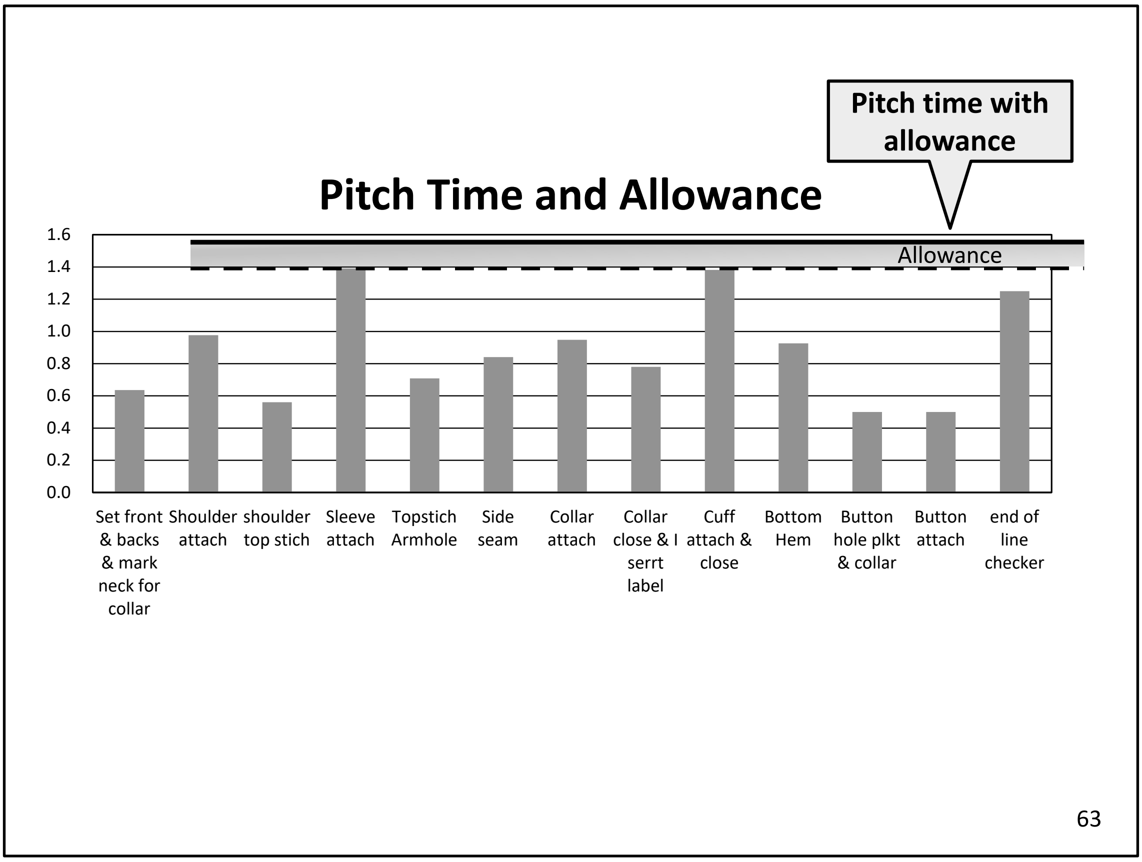
**Example : Divide Works and Allocate some of them to other Processes**

The figure shows an example of improving line balance by dividing work and allocate it to some other process.




**Pitch Time and Allowance**

The longest time consuming process (Bottle neck process) determines he theoretical pitch time.

But we have to consider some allowance over the theoretical pitch time.

The allowance consists of fatigue, rest, break down and so on.

TPS

# Toyota Production System

1

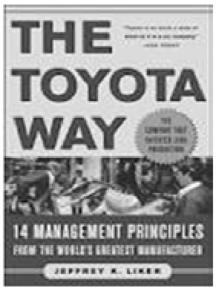
# Contents

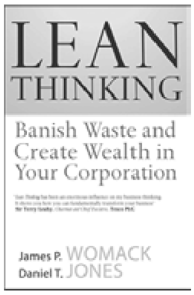


2

# 1. Background of TPS

- Japan after World War II
- Continuous and one-piece flow
- PDCA cycle
- *Kaizen*
- Lean Manufacturing

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**1. Background of TPS**

The concept of TPS can be expressed as lean thinking and problem solving.

The background of the concept is,

After World War II, most industries and supply base had been destroyed, and consumers had little money in Japan. An import carmaker, Ford then had a mass production system with tons of cash to make huge quantities of a limited number of models for a large US and international market. In contrast, Toyota needed to churn out low volume of different models using the same assembly line. Toyota had no cash and operated in a small country. Toyota needed to turn cash around quickly (from receiving the order to getting paid) .

Toyota determined to create a continuous material flow and a system of one-piece flow that flexibly changed according to customer demand , by eliminating waste, reducing work-in-process stock ,and standardizing processes throughout supply chain.

Toyota also adapted a systematic approach to problem solving ,known as the Deming Cycle or Plan-Do-Check-Act (PDCA cycle), a cornerstone of continuous improvement.

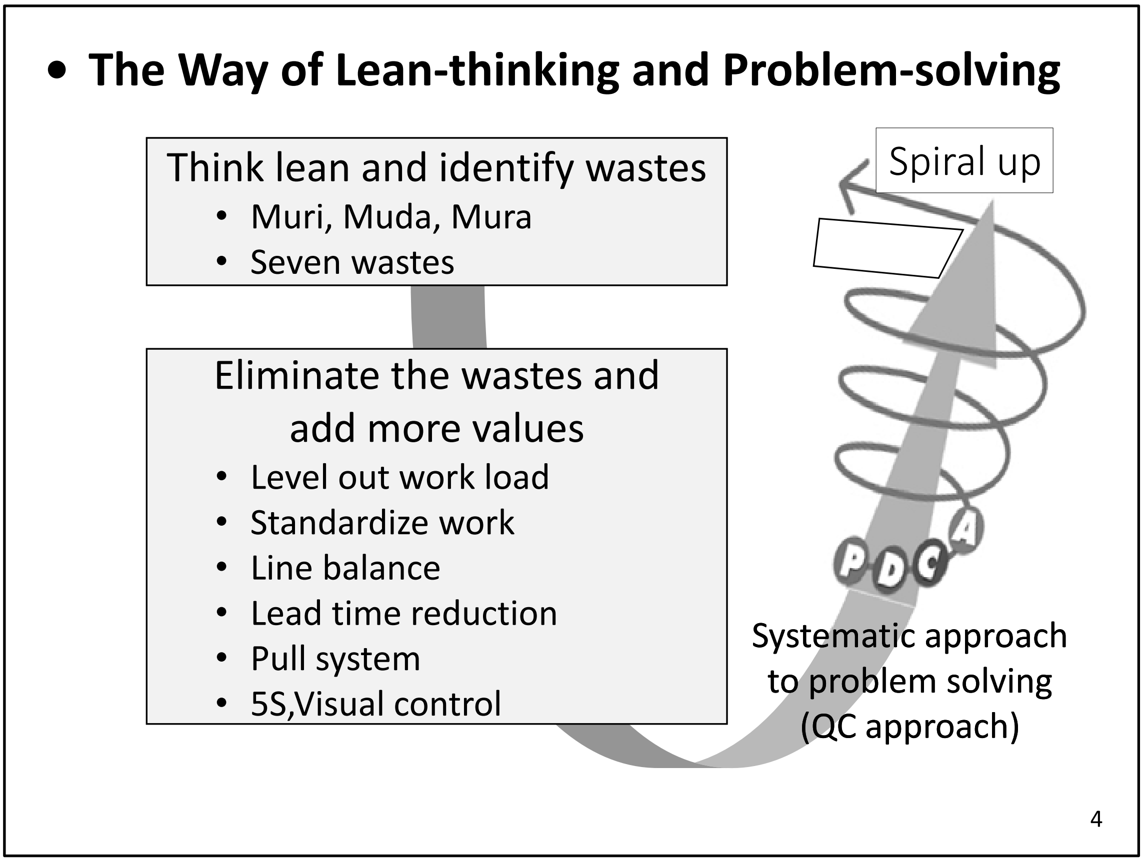
Japanese term for continuous improvement, Kaizen is the process of incremental improvements, achieving lean goal of eliminating all waste that adds cost without adding value.

Kaizen teaches individuals skills for working effectively in small groups, solving problems, documenting and improving processes, collecting and analyzing data, and self-managing within a peer group. It pushes the decision making (or proposal making) down to the workers and requires open discussion and a group consensus before implementing any decisions.

Kaizen is a total philosophy that strives for perfection and sustains lean production.

The researchers at MIT in the USA coined the term Lean thinking to capture the essence of their in-depth study of Toyota Production System. Lean thinking is a new way of thinking any activity and seeing the waste inadvertently. It has been accepted as a business system

for 21st century globally by many enterprises, including industry giants,such as Dell Computer, TESCO, Pratt Whitney, etc.




- **The Way of Lean-thinking and Problem-solving**

The way of Lean-thinking and problem-solving is,

Think how you can be lean and identify wastes around you.

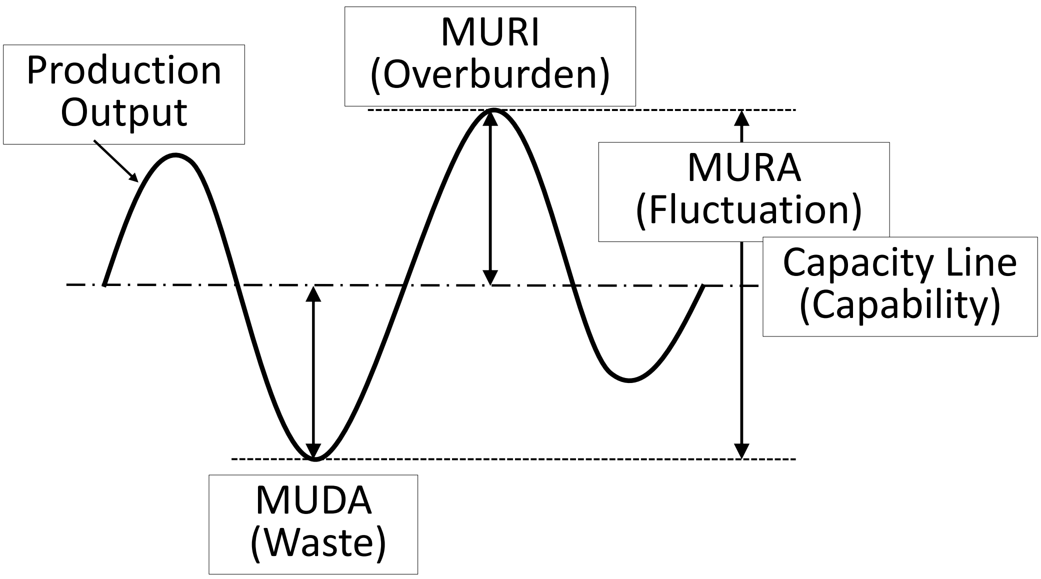
The wastes are muri, muda, mura or seven wastes.

After identifying wastes, eliminate them by implementing following things to add more values.

After eliminating them, think again how you can be lean and identify the wastes still remaining.

Spiral up this activity which is systematic approach, PDCA cycle to achieve the higher target.

- **MURI , MUDA , and MURA**




- **MURI , MUDA , and MURA**

  One way to define the waste is,

  This sine curve represents production output by day.

  The dash dot line is production capacity line.

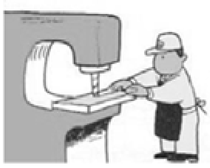
  When production is beyond the capacity line, it is overburden or Muri in Japanese.

  The production line has to work overtime. Next day production goes down below the capacity line. The production line finishes production before the end of working hour and waits for the rest of the time. This is waste, Muda in Japanese. And next day, production goes up again and Muri happens again. The situation like this is called fluctuation, Mura in Japanese.

  All of the overburden, waste, and fluctuation, MURI , MUDA , and MURA are wastes.

  If all production outputs are averaged over the period, the average is probably close to the capacity line. So if you can levelized the production, the wastes are eliminated.

## • Seven Wastes

| | | |
|---|---|---|
| Waste of overproduction |  | To produce sooner, faster or in greater quantity than the customer demand |
| Waste of waiting |  | People or parts that wait for a work to be complete |
| Waste of transportation |  | Unnecessary movement of things (parts or machines ) between processes |
| Waste of processing itself |  | Processing beyond the standard required by the customer |

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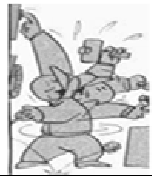
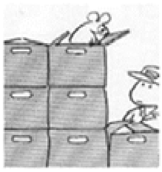
- **Seven Waste**

  Another way to define the waste, called Seven waste

- **Seven Wastes**

| | | |
|---|---|---|
| Waste of movement |  | Unnecessary movement of people within a process |
| Waste of defect |  | Not right first time, repetition or correction of a process |
| Waste of inventory |  | Raw material, work in progress or finished goods which is not having value added to it |

Waste is,
Any activity that consumes resources without creating value for the customer, or any activity for which the customer is not willing to pay.

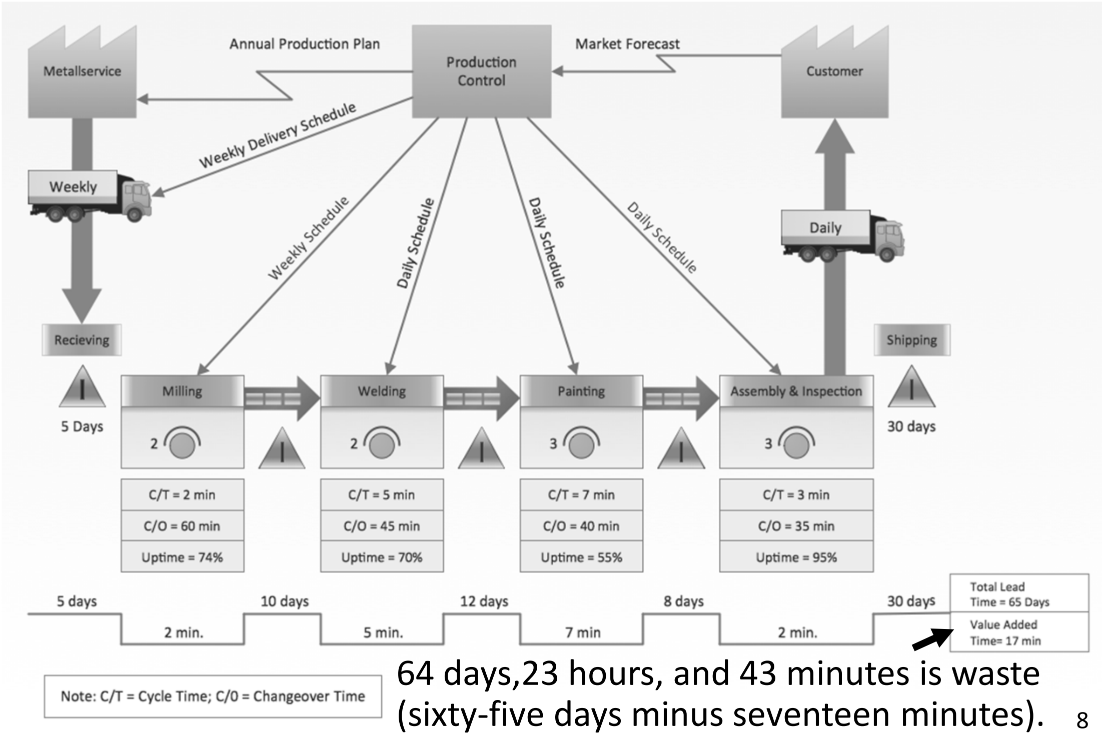
7

**Cont.**

Overproduction is the worst muda.

The reason is that overproduction is the root cause of most of other wastes, as it creates inventories, hides quality problems, and generates transportation and motions… Moreover, if overproduction isn’t considered as the worst waste, most supervisors will think that it is better to keep workers producing for avoiding the waste of waiting. This is obviously inconsistent with the JIT principle. Thus, overproduction is worse than waiting.

## • Waste in Supply Chain




64 days,23 hours, and 43 minutes is waste
(sixty-five days minus seventeen minutes). 8

- **Waste in Supply Chain**

There is a significant amount of waste in supply chain as shown in this chart.

This chart is called " Value Steam Map"

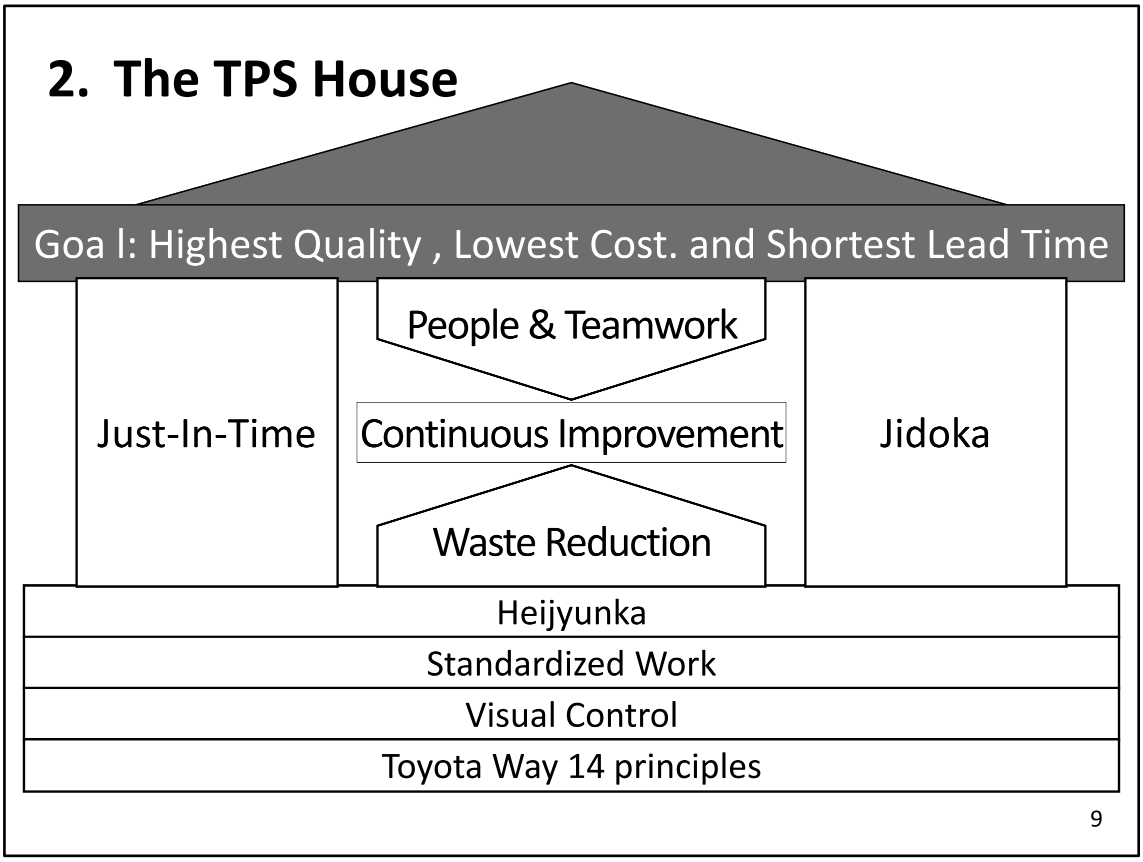
The map shows supply chain of a product from customer to suppliers with order information flow material flow.

The zig-zag graph in the bottom shows production time of each process and lead time from upstream process to down stream process.

The numbers in two boxes on the right corner are total lead time and value-added time which is production time.

The difference of two times is a waste, waiting time. Waiting for next process to start. It is 64 days,23 hours, and 43 minutes of waste.

## 2. The TPS House




**2. The TPS House**

This is called “TPS House” and shows an architecture of the system.

The goal of TPS is highest quality, lowest cost and shortest lead time.

When you build a house, you need solid and rigid foundations and build pillars and a roof on them.

Foundations are

Heijyunka: A system of production that levels the model and volume of products to efficiently meet customer demands while keeping inventory ,lead time , investment cost and manpower at minimum level.

Standard work is the work to make a correct product in most effective, safest, and easiest way.

Visual Control is a system of signs or information displays for layouts, material storage and tools to detect an abnormality and stop work for immediate action.

Then , two pillars

Jidoka is a system enables operators to build in quality at process and separate from machines for more efficient works

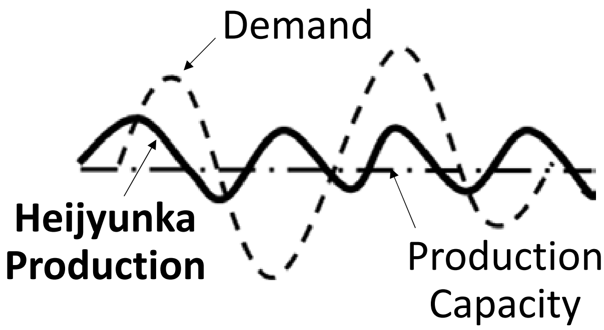
Just-In-Time is a system of production that makes and delivers just what is needed, just when it is needed, and just how many in the amount needed.

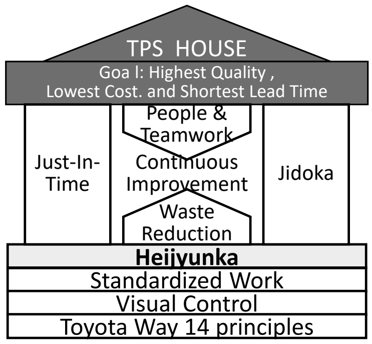
At last, but most importantly, people live here must maintain the house by doing Kaizens.

So that the house is always strong, safe, and lasts long. Just like Toyota’s car

# 3. Heijyunka (Leveling)

- To level the type and volume of production over a fixed period of time.
- Enables production to efficiently meet customer demands while keeping inventory ,lead time , capital cost and manpower at minimum level.

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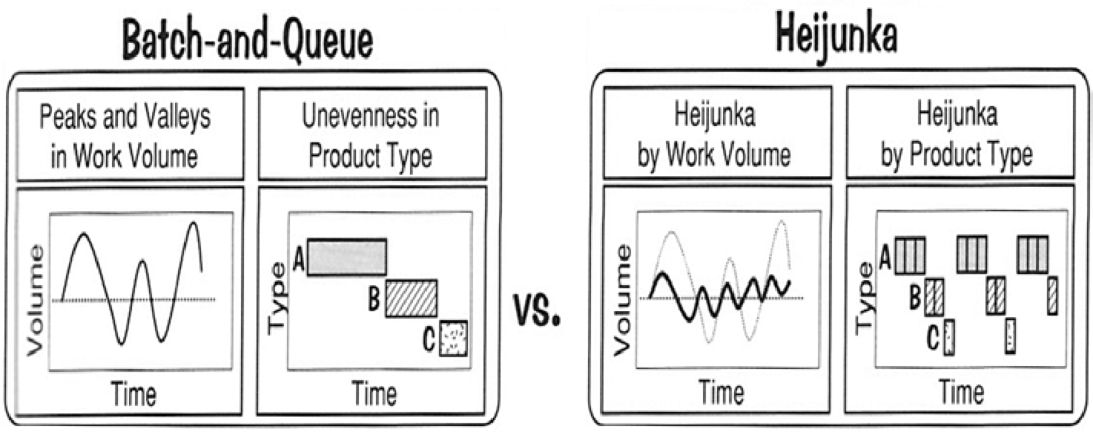
**3. Heijyunka (Leveling)**

Heijyunka Production

- **Batch Production vs Heijyunka Production**




Heijyunka makes production a stream flow and leads to;

- Single piece flow,
- Synchronized processes,
- No stagnations of material flow, and
- Multiskilled-operator-production.

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- **Batch Production vs Heijyunka Production**

  Comparison between batch production and Heijyunka production

  In batch production, there is peaks and valleys of workload and unevenness in product types.

  This means there is Muri, Muda, and Mura.

  In Heijyunka production, there is no peaks and valleys of workload and no unevenness of product types.

## Batch vs Heijyunka Pros and Cons

| | Batch | Heijyunka |
|---|---|---|
| 3Ms | | |
| Lead Time | | |
| Inventory | | |
| Change-over | | |
| Quality | | |
| Material | | |
| Others | | |

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- **Batch vs Heijyunka Pros and Cons**

Comparison between batch production and Heijyunka production

Here is a group discussion.

Please discuss which production is better for each of aspects in the matrix and describe the reason.

3Ms: Heijyunka is better because it levels workload and product types.

Lead time: Heijyunka is better because leveling product types and dividing production volume into a small lot size reduce production time of every product.

Inventory: Heijyunka is better because leveling product types and dividing production volume into a small lot size reduce inventory of every product.

Change-over: Batch production is better because it produces every product at one time, so only one change-over at a time.

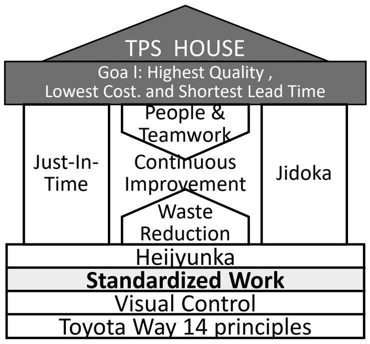
Quality: It is difficult to judge. :Heijyunka requires more change-overs than batch production. More change-overs more chances of mistakes in production. Batch production has a risk of large volume defects once a quality problem occurres.

Material: It also is difficult to judge. Heijyunka reduces the inventory of every material at production line but the material supplier needs to deliver small amount of material frequently according to Heijyunka schedule.

If any group finds other aspects, let’s discuss it.

# 4. Standardized Work

- Make correct product in most effective, safest, and easiest way.
- Establish precise procedures for each operator's work based on;
    - Takt time
    - Work sequence
    - Standard in-process stock
- Require all work elements should be in cycle.
  Any out-of-cycle breaks continuous flow and makes it to difficult maintain efficient and consistent production

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**4. Standardized Work**

The definitions of standardized work

- Provide a basis of Kaizen for
  - Elimination of MURI,MUDA, and MURA,
  - Better operator training, and
  - Safe and ergonomic work place.
- Consist of job instruction sheets and work manuals based on process study using;
  - Process Capacity Sheet,
  - Standardized Work Combination Table, and
  - Standardized Work Chart.

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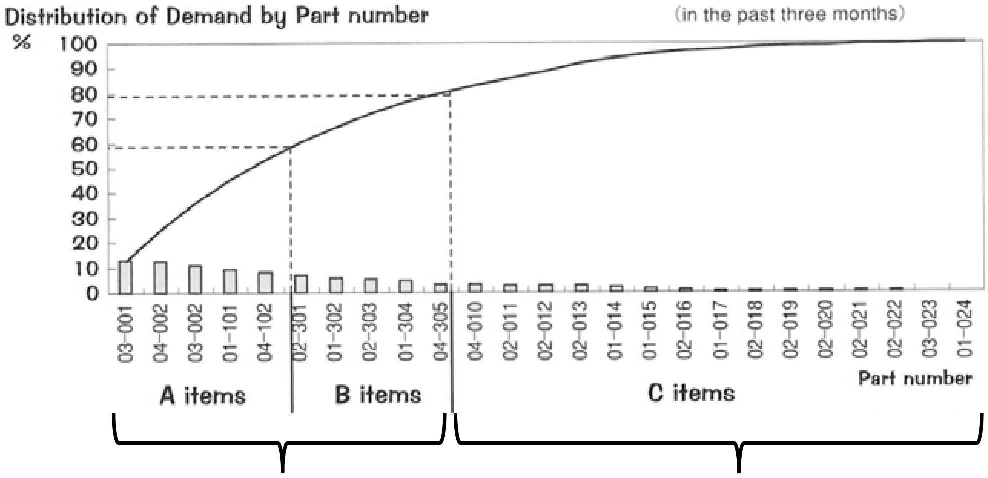
- **Steps to Heijyunka Production**
- P-Q chart analysis to determine Heijyunka or Batch production




High/mid runners
Heijyunka production
By pull system

Slow runners
Batch production
By reorder point system

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- **Steps to Heijyunka Production**

  First step to Heijyunka production is to draw a P-Q chart and analyze which product is produced by pull system or push system.

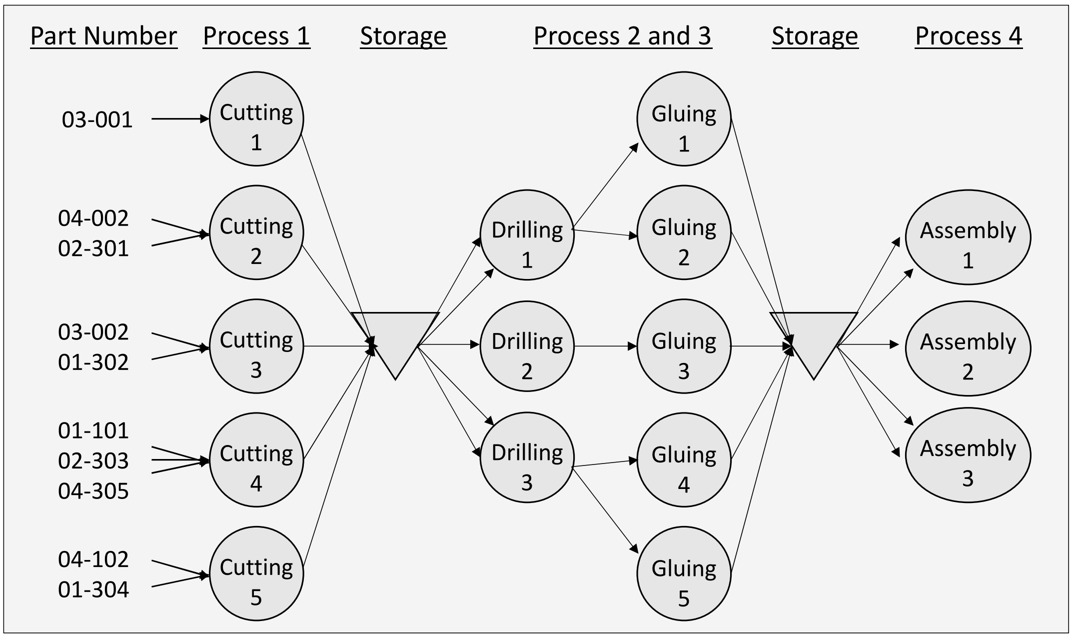
  P-Q chart is a Pareto chart that contains both bars and a line graph, where individual product demands are represented in descending order by bars, and the cumulative total demand as % is represented by the line.

  From this chart, define high and mid volume products which account for about 80 % of all products and low volume products which account for remaining 20 %.

  Heijyunka production by pull system should be applied for high and mid volume products because large amount of inventory reduction and lead time reduction can be expected.

  For low volume products batch production should be applied because of less effect of inventory reduction for frequent change-over than high and mid volume products.

## • Process Flow Chart

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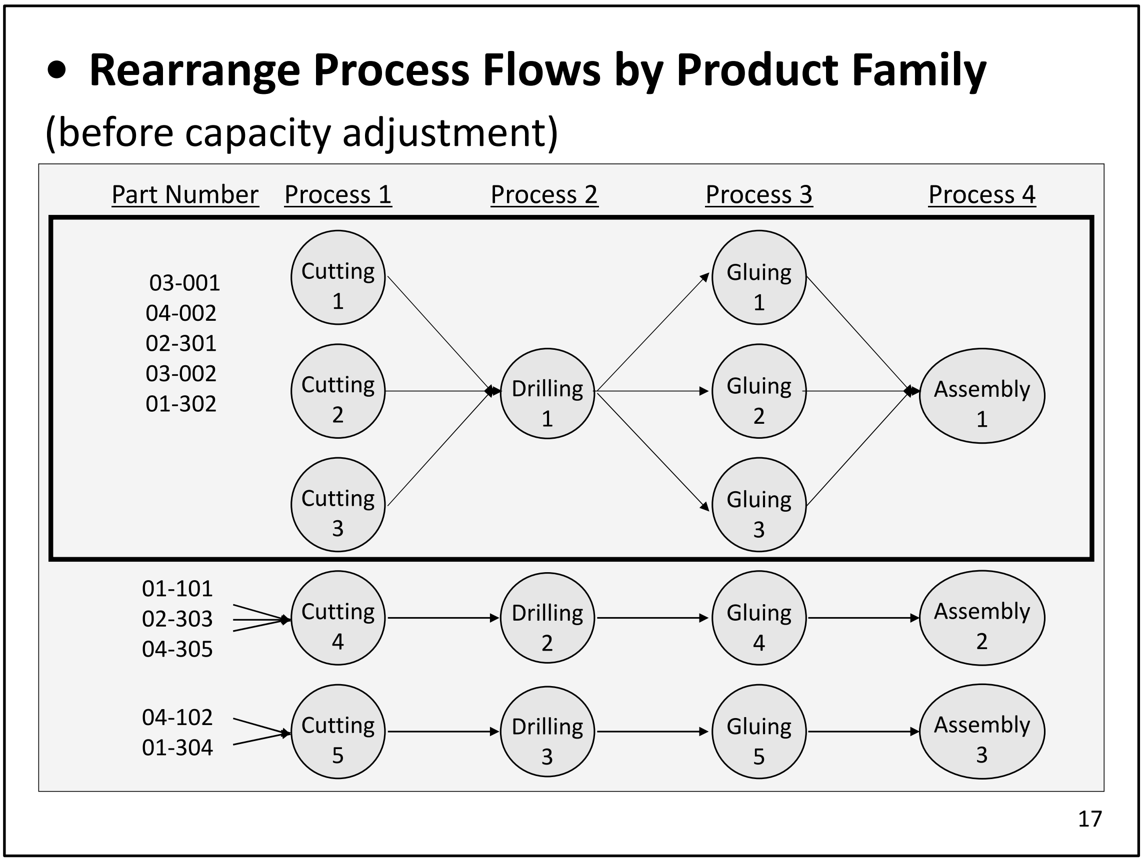
- **Process Flow Chart**

  Next step is to draw a process flow chart for the products selected for Heijyunka production.

  From the P-Q chart, 10 products are selected, those part numbers are 03-001, 04-002, 02-301 and so forth.

  There are five cutting machines, three drilling machines, five gluing machines, and three assembling lines.

  Because production requirements are not well planned for each machine and machines are not allocated properly, the flow is a zig-zag flow and work-in-process need to stored two times.




- **Rearrange Process Flows by Product Family**

  Next step is to rearrange process flows by product family to make the flows continuous and applicable for Heijyunka production.

  Product family means the products which production processes are the same or similar.

  Part No. 03-001, 04-002, 02-301, 03-002, and 01-302 are a family of products which go to the same process as above.

- **Calculate Takt Time;**

$$\text{Takt time} = \frac{\text{Available working time per shift}}{\text{Customer demand rate per shift}}$$

- **Determine Production Sequence**

| Part No. | Monthly demand | Demand per shift | Takt time Min. (Sec.) | Production sequence |
|---|---|---|---|---|
| 03-001 | 5,600 | 280 | 1.6 | 11.3÷1.6≑7.5<br>◎-◎-◎-◎-◎-◎-◎-◎ |
| 04-002 | 3,600 | 180 | 2.5 | 11.3÷2.5≑4.8<br>○---○---○---○---○ |
| 03-002 | 2,000 | 100 | 4.5 | 11.3÷4.5≑2.7 |
| 01-101 | 1,200 | 60 | 7.5 | 11.3÷7.5≑1.6<br>●---------●---------● |
| 04-102 | 800 | 40 | 11.3 | X-------------------X<br>△--------------------△ |
| Total | 13,200 | 660 | 0.68<br>(40.9) | Goal: ◎○●△X◎○◎○◎●◎△○◎○●△◎<br>Target: ◎◎◎◎◎◎◎◎○○○○○●●●△△XX |

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- **Calculate Takt Time and Determine Production Sequence**

Takt time is the time to produce one product to meet customer requirements based on the rate of sales.

Based on this takt time, we will decide production sequence of the five products selected for Heijyunka production.

First, calculate the takt time of each product based on the formula here.

For example, 03-001's takt time is 450 minutes divided by 280 pcs equals 1.6 minutes per piece.

450 minutes is an available working time per shift, 7.5 hours per day times 60 minutes.

After calculated all takt times, calculate the takt rate of each product, the rate is the slowest product takt time divide by the selected product takt time. For example, Part No. 03-001 takt time is 1.6, the takt time is 1.6 divided by 11.3, which is the takt time of 04-102, the slowest takt time, equals 7.5. This number means approximately produce 03-001 7.5 times more than 04-102. From the same calculation, the takt time rate of 04-002 is 4.8, 03-002 is 2.7, 01-101 is 1.6. Using the takt time rate and the symbol of each product, figure out the production sequence like this chart.

- **Check Process Capacity**

| Process Capacity Sheet | | Part #: 03-001 04-002 02-301 03-002 01-302 | | | | | | Supervisor | | Date:2019-1-20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Part Name: Standard Desk | | | | | | Line Name | | Max Output 660pcs | |
| Op.# | Process Description | M/C # | Base Time | | | Tool Change | | | Total time | Total Capacity per day | Note |
| | | | Man time | Auto time | Total | Pieces per change | Time to change | Time per pc | | | |
| 10 | Cutting | C1~3 | 25s | 80s | 105s | 3000 | 30m | 36s | 141s | 192<br>3 machines<br>576 | Three machines plus OT to meet daily demand |
| 20 | Drilling | D1 | 10s | 30s | 40s | 5000 | 20m | 5s | 45s | 600 | One machine plus OT |
| 30 | Gluing | G1-3 | 30s | 90s | 120s | 3000 | 5m | 1s | 131s | 206<br>3 machines<br>618 | Three machines plus OT to meet daily demand |
| 40 | Assembly | | 40 | 0 | 40 | 3000 | 5m | 1s | 41 | 658 | |

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- **Check Process Capacity**

After all takt times are known, check if all machine and manual processes have enough capacity to meet the takt times.

First, conduct time study for each process and find the cycle time of each time. The cycle time is a time to make one product and includes manual operation time(Man time), machine operation time (Auto time), and tool change time per piece. For example, Operation# 10, Cutting is, the base time 105 seconds, tool change time per piece is 36 seconds, and Total time is base time plus tool change time per piece equals 141 seconds. Here, the tool change time per piece is 30 minutes of time for cutter change every 3000 pieces divided by 3000 equals 36 seconds per piece. From the total time, total capacity per day can be gained with calculation of available working time per shift divided by the total time. The cutting total capacity per day is 27,000 seconds divided by 141 seconds equals 192 pieces. With three cutting machines together, the capacity is 192 times three equals 576 pieces. As Note said, this process needs to work overtime because the capacity of 576 is not enough to meet the demand.

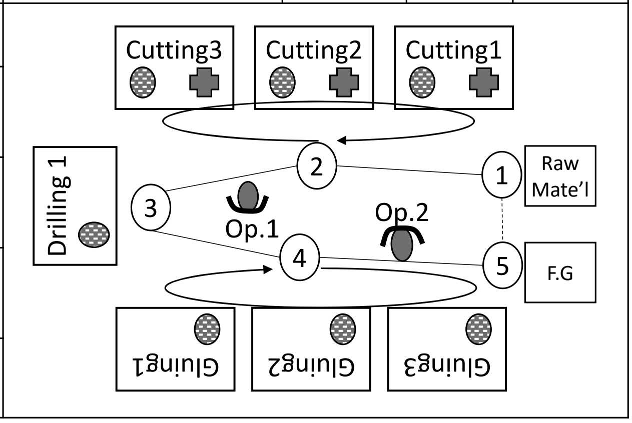
The same calculation for cycle time and capacity is done for all other processes, Operation# 20, Drilling, 30, Gluing, and 40 Assembling.

From all, the process capacity of this line is enough to meet the demand of 660 pieces with few hours of overtime.

- **Develop a Preliminary Standardized Work Chart**

(U-shape line)

| **Standardized Work Chart** | | Part #: | | | | | Supervisor | | Date:2019-1-20 |
|---|---|---|---|---|---|---|---|---|---|
| | | Part Name: Standard Desk | | | | | Line Name Cutting to Gluing | | Max Output 660pcs |
| Op.# | Process Description | Man time | Auto time | Wait time | Walk time | ① Working Sequence ---- Walking - - - Return to Start | SWIP | Safety | Quality (QC) |
| ① | Pick up raw material | | | | | | | | |
| ② | Unload, load part and start C1-3 | | Determine based on time study | | | | | | |
| ③ | Unload, load part and start D1 | | | | | | | | |
| ④ | Unload, load part and start G1-3 | | | | | | | | |
| ⑤ | Place F.G on pallet | | | | | | | | |

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- **Develop a Preliminary Standardized Work Chart**

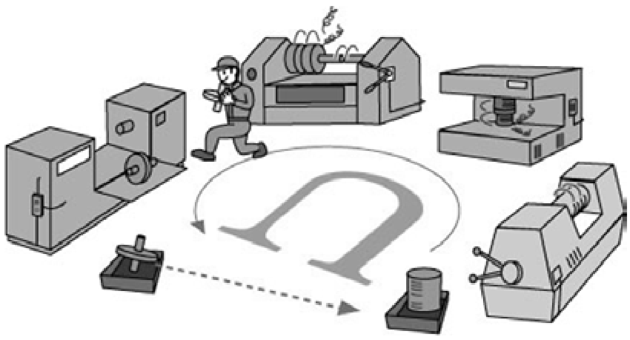
The standardized work chart shows operator movement and material location in relation to the machine and overall process layout. It should show takt time, work sequence, and standard WIP. This is used to design a continuous process flow.

The way that I suggest to design production flow is modify current production flow with Kaizen ideas as a preliminary standardized work chart and conduct time study to finalize the standardized work chart.

The Kaizen ideas for the selected products are continuous production flow and manpower reduction.

Based on the ideas, the chart was made as above.

- **Continuous Flow Examples; U Shape Line**
  - The machines, work stations, and parts locations are arranged in a series of processing steps
  - Avoids;
    - Isolated machines/ work stations,
    - Excessive inventory between steps,
    - Obstacles on the walking paths, and
    - Unnecessary walking.



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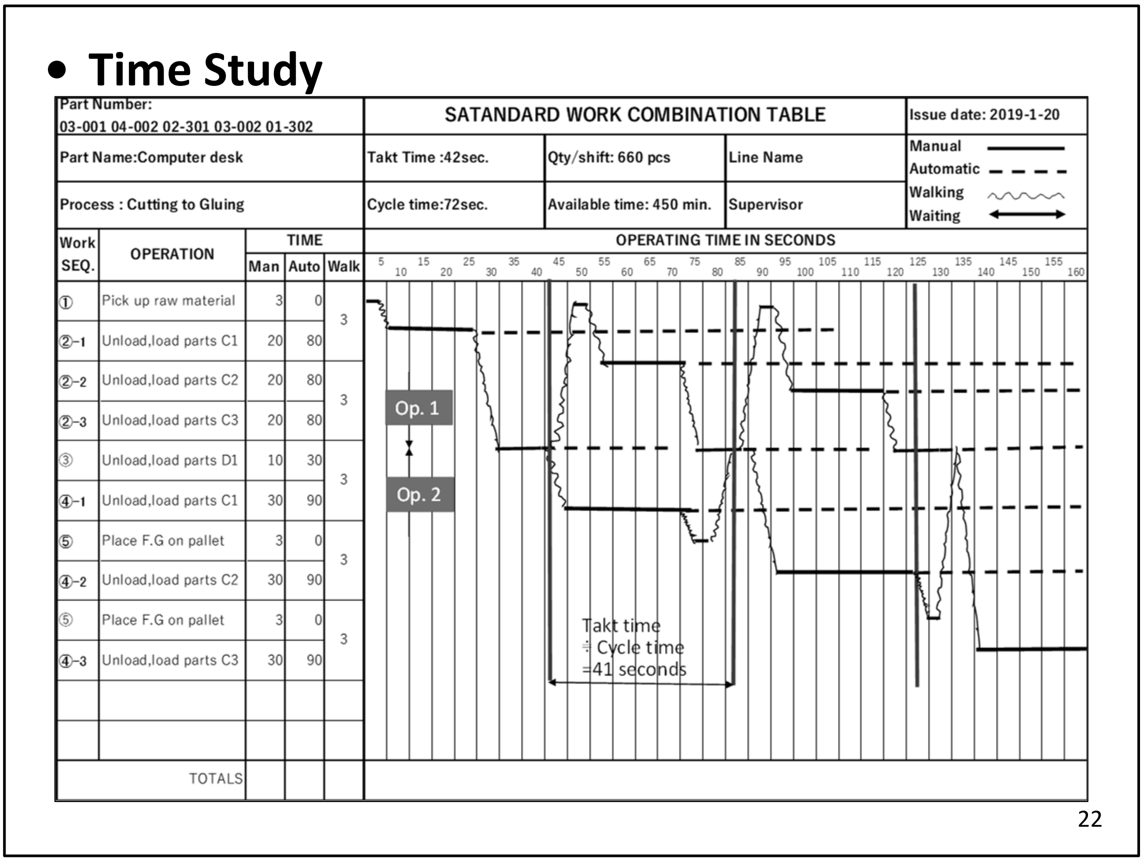
- **Continuous Flow Examples; U Shape Line**

The definition and benefits of U shape line is;




- **Time Study**

  The Standardized Work Combination Table shows the combination of manual work time, walk time, and machine processing time for each operation in a production sequence.

  The table shows that manual work as solid black lines, machine process as dot lines, waiting as wave lines, and walking as solid lines with arrows. The length of each line expresses how long the process takes to complete one cycle.

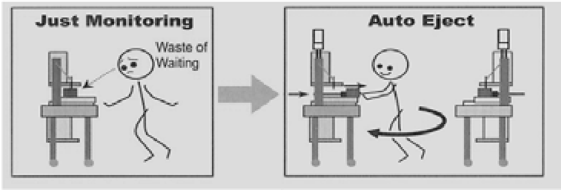
  Based on the preliminary work layout, conduct time study and put the result on the Standardized Work Combination Table as this slide.

  From this table, you determine if this work layout is applicable for production or not. For example, operator 1 cycle time is longer than operator 2 cycle time, you should see the waiting time in the operator 2 work, then you need the cycle time of operator 1 work by modifying the work layout. Or if you see that walking time takes a large amount of time, which is a waste,  you should change the layout to reduces the time.

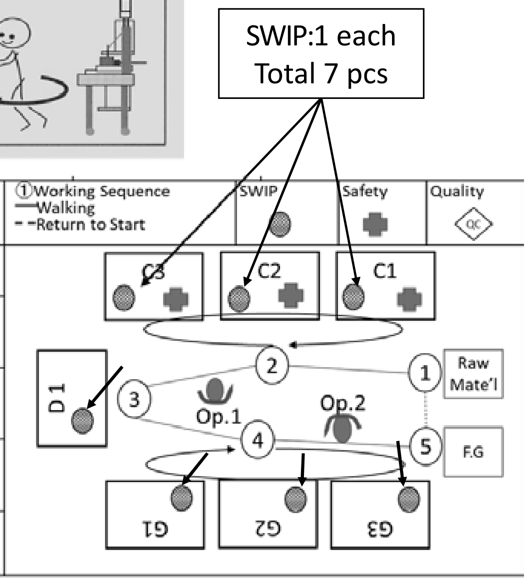
- **Standard Work-in-process Stock (SWIP)**

  A minimum stock needed for operation to proceed

  Example: between manual and machine processes




| Op.# | Process Description | Man time | Auto time | Wait time | Walk time | ①Working Sequence —Walking - -Return to Start | SWIP | Safety | Quality |
|---|---|---|---|---|---|---|---|---|---|
| ① | Pick up raw material | | | | | | | | |
| ② | Unload, load part and start C1-3 | | Determine based on time study | | | | | | |
| ③ | Unload, load part and start D1 | | | | | | | | |
| ④ | Unload, load part and start G1-3 | | | | | | | | |
| ⑤ | Place F.G on pallet | | | | | | | | |

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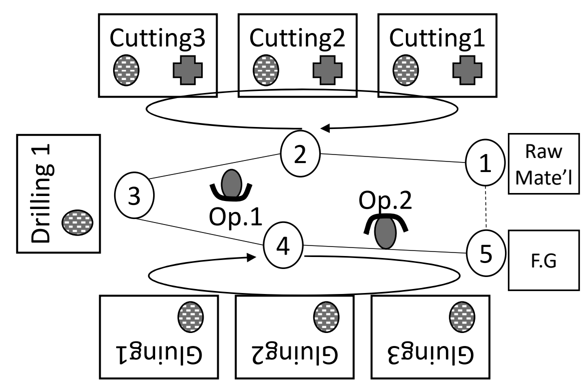
- **Standard Work-in-process Stock (SWIP)**

  Next step is to determine standard work-in-process stock. The standard work-in-process stock is a minimum stock needed for operation to proceed: for example: if you operate two machines with auto-ejects, you need one parts being in process at each machine so that the two machine keep running.  This line has seven machines as the chart shows. All machine should always have one parts at every machine as standard work-in-process stock.

# • Complete Standardized Work Chart

| **Standardized Work Chart** | Part #: 03-001 04-002 02-301 03-002 01-302 | Supervisor | Date:2019-1-21 |
|---|---|---|---|
| | Part Name: Standard Desk | Line Name Cutting to Gluing | Max Output 660pcs |

| Op.# | Process Description | Man time | Auto time | Wait time | Walk time | ① Working Sequence ---- Walking - - - Return to Start | SWIP | Safety | Quality |
|---|---|---|---|---|---|---|---|---|---|
| ① | Pick up raw material | 3 | 0 | 0 | 0 |  | | | |
| ② | Unload, load part and start C1-3 | 20 | 80 | 0 | 3 | | | | |
| ③ | Unload, load part and start D1 | 10 | 30 | 0 | 3 | | | | |
| ④ | Unload, load part and start G1-3 | 30 | 90 | 0 | 3 | | | | |
| ⑤ | Place F.G on pallet | 3 | 0 | 0 | 0 | | | | |



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- **Complete Standardized Work Chart**

  Finally you complete the standard work chart.

- **Job Instruction Sheet**

TWI-JI format is recommended

## Job Instruction Breakdown Sheet

Operation: Frame Marking/Shaft CP Inspection
Parts: Frame
Tools and Materials: Inkjet Printer Machine
Purpose: To identify the retractor sub part #, the date and the time is was built.

| Important Steps | Key Points | Reasons |
|---|---|---|
| A logical segment of the operation when something happens to advance the work. | Anything in a step that might - 1) Make or break the job 2) Injure the worker 3) Make the work easier to do (ex. Trick, knack, special timing, any additional information to make the job easier) | Reasons for the key points |
| **1. Load & Apply Mark to the Frame** | 1. As per profile<br>2. Press the start switch | 1. To ensure correct orientation<br>2. To activate the machine |
| **2. Install the Bushing** | 1. Bigger side of the frame facing up<br>2. Align the tab with the notch in the frame | 1. It is easiest to install if frame is in your hand<br>2. To ensure that is it fully seated flush |

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- **Job Instruction Sheet**

After you complete the standard work chart, you need to develop work manual so that operators can exactly follow the work designed in the chart. We recommend to apply TWI-JI (training within industry-job instruction) to develop work manual.

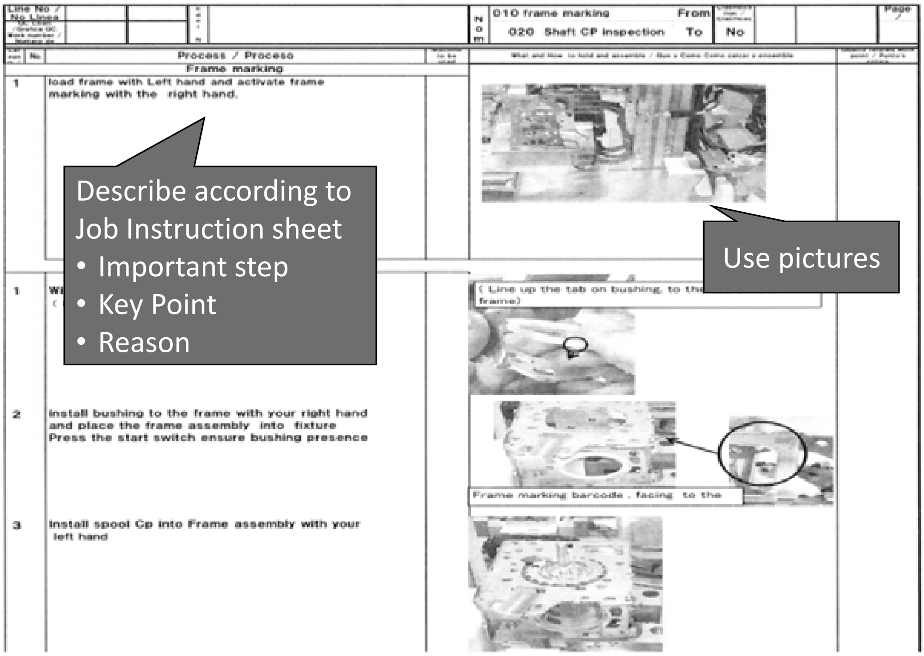
TWI is a dynamic program of hands-on learning and practice, teaching essential skills for supervisors, team leaders, and anyone who directs the work of others.

You begin with preparing job instruction sheet at first according to TWI- JI format as this slide shows. The job instruction sheet is for a supervisor of the line to train his/her operators. Then based on the job instruction sheet, develop work manual.

The sheet is made for a whole process in the standard work chart and describes the important steps, key points, and reason for each step.

The important step is a logical segment of the operation when something happens to advance the work. The key point is anything in a step that might make or break the job, injure the operator, or make the work easier to do. Reason is reason of the key point.

- **Work Manual**

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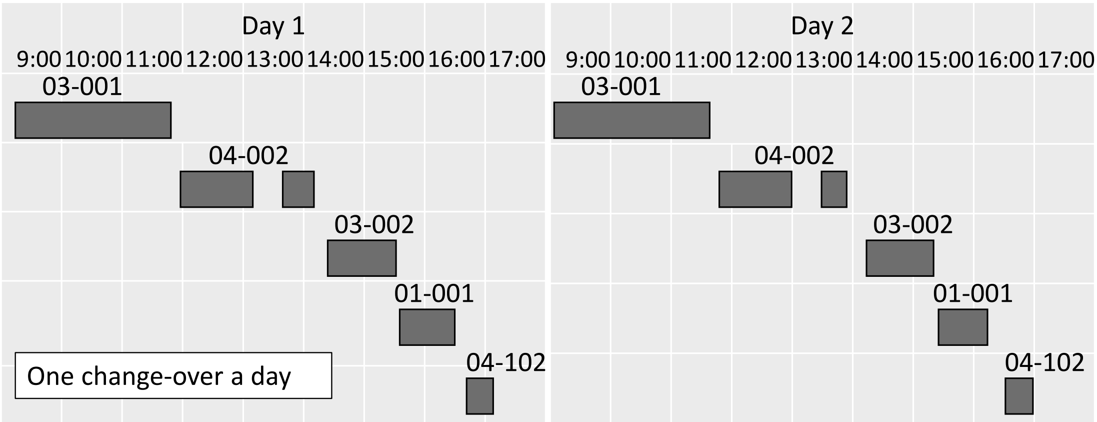
- **Work Manual**

  Work manual is to help operator complete his/her process in a given time effectively and produce a good product. The manual should describe the important step, key point, and reason according to the job instruction sheet. Use pictures to help operator visually understand the process.

## • Heijyunka Production Timetable

| Part No. | Daily Demand (pcs) | Cycle time (sec.) | Production time (hr) |
|---|---|---|---|
| 03-001 | 280 | 41 | 3.2 |
| 04-002 | 180 | 41 | 2.1 |
| 03-002 | 100 | 41 | 1.1 |
| 01-101 | 60 | 41 | 0.7 |
| 04-102 | 40 | 41 | 0.5 |
| Total | 660 | | 7.6 |




Monitor production status using Visual Control and Do Kaizens 27

- **Heijyunka Production Timetable**

  The last thing to get Heijyunka production started is to make a production timetable for each product and make sure that production is levelized as this slide shows.

- **Problems and Kaizens**
  - Insufficient production capacity
    e.g. long machine adjustment, long tool change
  - Long cycle time
    e.g. too much walk, too much material handling
  - Unstable production
    e.g. defects, machine down, mistakes
  - Demand fluctuation

  Kaizen Techniques
  - 5S,Visual control
  - Waste elimination
  - Jidoka
  - Pull system, etc

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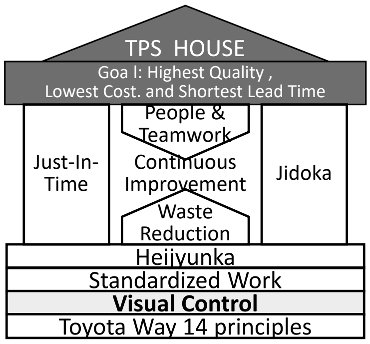
- **Problems and Kaizens**

  After you start Heijyunka production, you will face some problems. Those are the opportunities of Kaizens to achieve the goal of Heijyunka production, eliminating wastes and adding more value on the product.

## 5. Visual Control

- A system of signs, information displays, layouts, material storage and handling tools, and poka-yoke or mistake proofing devices.
- Makes product flow, operations standards, schedules and problems instantly ,visually identifiable
- Needs easy-to-understand standard ,

simple, clear and visual

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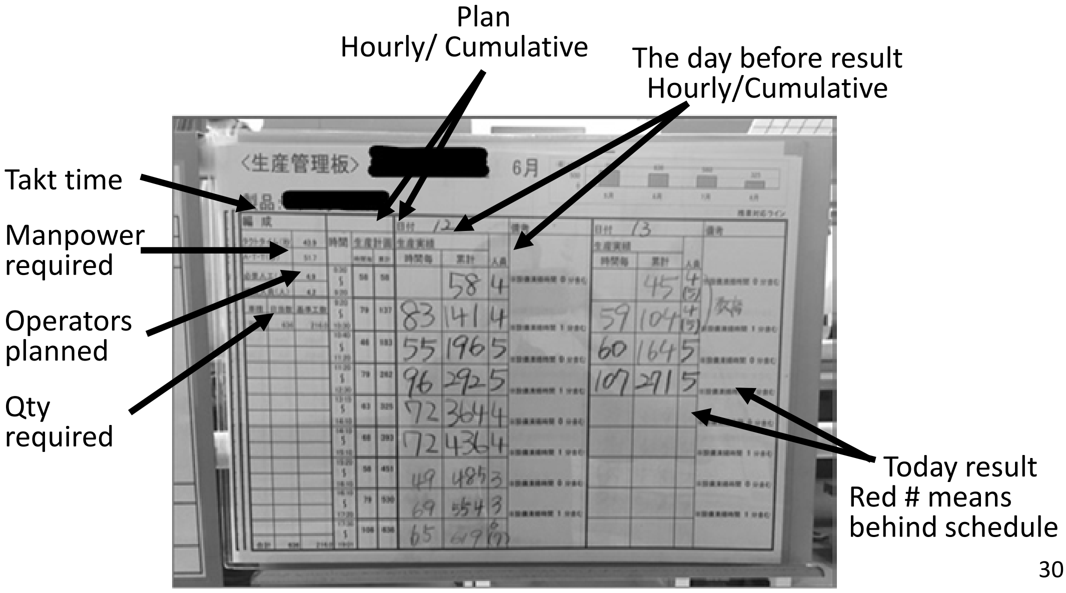
### 5. Visual Control

Visual control is as this slide shows;

# • Visual Control at Production Line

Production Control board

To show actual performance compared with plan on hourly basis

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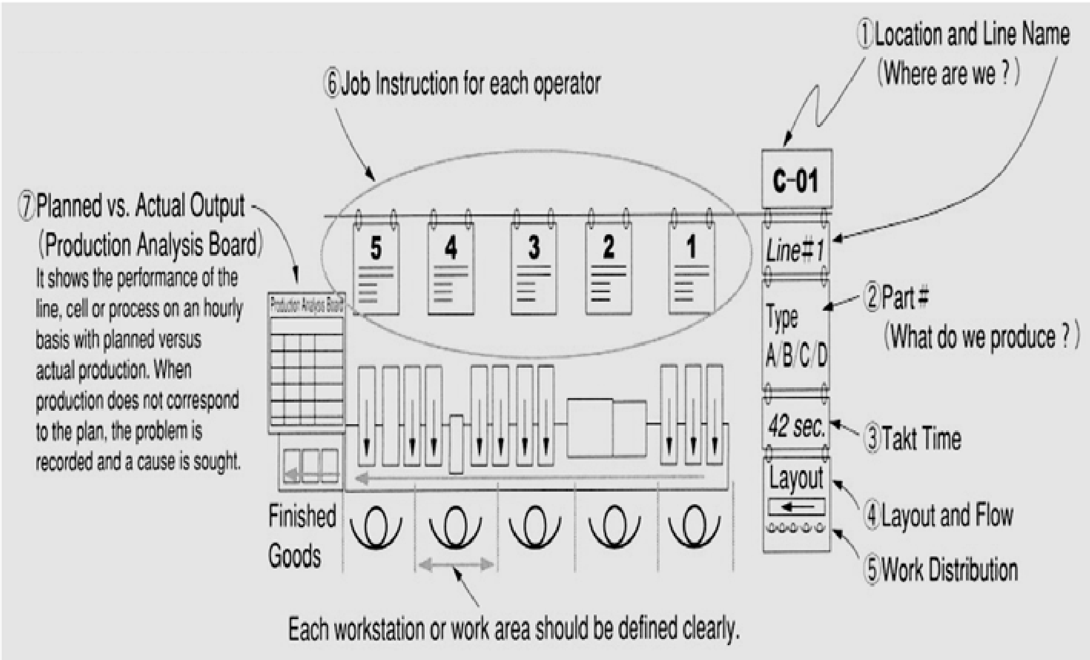
- **Visual Control at Production Line**

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- **Visual Control at Production Line**

  In addition to production control board, there are many signs, instructions, others for visual control as this slide shows.

- **Visual Control at Production Line**

Scrabble sheet

Operator
Day-off log sheet

Operator skill
training matrix

Line lay-out &
Operator assignment map

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**Cont.**

Operator day-off log sheet is for team leader or supervisor to see who and when to take day-off and adjust man-power accordingly.

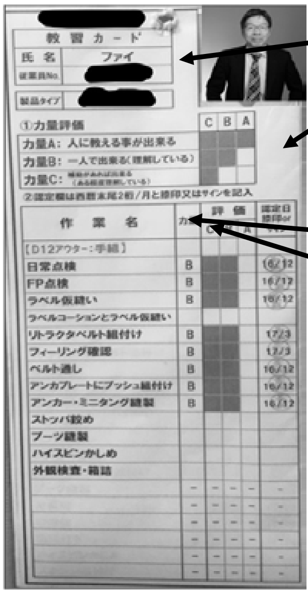
Operator skill matrix will be explained later.

Line lay-out and operator assignment map is for team leader or supervisor to adjust operator assignments according to operator's skill, attendance, or production requirement of the day.

Scrabble sheet is for everyone of the line to write suggestions, problems, and so forth and discuss them at QC circle or team meeting.

# • Operator Skill Card

To visualize the operator's training status by work element at lineside




- Operator name and photo
- Skill level
  - A: Can train others
  - B: Can make by her/himself
  - C: Needs assistance to make
- Work elements
- Required skill level for the element
- Team leader sign for the level judge

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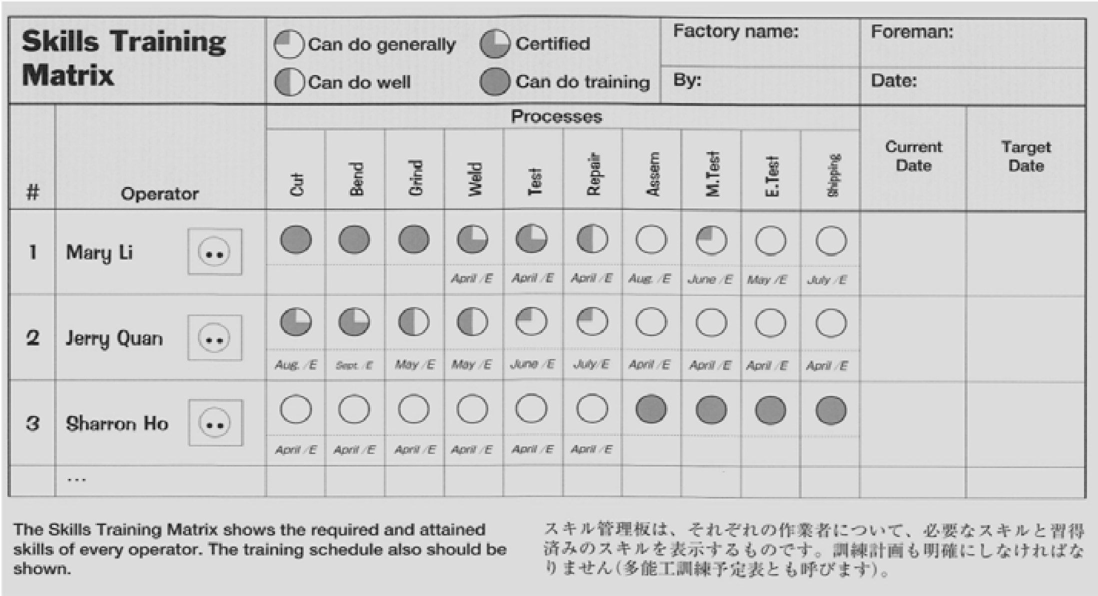
- **Operator Skill Card**

  The operator skill card is a tool to visualize the operator's training status by work element at lineside.

  The card is made for every operator working for the line individually and belongs to the operator.

- **Operator Skill Training Matrix**



**Skills Training Matrix**

Can do generally · Certified · Can do well · Can do training

Factory name: | Foreman: | By: | Date:

| # | Operator | Cut | Bend | Grind | Weld | Test | Repair | Assem | M.Test | E.Test | Shipping | Current Date | Target Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mary Li | | | | April /E | April /E | April /E | Aug. /E | June /E | May /E | July /E | | |
| 2 | Jerry Quan | Aug. /E | Sept. /E | May /E | May /E | June /E | July /E | April /E | April /E | April /E | April /E | | |
| 3 | Sharron Ho | April /E | April /E | April /E | April /E | April /E | April /E | | | | | | |
| | ... | | | | | | | | | | | | |

The Skills Training Matrix shows the required and attained skills of every operator. The training schedule also should be shown.

スキル管理板は、それぞれの作業者について、必要なスキルと習得済みのスキルを表示するものです。調練計画も明確にしなければなりません(多能工調練予定表とも呼びます)。

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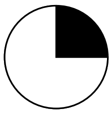
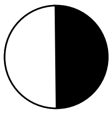
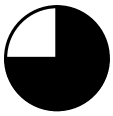
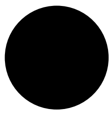
- **Operator Skill Training Matrix**

This is also a tool to visualize the operator’s training status

This training matrix can be used for the purposes; to formulate effective training programmes for skill development; to monitor and control timely progress of production; and, to make effective assignment or deployment plan into each production process.

- **Visual Control for Machines**

| | |
|---|---|
|  | Inexperience: Since he or she can not perform a task, a worker needs to practice or make an exercise to perform an actual task. |
|  | Dependent: A worker can perform a task with assistance from a skilled person. The worker needs to upgrade his/her skill. |
|  | Independent: A worker can perform a task without any assistance. At this level, the worker needs to upgrade his skills into an instructor's level |
|  | Able to instruct: A worker can not only perform a task completely but also work as an instructor or a resource person or a trainer. |

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- **Visual Control for Machines**

  Operator skill can be evaluated according to this matrix.

  These symbols are shown on the skill matrix for every operator so that skill level can be understood quickly.

• **Visual Control for Machines**

To make sure tightening securely

To make sure aligning properly

To check running condition visually
Blue: Low/ high
Red: Too high/ low
Green: Good

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**Cont.**

A green line paint on the bolt and nut for operator to make sure tightening securely

A triangle mark on the belt and a groove on the gear are to make sure aligning properly.

Color paints below numbers on the panel is to check running condition visually.

- **5S Examples**

To organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.

- Sort (Seiri)
- Set In Order (Seiton)
- Sanitation (Seiso)
- Standardize (Seiketsu)
- Sustain (Shitsuke)

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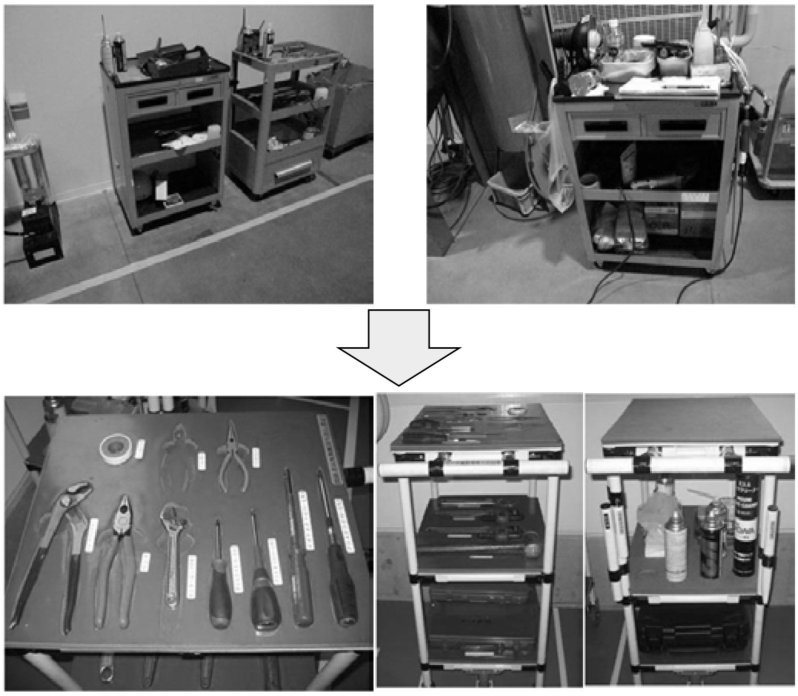
- **5S Examples**

The definition of 5S is;

- **Tool Cart Improvement**



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- **Tool Cart Improvement**

  Before improvement, hard to find and pick tools in the cabinets. After improvement, the tools can be found and picked much faster than before.

- **Mold Release Spray Cans**

Easy to find and easy to take

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- **Mold Release Spray Cans**

In plastic molding, mold release spray is used to spray lubricant on the surface of cavity and core of the mold to eject molded parts from the mold smoothly. The time to find the spray around the molding machine is a waste and slows the molding process.

Before improvement, the spray cans were put in a holder altogether. After improvement, the cans are put in different holders separately so that it is easy to find and easy to take.

- **Machine Cables, Tubes, etc**

Bundle hoses and cables
Fix them to machine
Easy to find oil leak or clean

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- **Machine Cables, Tubes, etc**

  Molding machines have cables and tubes around the machines.

  If those cables and tubes are loose on the floor like this picture, those are damaged and broken by dusts on the floor over the time. Then machine down occurs.

  To avoid that kind of problem, Bundle hoses and cables fix them to machine so that it is easy to find oil leak or clean.

## • Warehouse

Parts ID card attached to container (Kanban)


Parts location label attached to bin

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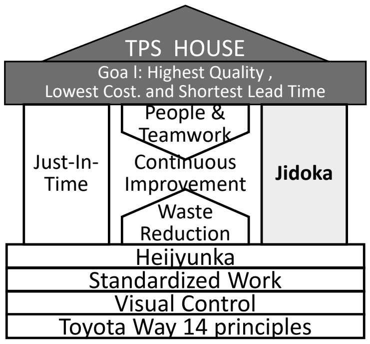
- **Warehouse**

  There are racks and shelfs to store the parts. At every bin of racks and shelfs, parts location label is attached to the bin.

  And on the parts container, parts ID card attached to container (Kanban). By this way, parts to be picked can be found and verified quickly.

# 6. Jidoka (Autonomation)

- Provides machines and operators the ability to detect an abnormality and stop work for immediate action.
- Enables operators to build in quality at process and separate from machines for more efficient works.
- Multi-machine handling
- Multi-process handling

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**6. Jidoka (Autonomation)**

The definition of Jidoka is;

- **The Origin of Jidoka**

  Sakichi Toyoda invented an automatic loom that would stop automatically for problems such as the warp (weft) cut in order to prevent loom from continuing to make defective products.

Auto Loom invented by Sakichi Toyoda

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- **The Origin of Jidoka**

  Sakichi Toyoda established Toyota Looming Machine Industry, the founding business of Toyota.

  He invented an automatic loom that would stop automatically for problems such as the warp (weft) cut in order to prevent loom from continuing to make defective products.

- **Steps of Jidoka**
  - Detect abnormality and stop production
  - Visualize the abnormality
  - Investigate the cause (Exp. Five whys)
  - Prevent reoccurrence

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- **Steps of Jidoka**

  The steps to establish Jidoka in production is;

- **Detect Abnormality and Stop Production**
  - Machine detects an abnormality and stops production with a detection device
  - Operator by him/herself detects an abnormality using the following tools and stops production
    - 5 S
    - Boundary(Go/No-go) sample
    - Production Control board
    - P-chart (In-process defect chart)
    - Min./Max. control
    - Kanban post , etc

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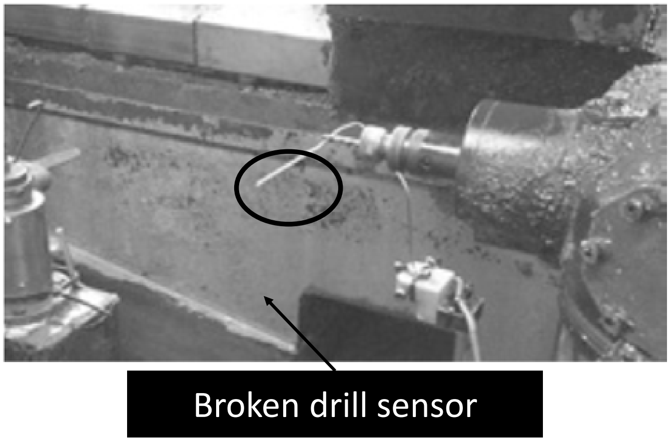
- **Detect Abnormality and Stop Production**

The first step is to detect abnormality and stop production.

This means;

- **Abnormality Detection Example**




After processing work, the sensor rises, and the process continues if it touches the drill tip. If it doesn’t touch, the drill is judged to be broken and the machine stops.

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- **Abnormality Detection Example**

  As an example of abnormality detection, there is a sensor mounted to the machine as this picture shows.

  After processing work, the sensor rises, and the process continues if it touches the drill tip. If it doesn’t touch, the drill is judged to be broken and the machine stops.

- **Visualize the Abnormality Using Andon**
  **How Andon works**
  - Highlight the status of operations at a glance
  - Tell immediately when something abnormal occurs
  - By pulling Andon cord, the operator must
    - Stop the line
    - Wait his/ her supervisor to come to the line
  - Supervisor to fix the problem and re-start the line immediately

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- **Visualize the Abnormality Using Andon**

  The next step is to visualize the abnormality using Andon.

  How Andon works is;

- **Andon Examples**

Visual type


Electric signboard
Factory of Toyota

Audio type


Color alarm light

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- **Andon Examples**

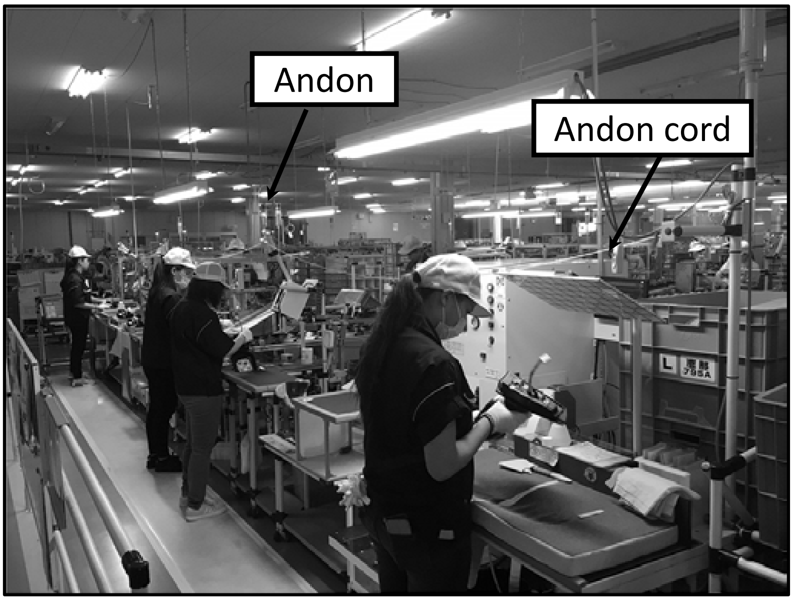
There are several types of Andons. In this slide, visual type Andon and audio type Andon.

Visual type Andon is;

If the lamp is blinking, the supervisor can find that there is something wrong with the position easily at a glance.

If the machine stops due to abnormality, restoration work (adjustment, repairs, etc.) is carried out and management thoroughly investigates the causes and takes steps to prevent reoccurrence.

- **Andon Examples**

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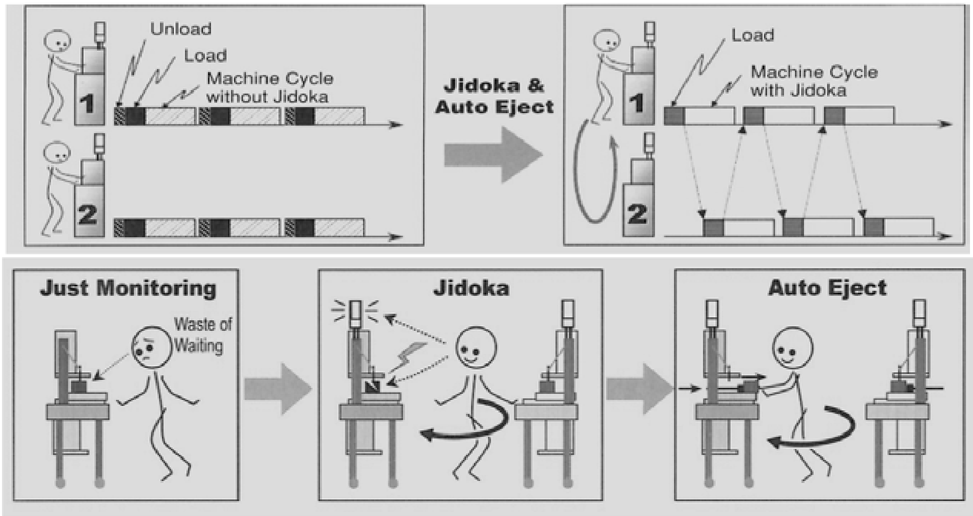
**Cont.**

In this picture, there is a cord connected with an Andon. The cord is hanging over the line.

Operators stop machines when they detect abnormality and pull the cord to turn on the Andon.

- **Multi-process/ Multi-machine Handling**

Jidoka enables operators to free from machines and do more value-added work.

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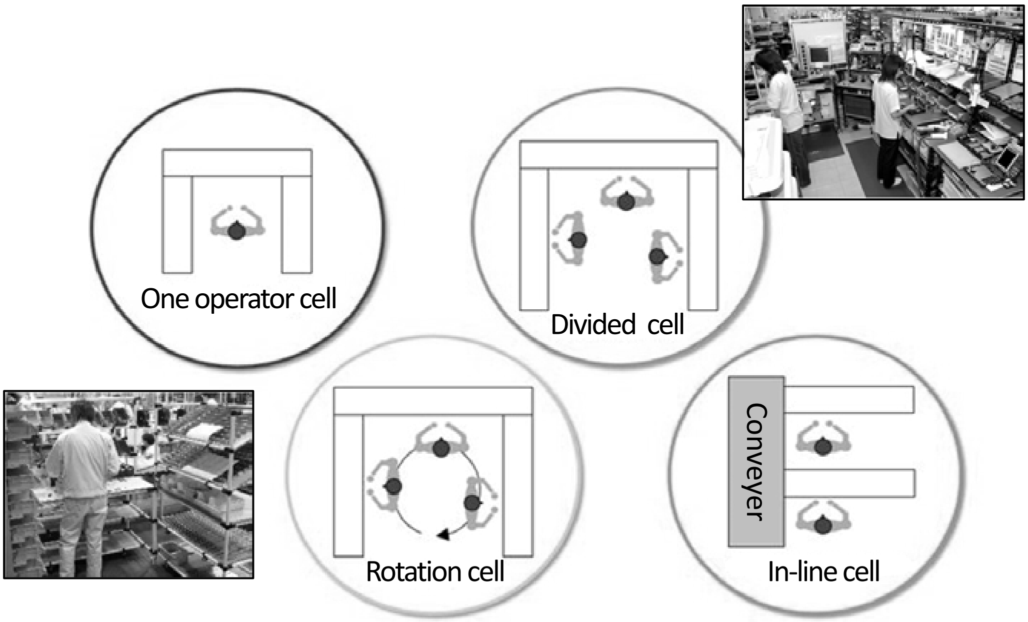
- **Multi-process/ Multi-machine Handling**

As the effects of JIDOKA, it enables operators to free from machines and do more value-added work.

Auto eject devices are attached to the two machines like upper right side of this picture, one operator can run those two machines.

After the operator loads the parts into machine 1 and starts the machine, the operator moves to machine 2 and loads the parts into machine 2 and starts the machine. The operator does not have to unload the finished parts because the auto ejects unload them. The operator has enough time to keep running the two machines. This is called, Multi-process or multi-machine handling

## • Multi-process/ Handling Examples

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- **Multi-process/ Handling Examples**

  Multi-process handling requires specific line lay-outs like this slide. The lay-out is also called cell.

  These cells are designed based on the number of operator and sequence of production process.

  Most of cells are U shape in which the machines, workstations, and parts locations are arranged in a series of processing steps

- **Multi-process/ Handling Examples**

Cell production advantages

- High-mix low-volume production
- One piece flow (One operator cell)
- Greater operator motivation
- Kaizen promoted by operators with ‘ownership’ on their area
- Closeness of cell members enhances;
    - Communication
    - Team work , etc

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**Cont.**

The Cell production advantages are;

- **Investigate Cause of the Abnormality**
  - Find the root cause by Five Whys & Genchi-Genbutsu
    - Five Whys;
      The practice of asking repeatedly whenever a problem occurs in order to get beyond surface symptoms and identify the root cause
    - Genchi-Genbutsu;
      The practice of going to see the actual work site to grasp and understand what really happened thoroughly
  - Prevent recurrence by eliminating the root cause

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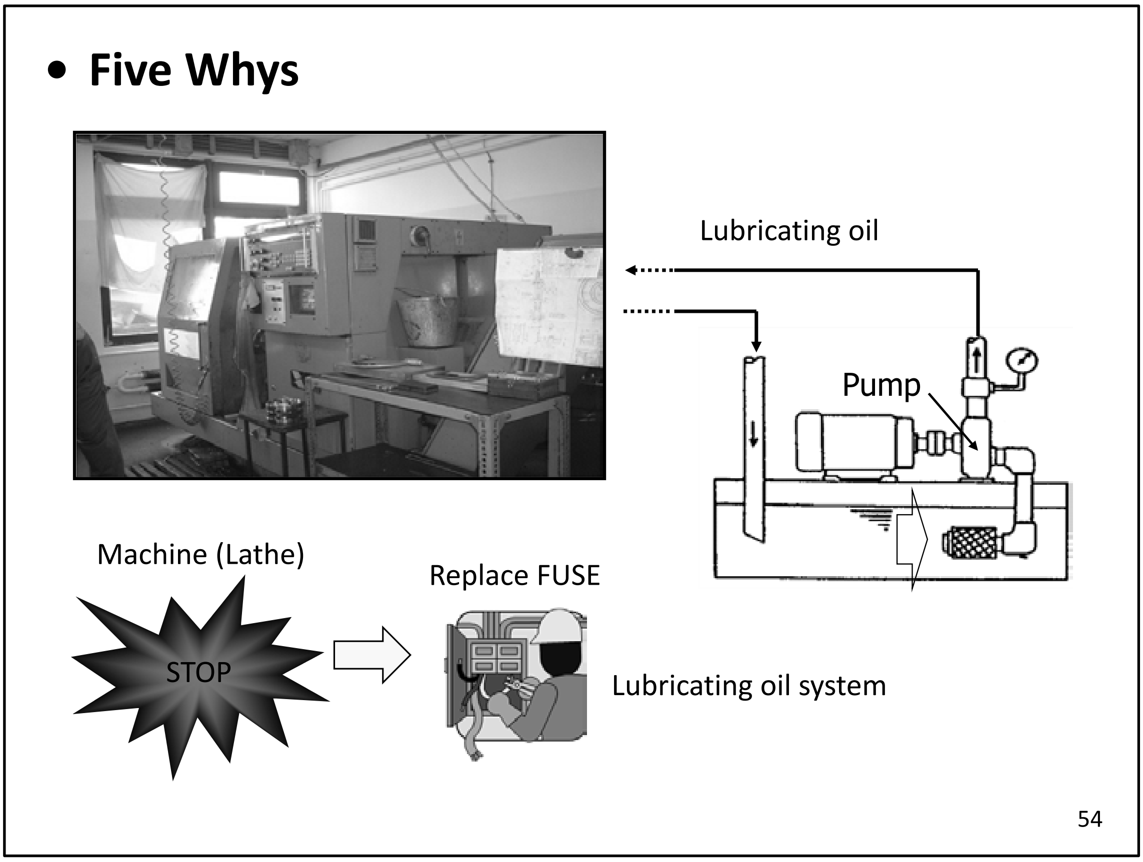
- **Investigate Cause of the Abnormality**

  The last two steps are to Investigate the cause and prevent reoccurrence.

  The way to find the root cause is Five Whys & Genchi-Genbutsu.




- **Five Whys**

  In this case, the lathe was stopped for fuse blow and we excersie five whys to find a roo cause of the fuse blow.

  It is common that a question is asked only once and the safety fuse is replaced. After a time, the machine will stop again because the real cause is not the fuse.

  The so-called 5Ws and 1H (who, what, where, when, why and how) are used in analyzing problems. To search for the root cause of problems, moreover, instead of asking “Why” once, it is repeated five times.

  This figure shows how it is practiced, taking the unknown stoppage of a lathe as an example.

- **Five Whys**

Q1: *Why* did the machine *stop*? ←1st why
A1: Because there was an overload and the fuse blew.

Q2: *Why* was there an *overload*? ←2nd why
A2: Because **the bearing** was ***not sufficiently luburicated***.

Q3: *Why* was it not lubricated? ←3rd why
A3: Because the **lubrication pump was not pumping sufficiently**

Q4: *Why* was it not pumping sufficiently? ←4th why
A4: Because the shaft of the pump was worn and rattling.

Q5: Why was the shaft worn out ? ←5th why
A5: *Because there was no strainer attached and metal scrap got in.*

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**Cont.**

By repeating “Why” five times, the root cause was found, and a filter was fixed at the suction of the pump to eliminate metal powder from the lubricating oil.

- **Rules of Five Whys Analysis**

1. Use a piece of paper or a whiteboard instead of computers.
2. Write down the problem and make sure that all people understand it.
3. Separate the causes into root cause and leakage cause for quality problem.
4. Pay attention to the logic of cause-and-effect relationship.
5. Make sure that root causes certainly lead to the mistake by reversing the sentences created as a result of the analysis with the use of the expression “and therefore”.
6. Try to make answers more precise.
7. Look for the cause step by step. Don’t jump to conclusions.

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- **Rules of Five Whys Analysis**

These are rules to analyze problem successfully and identify root cause by five whys.

- **Rules of Five Whys Analysis (Cont.)**

8. Base statements on facts and knowledge.
9. Assess the process, not people.
10. Never leave “human error”, “worker’s inattention”, "blame John" etc, as the root cause. (It's always John's fault)
11. Foster an atmosphere of trust and sincerity.
12. Ask the question “Why” until the root cause is determined, i.e. the cause the elimination of which will prevent the error from occurring again
13. When you form the answer for question "Why" - it should happen from the customer's point of view.

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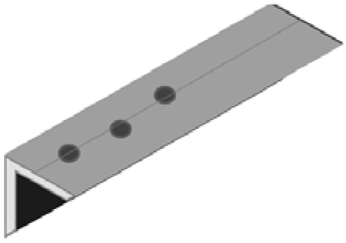
## • Five Whys Exercise

Addis Metal produces steel angles with the holes of 20mm diameter for construction companies. In their process of manufacturing a steel angle, the holes of 20mm diameter as shown below are cut. One day their customer found a defective angle of which holes were misaligned and deviated from their standard .



**Work procedure**

Before drilling the steel angle with a gauge (an iron plate with a hole in it) to make it easier for the drill tip to pick up the center of the hole on the angle, the holes of 5mm diameter are opened as pilot holes. However, some pilot holes were too shallow (insufficient), so that the drill tip could not pick up the center of the holes and it seems to be displaced (off-centered). As a result, it seems that the drill tip was swung randomly in the up, down, left, and right direction, resulting in the problem.

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## • Five Whys Analysis

In quality assurance, always identify two types of causes and take countermeasures for both of the causes. One is leakage cause, which is why the problem was not detected in the process. Another cause is root cause, which is why the problem was generated.

1. Root cause

   Why were the 20mm holes misaligned?

   ↓

   Because the 20mm drill tip was misaligned before tapping.

   ↓

   Why was the drill tip misaligned?

   ↓

   Because pilot holes to align the drill tip into the center of 20mm holes were too shallow too align.

   ↓

   Why was the drill of ϕ5 shallow?

   ↓

   Because the worker who made the pilot holes did not know how deep the hole to be.

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## • Five Whys Analysis (Cont.)

Root cause countermeasure example:
Prepare a standard to instruct how deep the worker make pilot holes.

2. Leakage cause

Why was not Addis Metal able to detect the defective angle before shipment ?

↓

Because the worker did not confirm the misalignment of the screw holes.

↓

Why was the worker not confirming the screw hole misalignment?

↓

Because there was no instruction to check the screw hole misalignment

Leakage cause countermeasure example (production):
Establish in-process inspection for finished parts based on the standards

Leakage cause countermeasure example (inspection):
To clarify inspection items by carefully examining possible defects or past problems

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- **Poka-Yoke (Fool Proof)**
  - Simple and inexpensive devices that help operators avoid mistakes caused by
    - the wrong parts ,
    - assembling in wrong direction ,
    - leaving out a parts , etc
  - Not only detects the abnormality but also stops the line to fix instantly.
  - A good Poka-Yoke;
    - Simple , with long life and low maintenance
    - High reliability
    - Inexpensive

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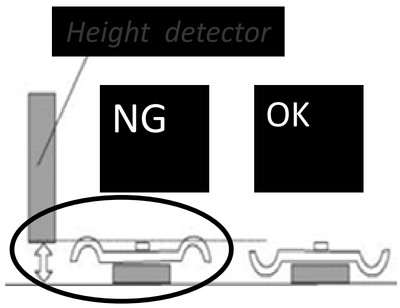
- **Poka-Yoke (Fool Proof)**

  The definition of Poka-Yoke is;

- **Poka-Yoke Examples**

Preventing the **upside down placement** of parts

| [Before Kaizen]<br>When fastening a circular part, NG occurred because the front and rear of the part were mistaken. | The fastening machine was adjusted *to* ***detect the differing height of the part when placed on its front and rear,*** *and not to operate when the product is placed upside down***.** |
|---|---|

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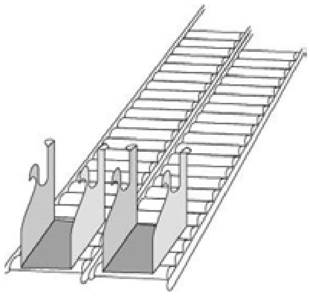
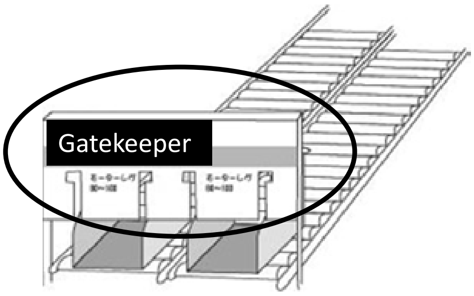
- **Poka-Yoke Examples**

Preventing **insertion** of wrong parts

| [Before Kaizen]<br>The wrong parts were put on the conveyor belt and they were fitted to the products. | Make **gatekeepers** according to part shapes so that only items with the right shape can pass. In doing so, prevent the attachment of wrong parts. |
|---|---|



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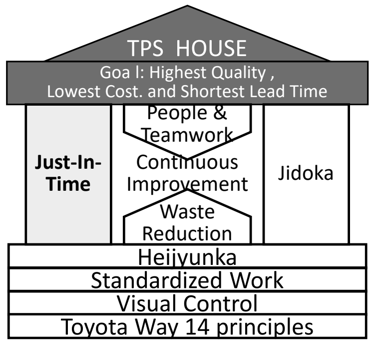
# 7. Just-In-Time

- A system of production that makes and delivers what is needed, just when it is needed, and just how many in the amount needed.
- Aims for the total elimination of all waste, typified by seven waste
- Relies on Heijyunka as a foundation and is comprised of three elements;
  - Takt time
  - Continuous flow
  - Pull system

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## 7. Just-In-Time

The definition of Just-In-Time is;

- **The Origin of Just-In-Time**
  - In 1953, following the end of the special demand business boom created by the Korean War, Toyota Motor Corporation was on the verge of bankruptcy due to excessive inventory.
  - Taiichi Ohno, having obtained ideas from the  method of replenishing stocks in American supermarkets, devised the original version of JIT for eliminating inventory MUDA and over-production MUDA.

- **The Origin of Just-In-Time**

  At supermarket

  - A customer in a supermarket takes the desired amount of goods off the shelf.
  - The store restocks the shelf to fill up the shelf


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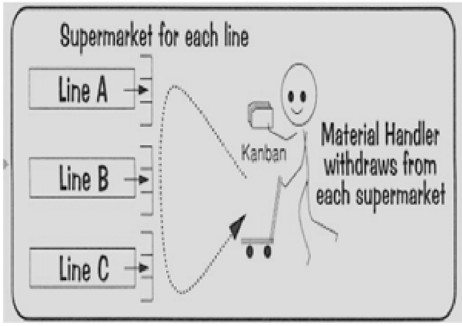
- **The Origin of Just-In-Time**

  What Taiichi Ohno saw at the supermarket in the USA is,

- **The Origin of Just-In-Time**

  At production line
  - A material handler that needed parts would go to a "store shelf" (the inventory storage point) for the particular part and "buy" (withdraw) certain amount of the parts the line needs
  - The "shelf" would be "restocked" by the line that produced the part, making only enough to replace the inventory that had been withdrawn.

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**Cont.**

Based on the supermarket operation in the USA, Ohno developed the similar system for his production line as this.

- **JIT Three Elements**

  1. Takt time

     How often to produce one product to meet customer requirements based on the rate of sales

$$\text{Takt time} = \frac{\text{Available working time per shift}}{\text{Customer demand rate per shift}}$$

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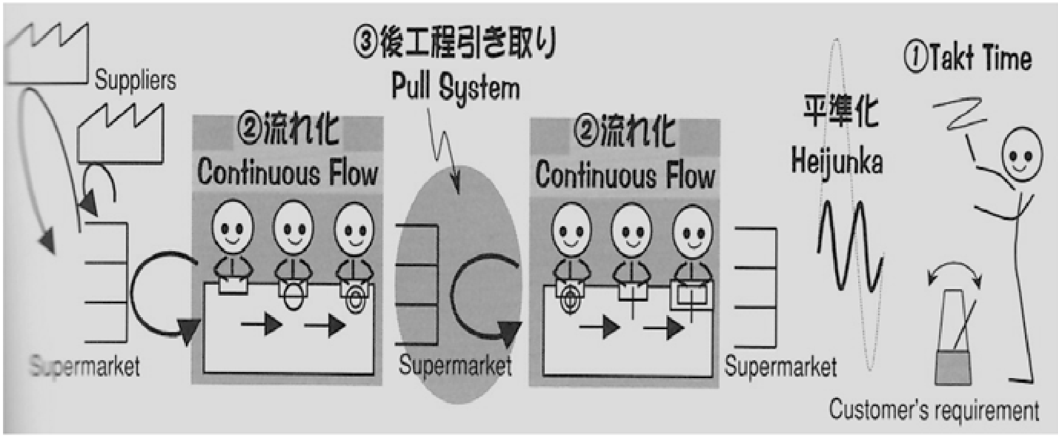
- **JIT Three Elements**

  The first element is Takt time.

  The definition of Takt time is;

- **JIT Three Elements**
  2. Continuous flow
     Produce and move one item at a time to match takt time with each item passed immediately without stagnation from process to process

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**Cont.**

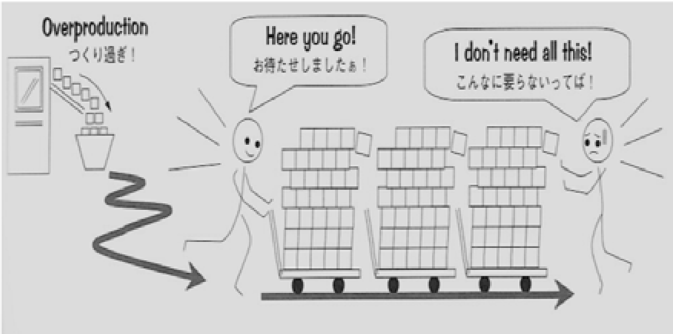
The second element is Continuous flow.

The definition of Continuous flow is;

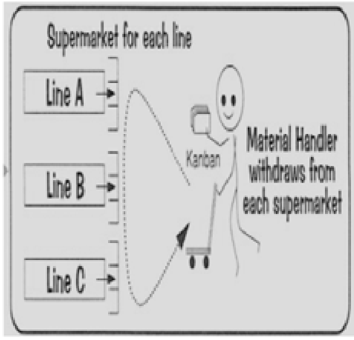
- **JIT Three Elements**

  3. Pull system
     - Enables to prevent overproduction and reduce the inventory in every process
     - Needs downstream operations providing information to upstream operations via Kanban

Push system




Pull system

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**Cont.**

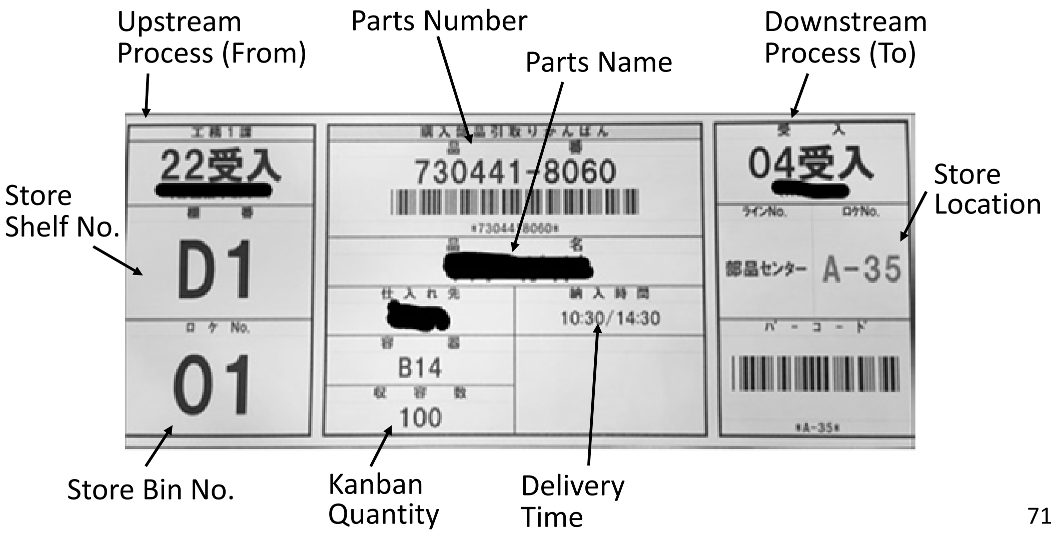
The third element is Pull system.

The definition of Pull system is;

- **Kanban**

  A signaling device that gives authorization and instruction for the production or withdrawal of items

<Withdrawal Kanban sample>

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- **Kanban**

  Kanban is a key tool of Pull system and a signaling device that gives authorization and instruction for the production or withdrawal of items.

  By controlling the number of Kanbans in the production, inventory of finished goods and components are minimized.

  Kanban is about regular envelope size as this shows.

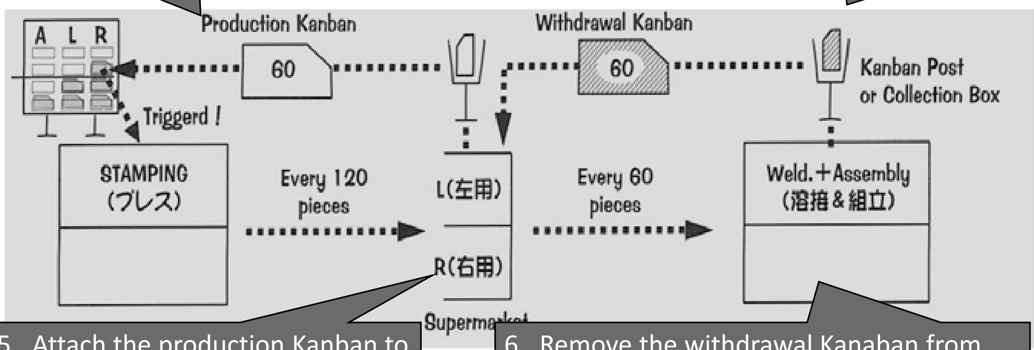
  There is much information on the Kanban as this;

- **Kanban**

3. Collect the production Kanbans from collection Box and keep them in reorder post
4. Release the Kanbans to stamping line for production when amount of production Kanbans reach reorder point

1. Collect the withdrawal Kanbans from Collection Box and go to the store and pick the stamping parts
2. Exchange the withdrawal Kanabans with production Kanbans attached to containers and put them in the Collection Box

Reorder Post




5. Attach the production Kanban to the finished goods container and keep the container at the store
6. Remove the withdrawal Kanaban from the container when first piece is used and put the Kanban in the Collection Box

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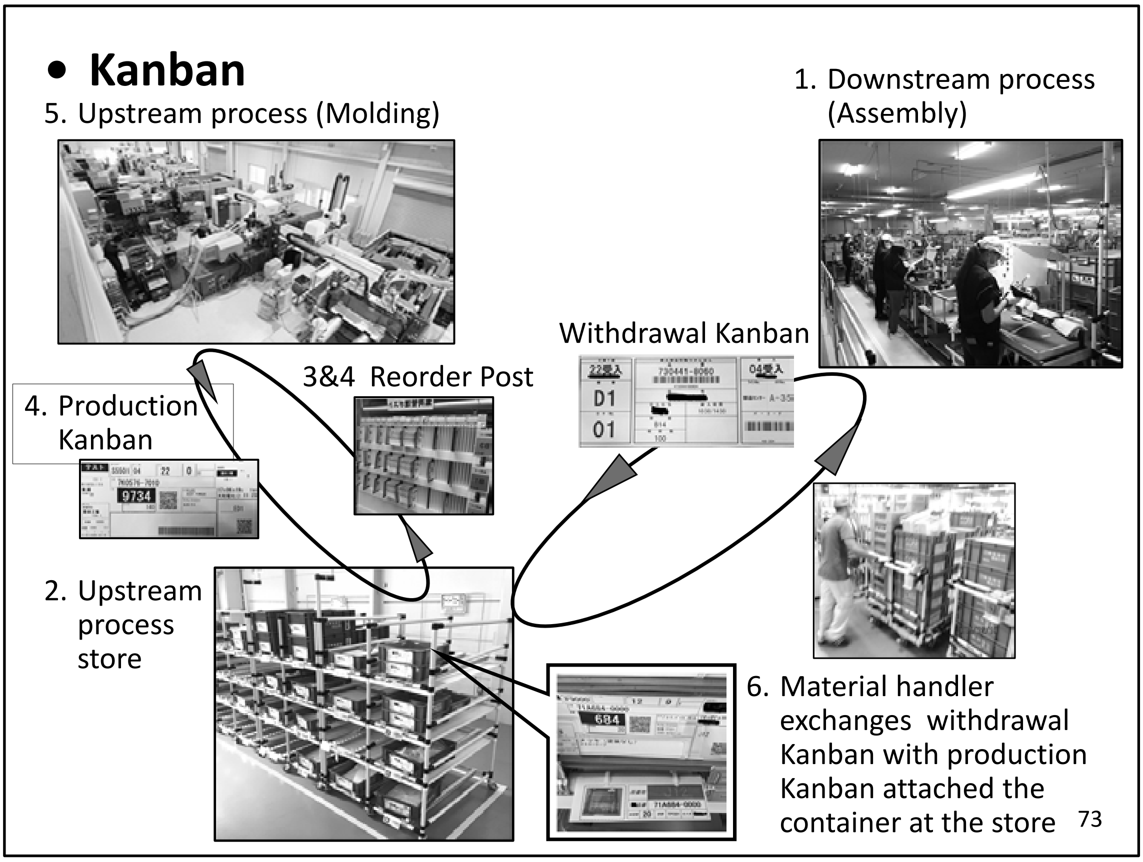
**Cont.**

From 1 to 6 in this slide explains how Kanban works.




**Cont.**

Using this slide, explain again how Kanban works.

Collect the withdrawal Kanbans from Collection Box in and

Go to the store and pick the parts and exchange the withdrawal Kanabans with production Kanbans attached to containers.

Collect the production Kanbans from collection Box and sort them in reorder post

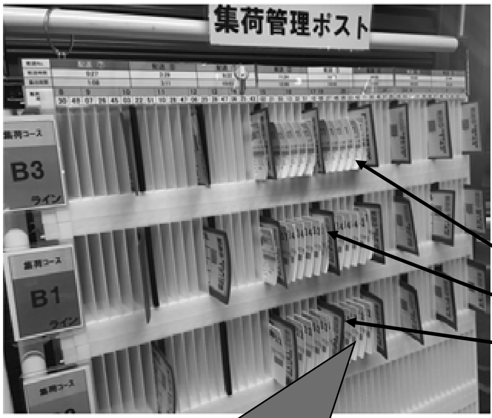
Release the Kanbans to upstream line for production when the time shown on the reorder post comes.

Attach the production Kanban to the finished goods container and keep the container at the store

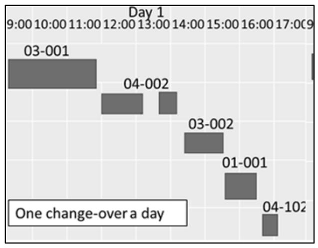
Exchanges withdrawal Kanban with production Kanban attached the container at the store.

## • Kanban Reorder Post (Heijyunka Post)

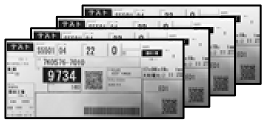
Reorder Post (Heijyunka Post)

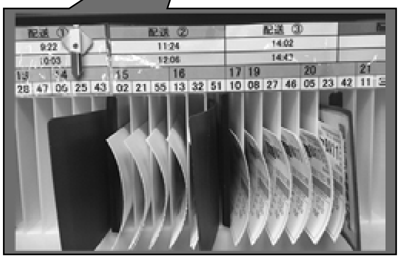



Heijyunka daily production schedule




Production Kanbans withdrawn






The withdrawn Kanbans are sorted into Heijyuka post according to Heijyunka daily schedule and issued to the line according to time table on the post.

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- **Kanban Reorder Post (Heijyunka Post)**

A Heijyunka post is a visual scheduling tool used in Heijyunka production.

The Heijyunka post is generally a wall schedule which is divided into a grid of boxes or a set of 'pigeon-holes'/ rectangular slots like this picture. The withdrawn Kanbans are sorted into Heijyunka post according to Heijyunka daily schedule and issued to the line according to time table on the post.

- **Kanban Six Rules**

1. Pull exactly the same amount of items as the amount of Kanbans from upstream.

2. Make exactly the same amount of items as the number of Kanbans pulled.

3. Do not make nor move any items without a Kanban

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- **Kanban Six Rules**

  There are rules that must be obeyed to run Kanban system precisely.

- **Kanban Six Rules**

4. Always attach a Kanban to the item until it is used.
5. Do not send defects and incorrect items to downstream.
6. Reduce the number of Kanbans carefully to lower inventory and reveal problems.

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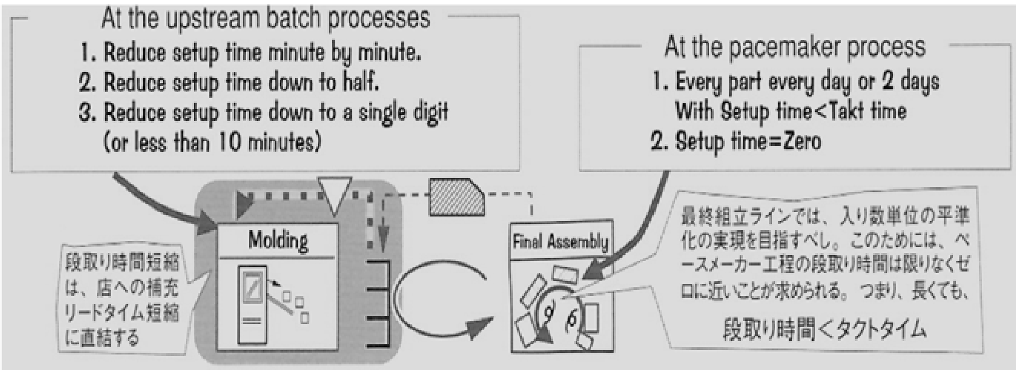
- **Change-over Kaizen**
  - Pull system increases changeovers
    - Tool , fixture and die setups
    - Component and material change
    - Work sequence change , etc

Kaizen Opportunity !

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- **Change-over Kaizen**

Pull system increases changeovers, in case of previous slide, you have to change products five time in a day.

Parts No.03-001,04-002,03-002,01-101, and 04-102 are produced to Heijyunka post every day.

Every time, following changes have to be done;

- **Change-over Kaizen**

Kaizen steps

1. Time study of the change-over process
2. Internal and external change-over elements separation
3. Process change from internal to external elements
4. Kaizen for internal elements reduction
5. Kaizen for external elements reduction
6. Standardization for new process
   - Internal change-over
     The work can be done only when a machine is stopped.
   - External change-over
     The work can be done while a machine is running.

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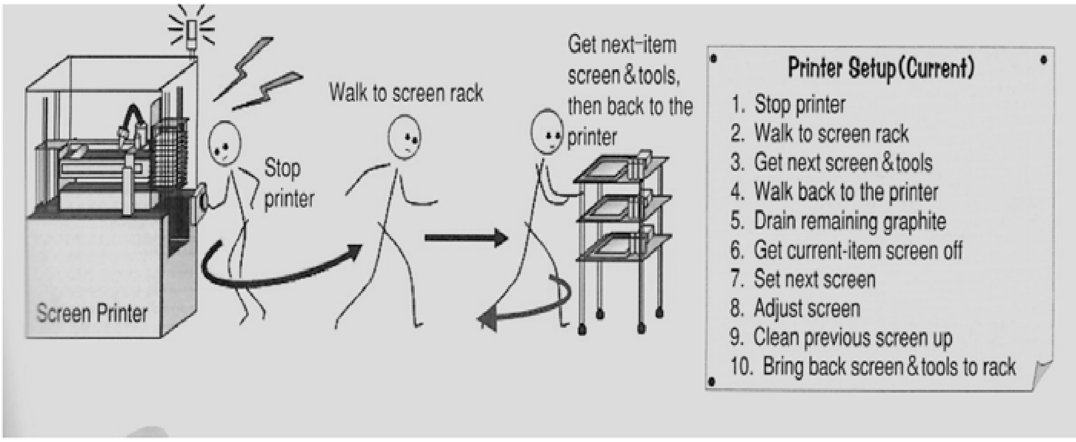
- **Change-over Kaizen; Exercise**
  1. Discuss which setup work elements are internal and external
  2. Discuss which internal element(s) can be changed to external

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- **Change-over Kaizen; Exercise**

There is a screen printer that needs to change the screen to new one.

Screen printer is a printing machine where a mesh of screen is used to transfer ink or graphite onto a product like a T-shirt, except in areas made impermeable to the ink by a blocking stencil on the screen. A blade or squeegee is moved across the screen to fill the open mesh apertures with ink.

To change screen, you need to do ten things from 1 to 10 on this picture.

Now let’s start exercise.

1. Discuss which setup work elements are internal and external
2. Discuss which internal element(s) can be changed to external

# 8. Value Stream Map

- A map to analyze the current state and design a future state for the series of events that take a product or service
- Shows supply chain of a product from customer to suppliers with
    - Order information flow
    - Material flow
- At Toyota, it is known as "material and information flow mapping

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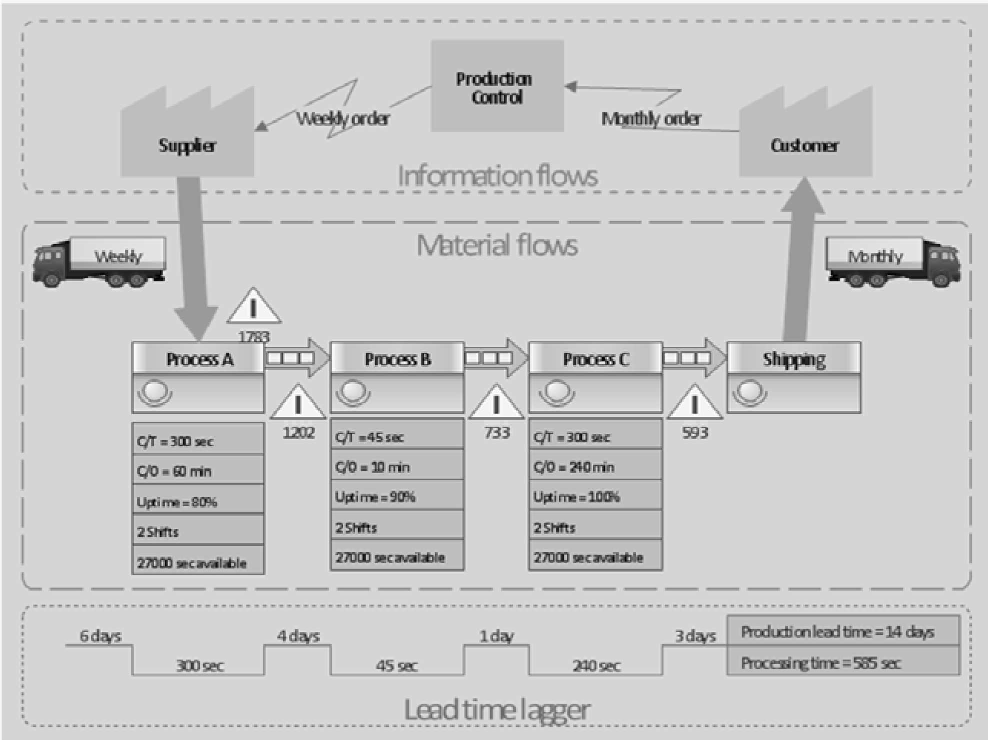
**8. Value Stream Map**

The definition of Value Stream Map is;

• **Value Stream Map; Sample**

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- **Value Stream Map; Sample**

  The map shows supply chain of a product from customer to suppliers.

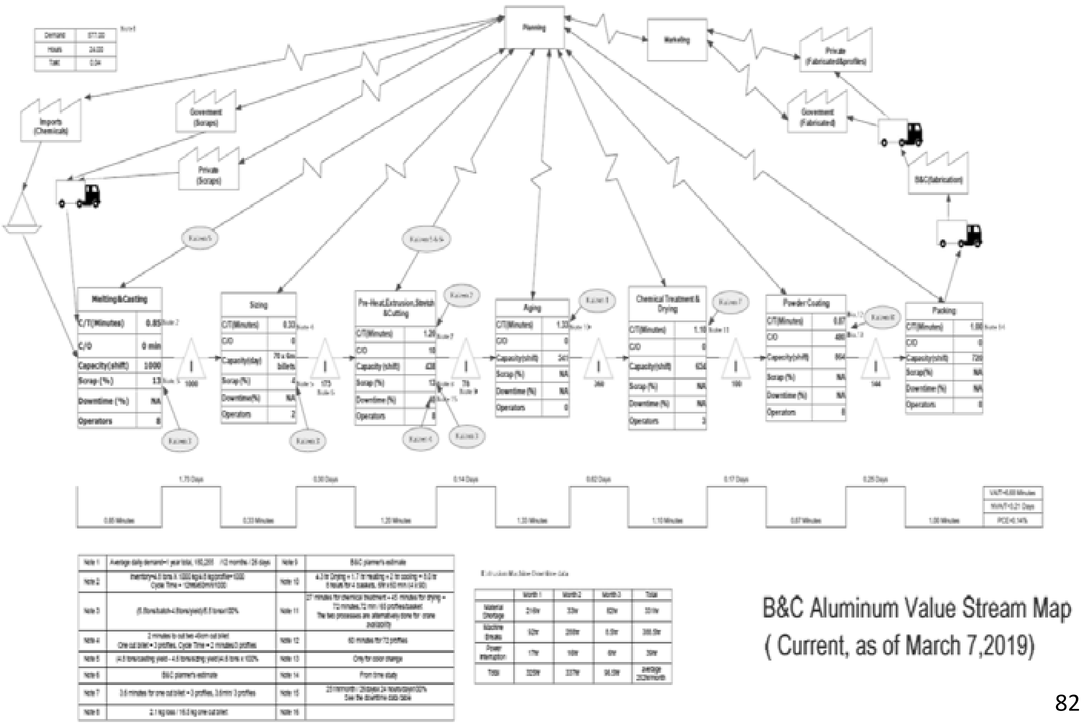
  It is made up of a three distinct looking parts: a material flow, a lead time ledger and information flow.

  It also uses standard symbols to represent items and processes, therefore knowledge of these symbols is essential to correctly interpret the production problems

  The lead time ledger ,a zig-zag graph in the bottom shows production time of each process and lead time from upstream process to down stream process. The numbers in two boxes on the right corner are total lead time and processing time which is production time.

  The difference of two times, 14 days and 535 seconds, is a waste, waiting time.

• **Value Stream Map; Sample from 4th Batch ICT**

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- **Value Stream Map; Sample from 4th Batch ICT**

  This VSM was drawn for B&C Aluminum by a 4th batch trainee.

  From this VSM, the trainee found eight Kaizen ideas.

- **Kaizen Ideas from the Value Stream Map**

| No. | Proposal |
|---|---|
| 1. | Aging time reduction |
| 2. | Extrusion process cycle time reduction |
| 3. | Scrap reduction |
| 4. | Machine Down Time Reduction |
| 5. | Decoupling point in production system for delivery lead time reduction |
| 6. | Visual control for delivery lead time reduction |
| 7. | Powder coating color change time reduction |
| 8. | Chemical coating and drying cycle time reduction |

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- **Kaizen Ideas from the Value Stream Map**

  These are the Kaizen ideas made after CFT members reviewed the map.

  Some of these were taken as ICT project themes.

TPM

# Total Productive Maintenance (TPM)

## 1. Points in TPM Concept

Note: Any copy is strictly prohibited without permission. This material is equated from the book, TPM, published by Japan Plant Maintenance Association.

1

### 1. Points in TPM Concept

TPM is an abbreviation of "Total Productive Maintenance" and is one of the all-participation types of productive maintenance management technology originated in Japan. It is a registered trademark of Japan Institute of Plant Maintenance.

The Japan Institute of Plant Engineers, Current: Japan Institute of Plant Maintenance (JIPM), defined it in 1971. Subsequently, the name of the PM Award was integrated into TPM in 2010 and is called TPM Award.

## 1.1 History of Maintenance

- Before1950's : **Breakdown Maintenance**
  - Take action/ Repair after breakdown
- 1951's : **Preventive Maintenance**
  - Take action like part & jig change before breakdown
- 1960's : **Productive Maintenance**
  - Take the actions of corrective maintenance & prevention to increase the productivity for cost minimum
- 1970's : **Total Productive Maintenance (TPM)**
- 1980's : **Predictive Maintenance**
  - Condition-based maintenance (CBM)
  - Time-based maintenance (TBM)

2

**1.1 History of Maintenance**

Historically, development and spreading of management technology related to machine maintenance in Japan are shown here.

Before 1950, it was the response to repair the machines / equipment only when they failed and stopped. But after 1951, the machines / equipment were shut down by predicting problems before its failure. That is, the preventive maintenance has been introduced. Furthermore, the awareness that led to the improvement of productivity by raising the operation rate of machines and equipment has been changed to a methodology based on management-centered.

It was developed further, and it led to the birth of "a productive-maintenance TPM with the participation of all employees at the factory-centered" 20 years later in 1971.

After that, when TPM methodology spread to the world and its effectiveness was recognized, "Overall TPM by all company and all departments" has been developed in 1982. In addition, it has been developed into "an innovative TPM that overlooks the entire business involving all stakeholders" since 2000.

## 1.2 7 Big Losses in Time

1) Breakdown
2) Set-up & Adjustment
3) Change of jigs
4) Speed loss
5) Idling time & Minor stoppages
6) Defects & Re-works
7) Start-up

3

First of all, the actual production starts after the preparation such as set-up of materials and jigs necessary for production by machines and equipment, in addition, setting and adjustment of operational conditions.

Other than that, there is repair work of the failure points of machinery and equipment. There is also inspection work on products including defective products and rework treatments. And the target products are obtained by completing such various work.

The characteristics of the TPM theory clarify the total time spent by above-mentioned work, and how much machinery and equipment are used for productivity by knowing how much time it takes to make only good quality products relative to the total time. You can also judge by them how well Kaizen activities are achieved.

For that purpose, the activities start by categorizing all losses, wastes, etc. into the seven major losses below, and express them all with time values.

**1.2 7 Big Losses in Time**

1) Breakdown, 2) Set-up and Adjustment, 3) Change of jigs, 4) Speed loss, 5) Idle Time & Minor stoppages, 6) Defects & Re-works and 7) Start-up

To collect data, use the following check sheets. And put together them and tabulate the following tables.

< Data Collection >

## Check Sheet for Identification of Downtime

being used with **the daily** and **weekly** Data Recording

| **Category**<br>(7 Big Losses) | Apr.<br>**01** | **02** | **03** | **04** | **05** | **06** | **07** | **Total** |
|---|---|---|---|---|---|---|---|---|
| 1. Breakdown | **(min)** | **(min)** | **(min)** | **(min)** | **(min)** | **(min)** | **(min)** | **(min)** |
| 2. Setup & Adjustment | | | | | | | | |
| 3. Change of jigs | | | | | | | | |
| 4. Speed loss | | | | | | | | |
| 5. Idling time & Minor stoppages | | | | | | | | |
| 6. Defects & Re-works | | | | | | | | |
| 7. Start-up | | | | | | | | |

4

This is a Check Sheet for recording daily and the weekly total for each Loss Time.

Fill and summarize each data into the blank columns in the check-list being used with the daily and weekly maintenance.

## Summation of Downtime

| **Category** (7 Big Losses) | Apr. | May | Jun. | Jul. | Aug. | Sep. | Total |
|---|---|---|---|---|---|---|---|
| 1. Breakdown | **(hrs)** | **(hrs)** | **(hrs)** | **(hrs)** | **(hrs)** | **(hrs)** | **(hrs)** |
| 2. Setup & Adjustment | | | | | | | |
| 3. Change of jigs | | | | | | | |
| 4. Speed loss | | | | | | | |
| 5. Idling time & Minor stoppages | | | | | | | |
| 6. Defects & Re-works | | | | | | | |
| 7. Start-up | | | | | | | |

5

This data sheet is for tabulation every month.

Summarize the downtime data whose frequency is to be identified into chronic or sporadic occurrence. It should be summarized at least more than six (6) months.

## Target of Loss Time reduced by Kaizen Activities

300 days/ year

| Big Losses | before | after |
|---|---|---|
| **1. Breakdown** | (hrs) | (hrs) |
| **2. Set-up & Adjustment** | → | ***Kaizen*** |
| **3. Change of Jigs** | | |
| **4. Speed Loss** | | |
| **5. Idling time & Minor Stoppages** | | |
| **6. Defects & Reworks** | | |
| **7. Start-up** | | |
| **Total time** | (hrs) | (hrs) |

6

To perform Kaizen activities by using TPM methodology, measure the Loss Time at which level of Downtime is before Kaizen (collect data for 12 months and allocate to 7 Big Losses).

If you perform Kaizen activities at the same time, the reducible time on each Loss Time is subtracted for each item. That is, it is the expected value that you want to obtain after Kaizen.

## Time Balance Bar Chart

<table>
<tr><td colspan="5">Total available time for operation- (a)</td></tr>
<tr><td colspan="4">Loading Time/ net available time</td><td>(b) Shutdown<br>Scheduled Breaks<br>Maintenance time<br>Daily meeting time<br>No order/ demand<br>Precautionary time</td></tr>
<tr><td colspan="3">Actual operating time</td><td>(c) Downtime<br>1. Breakdown<br>2. Setup & Adjustment<br>3. Change of jigs</td><td></td></tr>
<tr><td colspan="2">Net actual operating time</td><td>(d) Loss Time<br>4. Speed Loss<br>5. Idling time & Minor Stoppages</td><td></td><td></td></tr>
<tr><td>Value operating time</td><td>(e) Loss Time<br>6. Defects & Reworks<br>7. Start up</td><td></td><td></td><td></td></tr>
</table>

7

It can be understood that these seven major losses are almost all the factors that reduce the usable time of machinery and equipment. The time balances are shown in the Bar Chart indicating the categories in which, for any reasons, seven major losses cause time loss with respect to the useful life of the machinery / equipment.

Let's consider first the situation of machines and equipment. If it is always in good condition, they can be operated 24 hours a day, or 30 days a month or 365 days a year without a break. However, Such a perfect operation is actually impossible because maintenance of machinery and equipment is regularly performed, ex. for two months in one year. There is also an audit period based on ISO. On the other hand, if the production orders from customers are small or may not come at all, the production cannot be always continued. That is, it often happens that machines and equipment must be stopped unavoidably.

Furthermore, in developing countries, power outages occur frequently. And machinery and equipment are shut down. In addition, there are cases where they cannot be operated due to the lack of imported raw materials or spare parts.

Other than that, engineers and workers meet regularly in production sites. It is also natural for workers to take lunch and break every day.

Due to such circumstances, there is the time when machines and equipment cannot be operated. In the Time Balance Bar Chart, it is expressed by the term “(b) Shutdown”.

## 1.3 Kaizen Indicator of TPM

A. Availability Rate

B. Performance Rate

C. Good Quality Rate

D. Overall Equipment Effectiveness (O.E.E.)

8

**1.3 Kaizen Indicator of TPM**

The indicators used in TPM will be described based on the shutdown, downtime and loss times categorized by the 7 Big Losses.

The following should be kept in mind when you use it. In addition to zero failures of machines and equipment, and zero defects of products, etc., the emphasis is placed on reducing thoroughly the time when machines and equipment are not working effectively. That is, 7 Big Losses will be displayed all over time when considering the indexes, “A. Availability Rate”, “B. Performance Rate”, and “C. Quality Rate”. They are defined on the basis of those numerical values. Those values are further multiplied to be expressed “D. Overall Equipment Effectiveness (OEE)” as the overall index which represents the production efficiency of the machines and equipment. At the same time, these are used when evaluating the effect of activity as a kaizen index.

Therefore, only the time excluding the shutdown from the Total Available Time-(a), during which the efficiency of the machinery / equipment is to be evaluated by the TPM, is defined as “Loading Time” or “Net Available Time”.

Next, on the basis of this “Loading Time” or “Net Available Time”, it is determined how many hours the machinery / equipment itself has been in operation. There are important tasks such as preparation of materials to operate machines and equipment, and setting of manufacturing conditions such as temperature and line speed. In the meantime, machines and equipment cannot work. On the other hand, even if preparation for operation is completed and production by machines and equipment starts, there are the time when it is inevitable that failures occur for various reasons and that they must be stopped. It occurs frequently, especially on older machines and equipment.

That stop time is displayed as “(c) Downtime” in the Time Balance Bar Chart. And the time subtracted this “Downtime” from the above-mentioned “Loading Time” corresponds to the time when the machines and equipment are actually operated. It is displayed as “Actual Operating Time” in the Bar Chart.

Furthermore, if the machinery / equipment is actually operated, but not under proper conditions, that is, if it is not operated at the optimal Line Speed, production efficiency will drop. It is necessary to match the conditions to the Designed Capacity as much as possible.

In addition, there are occasions such as temporal stoppage for a short time. If the number of stoppage is repeated so often, the time loss cannot be ignored.

Although these are displayed as “(d) Loss Time” in the Time Balance Bar Chart, it means that Actual Operating Time is shortened accordingly. That is “Net Actual Operating Time”, which means the time actually spent on production.

On the other hand, among outputs obtained by production, there are some defective products and products that cannot be sold unless they are reworked. Some manufacture needs a trial run, i.e. a start-up loss before production. It is included to confirm whether the conditions are set to the optimum range before the full-scale production. Ultimately, it is limited only to the time worked for making good products by machines and equipment, which is “Value Operating Time”. It is the time deducted “(e) Loss Time” from “Net Actual Operating Time” in the Time Balance Bar Chart.

**A. Availability Rate (%) =** $$\frac{(a - b - c) \times 100\ (\%)}{(a - b)}$$

**Loading time (Net availability of equipment) = (a - b)**

**Actual operating time = (a - b - c)**

**a: Total available time for operation**

**b: Shutdown**

**c: Downtime**

**B. Performance Rate(%) =** $$\frac{\text{Ideal cycle time x Outputs x100 (\%)}}{\text{Actual operating time}}$$

**Outputs: n1 + n2** **n1 : (No. of good-finished)**

**n2 : (No. of defects and reworks)**

**Ideal cycle time: Ict**

(Note) Outputs is the total number of good-finished products (n1) and defects & reworks (n2)

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Firstly, what kind of Indicator is "Availability Rate"? It is the ratio of Actual operating time to Loading time shown in the Time Balance diagram. The formula is as follows.

A. Availability Rate = $$\frac{(a - b - c) \times 100\ (\%)}{(a - b)}$$

Loading Time (Net Available Time) : (a - b)

Actual Operating Time : (a - b - c)

"a" is the time of "Total available time for operation", "b" is the time of "Shutdown" and "c" is the time of "Downtime" (see "Time Balance Bar Chart").

Secondly, what kind of indicator is "Performance Rate"? It is the ratio of "Ideal Cycle Time x Outputs" to "Actual operating time" shown in the Time Balance Bar Chart. The formula is as follows. However, "Outputs" here is the sum of the number of good quality products and the number of defective products and reworks.

Also, "Ideal cycle time" represents the time required to make one output by production capacity (based on designed capacity) that the machine and equipment can exhibit.

B. Performance Rate = $$\frac{\text{Ideal cycle time x Outputs x100 (\%)}}{\text{Actual operating time}}$$

"Outputs" is the total number of good quality products (n1) and defective products & reworks (n2)

**C. Good Quality Rate (%) =**

$$\frac{\textbf{No. of good-finished (n1) x 100 (\%)}}{\textbf{Outputs (n1+n2) + material wastes (n3)}}$$

(Note) Outputs is the total number of good-finished products (n1) and defects & reworks (n2)

n3 : (No. of material wastes) = Start-up loss

10

Thirdly, what kind of indicator is "Good Quality Rate"? It is the ratio of "Number of good quality products" to the total of the number including outputs and material wastes (n3). The formula is as follows.

C. Good Quality Rate = $\frac{\text{No. of good quality (n1) x 100 (\%)}}{\text{Outputs (n1+n2) + material wastes (n3)}}$

Material wastes (n3) is the amount of start-up loss, etc.

Then, an indicator is defined the value obtained by finally multiplying the ratio of the above each equation A, B, & C. It is "Overall Equipment Effectiveness" (O.E.E.).

**D. Overall Equipment Effectiveness (O.E.E.)**

**O.E.E. (%) =**

**Availability Rate x Performance Rate x Good Quality Rate**

$$\frac{(a-b-c) \times Ict \times (n1 + n2) \times n1 \times 100\ (\%)}{(a-b) \times (a-b-c) \times (n1 + n2 + n3)}$$

**= (%)**

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OEE representing the overall effectiveness of the machinery / equipment is obtained by multiplying the values of “(A)Availability Rate”, “(B)Performance Rate” and “(C) Good Quality Rate” described above.

The formula is as follows.

D. Overall Equipment Effectiveness (O.E.E.) =

$$\frac{(a - b - c) \times Ict \times (n1 + n2) \times n1 \times 100\ (\%)}{(a - b) \times (a - b - c) \times (n1 + n2 + n3)}$$

**(Conditions) Before**

Ict: min. /piece, n1: pieces/year
n2: pieces/year, n3:pieces/year
a : Total available time for operation
b : Shutdown
c : Downtime

**After**

Ict : min. /piece, n1': pieces/year
n2' : pieces/year, n3':pieces/year
a': Total available time for operation
b': Shutdown
c': Downtime

| | Before | After |
|---|---|---|
| **Availability Rate (%)** | $\frac{(a - b - c) \times 100\ (\%)}{(a - b)}$ | $\frac{(a' - b' - c') \times 100\ (\%)}{(a' - b')}$ |
| **Performance Rate (%)** | $\frac{Ict \times (n1+n2) \times 100\ (\%)}{(a - b - c)}$ | $\frac{Ict \times (n1'+n2') \times 100\ (\%)}{(a' - b' - c')}$ |
| **Good Quality (finished) Rate (%)** | $\frac{n1 \times 100\ (\%)}{n1 + n2 + n3}$ | $\frac{n1' \times 100\ (\%)}{n1' + n2' + n3'}$ |
| **Overall Equipment Effectiveness (%)** | $\frac{(a-b-c) \times Ict \times (n1 + n2) \times n1 \times 100\ (\%)}{(a-b) \times (a-b-c) \times (n1 + n2 + n3)}$ | $\frac{(a'-b'-c') \times Ict \times (n1' + n2') \times n1' \times 100\ (\%)}{(a'-b') \times (a-b'-c') \times (n1' + n2' + n3')}$ |

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These indicators can also be used to compare the values before and after the TPM activity, and they show how much problems have occurred and where the problems that could not be solved are located.

This table is organized according to the mathematical formulas for each index.

## 1.4 Countermeasures for 7 Big Losses

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### 1.4 Countermeasures for 7 Big Losses

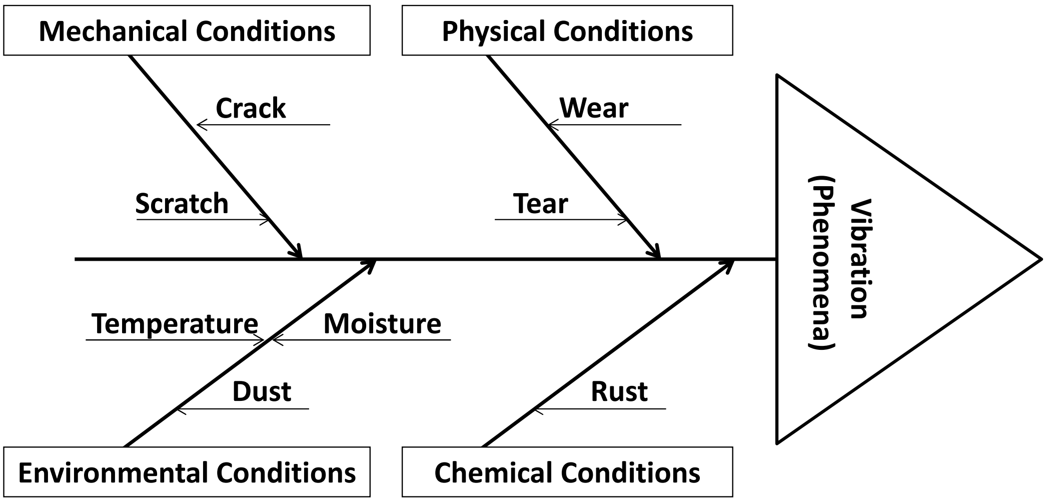
Finally, I will introduce a representative approach on how to reduce the time expressed as 7 Big Losses.

Cause Analysis and Countermeasures Setup for 7 Big Losses are explained step by step as follows.

## 1.4.1. Breakdown

### Cause Analysis

### ~ Cause Investigation by using Fish Bone Diagram ~

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**1.4.1. Breakdown**

First, let's observe the phenomenon of the target failure.

Next, the items considered to be the causes are presented, and they are stratified usually into 4M (Man, Method, Machine, Material) by the Fish Bone Diagram.

“Mechanical Conditions”, “Physical Conditions”, “Environmental Conditions” & “Chemical Conditions” are used as the stratification elements for the above case.

If the failure is complicated, it is difficult to find the true cause directly only by this illustration.

**PM Analysis** (Physical Phenomena Mechanism Analysis)

Clarification of the Mechanism from Motor Broken Phenomena to Identification of Root Cause

| Broken Part | Phenomena | Probable Cause | Root Cause |
|---|---|---|---|
| Motor | Broken | Vibration | Scratch |

Find the relationship among Phenomena, Probable cause and Root Cause

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**PM Analysis**

The recommended method is the Physical Phenomena Mechanism Analysis (PM Analysis).

It observes the phenomenon of failure and infers why it happened. Furthermore, it considers why the fact was inferred from its occurrence and selects the event that occurred before that. If you continue it, you will finally reach the root cause of the failure. This method is similar to the analysis of why and why, but the difference lies in clarifying the causal relationship, narrowing down the cause candidates, and displaying the connection as a mechanism.

The above figure is an example of PM analysis performed by taking a situation where a car has stopped moving as an example. That is, the phenomenon that the car does not move seems to indicate that the motor has failed. The reason why the motor broke down is that the motor was vibrating. The reason why the motor was vibrated is probably that some scratches were created in the bearing. When these causal events are arranged in chronological order and illustrated, the mechanism is expressed as above.

## Countermeasures & Implementation

| | |
|---|---|
| **Diagnoses** on machines | The activities on equipment should be carried out by checking the vibration and the sound of machines. |
| **CBM** for **Corrective** Maintenance<br>**TBM** for **Planned** Maintenance<br>CBM: Condition Based on Maintenance<br>TBM: Time Based on Maintenance | Maintain equipment in good conditions by **corrective action**<br>Maintain equipment in good conditions by **preventive action** |
| **Autonomous maintenance** | Maintain basic equipment condition through inspection, cleaning, bolt tightening & oiling |
| Industrial technical improvement | Restore deterioration<br>Correct design weakness |

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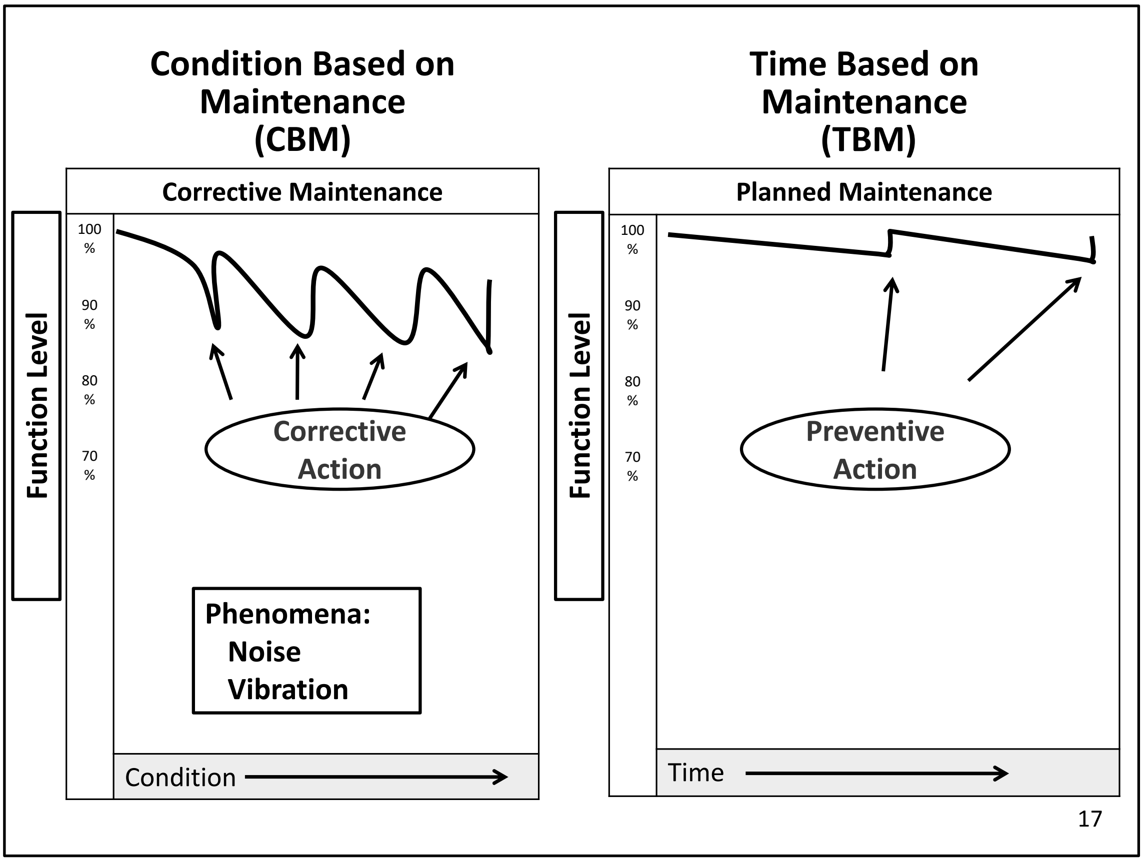
**Countermeasures & Implementation**

Next, countermeasures based on predictive and preventive maintenance will be described.

The machine / equipment must be operating under the most appropriate condition at that time. The operation status of the machine and equipment is diagnosed based on Predictive Maintenance Method, CBM and TBM, and jig replacement and oil replacement are performed as needed. Needless to say, the autonomous maintenance such as the daily maintenance, daily inspection, cleaning, bolt-tightening and oiling should be performed on a daily basis. However, it is necessary to make design changes by experts in parts where frequent breakdowns occur.




The CBM and TBM as the preventive maintenance will be described with reference to the above figure.

CBM is a maintenance activity that actually observes the state of deterioration of the functions of machines and equipment, repairs any degree of deterioration found, attempts to restore the function as much as possible, and prevents failures in advance. Nevertheless, machinery and equipment usually degrades over long periods of use and is the means to perform at its best.

On the other hand, TBM is a preservation act such as replacing parts with new ones after a certain period of time in order to prevent failure, even if there is no change on the mechanical equipment. Periodic repair is a typical TBM activity. Both methods are kinds of preventive maintenance.

# 1.4.2. Set-up & Adjustment

## Analysis and Countermeasure

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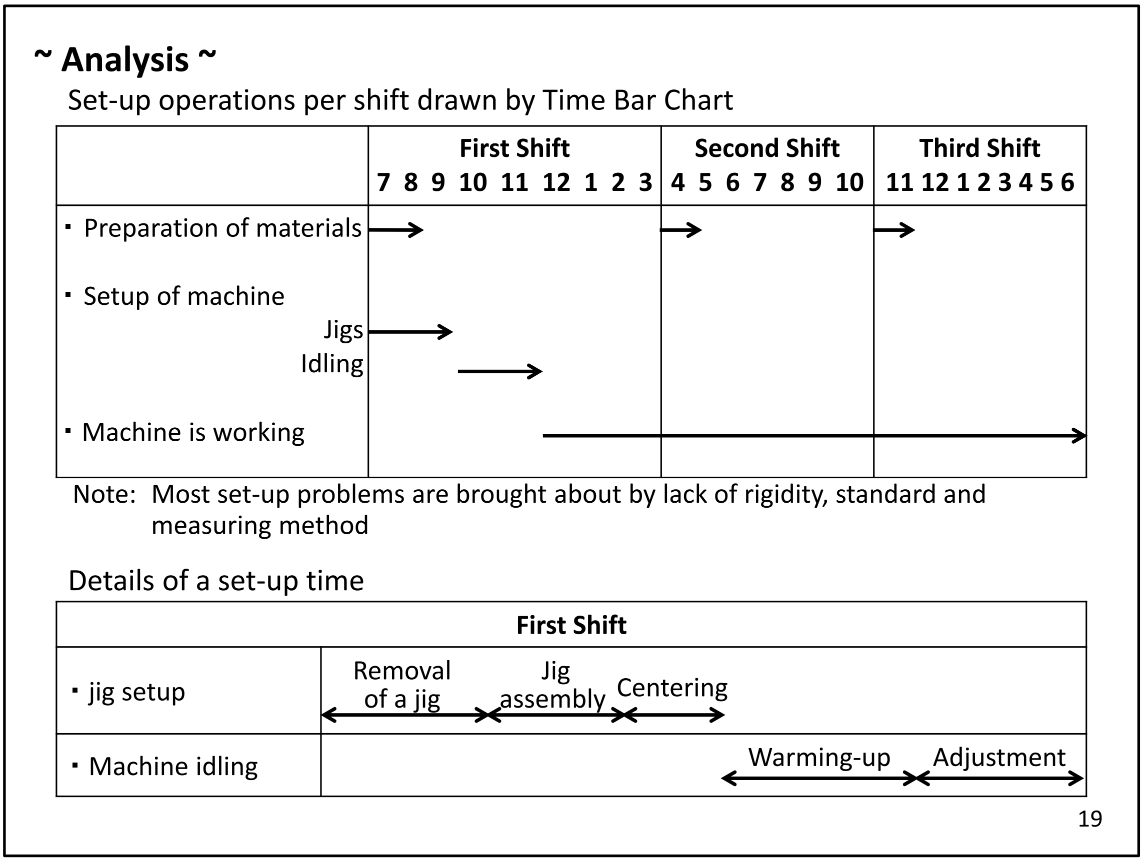
**1.4.2. Set-up & Adjustment**

**Analysis and Countermeasure**

When setup takes a long time, it often appears that it takes time to arrange materials and change jigs before the operation of machines and equipment. It is one of easy solutions to break those series of work into some components and combine them into parallel work. Also, depending on the content of work, perform while the machine and equipment are in operation. The time is greatly reduced by the two-point ideas.




This is an improvement that significantly reduces the long-term work related to Setup & Adjustment before starting production at a site where V-Belt is manufactured by press molding.

When setup takes a long time, it often appears that it takes time to arrange materials and change jigs before the operation of machines and equipment.

Confirm the time components on one cycle by bar drawing based on a machine's working time and its set-up operation time per shift.

## Countermeasure

### Conventional work procedure

| Works | Time consumption | | | |
|---|---|---|---|---|
| ・Jigs preparation | | | | |
| ・Jigs cleaning | | | | |
| ・Jigs assembly | | | | |
| ・Jigs setup | | | | |

### Parallel work procedure as Kaizen

| Works | Time consumption | | | |
|---|---|---|---|---|
| ・Jigs preparation | | | | |
| ・Jigs cleaning | | | | |
| ・Jigs assembly | | | | |
| ・Jigs setup | | | | |

20

It is one of easy solutions to break those series of work into components and combine them into parallel work.

It can be seen that the set-up & adjustment time have been reduced by half.

**Countermeasure**

- Classify **A. External** and **B. Internal** items in the table and discuss how to transfer internal to external

| **A. External Set-up** | **B. Internal Set-up** |
|---|---|
| ・Preparation of workbench<br>・Pre-heating dies | ・Replace of dies and jigs<br>・Centering and adjustment |
| **While the equipment is functioning/ the machine is working** | **While not functioning / not working** |

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There is a commonly used method for reducing the setup & adjustment time.

As shown in the above figure, if the action of the work element is possible, during the time when the machine equipment is operating, the operation of the machine equipment can be started quickly by shifting the Internal Setup & Adjustment work to the External Setup & Adjustment work. This is an improvement in Setup & Adjustment time.

## 1.4.3. Change of Jigs

**~ Countermeasures ~**

a. Determine both the **life span** of the material and the shape of the Jig.

b. Check the working condition of the **jig set**.

c. Check whether the material, shape and hardness of the product damages the jigs or not.

d. Many countermeasures are made here, because **this matter is strongly connected to the design and technology** of the jig.

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**1.4.3. Change of Jigs**

Jigs have the lifetime, so it is necessary to grasp the deterioration status and replace them in advance before breaking. If they are left until it breaks, they will lead to major failures of machinery and equipment.

## 1.4.4. Speed Loss

### a. The gap between the optimal and the current speed of machinery and equipment working

note: Speed loss comes from the vague equipment specification.

**~ Countermeasure ~**

Confirm the current speed and change it to the standard speed in use.

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**1.4.4. Speed Loss**

Speed Loss refers to the case where the production speed under operating machines and equipment is lower than the speed that can be originally achieved.

Check the specifications of the machinery and equipment provided by the manufacturer to confirm the standard speed of use. Measure the set speed when the machine is actually operating and compare it to the specification.

# 1.4.5. Idling time & Minor Stoppages

**a. Idling time**

**~ Countermeasure ~**

Do not take unnecessarily long time

**b. Minor Stoppages**

**~ Countermeasure ~**

Observe the phenomena thoroughly and clarify the mechanism of occurrences.

And take the adequate remedial actions.

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**1.4.5. Idling time and Minor Stoppages**

Idling must take a certain amount of time before operation to protect machinery and equipment, but it should not take unnecessarily long time.

As minor stoppages cannot be neglected repeatedly, it is important to identify stoppages that become chronic. Needless to say, if the cause is known, any countermeasures must be taken as soon as possible.

## 1.4.6. Defects & Reworks

No suggestion is given here because it will be discussed in Quality Control (QC).

## 1.4.7. Start-up

It is necessary work, but do not take an excessive time.

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**1.4.6. Defects and Reworks**

Defective products and reworked products are often generated during machines and equipment breakdowns. It is most important to prevent Breakdown first. Besides that, they will usually occur if there is a problem with setting the manufacturing conditions. In such case, it is necessary to set the production conditions carefully and accurately.

**1.4.7. Start-up**

It is necessary to make some outputs to make sure that the machinery / equipment has reached the optimum production conditions before entering the timing of full-scale production. That is a trial time to determine if a good product is obtained. It is an idea as one of countermeasures to set the conditions with extreme care and precise. In addition, not conducting the trial more than necessary leads to time reduction.

## 1.5 Autonomous Maintenance

Demonstrate an activity to familiarize operators with

a. **Daily Inspection**
b. **Cleaning**
c. **Oiling**
d. **Bolt -tightening**

activities at the workplace.

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**1.5 Autonomous Maintenance**

The most effective preventive method to prevent breakdowns on mechanical equipment is to carry out Autonomous Maintenance activities. That is, the four actions of a. Daily Inspection, b. Cleaning, c. Oiling and d. Bolt-tightening are performed carefully.

The main points of each activity are listed below.

## Daily Inspection Standard

| No. | Location | Detective part | Function/ Condition | Condition of work done | Comment | Person in charge |
|---|---|---|---|---|---|---|
| 1 | Motor | | | | | |
| 2 | Sliding part | | | | | |
| 3 | Driving part | | | | | |
| 4 | Fixed part | | | | | |

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Next, the standard related to Daily Inspection is shown in the above chart. Write the location of the important parts from the top. And for each part, add comments in the column next to them in the order of “Detective Part", “Function/Condition", “Condition of Work done", “Comment" and "Person in charge".

## Cleaning & Oiling Check points

| | ***Main body** of the equipment* | ***Auxiliary** of the equipment* |
|---|---|---|
| a. Find the cause of dirt, dust and oil leaks etc. | | |
| b. Cleaning the surrounding of the equipment | | |
| c. Lubrication | | |
| d. Improving accessibility for hard to reach places | | |

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Cleaning and Oiling Check points are shown in the above figure, divided into "Main Body" and "Auxiliary" parts.

## Cleaning Standard

Create **a temporary standard** for cleaning equipment with the **illustrated** parts, location/method/frequency, etc. as shown in the following table.

| No. | Location | Illustration with pictures | Method & Tool | Criteria | Frequency | Person in charge |
|---|---|---|---|---|---|---|
| 1 | Electric connect | | | | | |
| 2 | Sliding part | | | | | |
| 3 | Driving part | | | | | |
| 4 | Hydraulic part | | | | | |
| 5 | | | | | | |

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The standard related to Cleaning is shown in the above chart. Write the location of the important parts from the top. And for each part, add comments in the column next to them in the order of "Illustration with pictures", "Method & Tool", "Criteria", "Frequency" and "Person in charge".

## Oiling standard

| No. | location | Illustration with pictures | Lubricant type | Criteria | Frequency | Person in charge |
|---|---|---|---|---|---|---|
| 1 | Motor | | | | | |
| 2 | Sliding part | | | | | |
| 3 | Driving part | | | | | |
| 4 | Fixing part | | | | | |
| 5 | | | | | | |

30

The same one is applied to the Oiling Standard.

## Implementation

| Step | **Actions** |
| --- | --- |
| 1) | Confirm **a model machine and** the location in which the Autonomous maintenance activities would be applied to. |
| | The **function**, **mechanism** and **operation principles** of the machine |
| 2) | Supply tools, oil needed for activities |
| 3) | General cleaning of workplace |
| | Make **check points** clear on the machine and equipment parts |
| 4) | **Carry out cleaning, oiling and bolt-tightening** for the machine and equipment |
| 5) | All members **standardize** their activities with check points. |

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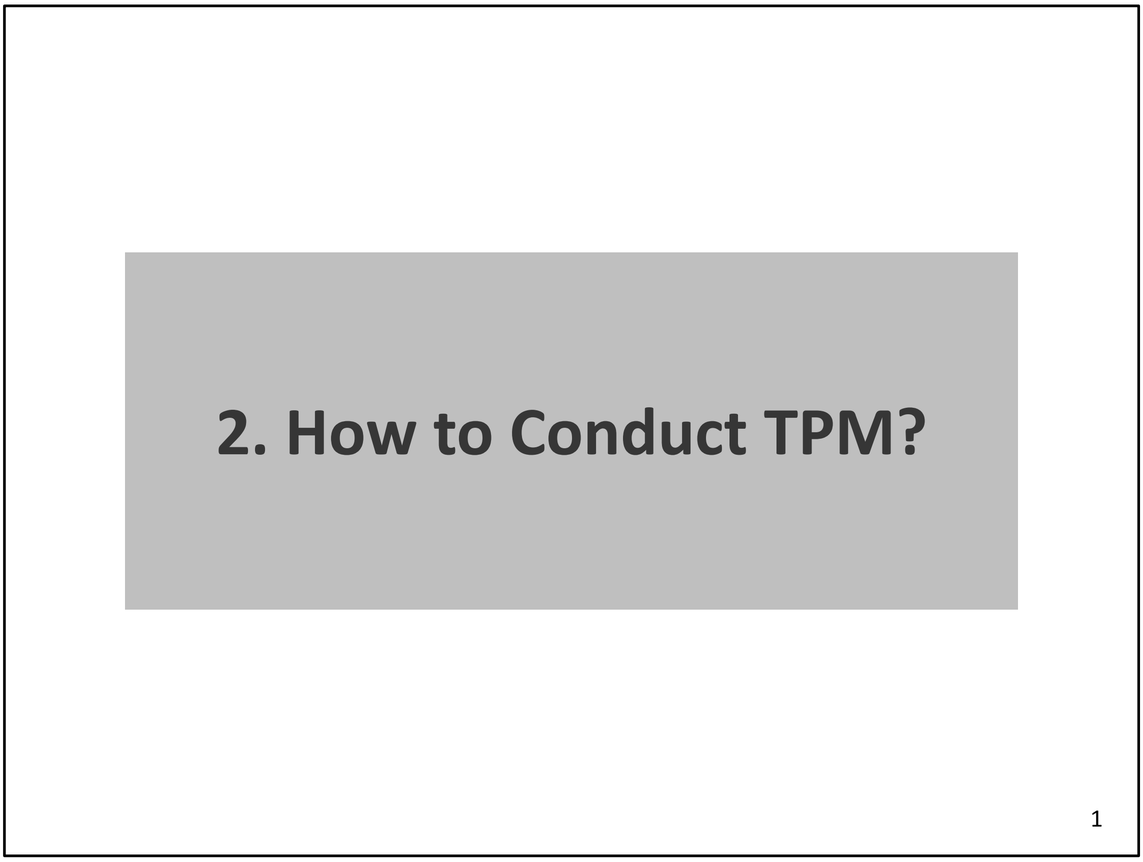
When carrying out Autonomous Maintenance, follow the above steps.




## 2. How to Conduct TPM?

# 2.1 Program of TPM Activities

**Preparation**

a. **Setup of Steering Committee organization for TPM Project**
b. **Education for Members of Steering Committee/ KPT or CFT**
c. **Making of the Project Plan by Steering Committee/ KPT or CFT**
d. **Kick-off ceremony**

| Project target: Pilot Machine | | Company target: All Machines |
|---|---|---|
| **Step- 1. Downtime Data Collection** | **Step-2. O.E.E. Calculation ~ Status-quo/ Before Kaizen ~** | **Step-9. Setup of the organization for Company-wide TPM** |
| ・ Breakdown | **Step-3. Cause Analysis** | **Step-10. Education for employees** |
| ・ Set-up & Adjustment | **Step-4. Countermeasure Setup** | **Step-11. Make the Master Plan by TPM committee** |
| ・ Idling time & Minor Stoppages | **Step-5. Implementation** | **Step-12. Kick-off ceremony** |
| ・Change of Jigs | **Step-6. O.E.E. Calculation ~ After Kaizen ~** | **Step-13. Autonomous Maintenance** |
| ・ Speed Loss | **Step-7. Evaluation of results** | **Step-14. Monitoring by Patrol** |
| ・ Defects & Reworks | **Step-8. Standardization** | **Step-15. Planned Maintenance** |
| ・ Start up | | |

2

### 2.1 Program of TPM Activities

This section introduces a series of activities on introducing and implementing TPM technology in a company.

First, launch the Steering Committee/ KPT or CFT to run the TPM Project. The members and others prepare for the educational program. Educate it to engineers in each section of the manufacturing department about TPM technology and show how to proceed. After that, select a Model-Machine at each department site and conduct OJT. After confirming that the productivity of machinery and equipment has been improved, the program is rolled out to all major machines in each department.

**Preparation: Setup Steering Committee/ KPT or CFT Organization for TPM Project**

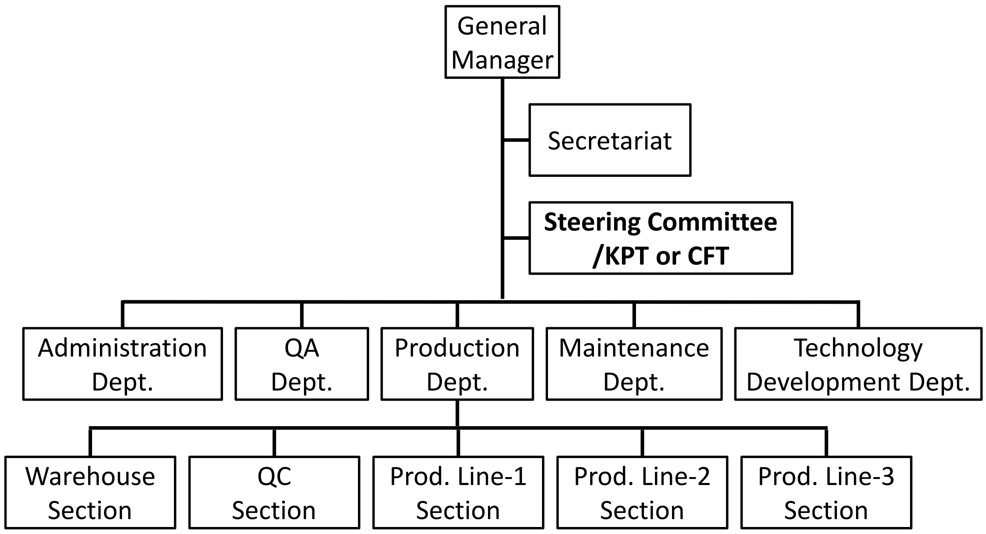



Fig-1

3

This is a diagram showing the structure of the Steering Committee/KPT. The head of each department, who participates in the Steering Committee as a representative, is consulted as an observer and responsible for coordinating the promotion. There are several mid-level employees here, who are responsible for supporting the activities of all departments during the actual TPM activity process.

**Preparation: Education for Members of Steering Committee /KPT or CFT ~ Familiarization ~**

<**TPM Program**>

a) Introduce the basis of the TPM concepts such as 7 big losses and availability rate, performance rate & O.E.E.

   note: Introduce the concept of **Overall Equipment Effectiveness (O.E.E.)** as an evaluation method.

b) Show how to setup TQM organization

c) Show the roles of the top management and the members of steering committee/ KPT

d) Show the steps to conduct TPM to the top management and managers in charge of maintenance and production departments

e) Facilitate a discussion of Autonomous Maintenance performance at the workplace.

4

First, the contents of the TPM Program are shown as one of the knowledge shared by the members of the Steering Committee/ KPT or CFT.

The detail description is omitted.

## Preparation: Making of the Project Plan by EKI Consultants and KPT or CFT Members in the company

| | Dec,2017 | Jan,2018 | Feb. | Mar. | Apr. | May | Jun. |
|---|---|---|---|---|---|---|---|
| a) Education on TPM Concept & How to conduct TPM Activity | ······→ | | | | | | |
| b) Committee Meeting with the top management | | ··→ | | | | | |
| c) Confirmation of Business Policy and setup Project Theme | | ··→ | | | | | |
| d) Data & Info. Collection and the analysis & summary | | | ······→ | | | | |
| e) Root cause analysis and Countermeasure setup | | | | ······→ | | | |
| f) Implementation | | | | | ······· | ······· | ··→ |
| g) Evaluation of results | | | | | | | ··→ |

5

This table shows a Project Plan for a Model-Machine for a pilot-run.

## 2.2 Step-1. Downtime Data Collection

**Macro Analysis on Time Losses**

- Summarize the **downtime data** whose frequency is to be identified into **chronic** or **sporadic** occurrence. The data collection period should be at least more than **six(6) months**.

**~ Explain loss definition ~ (Categories)**

1) Breakdown
2) Set-up & Adjustment
3) Change of jigs
4) Speed loss
5) Idling time & Minor stoppages
6) Defects & Re-works
7) Start up

- Address the time losses relevant to the model machine into above **Seven(7) categories**

6

**2.2 Step-1. Downtime Data Collection**

First, for the model-machinery and equipment to be improved, the 7 big losses that are reducing productivity are sorted into each category, and the degree of time for each of them is arranged in the unit of hour.

## Downtime Data

| Status-quo before Kaizen | | Expectation after Kaizen | |
|---|---|---|---|
| **1. Breakdown** | 500 **hrs.** | ⟶ | **hrs.** |
| **2. Set-up & Adjustment** | 1,500 **hrs.** | ⟶ | **hrs.** |
| **3. Change of Jigs** | 70 **hrs.** | ⟶ | **hrs.** |
| **4. Speed loss** | 210 **hrs.** | ⟶ | **hrs.** |
| **5. Idling time & Minor stoppages** | 70 **hrs.** | ⟶ | **hrs.** |
| **6. Defects & Re-works** | 220 **hrs.** | ⟶ | **hrs.** |
| **7. Start-up** | 30 **hrs.** | ⟶ | **hrs.** |
| **Confirm in percentage the project goal in relation to the targeted items** | | | |

7

Next, decide how much you want to reduce the time of 7 Big losses expected as a project for improvement.

## 2.3 Step-2. O.E.E. Calculation ~ Status-quo/ Before Kaizen ~

- Calculate the Availability Rate of Status-quo
- Calculate the Performance Rate of Status-quo
- Calculate the Good Quality Rate of Status-quo
- Calculate the Overall Equipment Effectiveness (O.E.E.) of Status-quo

~ Set-up of Project Goal as expected O.E.E. ~

8

**2.3 Step-2. O.E.E. Calculation ~ Status-quo/ Before Kaizen ~**

The Availability Rate, Performance Rate, Good Quality Rate and Overall Equipment Effectiveness (O.E.E.) are calculated before and after Kaizen using the numerical values of the 7 Big losses in the table “Downtime Data”.

## 2.4 Step-3. Cause Analysis

- Select several big downtime losses
- Discuss on the causes of downtime at the shop floor by members of EKI Consultants and Cross Function Team (CFT)
- Draw the relationship between the phenomena of downtime and the source of downtime with showing the mechanism.

  c.f. "PM Analysis"(Physical Phenomena Mechanism Analysis)

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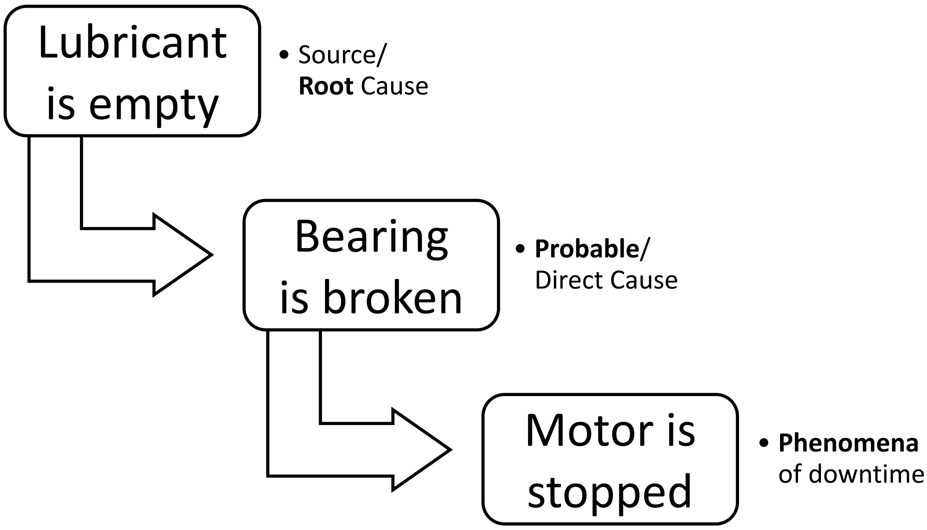
**2.4 Step-3. Cause Analysis**

When collecting data on the 7 Big losses, the loss of time should be known for the details. It is better to select a dozen or more of those times from the large values and express them in the Pareto diagram.

Perform a Cause Analysis by selecting only items that occupy about 80% of the total in the Pareto diagram. In that case, the method of Physical Phenomena Mechanism Analysis II (PM Analysis) is effective.

Example: Root Cause Analysis on Motor Breakdown Mechanism




10

An example of how to use PM Analysis is shown in this Scheme.

Why did the failure (here, Phenomena) occur? Because Bearing was damaged.

So why was Bearing damaged to be loosed? Because Lubricant was gone.

The empty lubricant is the Root Cause. By illustrating those relationships, the mechanism of the problem occurrence can be clarified.

## 2.5 Step-4. Countermeasure Setup

| Steps | Key Points | Activities |
|---|---|---|
| • **Breakdown time** | ~ Cause Investigation ~ | 5 Activities for Zero Breakdown |
| • **Set-up & Adjustments time** | ~ One cycle by bar drawing ~<br>~ Parallel work ~ | External and Internal Setup |
| • **Idling & Minor Stoppages time** | | |
| • **Jig Change time** | | |
| • **Speed Loss time** | Optimal conditions | |
| • **Defects & Reworks time** | Reduction of defects | Problem solving by QC, or Physical Phenomena Mechanism Analysis |
| • **Start up time** | | |

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**2.5 Step-4. Countermeasure Setup**

If you find the root cause in PM Analysis, you can take countermeasures using engineering technics of common sense.

There are many Losses that can be improved more easily.

The table shows the general method of TPM, which has already been explained in detail in the introduction of Points of TPM Concept.

# 2.6 Step-5. Implementation

- Pilot Run of countermeasures

| Activities | Apr., 2018 | May | Jun. |
|---|---|---|---|
| • Preparation | ・・・→ | | |
| • Countermeasure Trial with temporary manual | ・→ | | |
| • Check-up the results | ・→ | | |
| • Revision of the countermeasure, or select alternatives | | ・・・・・・・・・・→ | |
| • Confirmation of the best countermeasure | | | ・→ |
| • Standardization | | | ・→ |

12

**2.6 Step-5. Implementation**

This is a sample of a series of actions when Countermeasure is executed.

## 2.7 Step-6. O.E.E. Calculation ~ After Kaizen ~

Collect the downtime & the loss time data as “after Kaizen”, and calculate the following items

a) the Availability Rate

b) the Performance Rate

c) the Good Quality rate

d) the Overall Equipment Effectiveness (O.E.E.)

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**2.7 Step-6. O.E.E. Calculation ~ After Kaizen ~**

The value of the time data collected after the countermeasures have been performed is arranged into 7 Big losses, and the Availability Rate, Performance Rate, Good Quality Rate and O.E.E. are calculated in the same manner as before the improvement.

# 2.8 Step-7. Evaluation of Results

~ Compare Availability Rate, Performance Rate and O.E.E. between before and after Kaizen ~

| | Before | After | Improved Ratio |
|---|---|---|---|
| **Availability Rate** | | | |
| **Performance Rate** | | | |
| **Good Quality Rate** | | | |
| **O.E.E.** | | | |

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**2.8 Step-7. Evaluation of Results**

Next, calculate the degree of improvement on Availability rate, Performance rate, Good quality rate and O.E.E.

The above table shows the rate of increase of each Rate. It is easy to recognize the improvement.

## 2.9 Step-8. Standardization

Standard Operating Procedure (S.O.P.)

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### 2.9 Step-8. Standardization

For the countermeasures with good Kaizen results, indicate the work procedure as Standard Operating Procedure (S.O.P.) and document it.

That is a series of exercises on Kaizen's technical method in Pilot-run of TPM activity so far.

Let’s enter the full-scale company-wide TPM activity from the next page.

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# 2.10 Step-9. Setup of TPM Steering Committee/ KPT or CFT

・Organize TPM core group under the top management ・ Set-up regular meetings

| Members | Sub-Members | Roles |
|---|---|---|
| **Executives Facilitators/ Core Group** | | Patrol<br>Making of Master Plan |
| **Production Manager/ Director** | | Patrol<br>Autonomous Maintenance |
| **Maintenance manager** | Technical Staff | Planned Maintenance<br>Technical Improvement |
| **Line Managers** | Leaders | Pilot-run<br>Data collection on downtime |
| **QA Manager** | QCC Leaders | Data collection on defects |
| **Manager of Training Center** | Trainers/Staffs | Coordination<br>Education |

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**2.10 Step-9. Setup of TPM Steering Committee/ KPT or CFT**

In response to the company-wide TPM Project, each manufacturing department forms a TPM implementation department Group. The managers and their subordinates have the roles shown in the table.

## 2.11 Step-10. Education for Employees

- How to take downtime data
- How to fill the data into a check-sheet
- How to implement autonomous maintenance
- such as daily inspection, cleaning, oiling and bolt-tightening

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**2.11 Step-10. Education for Employees**

Educate technical staffs and workers working on the Front Line as an executing unit of the TPM Project about the tasks which they actually need to perform.

## 2.12 Step-11. Making of the Master Plan by EKI Consultants and CFT Members

Make a master plan of TPM activities in order to achieve **company-wide goal for three years**.

note; Master Plan will be prepared by Facilitators/ Core Group

~ Role of each Group ~

Each leader considers Action Plan for the group

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### 2.12 Step-11. Making of the Master Plan by EKI Consultants and CFT Members

Members of the Steering Committee will set a three-year goal for the master plan of TPM to be implemented company-wide.

Example: **Master Plan** Continue to 2

| **Stage** | **Preparation**<br>(Introduction by TPM Committee) | **Development**<br>(Activities by Project Team) |
|---|---|---|
| Activities Categories | **Apr. May. Jun. Jul. Aug. Sep.** | **Oct. Nov. Dec. Jan. Feb. Mar.** |
| · **Strategy making of TPM**<br>TPM Committee<br>Core Group | Setting of **TPM Purpose/ Pillars**<br>Scheduling of **Patrol and Award Event**<br><br>TPM **Campaign/ Kick-off Ceremony** | **TPM Goal Setup**<br><br>➢ Model machine selection<br>➢ O.E.E. Computation |
| · **Education**<br>Production Dept.<br>Small Group | TPM Concept/ Tools<br>> Data Analysis<br>> Loss Definition<br>> **Evaluation Method (O.E.E.)** | |
| · **Autonomous**<br>Production Dept.<br>Small Group | | **5S Practice** - The preparation of 5S standard -<br>(Temporary Manual)<br>> Cleaning & Oiling<br>> Inspection Checklist<br>**Optimal Operating Conditions**<br>(Temporary Manual) |
| · **Planned Maintenance**<br>Maintenance Dept.<br>Small Group | **Data Collection** on Downtime<br>(Chronic Failure) | Physical Analysis on Breakdown<br>~ Cause Investigation ~<br>**Countermeasure Establishment**<br>(Temporary Manual)<br>CBM & TBM Establishment |

20

Here is an example of a master plan. This shows preparations such as demonstrations performed by members of the TPM Committee in the first half of the first year, and the activities actually performed by Project Team members in each department from the second half. Detailed description is omitted.

Example: **Master Plan** -2

| Stage | Implementation (Pilot-run by Project Team) | | | | | | | Promotion (Company-wide Activities) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activities categories | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sep.** | **Oct.** | **Nov.** | **Dec.** | **Jun.** | **Feb.** | **Mar.** |
| · **Strategy making of TPM**<br>TPM Committee<br>Core Group | First Patrol | | Second Patrol | | Third Patrol | | | Regular Monthly Patrol<br>**Yearly Award** | | | | |
| · **Education**<br>Production Dept.<br>Small Group | Skill Training<br>**Corrective Actions** | | | | | | | Skill Training<br>Corrective Actions | | | | |
| · **Autonomous Maintenance**<br>Production Dept.<br>Small Group | ← **5S Activities** on Model machine, →<br>Monitoring,<br>5S Manual<br>Operational Manual | | | | | | | ← **5S Activities** →<br>by operators themselves | | | | |
| · **Planned Maintenance**<br>Maintenance Dept.<br>Small Group | ← **Preventive maintenance** →<br>activities on model machine,<br>Monitoring,<br>Preventive Maintenance Manual | | | | | | | ← **Preventive Maintenance** →<br>activities on other machines<br>by technicians in Maintenance division | | | | |

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Following the previous page, the activities to be performed in the next year are introduced. The first six months show the contents of Pilot-run by the Project Team. The latter half of the year shows activities that are carried out by company-wide activities. Here, the detailed explanation is omitted.

## 2.13 Step-12. Kick-off Ceremony

Declare TPM Project by the **vice-president** in **a kick-off ceremony**.

Demonstrate cleaning a model machine as the pilot run at the workplace in the presence of vice-president and the top management.

Prepare TPM campaign with company's philosophy & policy

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**2.13 Step-12. Kick-off Ceremony**

Here, I will introduce the procedure for starting the company-wide TPM Project under presence of the president.

First, a Kick-off Ceremony will be held, and the Vice President himself will demonstrate the importance of the TPM Project and the necessity of implementing the whole company together and show that it is a strong will of the President.

At that time, the company philosophy and vision will be prepared as a part of the TPM campaign.

## Plant Observation

- Familiarize self with the plant equipment and production process
  by using **a flow chart** and conducting a plant observation.

- Acquaint self with **the common problems** of an equipment's dysfunction and **its impact** to the production process.

< **Model Machine Selection** >

- Select one machine with **a major chronic downtime**. Label it as **a model machine** and implement the TPM program on this machine.

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At Kick-off Ceremony, we will continue to conduct Plant Observation at the site of TPM Project Start. In addition, a Model-Machine at the site is introduced

## 2.14 Step-13. Autonomous Maintenance

**Daily work of 4 Activities**

- Cleaning
- Bolt tightening
- Oiling
- Inspection

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### 2.14 Step-13. Autonomous Maintenance

This is one of the most important necessary activities in the TPM Project. It is a daily activity called Autonomous Maintenance and the most encouraged work.

In other words, it refers to four operations: Inspection, Cleaning, Bolt tightening, and Oiling.

## 2.15 Step-14. Monitoring by Patrol

- Plant Observation by the patrol with the top management and TPM members
- Check of continuous Kaizen activity

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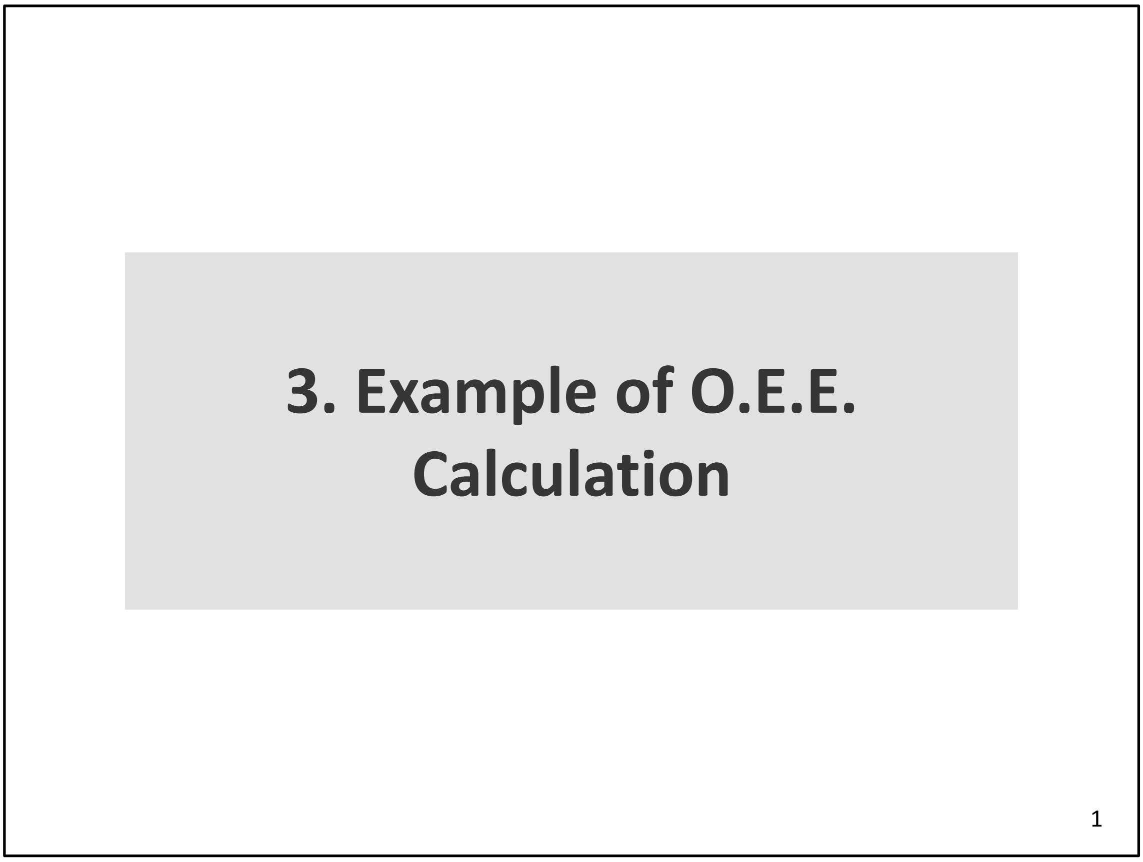
**2.15 Step-14. Monitoring by Patrol**

During this project, Top Management and Steering Committee members will work together on regular patrols to understand the status of implementation, evaluate it and give appropriate advice.




**3. Example of O.E.E. Calculation**

Here, we will use the 7 Big Losses values given by assumptions. And we will calculate the indicators to evaluate the productivity of machinery and equipment such as Availability rate, Performance rate, Good Quality Rate and Overall Equipment Effectiveness (O.E.E.)

## 7 Big Losses Data

**(Assumed value)** 300 days/ year

| Big Losses | Case -1 | Case - 2 |
|---|---|---|
| **1. Breakdown** | 1,250 (hrs.) | 500 (hrs.) |
| **2. Set-up & Adjustment** | 200 → | ***Kaizen*** 100 |
| **3. Change of Jigs** | 40 | 30 |
| **4. Speed Loss** | 200 | 100 |
| **5. Idling time & Minor Stoppages** | 100 | 50 |
| **6. Defects & Reworks** | 100 | 50 |
| **7. Start-up** | 10 | 10 |
| **Total time** | 1,900 (hrs.) | 840 (hrs.) |

2

Regarding 7 Big Losses Time Data (values given as assumption), the current level is assumed to be Case-1, and the values assuming that Loss time has been shortened by Kaizen activity are shown in Case-2.

## Time Balance Table

<table>
<tr><td colspan="5">Total available time for operation- (a)<br>300 days X 24 hrs. = 7,200 hrs/ year</td></tr>
<tr><td colspan="4">Loading Time/ Net available time<br>(a) - (b) = 7,200 - 1,440 hrs. = 5,760 hrs./ year</td><td>(b) Shutdown<br>Scheduled Breaks<br>Maintenance time<br>Daily meeting time<br>No order/ demand<br>Precautionary time</td></tr>
<tr><td colspan="3">Actual operating time<br>Case-1 (a) - (b) - (c) = 5,760 - 1,490 = 4,270 hrs.<br>Case-2 (a) - (b) - (c) = 5,760 - 630 = 5,130 hrs</td><td>(c) Downtime<br>1. Breakdown<br>2. Setup & Adjustment<br>3. Change of Jigs</td><td></td></tr>
<tr><td colspan="2">Net actual operating time<br>Case-1 (a) - (b) - (c) - (d) = 4,270 - 300 = 3,970 hrs.<br>Case-2 (a) - (b) - (c) - (d) = 5,130 - 150 = 4,980 hrs</td><td>(d) Loss Time<br>4. Speed Loss<br>5. Idling time & Minor Stoppages</td><td></td><td></td></tr>
<tr><td>Value operating time<br>Case-1 (a)-(b)-(c)-(d)-(e)<br>= 3,970-110= 3,860 hrs.<br>Case-2 (a)-(b)-(c)-(d)-(e)<br>= 4,980- 60= 4,920 hrs</td><td>(e) Loss Time<br>6. Defects & Reworks<br>7. Start up</td><td></td><td></td><td></td></tr>
</table>

$$\textbf{Availability Rate} = \frac{(a - b - c)\ X100\ (\%)}{(a - b)}$$

**Loading time (Net availability time of equipment) = (a - b)**
**Actual operating time = (a - b - c)**

$$\textbf{Performance Rate} = \frac{\text{Ideal cycle time X Outputs X100 (\%)}}{\text{Actual operating time}}$$

3

Next, it is shown in the Time Balance Table whether these 7 Big Losses relate to the available time, the performance time, and the time when good quality products can be produced for machinery and equipment.
The formulas for calculating Availability Rate and Performance Rate are listed below the table.

## Status-quo/ Before Kaizen

$$\text{Availability Rate} = \frac{(a - b - c) \times 100\ (\%)}{(a - b)} = \frac{4{,}270 \text{ hrs} \times 100\ (\%)}{5{,}760 \text{ hrs}} = 74.1\ (\%)$$

Loading time (Net available time)=(a - b) = (7,200 - 1,440) = 5,760 hrs
Actual operating time = (a - b - c) = (7,200 - 1,440 - 1,490) = 4,270 hrs

$$\text{Performance Rate} = \frac{\text{Ideal cycle time} \times \text{Outputs} \times 100\ (\%)}{\text{Actual operating time}}$$

$$= \frac{10 \text{ min.} \times 9{,}600 \text{ pcs} \times 100\ (\%)}{4{,}270 \text{ hrs}} = 37.5\ (\%)$$

| | | |
|---|---|---|
| Outputs: | n1 : (No. of good-finished) | = 9,000 pcs |
| | n2 : (No. of defects and reworks) | = 600 pcs |
| Start-up loss: | n3 : (No. of material wastes) | = 60 pcs |
| Ideal cycle time: | Ict : 10 min. /pcs | |

(Note) Outputs is the total number of good-finished products (n1) and defects & reworks (n2)

4

Availability Rate is the ratio of Actual operating time (a - b - c) to Loading Time, or Net available time (a - b)
The ratio of (7,200-1,440-1,490 = 4,270 hrs) to (7,200-1,440 = 5,760 hrs) is calculated.
On the other hand, Performance Rate is the ratio of the time required to obtain Outputs with respect to Actual Operating Time (a - b - c). It is calculated by multiplying the number of Outputs by the time required to make one piece. The time taken to make one piece here is called Cycle Time, and the Designed Time is called Ideal Cycle Time. In general, when the machine becomes old and the production speed slows, the cycle time becomes longer and the number of Outputs decreases. The number of Outputs is the sum of the number of good-finished products and the number of defects and reworks. It is assumed here that the ideal cycle time is 10 min./piece, the number of good-finished is 9,000 pcs, and the number of defects and reworks is 600 pcs, so the total is 9,600 pcs. Therefore, the performance rate is calculated to be 37.5 (%) as 10 min./pcs(=0.167hr/pcs) X 9,600 pcs X 100 (%) divided by 4,270 hrs.

$$\textbf{Good Quality Rate} = \frac{n1}{n1 + n2 + n3} \text{ X } 100(\%)$$

$$= 9{,}000/9{,}660 \text{ X } 100(\%) = 93.2\ (\%)$$

| | | | |
|---|---|---|---|
| Outputs: | n1 : (No. of good-finished) | = | 9,000 pcs |
| | n2 : (No. of defects and reworks) | = | 600 pcs |
| Start-up loss: | n3 : (No. of material wastes) | = | 60 pcs |

**Overall Equipment Effectiveness (O.E.E.) =**

Availability Rate X Performance Rate X Good Quality Rate = 24.8 (%)

5

Next, the formula for calculating the Good Quality Rate and Overall Equipment Effectiveness are listed.

## After Kaizen

$$\text{Availability Rate} = \frac{(a - b - c)\ X100\ (\%)}{(a - b)} = \frac{5{,}130\ \text{hrs}\ X100\ (\%)}{5{,}760\ \text{hrs}} = 89.1\ (\%)$$

Loading time (Net availability) = (a - b) = (7,200 - 1,440) = 5,760 hrs
Actual operating time = (a - b - c) = (7,200 - 1,440 - 630) = 5,130 hrs

$$\text{Performance Rate} = \frac{\text{Ideal cycle time X Outputs X100 (\%)}}{\text{Actual operating time}}$$

$$= \frac{10\ \text{min. X}\ 14{,}560\ \text{pcs X}\ 100\ (\%)}{5{,}130\ \text{hrs}} = 47.3\ (\%)$$

| | | |
|---|---|---|
| Outputs: | n1 : (No. of good-finished) | = 14,160 pcs |
| | n2 : (No. of defects and reworks) | = 400 pcs |
| Start-up loss: | n3 : (No. of material wastes) | = 60 pcs |
| Ideal cycle time: | Ict : 10 min./pcs | |

(Note) Outputs is the total number of good-finished products (n1) and defects & reworks (n2)

6

Subsequent pages show that calculations similar to those described above are performed to evaluate how much the productivity of machinery and equipment has improved after the Kaizen activity. The detail description is omitted.

**Good Quality Rate =** $\dfrac{n1}{n1 + n2 + n3}$ X 100(%)

= 14,160/14,620 X 100(%) = 96.9 (%)

| | | | |
|---|---|---|---|
| Outputs: | n1 : (No. of good-finished) | = | 14,160 pcs |
| | n2 : (No. of defects and reworks) | = | 400 pcs |
| Start-up loss: | n3 : (No. of material wastes) | = | 60 pcs |

**Overall Equipment Effectiveness (O.E.E.) =**

Availability Rate X Performance Rate X Good Quality Rate = 40.8 (%)

7

Here is the same as above

## O.E.E. Calculation

**Before**

Ict: min. /piece, n1 : pieces/year
n2: pieces/year, n3:pieces/year
a: Total available time for operation
b: Shutdown
c: Downtime

**After**

Ict: min. /piece, n1': pieces/year
n2': pieces/year, n3':pieces/year
a': Total available time for operation
b': Shutdown
c': Downtime

| | Before | After |
|---|---|---|
| Availability Rate | $\frac{(a - b - c) \times 100 (\%)}{(a - b)}$ = 74.1 (%) | $\frac{(a' - b' - c') \times 100 (\%)}{(a - b)}$ = 89.1 (%) |
| Performance Rate | $\frac{Ict \times (n1+n2) \times 100 (\%)}{(a - b - c)}$ = 37.5 (%) | $\frac{Ict \times (n1'+n2') \times 100 (\%)}{(a - b - c)}$ = 47.3 (%) |
| Good Quality (finished) Rate | $\frac{n1 \times 100(\%)}{n1 + n2 + n3}$ = 9,000/9,660 = 93.2 (%) | $\frac{n1' \times 100(\%)}{n1' + n2' + n3'}$ = 14,160/14,620 = 96.9 (%) |
| Overall Equipment Effectiveness | $\frac{(a-b-c) \times Ict \times (n1 + n2) \times n1 \times 100 (\%)}{(a-b) \times (a-b-c) \times (n1 + n2 + n3)}$ = 0.71 X 0.375 X 0.932 = 24.8 (%) | $\frac{(a'-b'-c') \times Ict \times (n1' + n2') \times n1' \times 100 (\%)}{(a'-b') \times (a'-b'-c') \times (n1'+ n2'+ n3')}$ = 0.891X 0.473 X 0.969 = 40.8 (%) |

8

This is the comparison of the values before and after improvement in the list for each Rate.

# PRODUCTION PLANNING

# Production Planning

1

## Contents



2

# 1. Production Planning Outline (What is Production Planning?)

- To determine what, when and how many to make
- To secure profitability, quality, and on-time delivery
- To run management cycle
  (Plan, do, check and action )

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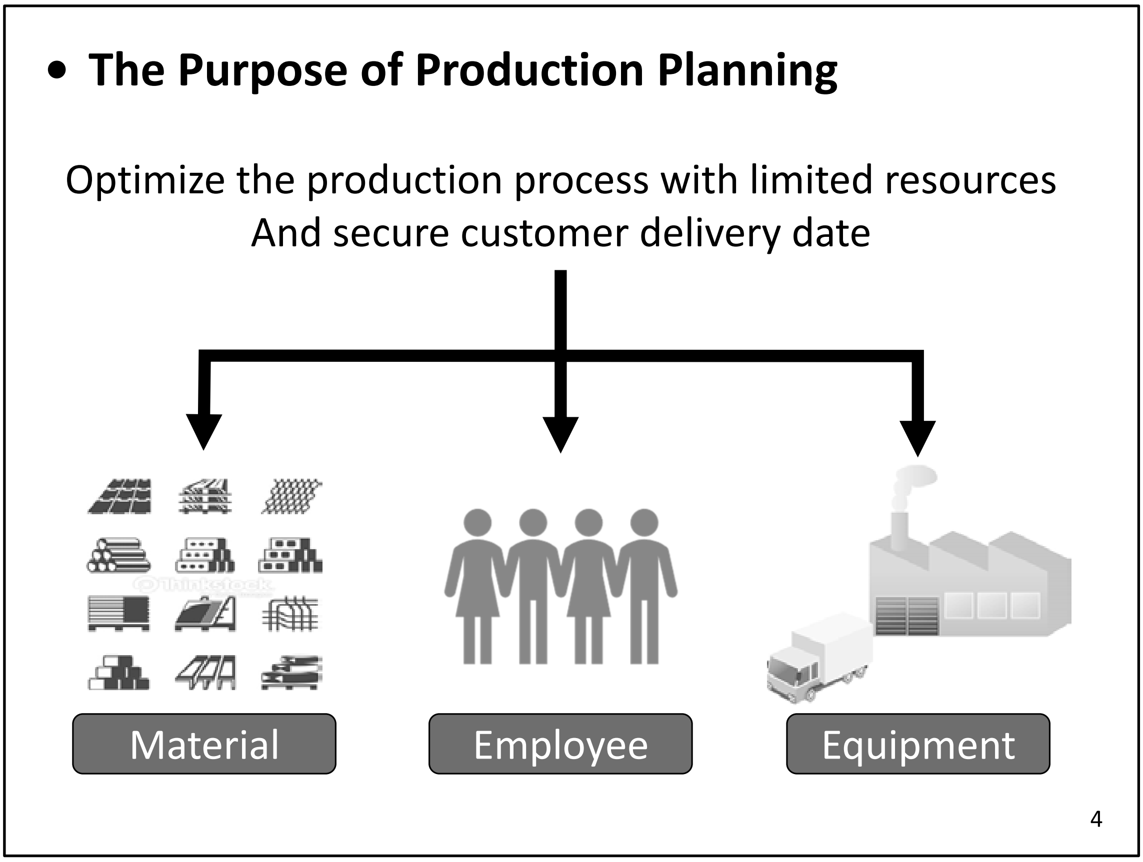
1. Production Planning Outline (What is Production Planning?)




- **The Purpose of Production Planning**

  The purpose of production planning is to optimize the production process with limited resources and secure customer delivery date.

- **The Plans to be Made**

  - Production process sequence (BOM)
  - Production schedule
  - Resource allocation

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- **The Plans to be Made**

  There are three plans to be made to start production.

  Production process sequence (BOM), production schedule, and resource allocation

  We will go through each of these.

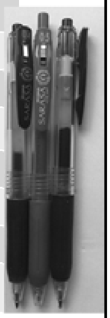
## • Production Sequence

Instruct who to make, what to be used, for which process

in sequential and structural order ➡ Bill of Material (BOM)

- SARASA, Black
  - Case Upper, Black assy
    - Case Upper
    - Clip,Black
    - Button,Black
    - Pusher
    - Plate Spring
  - Case Lower, Black assy
    - Case Lower
    - Rubber, Black
  - Ink Cartridge, Black
  - Coil Spring

| Seq. | Description | Use | Material | Process | Supplier |
|---|---|---|---|---|---|
| 0 | SARASA,Black | 1 | NA | Assembling | In-house |
| 1 | Case Upper, Black assy | 1 | NA | Assembling | In-house |
| 2 | Case Upper | 1 | PMMA | Molding | In-house |
| 2 | Clip, Black | 1 | ABS | Molding | Addis Plastics |
| 2 | Button, Black | 1 | ABS | Molding | Addis Plastics |
| 2 | Pusher | 1 | PP | Molding | Addis Plastics |
| 2 | Plate Spring | 1 | SUS | Stamping | In-house |
| 1 | Case Lower,Black assy | 1 | NA | Assembling | In-house |
| 2 | Case Lower | 1 | PMMA | Molding | In-house |
| 2 | Rubber, Black | 1 | NBR | RIM | Sheba Rubber |
| 1 | Ink Cartridge, Black | 1 | NA | Ink mfg. | Anbessa Inks |
| 1 | Coil Spring | 1 | SWC | Rolling | Addis Springs |



6

- **Production Sequence**

The first plan is production sequence, in other words, Bill Of Material (BOM).

BOM is to instruct who to make, what to be used, for which process in sequential and structural order.

The BOM in the slide is for a ball point pen called "SARASA" shown in the picture.

The left side shows a structure of SARASA in tree shape.

As top level, the pen comprises of four parts, Case Upper Black assy, Case Lower assy, Ink Cartridge, Black, and Coil Spring.

Those four parts are made from the components shown in the tree as second level. Case Upper, Black assy is made with Case Upper, Clip, Black, Button, Black, Pusher, and Plate Spring. Other three parts also have components shown in tree.

Right side shows Sequence, description, Use, Material, process, and supplier of every SARASA parts.

The Use is how many pieces of this parts are used to make one SARASA.

Take Case Upper as an example. The sequence of Case Upper is 2. This indicates this parts is used for Sequence 1 parts, Case Uper, Black assy.

The Use of Case Upper is 1, means one piece of Case Upper is used to make one of SARASA. The Material is PMMA, the Process is molding, and the supplier is in-house, which means the manufacturer of SARASA makes Upper Cover by itself.

Above all, the bill of material includes all kind of information to make one SARASA pen.

- **Production Schedule**

Instruct which product to make, when to make and how many to make

➡ Spreadsheet

| Week | 17/12/4 | 17/12/11 | 17/12/18 | 17/12/25 | 18/1/1 | 18/1/8 | 18/1/15 | 18/1/22 | 18/1/29 |
|---|---|---|---|---|---|---|---|---|---|
| Customer order | 1200 | 960 | 1000 | 920 | 1240 | 1160 | 1080 | 1000 | 920 |
| Opening balance | 1200 | 1000 | 1040 | 1040 | 1120 | 920 | 800 | 760 | 800 |
| Production | 1000 | 1000 | 1000 | 1000 | 1040 | 1040 | 1040 | 1040 | 1040 |
| Closing balance | 1000 | 1040 | 1040 | 1120 | 920 | 800 | 760 | 800 | 920 |

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- **Production Schedule**

  The second plan of three production is production schedule.

  Production schedule is to instruct production people which product to make, when to make and how many to make.

  The schedule can be expressed in a spreadsheet like this slide.

  This spreadsheet shows that customer order, opening balance, production, and closing balance by week.

  Production quantity should be determined based on customer order and stock condition of the product, which is Opening balance in the spreadsheet.

  We will learn later how we calculate production quantity based on the Customer order and Opening balance.

  The closing balance is the product stock after production and shipment to customer.

# • Resource Allocation

| Process | Product | Production Qty (pcs/day) | Required production time (hrs/day) | No.of workers available | workers available as hours | No.of machines available | Machines available as hours | Load (%) 50% 100% 150% |
|---|---|---|---|---|---|---|---|---|
| Assembling | SARASA, Black | 1200 | 18.9 | 3 | 21 | N/A | N/A | |
| Molding | Case Lower | 1200 | 25 | 1 | 7 | 3 | 22 | |
| Stamping | Plate Spring | 1200 | 7.1 | 1 | 7 | 1 | 7.5 | |

Question : What is overburden in this plan?

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- **Resource Allocation**

  The third plan of three production is resource allocation.

  The resource allocation is a resource requirement plan to determine the number of machines or operators and work hours.

  Here in this slide, the assembling process of SARASA, Black needs to produce 1200 pcs of SARASA, Black a day and work for 18.9 hours with three operators.

  Total available time of three operators is 21 hours. Load percent is 18.9 hours divided by 21 hours equals 90%.

  The molding process needs to produce 1200 pcs of Case Lowe with 3 machines and one operator a day. The Load percent is 25 hours of required production time divided by 22 hours of machine available hours equals 113%.

  If the Load % is above 100%, it means overburden and requires to work overtime.

  The calculation of required production time is explained later in this class.

- **Set Targets and Check for better Planning**
  - Productivity
  - On-time delivery %
  - Inventory

Actions must be take if the target is not met

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- **Set Targets and Check for better Planning**

  Production planning is a part of PDCA cycle.

  Targets should be set prior to production as this slide shows.

  Based on the targets, production plan should be made.

  For example, if productivity target is 5% better than current, required production time in resource allocation should be 5% less than the calculated time.

  After production is completed, see if the targets are met or not.

  Based on the result, the way of production planning should be reviewed and modified if needed.

  For example, if the inventory result is worse than the target and it is due to inaccuracy in forecasting customer order, production planning needs to modify how customer orders are forecasted.

## 2. Customer Order Decoupling Point (CODP)

- Traditionally defined as the point in the value chain for a product, where the product is linked to a specific customer order.
- The point at which demand changes from independent to dependent.
- It is the point at which the firm becomes responsible for determining the timing & quantity of material to be purchased, made, or finished.
- It's the last point at which inventory is held.
- The CODP divides operations stages:
  Forecast-driven (upstream of CODP)
  Customer order driven (the CODP and downstream).

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**2. Customer Order Decoupling Point (CODP)**

The definition of customer order decoupling point is;

- **Background of CODP**
  - Coined in 1985, by Hoekstra and Romme
  - Widely used in Production and manufacturing fields
  - Main content of research topics on postponement strategies
  - Concept emerged to structure the value streams of different product-market combinations with regards to role of stock points.
  - These points are vital in optimizing supply chain.

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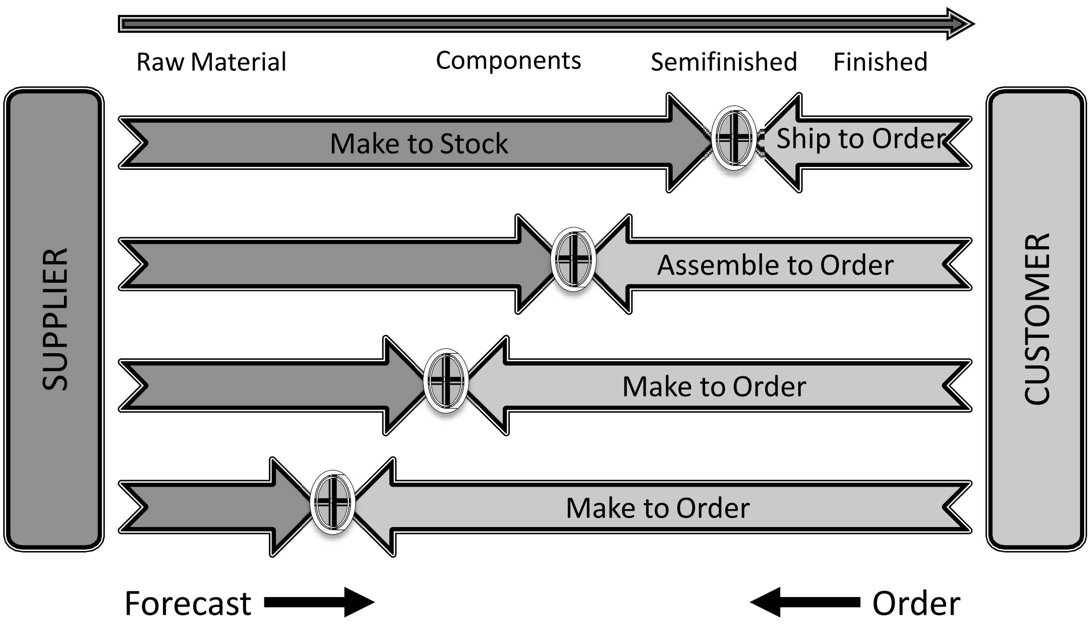
- **Background of CODP**

  The background of CODP is;

- **Positioning Inventory in Supply Chain**

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- **Positioning Inventory in Supply Chain**

  The positions of decoupling and ways to order are expressed in this chart.

  Top one has a decoupling point at the Finished in the supply chain.

  From Raw Material to Semifinished, production is Make to Stock.

  Finished goods is shipped to order.

  Second one has a decoupling point at the Component in the supply chain.

  In this supply chain, Raw Material and components are made to stock, Semifinished and Finished are assembled to order.

  We determine decoupling point based on how we manage supply chain as next shows.

- **Upstream of CODP**
  - Goods flow control upstream of the CODP is forecast-driven
  - Push production is governed by forecasts & assumptions about status of shop floor
  - Lead Time increases from M-T-S to E-T-O
- **Downstream of CODP**
  - Activities in the goods flow are planned and controlled based upon actual customer orders
  - Order-driven being equivalent to "working in pull flow"
  - Lead time is impacted by customer

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- **Upstream and Downstream of CODP**

  How to manage the supply chain of upstream and downstream of CODP is;

- **Types of Productions and Companies**
  **(on Manufacturing situation)**
  - **Make-to-stock (MTS) companies**:
    Companies that serve customers from finished goods inventory. It includes all options regarding keeping inventory in the distribution system; either at distributors, wholesalers or retailers. Product is produced to stock with respect to the form.
  - **Assemble-to-order (ATO) companies**:
    Companies that combine a number of preassembled modules to meet a customer's specifications. A primary task is to define a customer's order in terms of alternative components since these are carried in inventory
  - **Make-to-order (MTO) companies**:
    companies that make the customer's product from raw materials, parts, and components. It is selected for special products with wide range and low individual product volume per period.
  - **Engineer-to-order (ETO) companies**:
    Companies that will work with the customer to design and then make the product.

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- **Types of Productions and Companies**

  Types of Productions and Companies to determine CODP are;

- **Market Types & CODP**

| Sector | Companies | Market Type | CODP | Comment |
|---|---|---|---|---|
| Automobile | Honda | ATO | Semi finished | Multiple levels of supplier. Accessories & assemblies as per product. |
| Aircraft | Boeing | MTO | Components, Raw Material | Heavy finished product, with complex assembly |
| | Airbus | MTO | Components, Raw Material | |
| Food (Packaged) | Nestle | MTS | Finished | Standard sizes of end product & forecast driven |
| | Parle Agro | MTS | Finished | |
| Pharmaceuticals | Sun Pharma | MTS | Finished | The demand is sporadic & with intense standards, regulations. |
| | Alkem | MTS | Finished | |

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- **Market Types & CODP**

  This matrix shows types of CODP by sector.

- **New Trend in CODP**
  - With increasing in Customized end product, more focus on shifting CODP in upstream. Like In cars, apparels, eatables, consumer goods more flexibility on customer side.
  - Investing in research creating a methodology for defining the “optimal” position of CODP for a closer and mutually beneficial cooperation with the customers.
  - Service companies also focusing on CODP to improve customer satisfaction.
  - CODP is used as a foundation for developing a reliable order promise process for mass customizers.

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- **New Trend in CODP**

  CODP determination becomes more important as below;

- **Classification by Product Type**

(1) Low-mix high-volume production
(2) High-mix low-volume production

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- **Classification by Product Type**

  There are two types of products depending on product variation and volume as below.

- **Low-mix High-volume Production**

(1) Low-mix high-volume production

A few types of products with high volume, like sugar, cement, etc.

・Production plan is easier.
・Production line is simpler.
=> Clearly this style is better, but ・・・

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- **Low-mix High-volume Production**

Low-mix high-volume production is;

- **High-mix Low-volume Production**

(2) High-mix low-volume production

Demand > Supply : Any products can be sold.
Demand < Supply : Need to fulfill the various customer request.

Many companies need to produce various types of products with low volume.
e.g. shoes, garment, etc.

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- **High-mix Low-volume Production**

  If demand exceeds supply, any product will sell.

  But, as supply capacity increases and supply exceeds demand, customers will choose products and only products that better meet customer needs will be sold. In other words, companies need to produce many types of products to meet the diverse needs.

  Many companies need to produce various types of products with low volume.

- **High-mix Low-volume Production**

Process to make production plan is same.
Points are,
- Detail of order (products type & quantity)
- Delivery date
- Stock situation (materials & products)
- Purchase lead time
- Assembly lead time (operators & machine)

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**Cont.**

The method of production planning is basically the same. Points are;

- **High-mix Low-volume Production**

You need to consider more about,

- Order change / discrepancy with forecast
- Low work ratio because of often set-up
- Accuracy of standard time

Very easy to happen discrepancy with plan.

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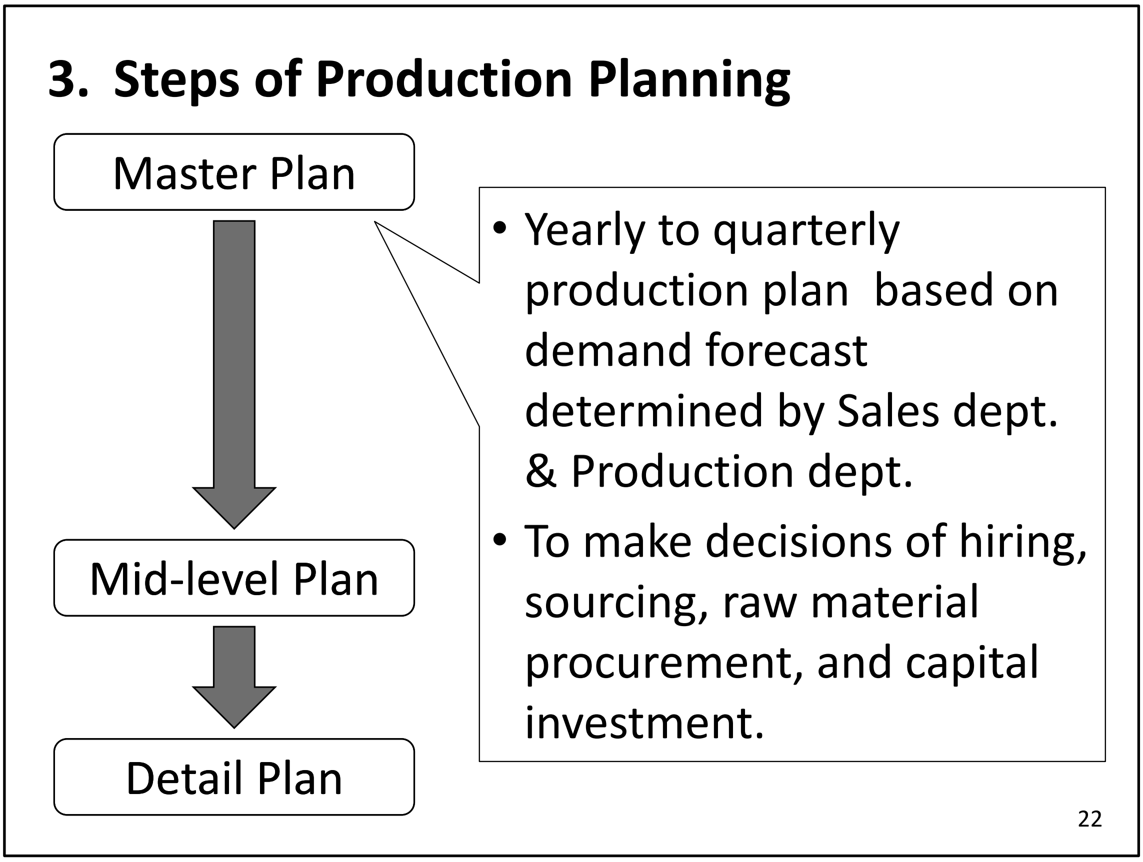
**Cont.**

Furthermore, high-mix low-volume production has changes in orders, deviations from forecasts, flow productivity due to frequent setup changes, inaccuracy in standard time, and complicated planning easily lead to deviations from production planning.

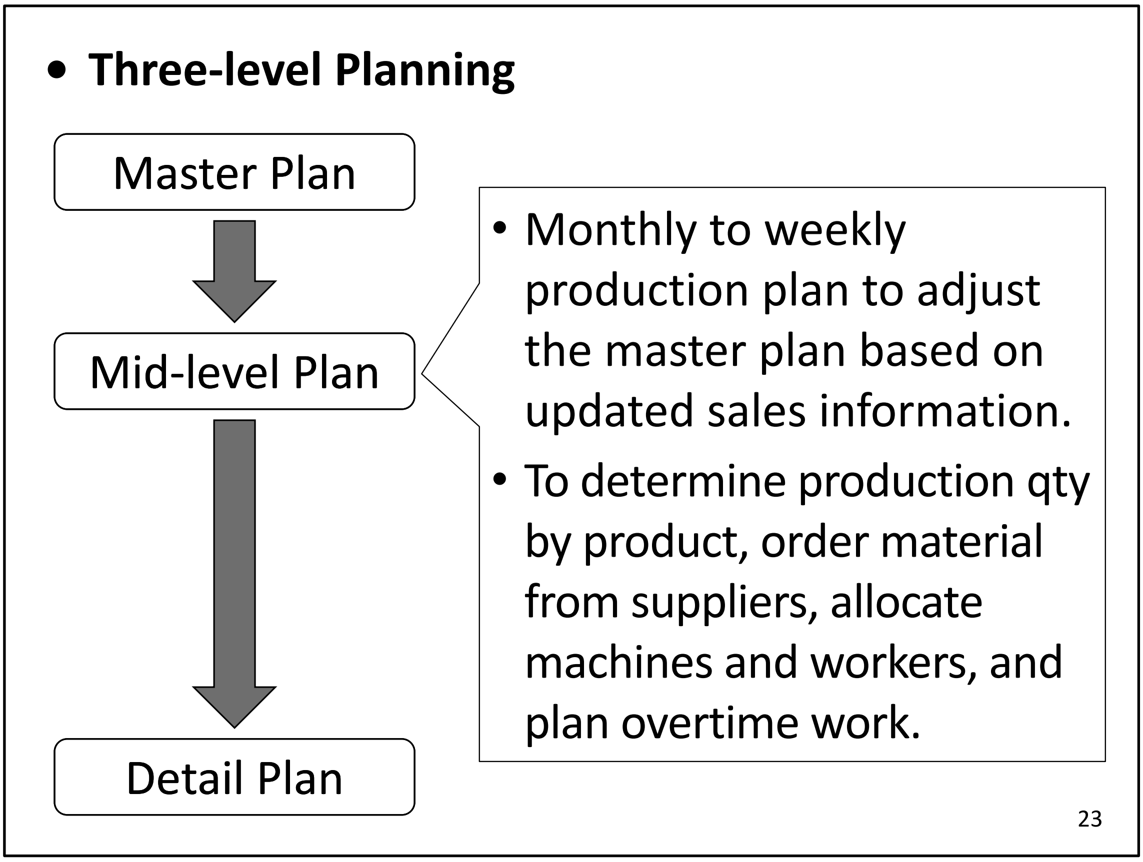
It is necessary to set the optimal lot size and update the standard time.




**3. Steps of Production Planning**

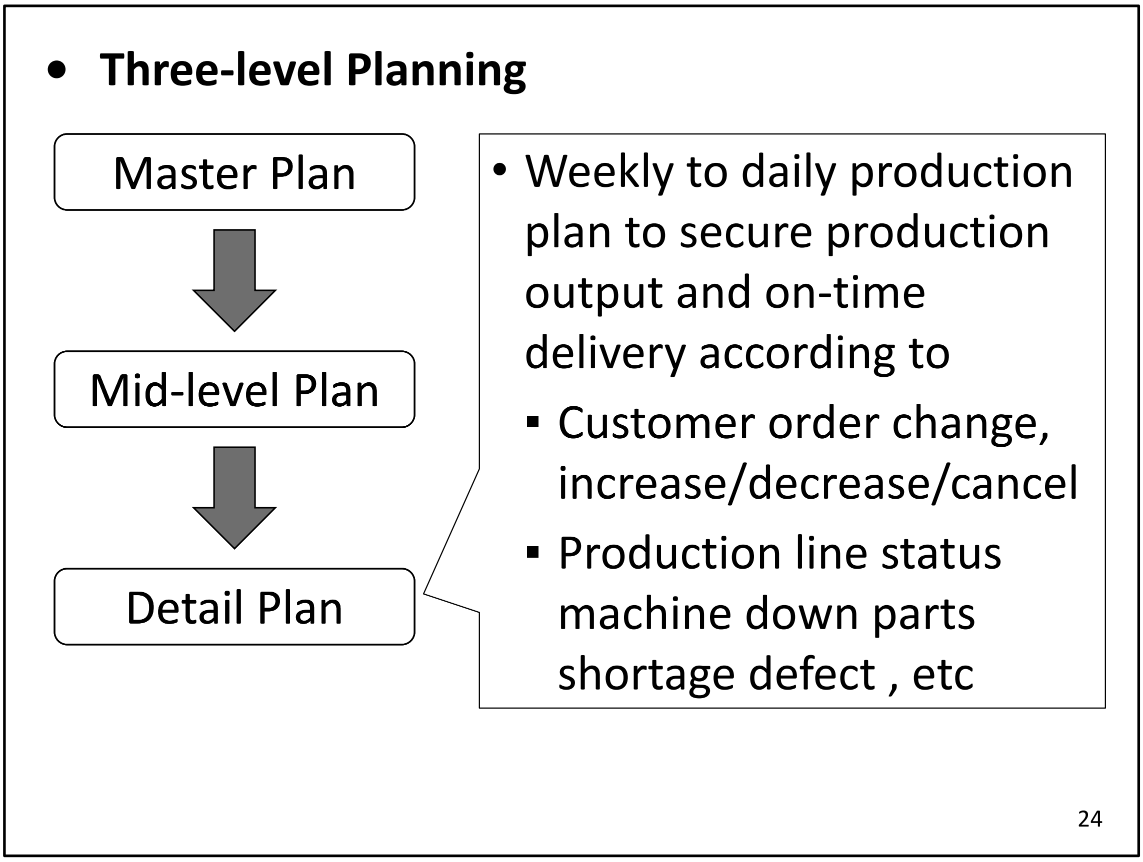
Depending on the period that production plan covers, there are three levels of plans as this slide shows.

The first plan is Master Plan, which is;




- **Three-level Planning**

  The second plan is Mid-level Plan, which is;




**Cont.**

The third plan is Detail Plan, which is;

- **Three-level Planning**

| Period | To be planned | Purpose |
|---|---|---|
| Master (Yearly) | • Sales<br>• Quantity<br>• Capacity<br>• Man power | • To consider investment and hiring |
| Mid-level (Monthly) | • Quantity by products | • To make material procurement plan |
| Detail (Daily) | • Order of products by line | • Operator arrangement and work instruction |

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**Cont.**

This slide summarizes three-level planning.

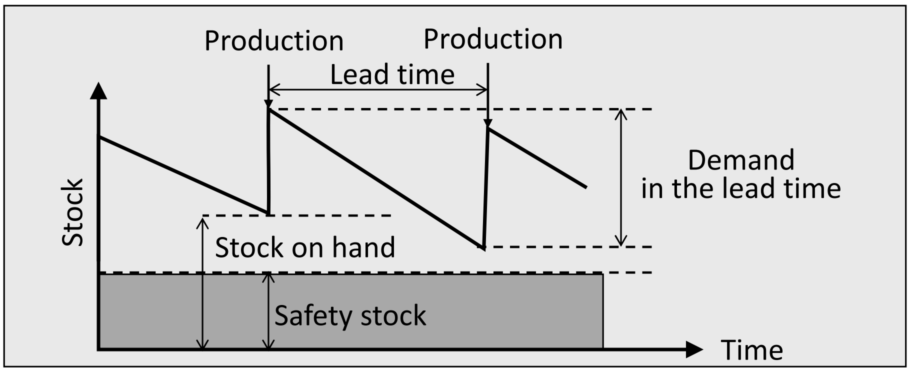
Master plan includes sales, production, production capacity, number of operators, and more.

The purpose is used to consider capital investment and personnel hiring.

Mid-level plan includes production volume for each product. The purpose is to use in raw material procurement planning.

Detail plan includes the order of production for each production line. It is used for allocating operators and giving instructions to production lines.

- **Requirement Calculation**
  - Net requirement calculation
    = (Demand in the lead time )
    + (Safety stock)-(Stock on hand)
  - Lot sizing
    Round up with a production batch quantity to control production quantity and purchase orders while preventing orders from being created in non-economic quantities.

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- **Requirement Calculation**

The net requirement , how many to make the product, can be calculated as this.

(Demand in the lead time ) + (Safety stock) - (Stock on hand)

We will go learn more about this formula later, now just understand that you need the three numbers, demand in the lead time, safety stock, and stock on hand.

Net requirement needs to be rounded with lot size. This is called lot sizing.

The lot sizing is to round up with a production batch quantity to control production quantity and purchase orders while preventing orders from being created in non-economic quantities.

Take bolts or nuts as an example. Bolts and nuts are sold as specific units, like 1000 or 2000 pcs rather than one at a time.

This is because selling only one at a time is not economical for manufactures.

- **Lead Time**
  - A key element for production planning to meet on-time delivery
  - The amount of time between the initiation of some process and its completion; the time required before something can be provided or delivered.

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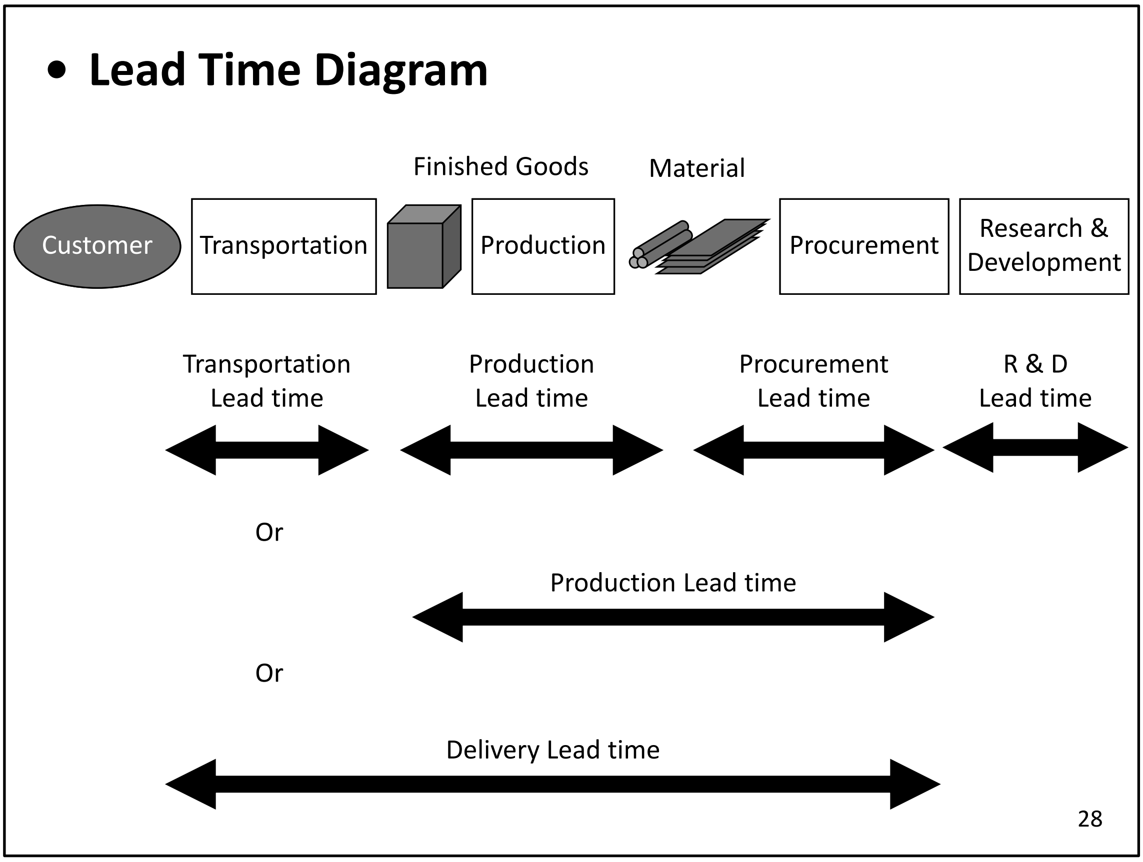
- **Lead Time**

  The definition of lead time is;

  ・ A key element for production planning to meet on-time delivery, and
  ・ The amount of time between the initiation of some process and its completion ;

  the time required before something can be provided or delivered.

  We need a lead time to determine how often and how many to produce very product.




- **Lead Time Diagram**

  There are several types of lead time.

  You need to know which type of lead time is required for your production planning.

  From research and development to product shipment, there are

  R&D lead time, procurement lead time, production lead time, transportation lead time, and delivery lead time.

  When you need to tell a delivery date to your customer, that is delivery lead time, which includes the times of material procurement, finished goods production, and finished goods transportation to customer.

- **Lead Time Exercise**

Shoes company A received an order of 120 pairs of shoes. This is repeated order. No design is needed.

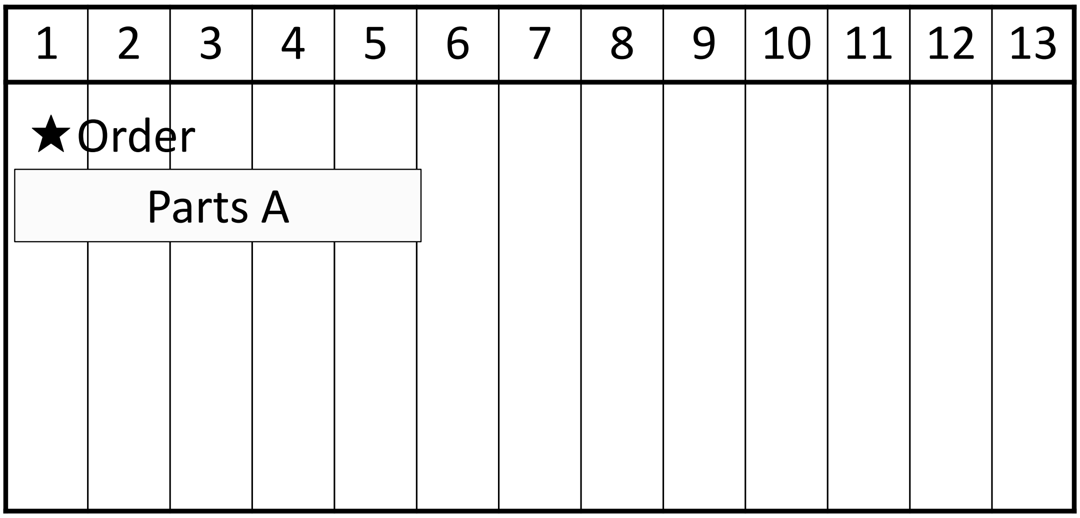
The shoes are made from 3 parts (parts A,B and D).

- Part A…purchase, lead time 5 days
- Part B…purchase, lead time 6 days
- Part D…made from Material C, lead time 4 days
- Material C…purchase, lead time 5 days
- Assembly…Use A,B and D, lead time 2days

Capacity of making part D is 60pcs/day, assembly is 40 pairs/day. When can you deliver the shoes?

29

- **Lead Time Exercise Answer**



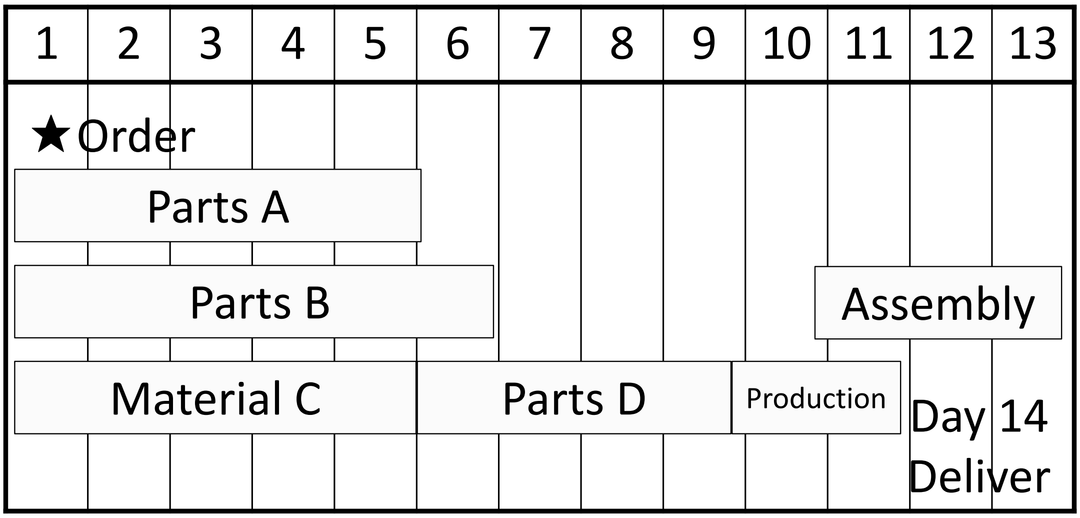

Ans :

30

- **Lead Time Exercise Answer**

  Please draw the lead time of each parts on this matrix.

- **Lead Time Exercise Answer**




Ans : Delivered on $14^{th}$ day

31

**Cont.**

The answer is that you can deliver the shoes on 14th day.

- **Requirement Calculation**

| Week | 12/4 | 12/11 | 12/18 | 12/25 | 1/1 | 1/8 | 1/15 | 1/22 | 1/29 |
|---|---|---|---|---|---|---|---|---|---|
| Demand | 1,200 | 960 | 1,000 | 920 | 1,240 | 1,160 | 1,080 | 1,000 | 920 |
| Stock on-hand | 1,200 | 1,000 | 1,040 | 1,040 | 1,120 | 920 | 800 | 760 | 800 |
| Safety stock | 1,000 | 1,040 | 1,040 | 1,120 | 920 | 800 | 760 | 800 | 920 |
| Production (net) | 1,000 | 1,000 | 1,000 | 1,000 | 1,040 | 1,040 | 1,040 | 1,040 | 1,040 |
| Production (Lot size = 50) | 1,000 | 1,000 | 1,000 | 1,000 | 1,050 | 1,050 | 1,050 | 1,050 | 1,000 |

32

- **Requirement Calculation**

  In the previous slide, we learned how to calculate the production requirement as below,

  Demand in the lead time + Safety stock-Stock on hand

  Then, the requirement needs to be rounded with lot size. This is called lot sizing.

  This matrix shows all of these numbers

  Take the week of 1/1 as example,

  Customer demand for the week is 1240pieces,

  Stock on hand is the finished goods stocked on hand and there are 1120 pieces of them.

  Safety stock is the stock to avoid missing shipment due to production problem and there are 920 pieces of them.

  From these numbers and formula on the above, production requirement is

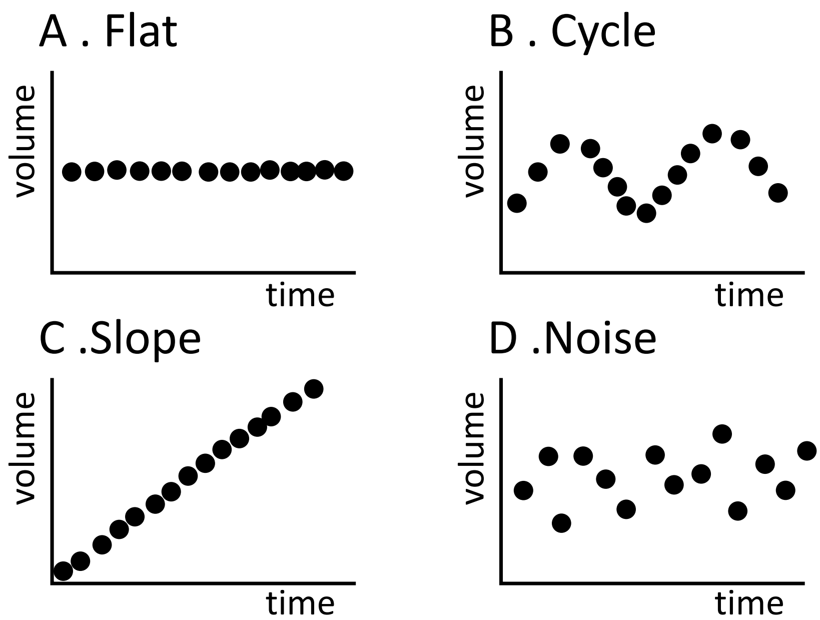
  1240 plus 920 minus 1120 equals 1040

  Now we need to round up this 1040 pieces with lot size, which is 50.

  1040 divided by 50 equals 20.8. Change 20.8 to 21 and times 50 equals 1050 pieces.

  This is the production requirement for the week of 1/1 after lot sizing.

- **Demand Forecast**
  - Demand Trend




33

- **Demand Forecast**

  If your customer gives you the enough orders to make a production plan for the delivery lead time, you can use those orders to calculate production requirements according to the formula in the previous slide.

  But, your customers usually do not give you many orders because they want to avoid excessive stocks due e to market change or maximize their cashflow.

  Therefore, you need to forecast the demand by some way to make a production plan for the delivery lead time.

  We learn now how to forecast demand. First step is to analyze the market from a graph of volume and time.

  We call it trend analysis. Here are four types of trend, flat, cycle, slope and noise.

  Based on the trend type, we can select a method to forecast demand.

- **Demand Forecast**
  - Actual sales figure (kpcs/month)

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Jan | 100 | 105 | 110 |
| Feb | 80 | 90 | 90 |
| Mar | 110 | 100 | 120 |
| Apr | 130 | 135 | 140 |
| May | 120 | 115 | 110 |
| Jun | 80 | 100 | 90 |
| Jul | 100 | 110 | 120 |
| Aug | 120 | 110 | 120 |
| Sep | 140 | 150 | 140 |
| Oct | 110 | 120 | 130 |
| Nov | 100 | 90 | 110 |
| Dec | 100 | 110 | 120 |
| Ave | 107 | 111 | 117 |

34

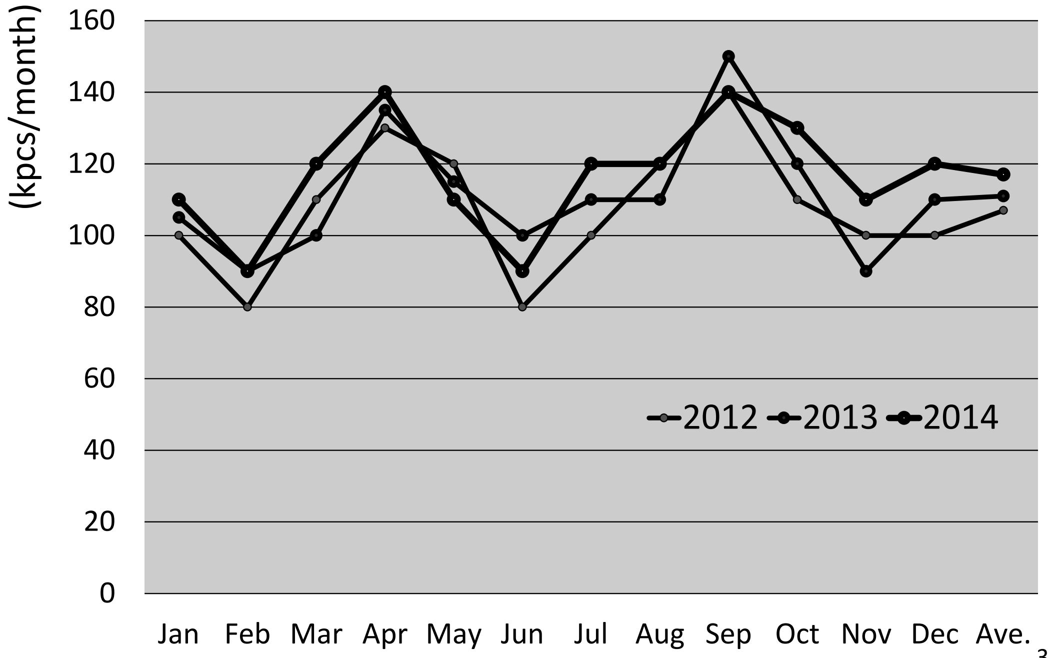
**Cont.**

To make a graph of volume and time, you need to collect data, actual sale figure.

This table shows the monthly sales volume of a company for each year.

You can see that 100k sold in January 2012 and 120k in December 2014.

- **Demand Forecast**
  - Visualize




35

**Cont.**

From the data in the previous slide, you can make a sales-by-month graph as this slide shows.

You can determine that the trend is a cycle.

This trend is also called seasonal demand. Always high demand on April and September and low demand on February and November.

- **Demand Forecast**
  - Methods of demand forecasting

(1) Simple averaging
(2) Moving averaging
(3) Exponential smoothing
(4) Seasonal adjusting

36

**Cont.**

As the methods of demand forecasting , there are four formulas.

(1) Simple averaging
(2) Moving averaging
(3) Exponential smoothing
(4) Seasonal adjusting

Actually, there are more formulas if you search literatures about demand forecasting, such as fuzzy theory so forth.

But these four should be good enough practically.

- **Demand Forecast**

(1) Simple averaging

$$S_{t+1}, S_{t+n} = \frac{\sum_{0}^{n-1} a_n}{n}$$

S : forecast
a : actual
n : # of buckets

Actual (4 buckets)

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|
| 110 | 90 | 120 | 140 | | | | |

$$n=4, \quad S= \frac{110+90+120+140}{4} =115$$

37

**Cont.**

The formula below is for simple averaging.

This example shows how to forecast sales after May when actual sales data from January to April are available.

The number of buckets, is the number of months that are used as the denominator of averaging, here it is four months.

Practically speaking, 3 to 4 months are long enough for this method.

- **Demand Forecast**

(1) Simple averaging

$$S_{t+1}, S_{t+n} = \frac{\sum_{0}^{n-1} a_n}{n}$$

S : forecast
a : actual
n : # of buckets

Actual (4 buckets) | Forecast

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|
| 110 | 90 | 120 | 140 | **115** | **115** | **115** | **115** |

$$n=4, \quad S= \frac{110+90+120+140}{4} =115$$

38

**Cont.**

The result of averaging the sales of January to April is 115. This is the demand forecasted for next four months from May to August.

- **Demand Forecast**

(2) Moving averaging

$$S_{t+1} = \frac{\sum_{m=0}^{n-1} a_{t-m}}{n}$$

S : forecast
a : actual
n : # of buckets

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|
| 110 | 90 | 120 | 140 | 115 | | | |

$$n=4,\ S_{May} = \frac{110+90+120+140}{4} = 115$$

39

**Cont.**

Next is moving averaging.

Similar to the simple averaging, but this method uses the last months of actual sales for only the current month's forecast.

Here, The average of January to April sales, which is 115, is used only for May forecast.

- **Demand Forecast**

(2) Moving averaging

$$S_{t+1} = \frac{\sum_{m=0}^{n-1} a_{t-m}}{n}$$

S : forecast
a : actual
n : # of buckets

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|---|
| Y-2914 | 110 | 90 | 120 | 140 | 110 | 90 | 120 | 120 |
| forecast | | | | | 115 | 115 | 115 | 115 |

$$n=4,\ S_{Jun}= \frac{90+120+140+110}{4} =115$$

40

**Cont.**

When May production is completed and June demand needs to be forecasted, the months for which actual sales are averaged change from January to April, to February to May.

Therefore, the average of February to May sales is 115, this is the demand forecasted for the month of June.

- **Demand Forecast**

(2) Moving averaging

Considerations

- “Noise” can be eliminated.
- “Slope” can be reflected.
- “Cycle” is hard to be reflected.

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**Cont.**

The advantage of moving averaging is;

“Noise” can be eliminated,

“Slope” can be reflected, and

“Cycle” is hard to be reflected.

- **Demand Forecast**

(3) Exponential smoothing

$$S_{t+1} = \alpha \cdot a_t + (1-\alpha) \cdot S_t$$

$0 < \alpha \leqq 1$

S : forecast
a : actual
α : constant

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|---|
| forecast | 105 | | | | | | | |
| Actual | 110 | | | | | | | |

$\alpha=0.6, \quad S_{Feb}=0.6\times110+(1-0.6)\times105=108$

42

**Cont.**

Next is exponential smoothing.

The exponential smoothing is to take a weighted average of forecast and actual by using weighting constants . Whereas in the simple moving average the past sales data are weighted equally, exponential smoothing is used to assign exponentially decreasing weights over time

The weighting constant α is increased when actuals are more important than forecasts and is reduced when forecasts are more important than actuals.

Here, assuming that the weighting factor is 0.6, that is, the actual is more important, the forecast of February is 108 from the forecast and actual of January.

- **Demand Forecast**

(3) Exponential smoothing

$$S_{t+1} = \alpha \cdot a_t + (1-\alpha) \cdot S_t$$

S : forecast

a : actual

$0 < \alpha \leqq 1$ α : constant

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|---|
| forecast | 105 | 108 | ? | | | | | |
| Actual | 110 | 100 | | | | | | |

$\alpha=0.6$, $S_{Feb}=0.6\times110+(1-0.6)\times105=108$

43

**Cont.**

When February actual is available, we will use the same calculation to make March forecast.

Assuming that the actual of February is 100, what is the forecast of March?

- **Demand Forecast**

(3) Exponential smoothing

$$S_{t+1} = \alpha \cdot a_t + (1-\alpha) \cdot S_t$$

$0 < \alpha \leqq 1$

S : forecast
a : actual
α : constant

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|---|
| forecast | 105 | 108 | 103 | | | | | |
| Actual | 110 | 100 | | | | | | |

$\alpha=0.6,\ S_{Feb}=0.6\times100+(1-0.6)\times108=103$

44

**Cont.**

The answer is 103.

- **Demand Forecast**

(3) Exponential smoothing

Considerations

- More accuracy based on both forecast and actual.
- Can reflect “Slope”.
- Can eliminate “Noise”.
- Hard to reflect “Cycle”.

45

**Cont.**

The advantage of exponential smoothing is ;

More accuracy based on both forecast and actual,

Slope can be reflected,

Noise can be eliminated,

Cycle is hard to reflect.

- **Demand Forecast**

(3) Exponential smoothing

| | 2012 | 2013 | 2014 | TOTAL | % |
|---|---|---|---|---|---|
| Jan | 100 | 105 | 110 | | |
| Feb | 80 | 90 | 90 | | |
| Mar | 110 | 100 | 120 | | |
| Apr | 130 | 135 | 140 | | |
| May | 120 | 115 | 110 | | |
| Jun | 80 | 100 | 90 | | |
| Jul | 100 | 110 | 120 | | |
| Aug | 120 | 110 | 120 | | |
| Sep | 140 | 150 | 140 | | |
| Oct | 110 | 120 | 130 | | |
| Nov | 100 | 90 | 110 | | |
| Dec | 100 | 110 | 120 | | |
| TOTAL | | | | | |

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**Cont.**

Next is seasonal adjusting.

Here is again the monthly sales figures for each year.

Calculate the total for the year and the total for each month for three years.

- **Demand Forecast**

(4) Seasonal adjusting

| | 2012 | 2013 | 2014 | TOTAL | % |
|---|---|---|---|---|---|
| Jan | 100 | 105 | 110 | 315 | |
| Feb | 80 | 90 | 90 | 260 | |
| Mar | 110 | 100 | 120 | 330 | |
| Apr | 130 | 135 | 140 | 405 | |
| May | 120 | 115 | 110 | 345 | |
| Jun | 80 | 100 | 90 | 270 | |
| Jul | 100 | 110 | 120 | 330 | |
| Aug | 120 | 110 | 120 | 350 | |
| Sep | 140 | 150 | 140 | 430 | |
| Oct | 110 | 120 | 130 | 360 | |
| Nov | 100 | 90 | 110 | 300 | |
| Dec | 100 | 110 | 120 | 330 | |
| TOTAL | 1,290 | 1,335 | 1,400 | 4,025 | |

47

**Cont.**

Next, calculate the ratio of three-year total of each month to the grand total.

- **Demand Forecast**

(4) Seasonal adjusting

| | 2012 | 2013 | 2014 | TOTAL | % |
|---|---|---|---|---|---|
| Jan | 100 | 105 | 110 | 315 | 7.8 |
| Feb | 80 | 90 | 90 | 260 | 6.5 |
| Mar | 110 | 100 | 120 | 330 | 8.2 |
| Apr | 130 | 135 | 140 | 405 | 10.1 |
| May | 120 | 115 | 110 | 345 | 8.6 |
| Jun | 80 | 100 | 90 | 270 | 6.7 |
| Jul | 100 | 110 | 120 | 330 | 8.2 |
| Aug | 120 | 110 | 120 | 350 | 8.7 |
| Sep | 140 | 150 | 140 | 430 | 10.7 |
| Oct | 110 | 120 | 130 | 360 | 8.9 |
| Nov | 100 | 90 | 110 | 300 | 7.5 |
| Dec | 100 | 110 | 120 | 330 | 8.2 |
| TOTAL | 1,290 | 1,335 | 1,400 | 4,025 | 100 |

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**Cont.**

This monthly ratio is used as the seasonal factor.

- **Demand Forecast**

(4) Seasonal adjusting

Considerations

- Can reflect “Cycle”.
- Can eliminate “Noise”.
- Hard to reflect “Slope”.

49

**Cont.**

The advantage of seasonal adjusting is;

Cycle can be reflected,

Noise can be eliminated, and

Slope is hard to reflect.

- **Demand Forecast**

Exercise

Make a monthly forecast of 2015 which you think best for the company.

Hint

Consider yearly and monthly forecast separately.

50

**Cont.**

We learned four types of demand forecasting methods.

Let’s try this method to answer the exercise.

Make a monthly sales forecast for year 2015.

The forecast and actual data up to the previous year are shown on the next page.

- **Demand Forecast**
  - Forecast and Actual sales figure (kpcs/month)

| | 2012 (A) | 2013 (F) | 2013 (A) | 2014 (F) | 2014 (A) | 2015 (F) |
|---|---|---|---|---|---|---|
| Jan | 100 | 110 | 105 | 116 | 110 | |
| Feb | 80 | 88 | 90 | 99 | 90 | |
| Mar | 110 | 121 | 100 | 110 | 120 | |
| Apr | 130 | 143 | 135 | 149 | 140 | |
| May | 120 | 132 | 115 | 127 | 110 | |
| Jun | 80 | 88 | 100 | 110 | 90 | |
| Jul | 100 | 110 | 110 | 121 | 120 | ? |
| Aug | 120 | 132 | 110 | 121 | 120 | |
| Sep | 140 | 154 | 150 | 165 | 140 | |
| Oct | 110 | 121 | 120 | 132 | 130 | |
| Nov | 100 | 110 | 90 | 99 | 110 | |
| Dec | 100 | 110 | 110 | 121 | 120 | |
| TOTAL | 1,290 | 1,419 | 1,335 | 1,469 | 1,400 | |

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**Cont.**

Please start the exercise.

- **Demand Forecast**

①Yearly forecast by Exponential smoothing

| | TOTAL |
|---|---|
| 2014(F) | 1,469 |
| 2014(A) | 1,400 |
| 2015(F) | 1,421 |

α=0.7, because previous forecast was not considered deeply.

$$S=0.7\times1400+(1-0.7)\times1469=1421$$

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**Cont.**

First, we use the 2014 forecast and actual to calculate the 2015 froecast by exponential smoothing.

Because the 2014 forecast was not considered deeply, considering actual is more important, set α as 0.7.

Substituting the number into the formula described earlier gives 1421.

- **Demand Forecast**

② Monthly forecast using seasonal adjusting.

| | 2012 | 2013(A) | 2014(A) | TOTAL | % | 2015(F) |
|---|---|---|---|---|---|---|
| Jan | 100 | 105 | 110 | 315 | 7.8 | ② |
| Feb | 80 | 90 | 90 | 260 | 6.5 | |
| Mar | 110 | 100 | 120 | 330 | 8.2 | |
| Apr | 130 | 135 | 140 | 405 | 10.1 | |
| May | 120 | 115 | 110 | 345 | 8.6 | |
| Jun | 80 | 100 | 90 | 270 | 6.7 | |
| Jul | 100 | 110 | 120 | 330 | 8.2 | |
| Aug | 120 | 110 | 120 | 350 | 8.7 | |
| Sep | 140 | 150 | 140 | 430 | 10.7 | |
| Oct | 110 | 120 | 130 | 360 | 8.9 | |
| Nov | 100 | 90 | 110 | 300 | 7.5 | |
| Dec | 100 | 110 | 120 | 330 | 8.2 | ② |
| TOTAL | 1,290 | 1,335 | 1,400 | 4,025 | 100 | ① 1,421 |

53

**Cont.**

Next, the annual total of 1421 is allocated to the month by the seasonal factors.

As example, 1421 x 7.8% is the forecast for January, and the other months are calculated in the same way.

- **Demand Forecast**

② Monthly forecast using seasonal adjusting.

| | 2012 | 2013(A) | 2014(A) | TOTAL | % | 2015(F) |
|---|---|---|---|---|---|---|
| Jan | 100 | 105 | 110 | 315 | 7.8 | ② 111 |
| Feb | 80 | 90 | 90 | 260 | 6.5 | 92 |
| Mar | 110 | 100 | 120 | 330 | 8.2 | 117 |
| Apr | 130 | 135 | 140 | 405 | 10.1 | 143 |
| May | 120 | 115 | 110 | 345 | 8.6 | 122 |
| Jun | 80 | 100 | 90 | 270 | 6.7 | 95 |
| Jul | 100 | 110 | 120 | 330 | 8.2 | 117 |
| Aug | 120 | 110 | 120 | 350 | 8.7 | 124 |
| Sep | 140 | 150 | 140 | 430 | 10.7 | 152 |
| Oct | 110 | 120 | 130 | 360 | 8.9 | 127 |
| Nov | 100 | 90 | 110 | 300 | 7.5 | 106 |
| Dec | 100 | 110 | 120 | 330 | 8.2 | ② 117 |
| TOTAL | 1,290 | 1,335 | 1,400 | 4,025 | 100 | ① 1,421 |

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**Cont.**

The result is this.

By calculating the annual forecast with exponential smoothing, the slope effect was reflected, and then, by distributing it with seasonal factor, the cycle effect was reflected.

When calculating the yearly figures, it should be enough to simply apply the past growth rates.

- **Lot Size**

How to decide lots size?

Bigger lot leads to
longer lead time and bigger stock.

Smaller lot leads to
more tool change time.

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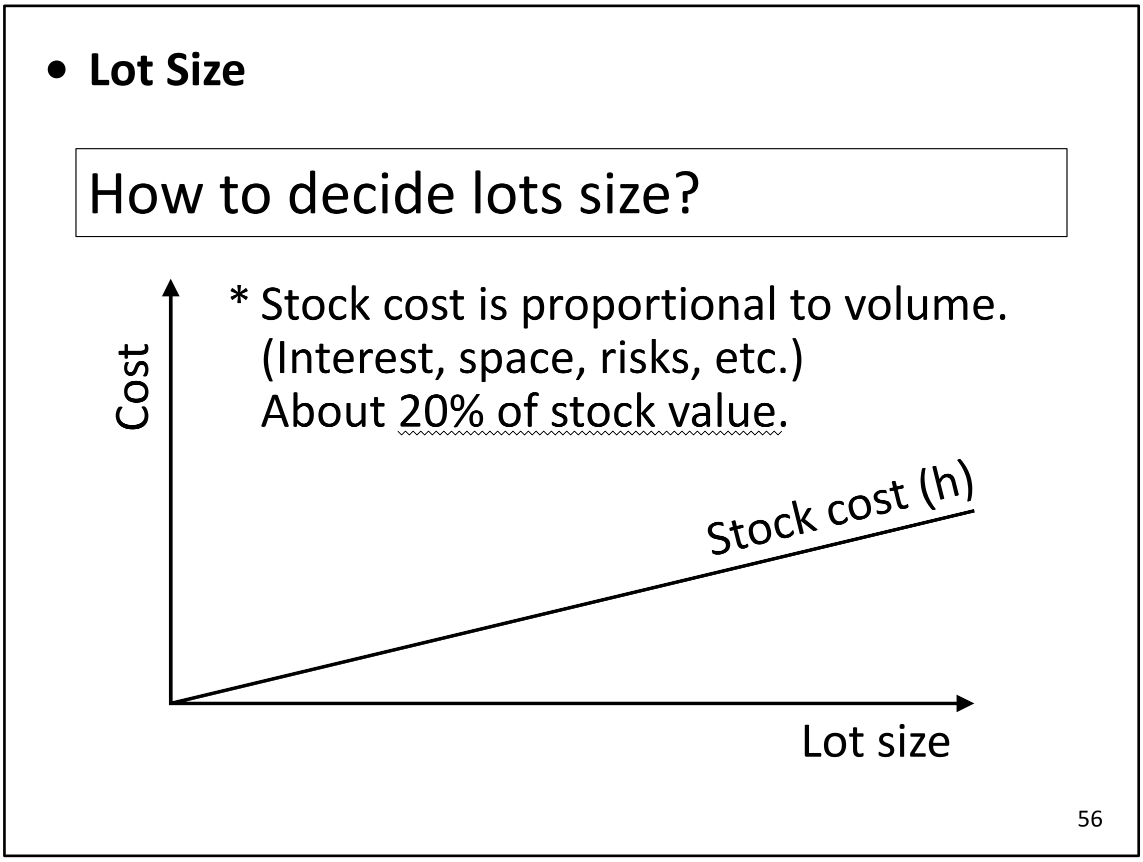
- **Lot Size**

  Larger lot sizes lead to longer lead times and larger inventory.

  Smaller lot leads to more tool change time.



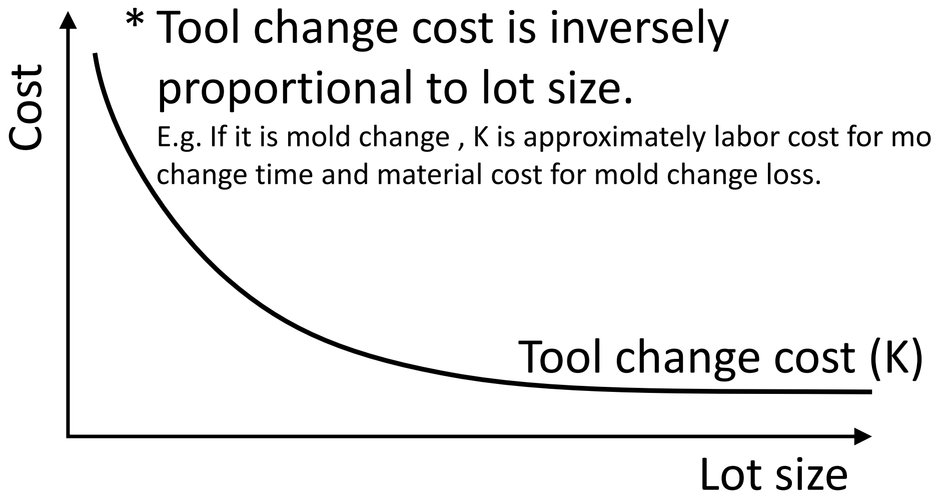

**Cont.**

Lot size and stock cost are in a proportional relationship, and it is generally said that stock cost is about 20% of stocked product value.

The stock cost breaks down into interest for purchasing materials, warehouse space cost, and obsolescence risk.

- **Lot Size**

How to decide lots size?

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**Cont.**

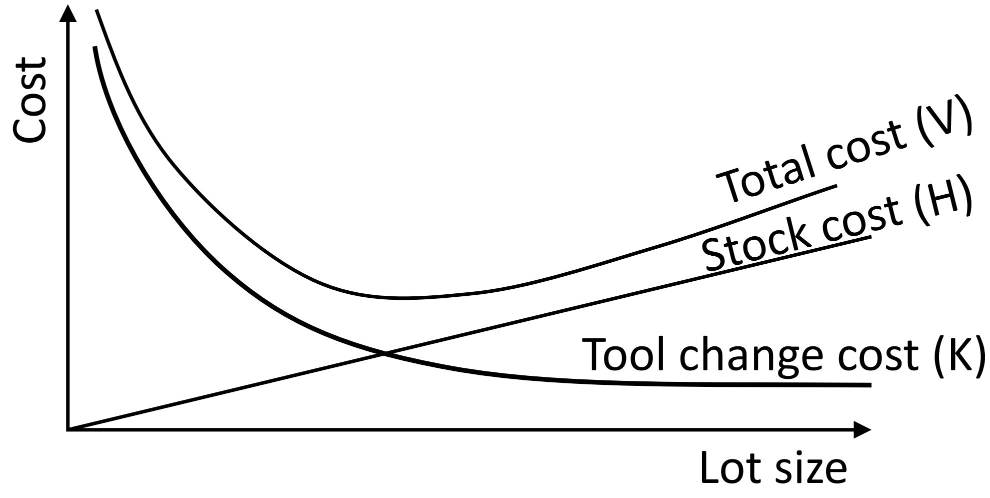
The tool change cost is inversely proportional to the lot size.

If the tool change takes one hour, the labor cost for one hour is divided by the lot size.

The cost of 1000 pcs of lot size is 1/1000 hours of work, while the cost of10pcs lot is 1/10 hours of work.

- **Lot Size**

How to decide lots size?

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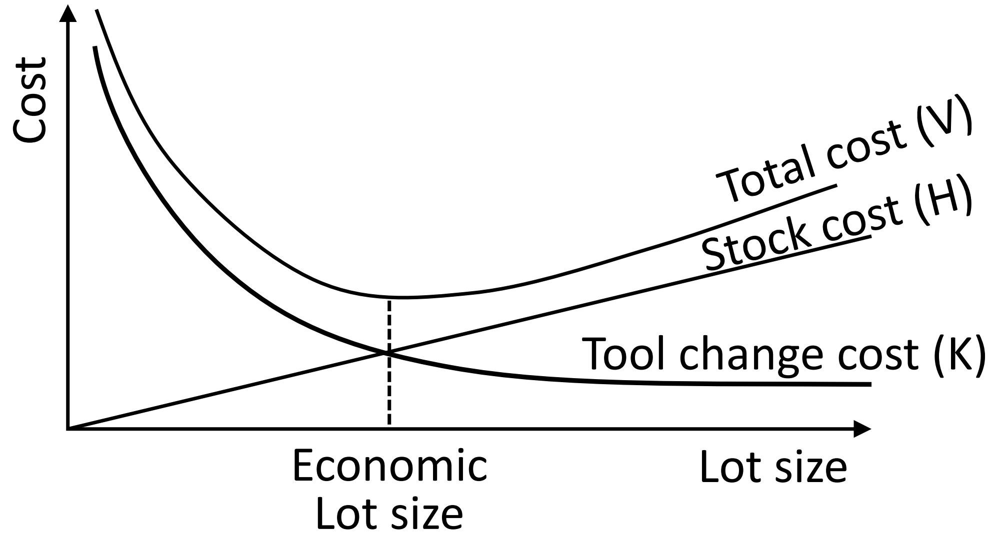
**Cont.**

This is the total of the stock cost and the tool change cost.

- **Lot Size**

How to decide lots size?

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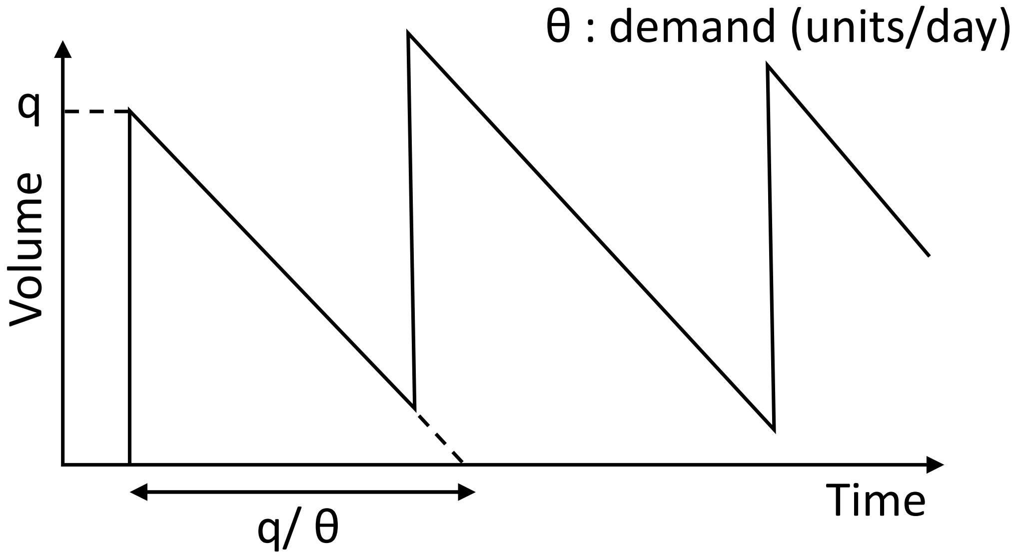
**Cont.**

Economic lot size or economic order quantity (EOQ) is the lot size or order quantity that minimizes the total stock costs and tool change costs.

It is the crossed point of two lines as above.

- **Lot Size**

How to decide lots size?




60

**Cont.**

The volume of inventory changes like this during production.

It increases by q , the lot size and it decreases by demand θ, demand.

- **Lot Size**

How to decide lots size?

$$V = \frac{q}{2} H + \frac{\theta}{q} K \Rightarrow \frac{dV}{dq} \rightarrow 0$$

↑ Average stock ↑ Number of production

$$\text{*Economic Lot size } (q') = \sqrt{\frac{2 \cdot K \cdot \theta}{H}}$$

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**Cont.**

First, the total cost, V is the sum of stock cost, H multiplied by the average stock amount, q/2 and the tool cost, K multiplied by the frequency, θ/q. This is differentiated with respect to q, and the point where the value becomes zero is the economic lot size.

- **Lot Size**

Exercise

Calculate economic lot size in following condition.

- Demand(θ) : 100 pcs/day
- Cost of manufacture(c) : 500 birr/pc
- Tool change cost (K) : 2000 birr/change
- Stock cost (h) : 2.5 birr/pc・day

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**Cont.**

Use this formula with following values to find the economic lot size.

- **Lot Size**

Answer

$$\text{Economic Lot size} = \sqrt{\frac{2 \cdot K \cdot \theta}{h}}$$

$$= \sqrt{\frac{2 \cdot 2000 \cdot 100}{2.5}}$$

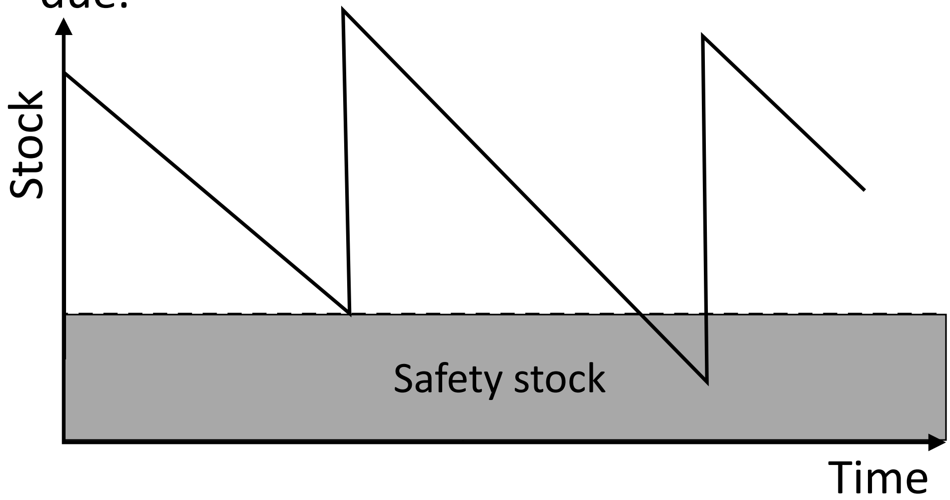
$$= 400$$

63

**Cont.**

The answer of economic lot size is 400 pcs.

- **Safety Stock**
  - To absorb the gap between customer due date and production lead time.
  - To absorb customer order fluctuation.
  - To absorb production behind or supplier past-due.

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- **Safety Stock**

  The definition of safety stock is;

- **Safety Stock Calculation**

Safety stock = $\alpha S \times \sigma D \times \sqrt{(LT + OC)}$

$\alpha S$: Safety factor
= Inverse normal distribution index of stock-out incidence

| Stock-out allowance (%) | 1 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|
| $\alpha S$ | 2.33 | 1.65 | 1.29 | 0.85 | 0.53 |

$\sigma D$ : Standard deviation of demand
LT : Lead Time
OC : Order Frequency

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- **Safety Stock Calculation**

The formula of safety stock calculation is this.

Here, safety factor is inverse normal distribution index of stock-out incidence.

The factor means frequency allowance of stock-out incidence.

As example, if you can allow stock-out condition up to 5 % of the frequency, the factor is 1.65.

σD is standard deviation of demand, which can be calculated based on the past demand data.

- **Safety Stock Calculation**

Exercise

Calculate safety stock in following condition.
- Stock-out allowance:1%
- Production Lead Time: 5 days
- Order cycle:5 days
- Demand: as below

(pcs)

| Wk 1 | Wk 2 | Wk 3 | Wk 4 | Wk 5 | Wk 6 | Wk 7 | Wk 8 | Wk 9 | Wk 10 |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 12 | 13 | 9 | 11 | 10 | 14 | 12 | 8 | 12 |

66

**Cont.**

Let’s try an exercise for safety stock calculation.

Calculate the sample standard deviation of demand based on the table.

The number of data is only 10. Therefore, the standard deviation is not population standard deviation, but sample standard deviation.

- **Safety Stock Calculation**

Answer

$$\text{Safety stock} = \alpha S \times \sigma D \times \sqrt{(LT + OC)}$$
$$= 2.33 \times 1.85 \times \sqrt{10}$$
$$= 13.63$$
$$\cong 14$$

| Stock-out allowance (%) | 1 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|
| αS | 2.33 | 1.65 | 1.29 | 0.85 | 0.53 |

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**Cont.**

The answer of safety stock is 14.

## • Calculation Result and Adjustment

- If production requirements fluctuate and cause overtime (“ Muri ”) or low productivity (“Muda”), by using safety stock, adjust Production④, as below, ⑥,⑦, and ⑧ in Production⑤.

| | Monthly forecast | | | Yearly forecast | | |
|---|---|---|---|---|---|---|
| | May | June | July | August | September | October |
| Demand① | 115 | 115 | 115 | 143 | 119 | 101 |
| Safety stock② | 30 | 30 | 30 | 30 | 30 | 30 |
| Stock on-hand③ | 25 | 30 | 30 | 30 | 12 | 18 |
| Production after lot sizing ④ (before adjustment) ①+②- ③ | 120 | 115 | 115 | 145 ⑥ | 135 ⑦ | 115 ⑧ |
| Production after lot sizing⑤ (after adjustment) | 120 | 115 | 115 | 125 | 125 | 125 |
| Closing balance ⑤－①+③ | 30 | 30 | 30 | 12 | 18 | 42 |

Assumption;
The product is shipped once a month. The production line produces the same amount of product every day. Then, production lead time is one month.

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- **Calculation Result and Adjustment**

According to the formulas, all the numbers are calculated in the spreadsheet as shown here.

But this is not the end of production planning. Notice the numbers of Production after lot sizing ( before adjustment) are fluctuating. 115 pcs on July and 145 pcs on August.

If production requirements fluctuate like this and cause overtime (“ Muri ”) or low productivity (“Muda”), by using safety stock adjust production requirements as below, Production after lot sizing( after adjustment)⑤.

Do not forget to check if the requirements fluctuate and levelized them if the fluctuation causes overtime or overburden by reducing or increasing safety stock.

## • Material Order Planning

| Seq. | Description | Use | Material | Process | Supplier | |
|---|---|---|---|---|---|---|
| 0 | SARASA, Black | 1 | NA | Assembling | In-house | Production plan |
| 1 | Case Upper, Black assy | 1 | NA | Assembling | In-house | Material Order Plan |
| 2 | Case Upper | 1 | PMMA | Molding | In-house | |
| 2 | Clip, Black | 1 | ABS | Molding | Addis Plastics | |
| 2 | Button, Black | 1 | ABS | Molding | Addis Plastics | |
| 2 | Pusher | 1 | PP | Molding | Addis Plastics | |
| 2 | Plate Spring | 1 | SUS | Stamping | In-house | |
| 1 | Case Lower, Black assy | 1 | NA | Assembling | In-house | |
| 2 | Case Lower | 1 | PMMA | Molding | In-house | |
| 2 | Rubber, Black | 1 | NBR | RIM | Sheba Rubber | |
| 1 | Ink Cartridge, Black | 1 | NA | Ink mfg. | Anbessa Inks | |
| 1 | Coil Spring | 1 | SWC | Rolling | Addis Springs | |

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- **Material Order Planning**

  From now, we learn the ways to order components and materials. We call this process material order planning.

  On this BOM, sequence 0 item, SARASA,Black, is called finished goods. The plan to produce finished goods, here it's SARASA, Black, is production plan. Below sequence 0, all items are either of sub-assemblies, components, or raw materials and are ordered by the process owner of finished goods production. This is why it's called material order plan, not production plan.

- **Material Order Planning Types**

(1) as-required
(2) Fixed period ordering
(3) Fixed quantity ordering

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- **Material Order Planning Types**

  There are three types of material order planning as below.

  (1) As-required
  (2) Periodic reordering
  (3) Fixed quantity ordering

- **Material Order Planning Types**

(1) as-required

Order when it is required.

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**Cont.**

As-required is a method to place an order each time it is needed.

- **Material Order Planning Types**

(2) Fixed period ordering

Order is issued periodically based on the latest demand forecast and inventory status to minimize inventory.

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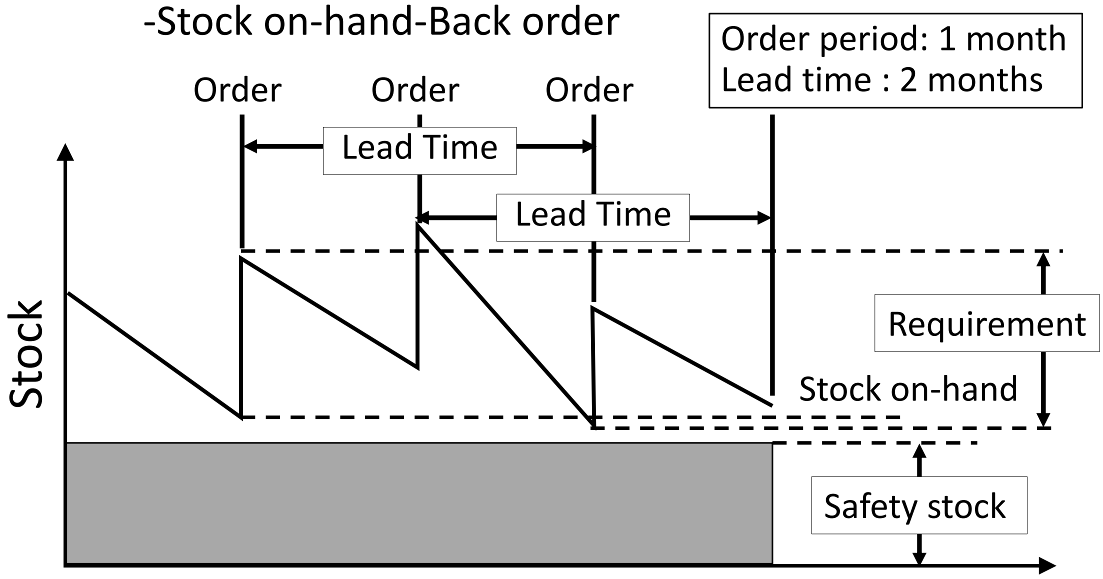
**Cont.**

Periodic reordering is a method to order periodically based on the latest demand forecast and inventory status to minimize inventory.

- **Fixed Period Ordering**

  Order Quantity:

  = Requirement in lead time + Safety stock -Stock on-hand-Back order

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- **Fixed Period Ordering**

  This graph explains how fixed period ordering works.

  The order period is fixed as one month.

  The procurement lead time is two months.

  The order quantity is requirement in the lead time plus safety stock minus stock on hand minus back order.

  We will go through each of these on next slide.

- **Fixed Period Ordering**
  - Requirement in the lead time
    = Finished Goods production quantity × usage
    Or
    = Upper level item requirement × usage
  - Safety stock=$\alpha S \times \sigma D \times \sqrt{(LT + OC)}$
    Same as the safety stock in the production requirement calculation
  - Stock on-hand ;
    Material in the line or warehouse
  - Back order ;
    Material not received against the current order

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**Cont.**

Requirement in the lead time, safety stock, stock on-hand, and back order are explained as below.

- **Material Order Planning**

(3) Fixed quantity ordering

Replenishment order is made with a fixed quantity whenever on-hand stock falls to reorder point.

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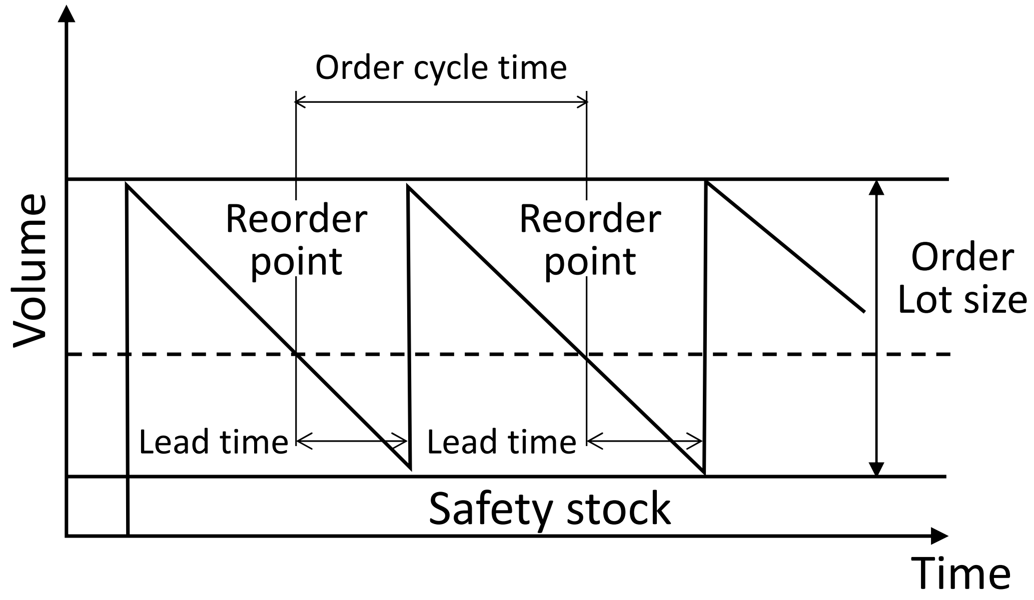
- **Material Order Planning**

The definition of fixed quantity ordering is;

- **Fixed Quantity Ordering**

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- **Fixed Quantity Ordering**

  This graph explains how fixed quantity ordering works.

  When the stock quantity drops to the reorder point, order the quantity predetermined as lot size, which is a fixed quantity.

  After placing an order with a certain lead time, the inventory goes back to the same point as before.

  The reorder point must be set by adding the quantity consumed in lead time to the safety stock.

- **Monthly Production Meeting**
  - Prepared by PC dept. ,chaired by plant manager
  - Attendees
    - Production
    - Production Engineering
    - Quality Control
    - Sales, etc
  - Information sharing and decision making
    - Trend analysis based on 6-month forecast
    - Capacity review
    - Manpower/machine allocation
    - In-house or outsourcing
    - Previous month KPI review

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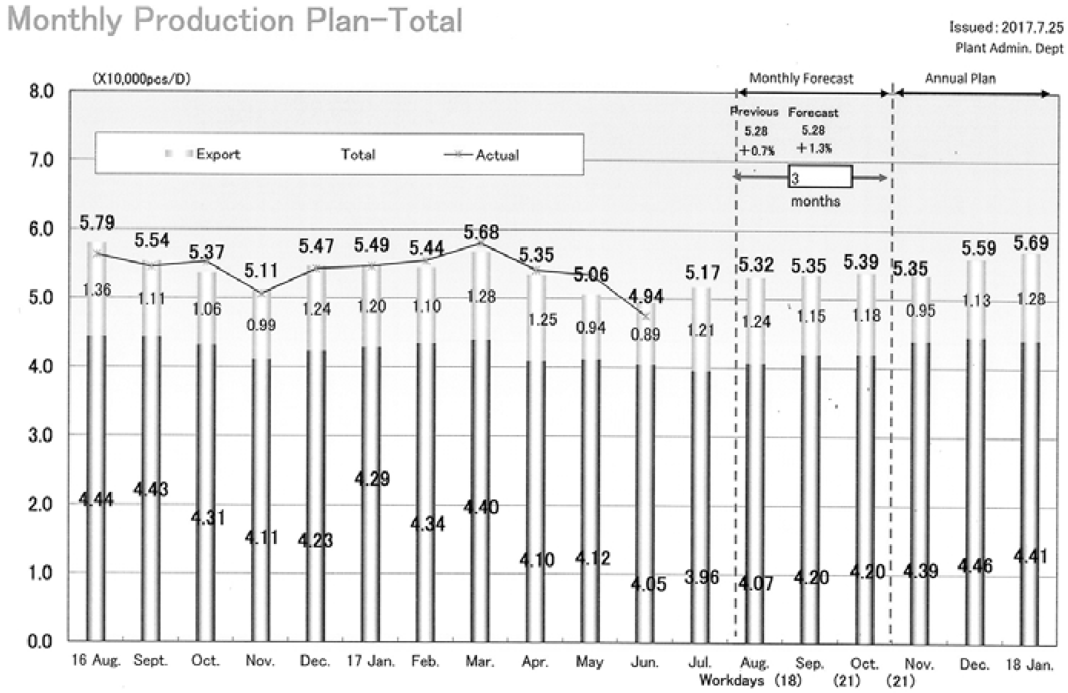
- **Monthly Production Meeting**

  Many of manufacturing companies in Japan have a regular meeting to review the production plan and make necessary decisions with related departments in the company.

  As an example, the monthly production meeting is held with following participants and agenda.

- **Monthly Production Meeting**




78

**Cont.**

Much information about production is reviewed using many graphs like these at the meeting.

This graph shows production quantities of plan and actual by month.

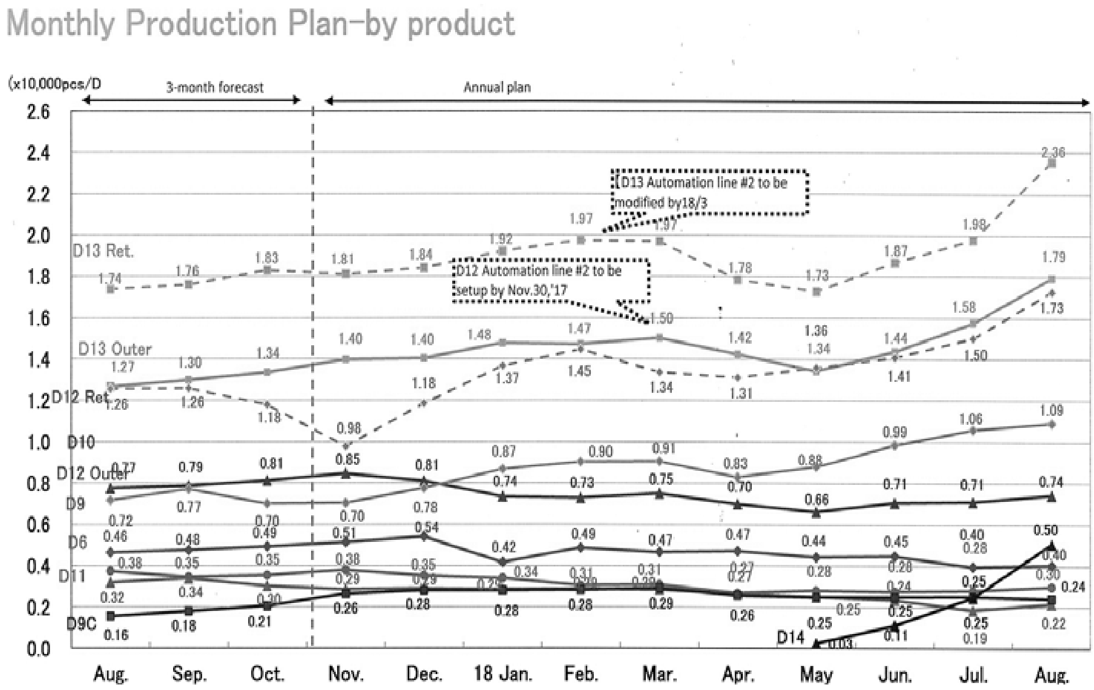
Bar graph shows planned production quantities by month. Blue bars are domestic products and pink bars are export products.

A solid blue line is actual production quantity by month. Because this company adopts Kanban system, which is a kind of make-to-order system,

production actuals are slightly different from plans. From this graph, we analyze the market trend, fluctuating, stable, increasing, or decreasing.

Based on the analysis, decisions are made, such as hiring operators, buying machines, and so forth.

## • Monthly Production Meeting

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**Cont.**

The next graph is production plan and actual by month and product.

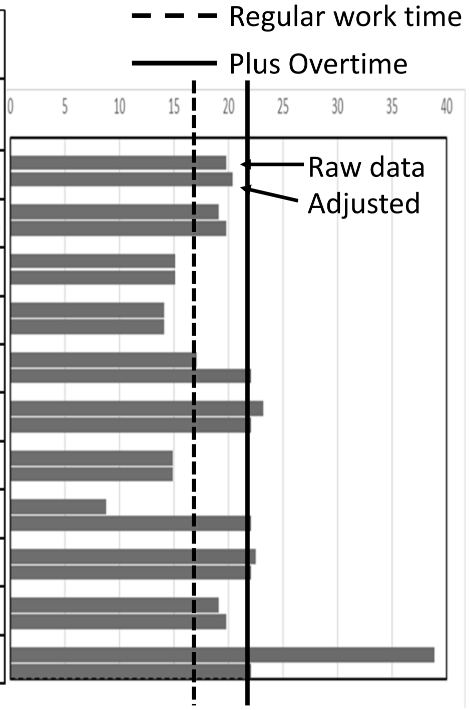
The previous graph shows the sum of all products, but this shows all products individually.

After we know the overall market trend from the previous graph, we analyze which product particularly changed or will change.

- **Monthly Production Meeting**

Machine capacity review

| Line No. | Capacity (hrs/day) Reg WT | Plus OT | Op. Avail.% | Load(hrs/day) Aug rough | Aug. adjust. |
|---|---|---|---|---|---|
| 5t-1 | 17.3 | 22.8 | 95.2 | 20.4 | 19.8 |
| 5t-2 | 17.3 | 22.8 | 95.1 | 19.1 | 19.8 |
| 17t-1 | 17.3 | 22.8 | 93 | 15.1 | 15.1 |
| 18t-1 | 17.3 | 22.8 | 95.1 | 14.1 | 14.1 |
| 18t-2 | 17.3 | 22.8 | 92.9 | 17.1 | 22.1 |
| 18t-3 | 17.3 | 22.8 | 95.1 | 23.2 | 22.1 |
| 18t-4 | 17.3 | 22.8 | 95.1 | 14.9 | 14.9 |
| 18t-5 | 17.3 | 22.8 | 90 | 8.8 | 22.1 |
| 18t-6 | 17.3 | 22.8 | 94 | 22.5 | 22.1 |
| 18t-7 | 17.3 | 22.8 | 95.1 | 19.1 | 19.1 |
| 18t-8 | 17.3 | 22.8 | 98.1 | 38.9 | 22.1 |

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**Cont.**

After market trend review, production lines are reviewed.

This graph shows daily running hours by machine.

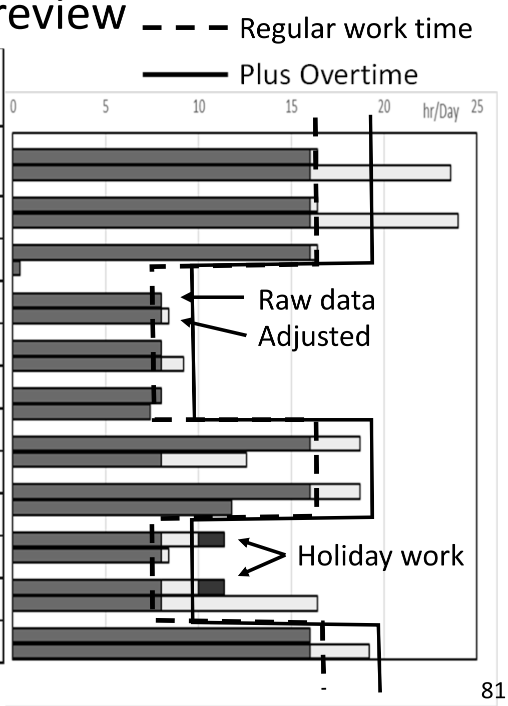
For example, line 18t-8 needs to run 38.9 hours a day. The machine's availability rate is 98.1% and the machine can run 17.3 hours in regular work time and 22.8 hours with overtime. The upper bar is running hours before adjustment and lower bar is running hours after adjustment. The upper line goes far beyond regular work time and plus overtime lines. By transferring some molds to the machines that have low running hours like line No.18t-5, the load is reduced from 38.9hours to 19.1hours as lower bar shows.

At the meeting, members check if any machines that have very low or very high loads even after adjustment and make necessary decisions such as initiate Kaizen projects to reduce cycle times or outsource some parts to reduce the load.

- **Monthly Production Meeting**

Assembly line manpower review

| Line No. | Manpower(#of ops./day) | | | Shift | Load(ops./day) | |
|---|---|---|---|---|---|---|
| | Normal | Max | Optimal | | Aug.rough | Aug.adjust. |
| V3 | 2 | 2 | 2 | 2 | 5.9 | 4 |
| V4 | 2 | 2 | 2 | 2 | 6 | 4.1 |
| V5 | 2 | 4 | 4 | 2 | 0.1 | 4.1 |
| L2 | 3 | 5 | 4 | 1 | 4.2 | 3 |
| L5 | 3 | 4 | 4 | 1 | 4.6 | 3 |
| L8 | 4 | 6 | 4 | 1 | 3.7 | 4 |
| C4 | 3 | 5 | 4 | 2 | 7.9 | 7 |
| C5 | 3 | 5 | 4 | 2 | 5.9 | 7 |
| K1 | 4 | 5 | 4 | 1 | 4.2 | 7 |
| K2 | 4 | 5 | 4 | 1 | 10.1 | 7.1 |
| A1 | 3 | 5 | 4 | 2 | 7.2 | 6 |




**Cont.**

This graph shows daily working hours by assembly line (manual production line).

For example, A1 line holds 3 operators in normal layout line, 5 operators in maximum layout line, and 4 operators in optimal layout line.

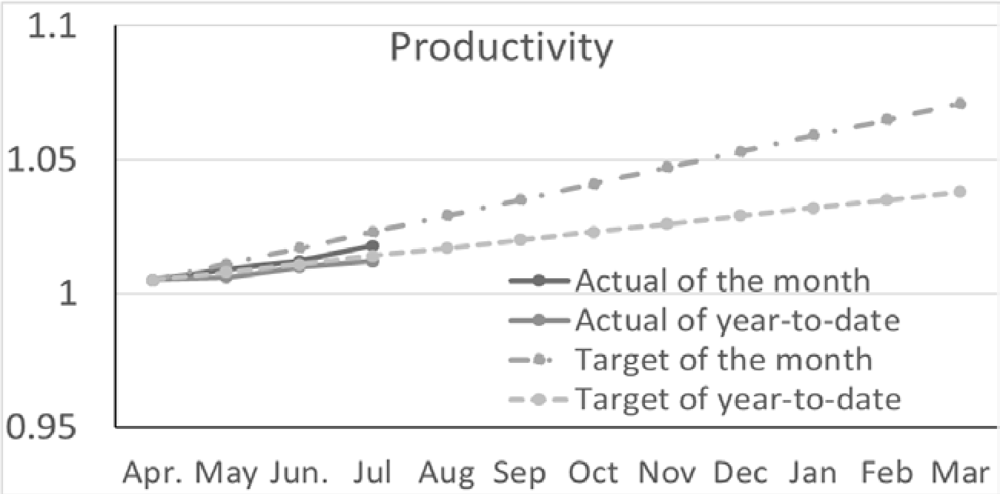
The load of this line requires 7.2 operators before adjustment as lower bar shows and 6 operators after adjustment as upper bar shows.

The way to adjust loads is to transfer some products from one line to other line or rearranging line layouts.

At the meeting, members will check if any lines that need to work over holidays or more and make necessary decisions such as hiring temporary operators or outsource some products.

- **Monthly Production Meeting**

Previous month KPI review




Other KPIs

- Quality target
- On-time delivery
- Cost reduction activity

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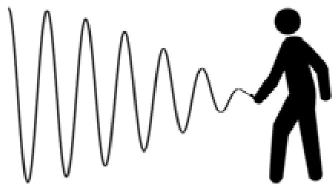
**Cont.**

The key performance indicators of previous month production, such as productivity, quality, or on-time delivery are reviewed at the meeting.

This graph shows productivity of actual and target by month. If the actual productivity is below target, plant manager usually directs production managers to initiate Kaizen activities at the meeting.

## 4. Bull-Whip Effect

- The final customer places an order (whip) and order fluctuations build up upstream the supply chain.



- Named for the way the amplitude of a whip increases down its length.
- The further from the originating signal, the greater the distortion of the wave pattern.

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**4. Bull-Whip Effect**

Bull-whip effect is a critical word for supply chain management.

The Bull-whip effect is explained as this;

- **Bull-Whip Effect**
  - A distribution channel phenomenon in which forecasts yield supply chain inefficiencies.
  - Forecast accuracy decreases as one moves upstream along the supply chain.
  - Inventory swings increase in response to shifts in customer demand as one moves further up the supply chain


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- **Bull-Whip Effect**

  You need to understand the effect for supply chain management as below.

- **Bull-Whip Effect**
  - Volvo[1] suffered a glut in green car market in the 1990s.
  - Sales and marketing developed a program to move the excess inventory.
  - While successful in generating the desired market pull, manufacturing did not know about the promotional plans.
  - Instead, they read the increase in sales as an indication of growing demand for green cars and ramped up production.

[1] Swedish multinational manufacturing company .Its core activity is the production, distribution and sale of trucks, buses and construction equipment,

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**Cont.**

Here is a case of Bull-Whip effect, which Volvo, a Swedish manufacturing company, had gone through.

- **Bull-Whip Effect**

1. Causes

   1.1 Behavioral causes

   - Misuse of safety stock policies
   - Mis-perceptions of feedback and time delays
   - Panic ordering reactions after unmet demand

   1.2 Operational causes

   - Dependent demand processing
   - Lead time variability (forecast error during replenishment lead time)
   - Lot-sizing
   - Sales promotion and forward buying

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**Cont.**

The causes of Bull-Whip effect are;

- **Bull-Whip Effect**
  - Countermeasures
    - Just in time replenishment (JIT, Kanban system)
    - Strategic partnership
    - Information sharing
    - Smooth the flow of products
      - Coordinate with retailers to level orders evenly
      - Reduce lot sizes
      - Smaller and more frequent replenishments
    - Eliminate pathological incentives
      e.g. Every day low price policy

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**Cont.**

The countermeasures to avoid Bull-Whip effect are;

- **Bull-Whip Effect**

The stock increases as BOM level goes down.

| Lv. | Description | Use | Material | Process | Supplier |
|---|---|---|---|---|---|
| 0 | SARASA,Black | 1 | NA | Assembling | In-house |
| 1 | Case Upper, Black assy | 1 | NA | Assembling | In-house |
| 2 | Case Upper | 1 | PMMA | Molding | In-house |
| 2 | Clip, Black | 1 | ABS | Molding | Addis Plastics |
| 2 | Button, Black | 1 | ABS | Molding | Addis Plastics |
| 2 | Pusher | 1 | PP | Molding | Addis Plastics |
| 2 | Plate Spring | 1 | SUS | Stamping | In-house |
| 1 | Case Lower,Black assy | 1 | NA | Assembling | In-house |
| 2 | Case Lower | 1 | PMMA | Molding | In-house |
| 2 | Rubber, Black | 1 | NBR | RIM | Sheba Rubber |
| 1 | Ink Cartridge, Black | 1 | NA | Ink mfg. | Anbessa Inks |
| 1 | Coil Spring | 1 | SWC | Rolling | Addis Springs |

Stock amounts
of Case Upper parts .

Stock amounts
of Case Lower parts

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**Cont.**

The amount of stock increases as the level of BOM goes down for Bull-whip effect like this.

For example, under the leve1 of Case Upper, Black assy, there are four of level 2 parts, Case Upper, Clip, Button, Pusher, and Plate Spring.

As we learned in material

- **Bull-Whip Effect**

## Exercise

Make a production plan for Outer assy for the week of 11 to 13 and make material order plans for Base subassy and screws to support the Outer assy production plan based on the following instruction.

1. Determine the Outer demand forecast for wk11 to wk13 by averaging the demands of wk7 to wk10. (Simple averaging)
2. Calculate Outer assy бD (Standard deviation of demand) based on the following data.
3. The Outer assy stock-out allowance is 1%. The lead time and order frequency are 5 days each. With the бD on the above ,calculate the Outer assy safety stock.

| Wk 1 | Wk 2 | Wk 3 | Wk 4 | Wk 5 | Wk 6 | Wk 7 | Wk 8 | Wk 9 | Wk 10 |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 12 | 13 | 10 | 11 | 10 | 14 | 12 | 8 | 10 |

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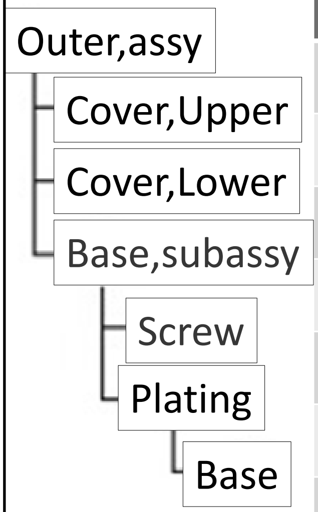
**Cont.**

Let’s try this exercise to understand the way of production planning and material order planning fully.

Also let’s see how Bull-whip effect happens through this planning.

## Outer assy Bill of Material is below




| Seq | Description | Use | Material | Process | Supplier |
|---|---|---|---|---|---|
| 0 | Outer,assy | 1 | - | assembling | In-house |
| 1 | Cover, | 1 | ABS | molding | X Plastics |
| 1 | Cover, Lower | 1 | ABS | molding | X Plastics |
| 1 | Base subassy | 1 | - | assembling | In-house |
| 2 | Screw | 2 | SWC | rolling | Z Fastener |
| 2 | Plating | 1 | - | plating | In-house |
| 3 | Plate ,Base | 1 | S25C | stamping | In-house |

4. The lead time of Base subassy and screw is 5days. Base suabby safety stock is 5pcs and screw safety stock is 10pcs.

No need to consider the back orders and lot sizing for all parts.

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**Cont.**

Outer assy Bill of Material is this.

And the lead time of Base subassy and screw is 5days.

Base suabby safety stock is 5pcs and screw safety stock is 10pcs.

We do not need to consider the back orders and lot sizing for all parts.

## Fill the all blanks of below sheet.

| | Wk 9 | Wk 10 | Wk 11 | Wk 12 | Wk 13 |
|---|---|---|---|---|---|
| Outer demand forecast | Comp. | Comp. | | | |
| Outer Safety stock | Comp. | Comp. | | | |
| Outer on-hand beginning. | Comp. | Comp. | 0 | | |
| Outer Requirement | Comp. | Comp. | | | |
| Outer on-hand ending. | Comp. | Comp. | | | |
| Base subassy Safety stock | Comp. | 5 | 5 | 5 | 5 |
| Base subassy on-hand beginning | Comp. | 0 | | | Indefinite |
| Base subassy Requirement | Comp. | | | | Indefinite |
| Base subassy on-hand ending | Comp. | | | | Indefinite |
| Screw Safety stock | 10 | 10 | 10 | 10 | 10 |
| Screw on-hand beginning | 0 | | | Indefinite | Indefinite |
| Screw Requirement | | | | Indefinite | Indefinite |
| Screw on-hand ending | | | | Indefinite | Indefinite |

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**Cont.**

Fill all the blanks on this sheet from all the calculations above.

## Demand calculation by simple averaging

$$S_{t+1}, S_{t+n} = \frac{\sum_{0}^{n-1} a_n}{n}$$

S : forecast
a : actual
n : # of buckets

Actual (3 weeks) — Forecast

| wk7 | wk8 | wk9 | wk10 | wk11 | wk12 | wk13 |
|---|---|---|---|---|---|---|
| 14 | 12 | 8 | 10 | 11 | **11** | **11** |

$$n=4, \quad S = \frac{14+12+8+10}{4} = 11$$

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**Cont.**

Demand calculation by simple averaging is shown here.

- Requirement calculation;
  Demand in the lead time + Safety stock
  – Stock on-hand
- Safety stock calculation;

$$= \alpha S \times \sigma D \times \sqrt{(LT + OC)}$$
$$= 2.33 \times 1.729 \times \sqrt{10}$$
$$= 2.33 \times 1.729 \times 3.162$$
$$= 12.738$$
$$\cong 13$$

Sample standard deviation

| Stock-out allowance (%) | 1 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|
| αS | 2.33 | 1.65 | 1.29 | 0.85 | 0.53 |

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# Answer

| | Wk 9 | Wk 10 | Wk 11 | Wk 12 | Wk 13 |
|---|---|---|---|---|---|
| Outer demand forecast | Comp. | Comp. | 11 | 11 | 11 |
| Outer Safety stock | Comp. | Comp. | 13 | 13 | 13 |
| Outer on-hand beginning. | Comp. | Comp. | 0 | 13 | 13 |
| Outer Requirement | Comp. | Comp. | 24 | 11 | 11 |
| Outer on-hand ending. | Comp. | Comp. | 13 | 13 | 13 |
| Base subassy Safety stock | Comp. | 5 | 5 | 5 | 5 |
| Base subassy on-hand beginning | Comp. | 0 | 5 | 5 | Indefinite |
| Base subassy Requirement | Comp. | 29 | 11 | 11 | Indefinite |
| Base subassy on-hand ending | Comp. | 5 | 5 | 5 | Indefinite |
| Screw Safety stock | 10 | 10 | 10 | 10 | 10 |
| Screw on-hand beginning | 0 | 10 | 10 | Indefinite | Indefinite |
| Screw Requirement | 68 | 22 | 22 | Indefinite | Indefinite |
| Screw on-hand ending | 10 | 10 | 10 | Indefinite | Indefinite |

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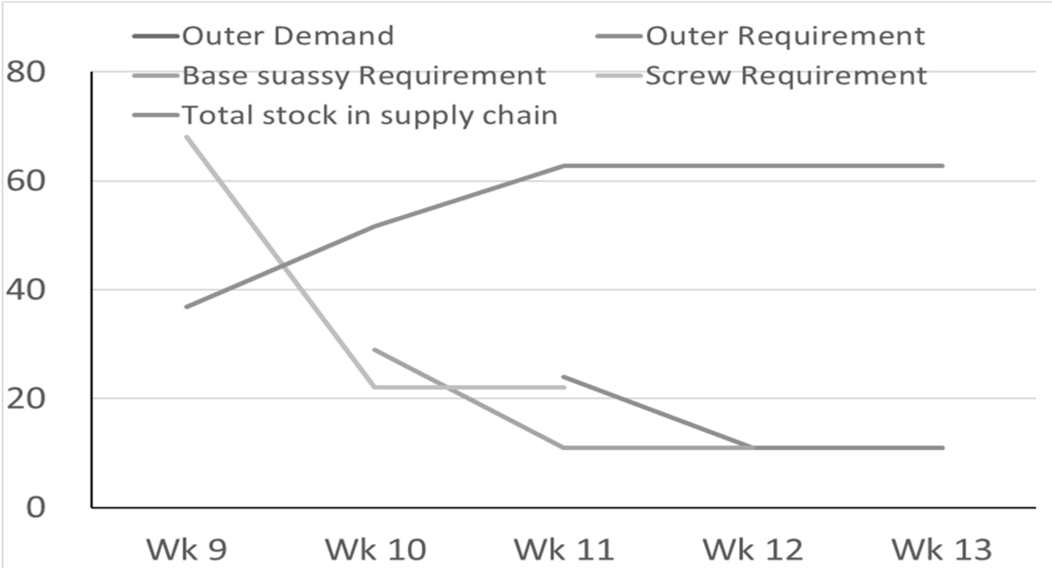
- **Bull-whip Effect**

Demand is 11pcs only, but stocks are;
24pcs Outers, 29pcs Bases, and 34sets (68pcs) Screws.

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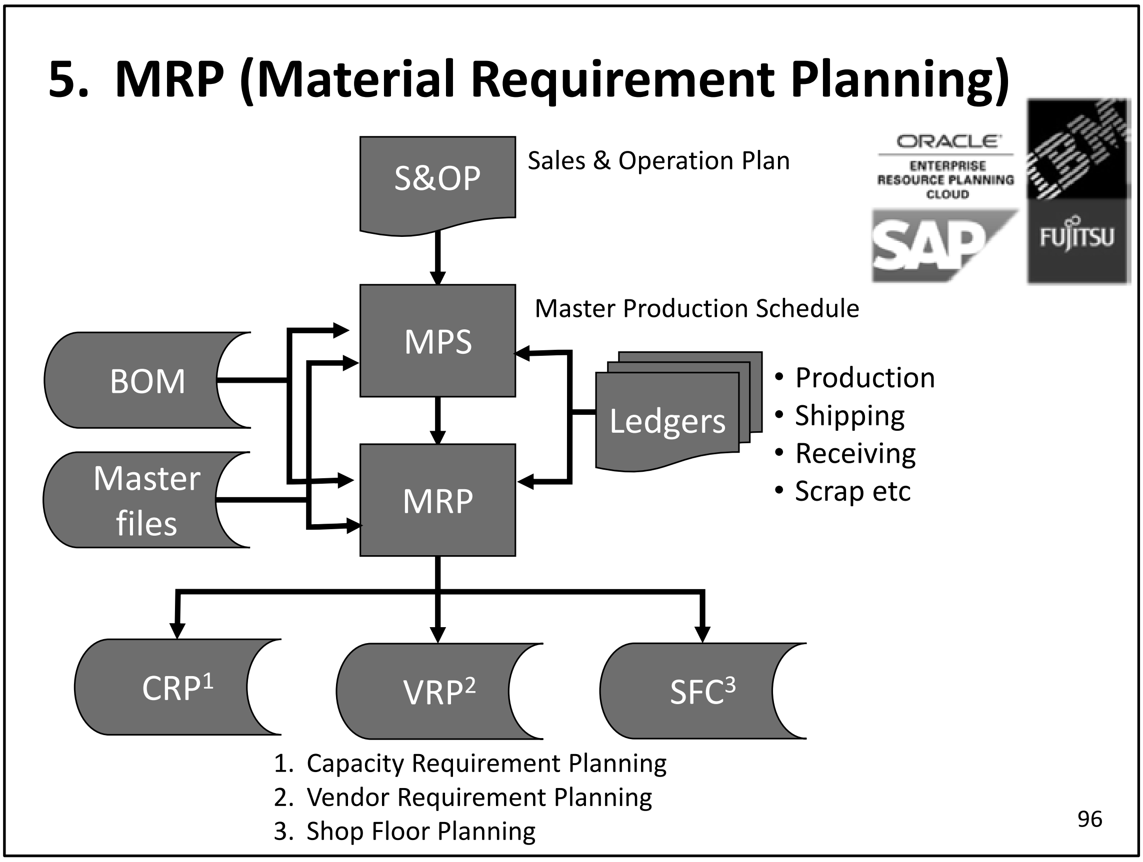
**Cont.**

This graph shows Outer demand, Outer requirement, and the stocks of Base subassy and Screw by week. From this, demand is 11pcs only, but stocks are; 24pcs Outers, 29pcs Bases, and 34sets(68pcs) Screws.




### 5. MRP (Material Requirement Planning)

Material requirements planning (MRP) is a production planning, scheduling, and inventory control system used to manage manufacturing processes. Most MRP systems are software-based like this diagram. IT companies, like IBM, ORACLE, SAP, and Fujitsu provide MRP softwares.

MRP works backward from a sales & operation plan (S&OP), a production plan for finished goods to develop requirements (MPS),and MRP for components and raw materials as this flowchart.

**S&OP**

Sales and operations planning (S&OP) is an integrated business management process that includes an updated forecast that leads to a sales plan, production plan, inventory plan.

**MPS**

It is a plan for individual products to be produced in each time period such as production, staffing, inventory, etc.

The information input into MRP systems comes from three main sources: a bill of materials(BOM & Master files), a master schedule (MPS), and an inventory records file(Ledgers).

**BOM & Master files**

The bill of materials is a listing of all the raw materials, component parts, subassemblies, and assemblies required to produce one unit of a specific finished product.

**Ledgers**

The inventory records are filed in fixed formats, called ledgers. The ledgers provide an accounting of how much inventory is already on hand or on order, and thus should be subtracted from the material requirements. The inventory records file is used to track information on the status of each item by time period. Ledgers include production output, raw material and component receipts, shipping records, and the amount of scrapped parts.

The main outputs from MRP include three primary reports.

1) Capacity Requirement Planning (CRP)
   It generates a workload report by production line to review requirements, available production capacity, and load %.
2) Vendor Requirement Planning (VRP)
   It generates purchase orders for purchased components and raw materials .
3) Shop floor Planning
   It generates production orders for in-house components. The orders include capacity requirements at the detailed planning level and these are dispatched during capacity leveling.

- **MRP (Material Requirement Planning)**
  - Manual data entry always exist and must be 100% accurate.
  - Always needs the expert to fix problem other than simple mistake.
  - Software itself is maybe reasonable price but consulting or customizing is very costly.
  - Tends to be a black box and left unused.

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**Cont.**

MRP systems offer a number of potential benefits to manufacturing firms. Some of the main benefits include helping production managers to minimize inventory levels and the associated carrying costs, track material requirements, determine the most economical lot sizes for orders, compute quantities needed as safety stock, allocate production time among various products, and plan for future capacity needs. The information generated by MRP systems is useful in other areas as well.

However, MRP systems also have several potential drawbacks as above.

You may encounter serious problems with the outputs of its MRP system. The problems could range from missing parts and excessive order quantities to schedule delays and missed delivery dates.

The key to making MRP implementation work is to provide training and education for all affected employees.

# COST AND ACCOUNTING

# Cost & Accounting

1

**Cost & Accounting**

The final target of all private company is to make profit. KAIZEN also are implemented to make more profit.

All KAIZEN consultants are requested to analyze how much profit the company made.

To know a company's situation in terms of profit, Accounting is a basic tool.

Accounting gives two financial statements from which we are able to know the company's financial situation.

To learn accounting we must know the concept of cost.

So, most of all lectured in this class is about concept of cost.

A little explanation about financial statement will be provided at the end.

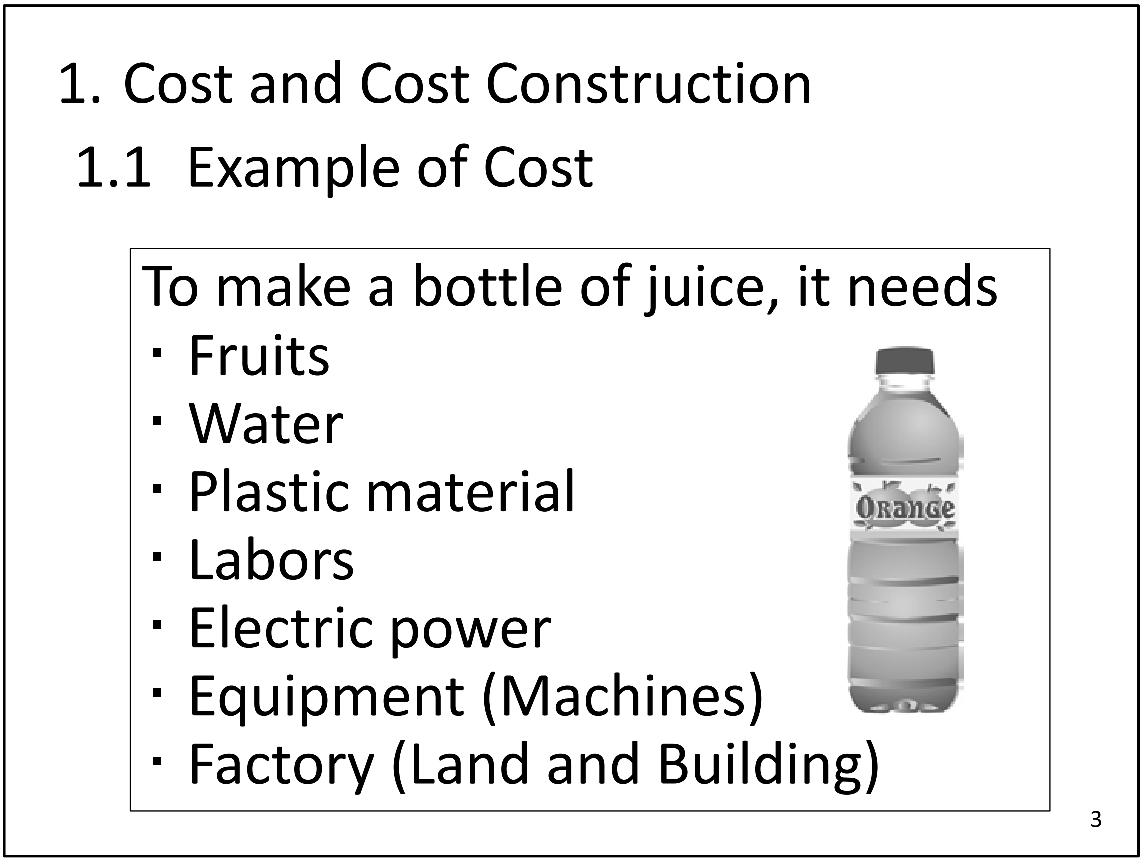
**Contents**

Contents of this class are like this.

First, I will explain about concept of cost and cost construction

Then I will explain about Break-even point.

After that, I explain about profit and loss statement and balance sheet.




**1. Cost and Cost Construction**

**1.1 Example of Cost**

Let's Consider the cost of making fruit juice.

In order to make one bottle of juice, the following costs are required:

・Fruits

・Water

・Plastic material

・Labors

・Electric power

・Equipment (Machines)

・Factory (Land and Building

## Exercise 1

Calculate how much money is needed for produce one bottle of juice.
(This factory plans to produce 300 bottles/ day)

- Fruits : 300 birr/300 bottles
- Water : 10 birr/20 bottles
- Plastic material : 20birr/20 bottles
- Labors : 900 birr/day
- Electric power : 600 birr/day

4

## Answer 1

| Item | Formula | Result |
|---|---|---|
| Fruits | 300birr on 300bottles | 1birr/bottle |
| Water | 10birr on 20 bottles | 0.5birr/bottle |
| Plastic material | 20birr on 20bottles | 1birr/bottle |
| Labors | 900birr on300bottles | 3birr/bottle |
| Electric power | 600birr on 300bottles | 2birr/bottle |
| Total | | 7.5birr/bottle |

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Costs to make a bottle of juice are calculated by the formulas.

The total cost per bottle is 7.5birr.

## 1.2 Example of Cost (How about others)

To make a bottle of juice, it needs

- Fruits
- Water
- Plastic material
- Labors
- Electric power
- Equipment
- Factory (Land and Building)

?

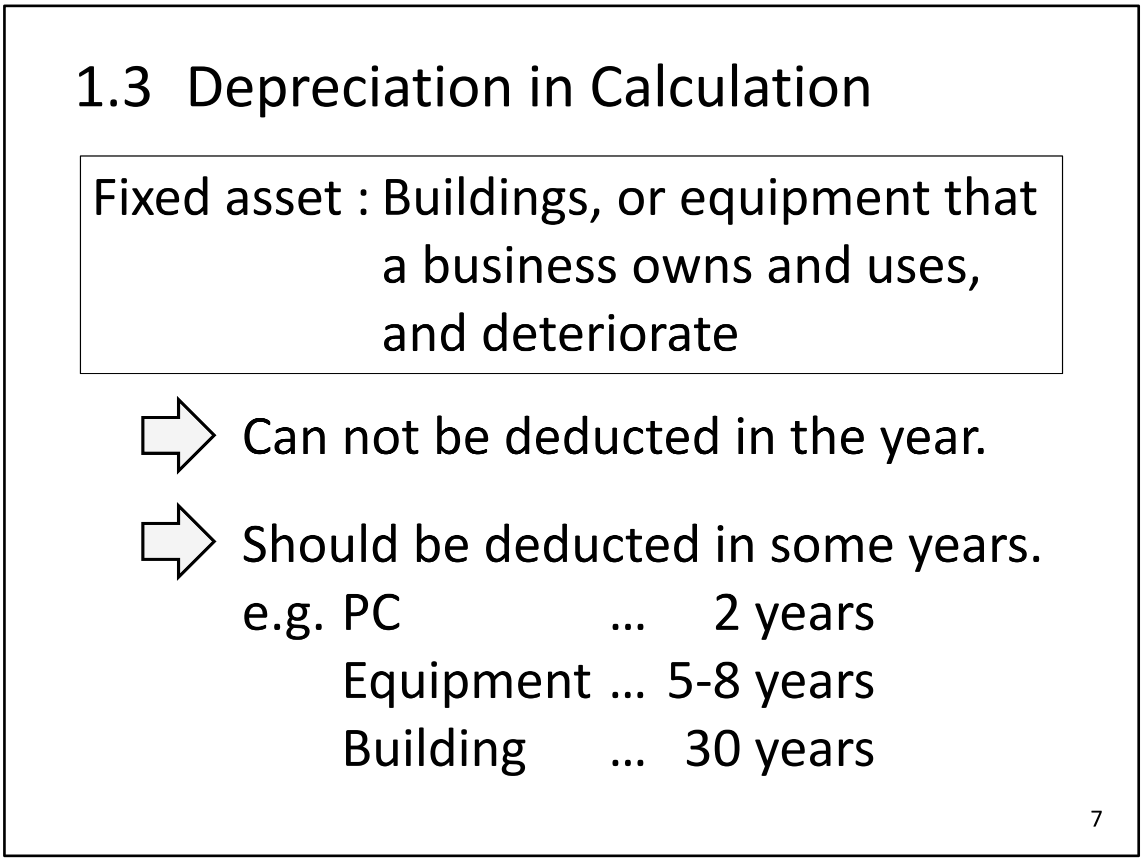

6

**1.2 Example of Cost (How about others)**

We have calculated the costs but were they enough?

There is a Factory and Equipment to make a bottle of juice.

How the costs should be calculated?




**1.3 Depreciation in Calculation**

Here, we must learn about “Depreciation”

Depreciation is an accounting method of allocating the cost of an Asset over its useful life.

What is Asset?

Asset is something valuable owned by a company for steering the business.

Cash in company’s bank account is one of the assets.

Building and equipment are called Fixed asset.

Cost (Value) of Fixed asset is same as the amount of money paid to purchase.

To produce a bottle of juice, for example, we need Fixed assets like factory (building) and equipment.

So we should count the Fixed asset as a part of cost to produce a bottle of juice.

But for accounting, we can’t count all amount of money (value) of the Fixed assets as a cost to producing a bottle of juice because building and equipment are used for many years and produce a lot of bottle of juice.

Depreciation represents how much of an asset's value has been used up for producing the products in a certain period .

So, “cost” of Fixed asset should be calculated as paid money (value) divided by certain years.

Certain years represent life of asset and determined by accounting rule of the country.

--- Cont.

Fixed asset : Land
no deteriorate

No deduction

8

You may have question how about the land where the factory is built.

Land is a asset and it is necessary for producing products but does not deteriorate.

Building and equipment deteriorate over the years of usage. But land idoes not deteriorate.

So, we should not put the value of land in the cost to make a bottle of juice.

# 1.4 Depreciation in Meaning (Reference)

1. Necessary cost to keep the business
   To prepare for replacement
2. Advantage for investment
   (Tax reduction)
   Tax= Profit ×tax ratio
   Profit= Sales-Cost
   Cost = Real Cost + Cost of apparent
   (Depreciation cost)

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**1.4 Depreciation in Meaning (Reference)**

Depreciation has two meanings.

First, Depreciation is understood as a cost to keep the business.

Equipment, for instance, deteriorate and break after some period of years so a company we must save money every year to prepare for future replacement to continue business.

Depreciation, In that sense, is a cost for continuing the business.

Second, Depreciation gives a company an advantage for investment.

Taxes are levied on profits.

When the profit reduced by the depreciation, the tax becomes lower thus Depreciation gives an incentive to companies to make new investment .

# Exercise 2

Calculate the monthly depreciation value.

| Asset | Life time | Price (birr) | Depreciation (birr/month) |
|---|---|---|---|
| PC | 2 years | 24,000 | |
| Equipment | 5 years | 54,000 | |
| Building | 30 years | 324,000 | |

10

## Answer 2

Calculate the monthly depreciation value.

| Asset | Life time | Price (birr) | Depreciation (birr/month) |
|---|---|---|---|
| PC | 2 years | 24,000 | 1,000 |
| Equipment | 5 years | 54,000 | 900 |
| Building | 30 years | 324,000 | 900 |

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## Exercise 3

Calculate how much money is needed for a bottle of juice. (This factory plans to produce 300 bottles/day)

- Fruits : 300 birr/300 bottles
- Water : 10 birr/20 bottles
- Plastic material : 20birr/20 bottles
- Labors : 900 birr/day
- Electric power : 600 birr/day
- Equipment : 900birr/month
- Factory (Building) : 900birr/month

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# Answer 3

| Item | Formula | Result |
|---|---|---|
| Fruits | 300birr divided by 300bottles | 1birr/bottle |
| Water | 10birr divided by 20bottles | 0.5birr/bottle |
| Plastic material | 20birr divided by 20bottles | 1birr/bottle |
| Labors | 900birr divided by 300bottles | 3birr/bottle |
| Electric power | 600birr divided by 300bottles | 2birr/bottle |
| Equipment depreciation expense | 900birr on 30days on 300 bottles | 0.1birr/bottle |
| Factory depreciation expense | 900birr on 30days on 300 bottles | 0.1birr/bottle |
| Total | | 7.7birr/bottle |

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# 1.5 Type of Cost

- Standard cos (Planned cost)
- Actual Cost

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**1.5 Type of Cost**

There are two types of cost.

The one is Standard cost and the other is Actual cost.

Standard cost is used for planning and Actual cost is used for managing and accounting.

# 1.6 Standard Cost

Standard cost is to make plan of the cost.

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**1.6 Standard Cost**

## 1.7 Actual Cost

Actual cost is the result and used to plan the standard cost and to analyze the difference and to take action to improve

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Set Standard cost (P1) → Actual cost (C) → Set Standard cost (P2)

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**1.7 Actual Cost**

# 1.8 Example (Standard & Actual Cost)

Standard cost

Calculation of how much money will be needed for a bottle of juice. (This factory plans to produce 300 bottles/day)

- Fruits : 300 birr/300 bottles
- Water : 10 birr/20 bottles
- Plastic material : 20birr/20 bottles
- Labors : 900 birr/day
- Electric power : 600 birr/day
- Equipment : 900birr/month
- Factory (Building) : 900birr/month

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**1.8 Example (Standard & Actual Cost)**

Here is a example of standard and actual cost.

You may understand the idfference.

| Item | Formula | Result |
|---|---|---|
| Fruits | 300birr divided by 300bottles | 1birr/bottle |
| Water | 10birr divided by 20bottles | 0.5birr/bottle |
| Plastic material | 20birr divided by 20bottles | 1birr/bottle |
| Labors | 900birr divided by 300bottles | 3birr/bottle |
| Electric power | 600birr divided by 300bottles | 2birr/bottle |
| Equipment depreciation expense | 900birr on 30days on 300 bottles | 0.1birr/bottle |
| Factory depreciation expense | 900birr on 30days on 300 bottles | 0.1birr/bottle |
| Total | | 7.7birr/bottle |

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## --- Cont.

### Actual cost

Calculation of how much money is needed for a bottle of juice
(This factory actually produced 250 bottles per day)

Conditions

- Fruits : The factory already purchased fruits and paid fruits for 300 bottles
- Water : The factory pay the expense consumed
- Plastic material : The factory pay the expense consumed
- Labors : The factory pay the labor expense by daily basis
- Electric power : The company contract daily basis (birr/day)
- Equipment : Depreciation is done daily basis (900birr/month, 30birr/day)
- Factory (Building) : Depreciation is done daily basis (900birr/month, 30birr/day)

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| Item | Formula | Result |
|---|---|---|
| Fruits | 300birr divided by 250bottles | 1.2birr/bottle |
| Water | 10birr divided by 20 bottles | 0.5birr/bottle |
| Plastic material | 20birr divided by 20bottles | 1birr/bottle |
| Labors | 900birr divided by 250bottles | 3.6birr/bottle |
| Electric power | 600birr divided by 250bottles | 2.4birr/bottle |
| Equipment depreciation expense | 900birr on 30days on 250 bottles | 0.12birr/bottle |
| Factory depreciation expense | 900birr on 30days on 300bottles | 0.12birr/bottle |
| Total | | 8.94birr/bottle |

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You should compare the two results, standard and actual cost.

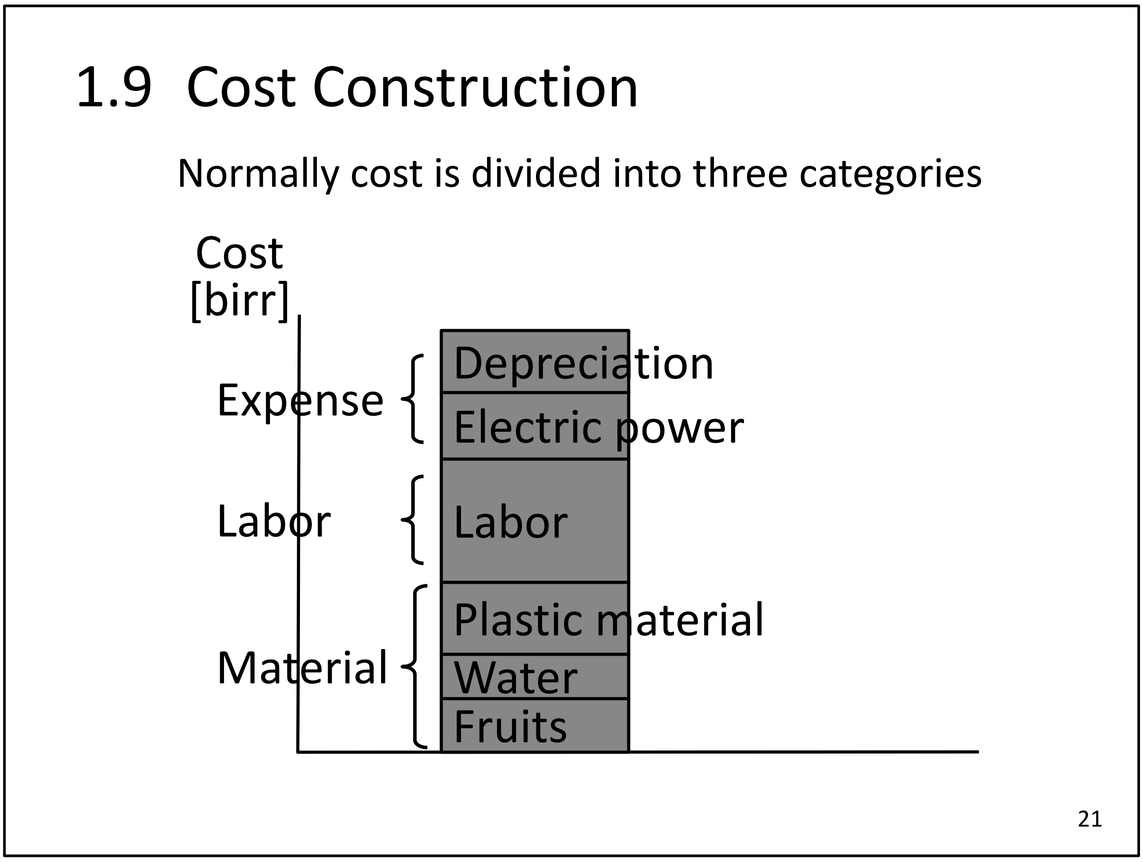
Standard cost of a one bottle of juice was 7.7birr and actual cost is 8.9birr.

The difference comes mainly from the quantity of the bottle of juice produced.

Some cost of a bottle of juice depend on the produced quantity but some are independent.

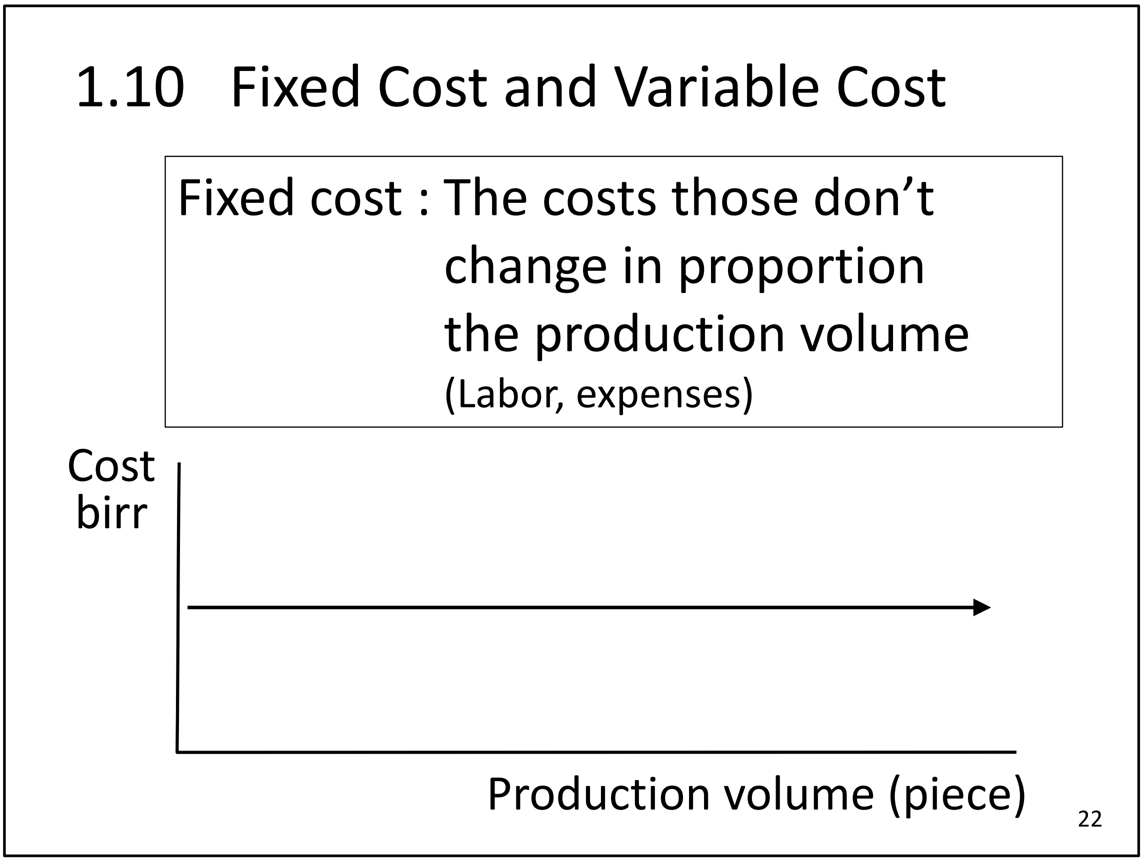
Why the difference comes?

You will learn the reason by next lesson of “Fixed cost and Variable cost”




**1.9 Cost Construction**

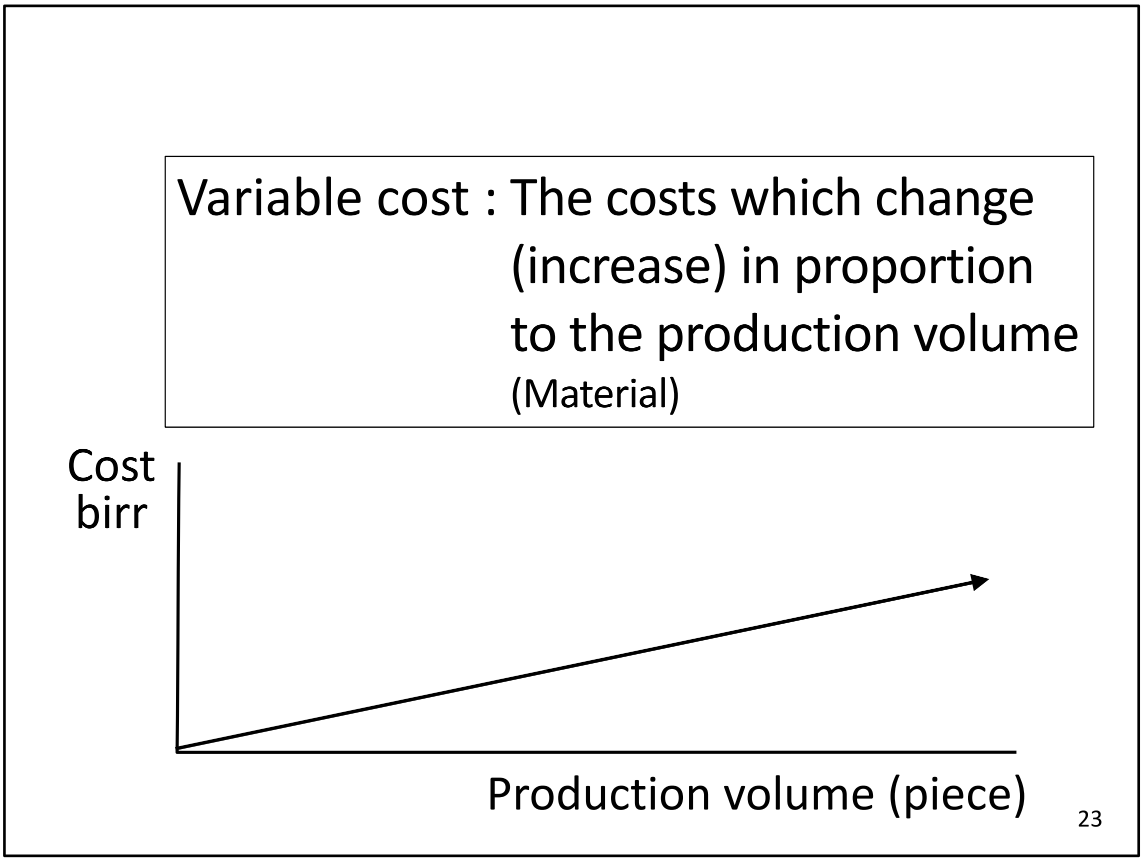
Cost is, normally, divided into three categories i.e. Expense, Labor and Material.




**1.10 Fixed Cost and Variable Cost**

Fixed cost is the cost that doesn't change in proportion to the production volume.

Labor cost and expenses are the fixed cost.




Variable cost is the cost that changes in proportion to the production volume.

Material cost is a variable cost.

## Discussion

Identify fixed cost or variable cost.

- Fruits : 300 birr/300 bottles …
- Water : 10 birr/20 bottles …
- Plastic material : 20 birr/20 bottles…
- Labors : 900 birr/day …
- Electric power : 600 birr/day…
- Equipment : 900 birr /month…
- Factory : 900 birr/month …

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You should separate the costs to fixed ad variable.

- Fruits : Material
- Water : Material
- Plastic material : Material
- Labors
- Electric power : Expenses
- Equipment : Expenses
- Factory: : Expenses

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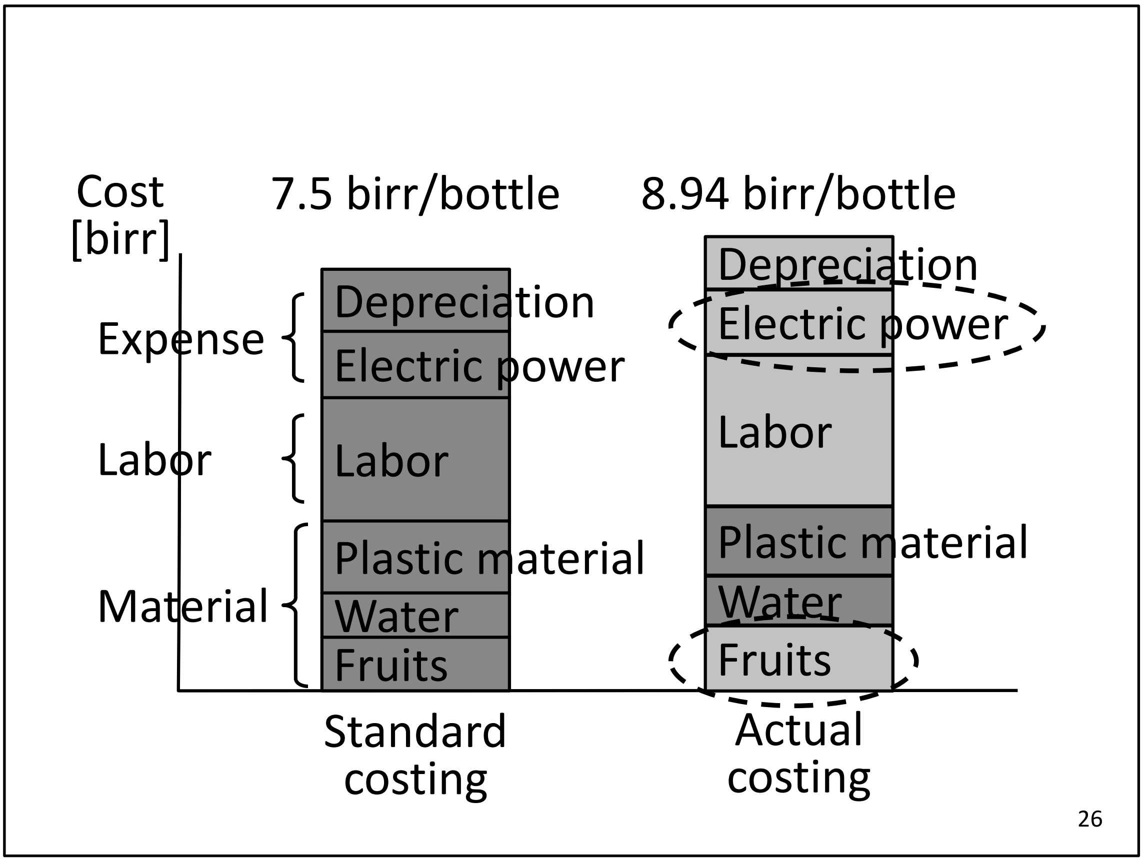
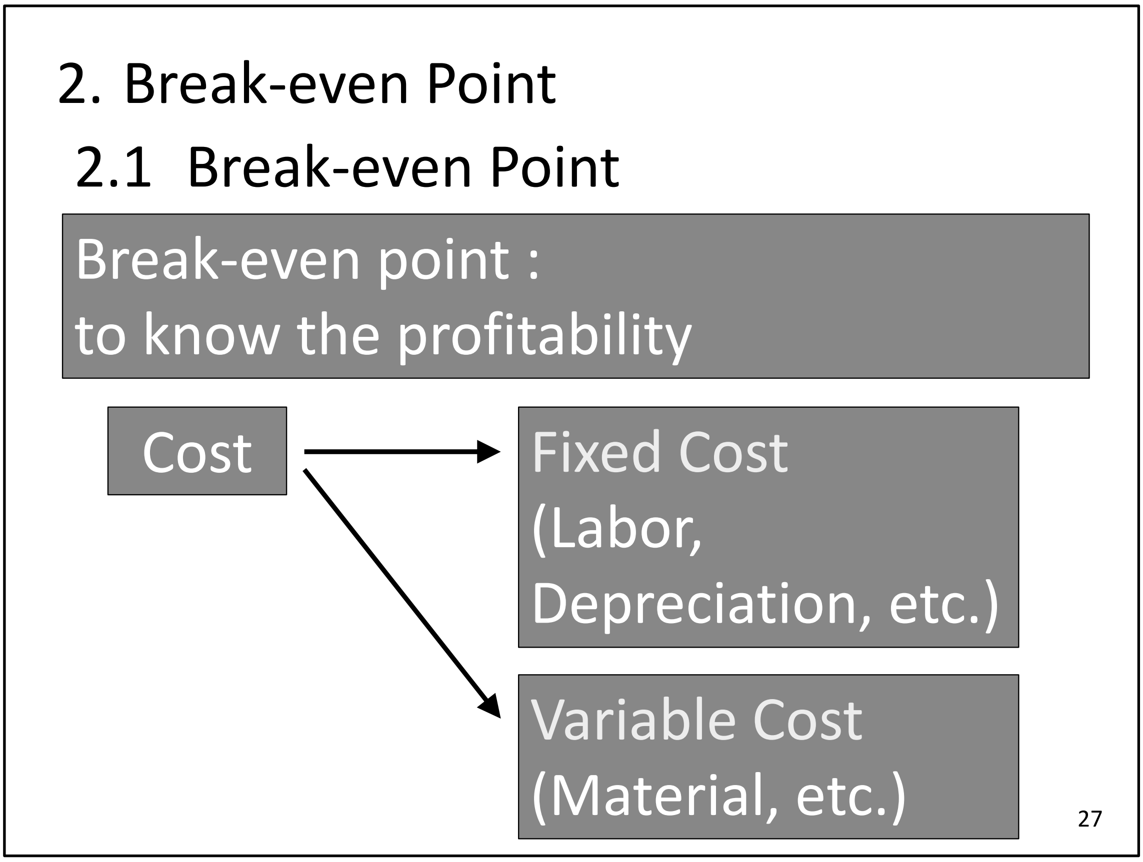



This slide shows the cost construction of standard cost and actual cost of a bottle of juice visually.

You know the plastic material and water are variable costs.

If you can change the cost of fruits and electric power to variable cost, you can reduce the actual cost even though the production volume is changed.




## 2. Break-even Point

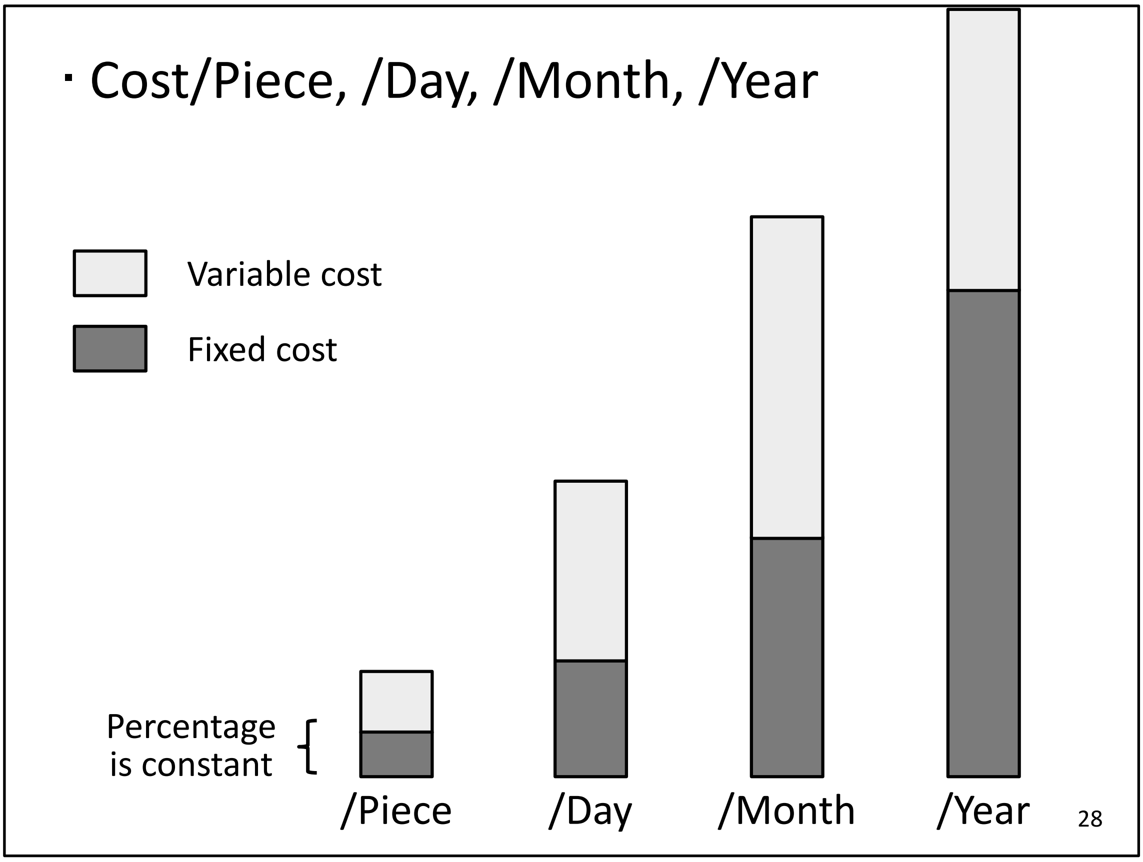
### 2.1 Break-even Point

Now, I would like to explain the break-even point.

We have already learned that costs are made up of fixed costs and variable costs.

Fixed costs such as labor costs, rent, depreciation, etc. remain the same regardless of whether sales (production volume) increase or decrease. These costs represent a uniform burden.

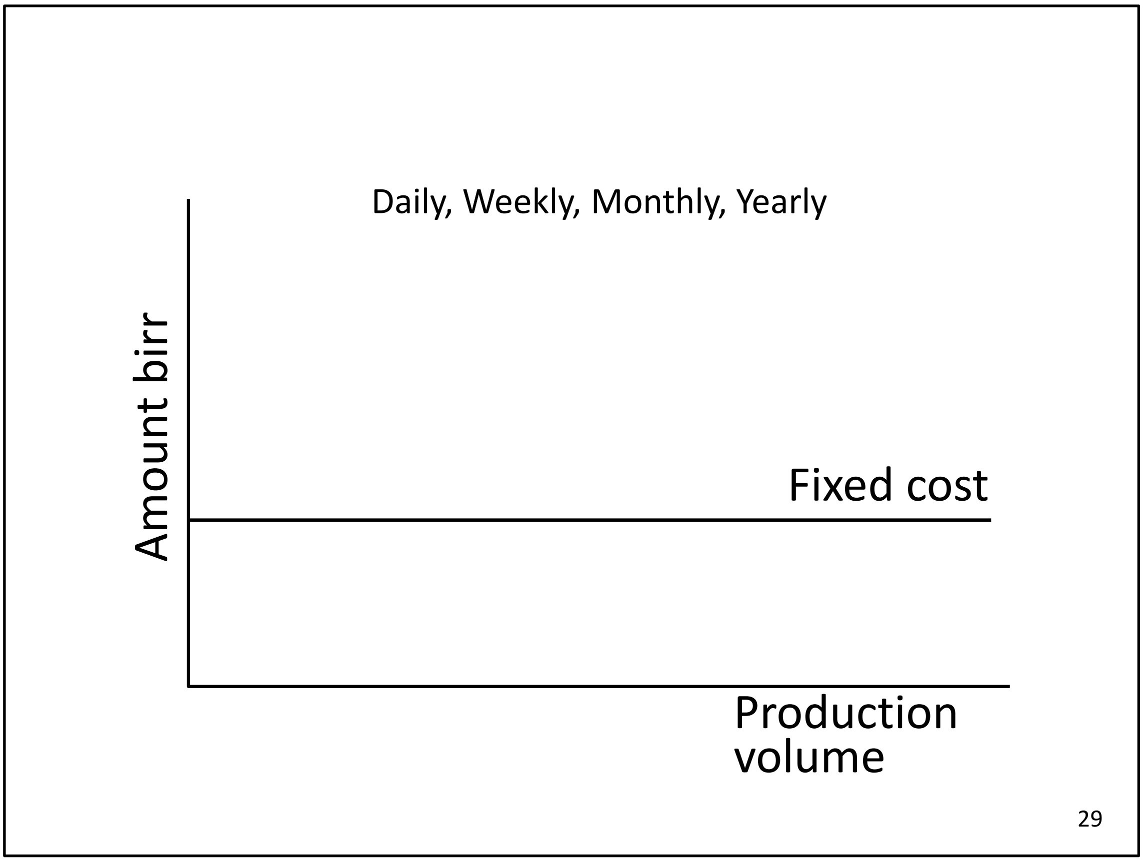
On the other hand, variable costs such as materials and parts costs, outsourcing costs, etc. rise and fall in proportion to sales.




・**Cost/Piece, /Day, /Month, /Year**

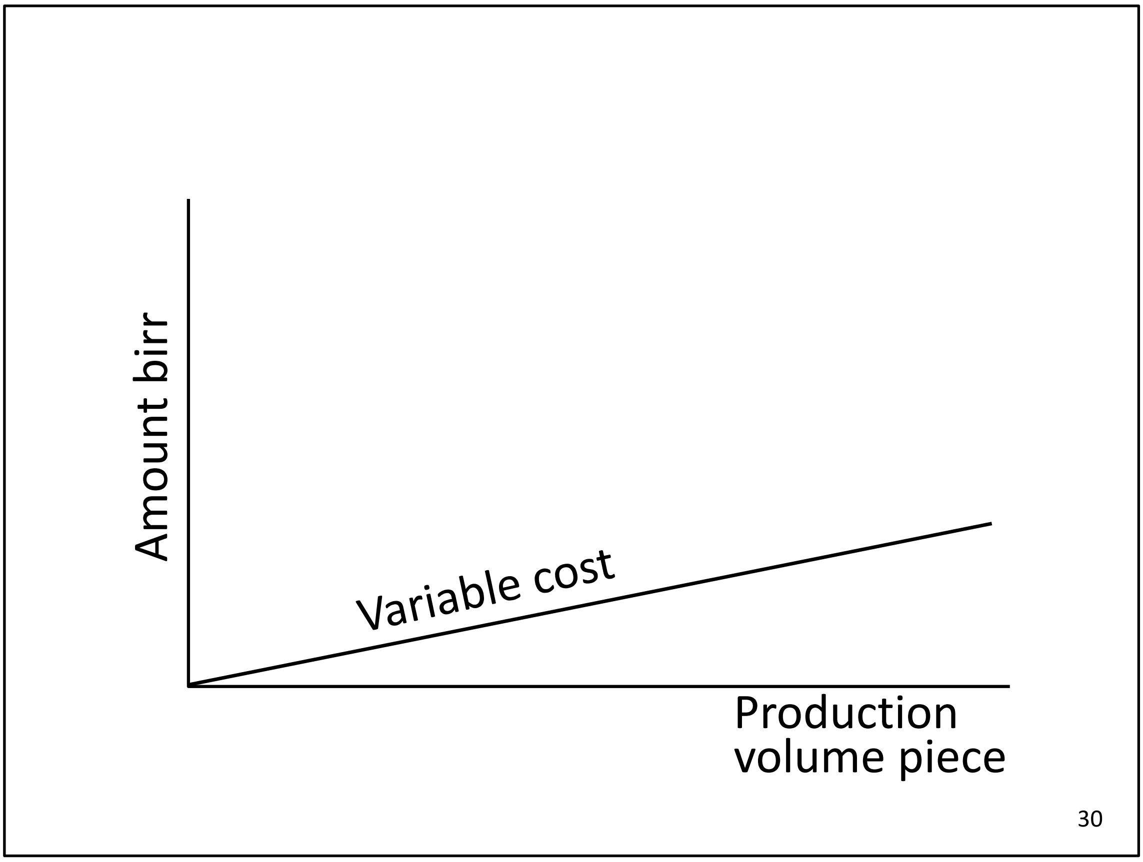
We can count cost per piece, per day, per month and per year.

The ratio of variable and fixed cost is constant.

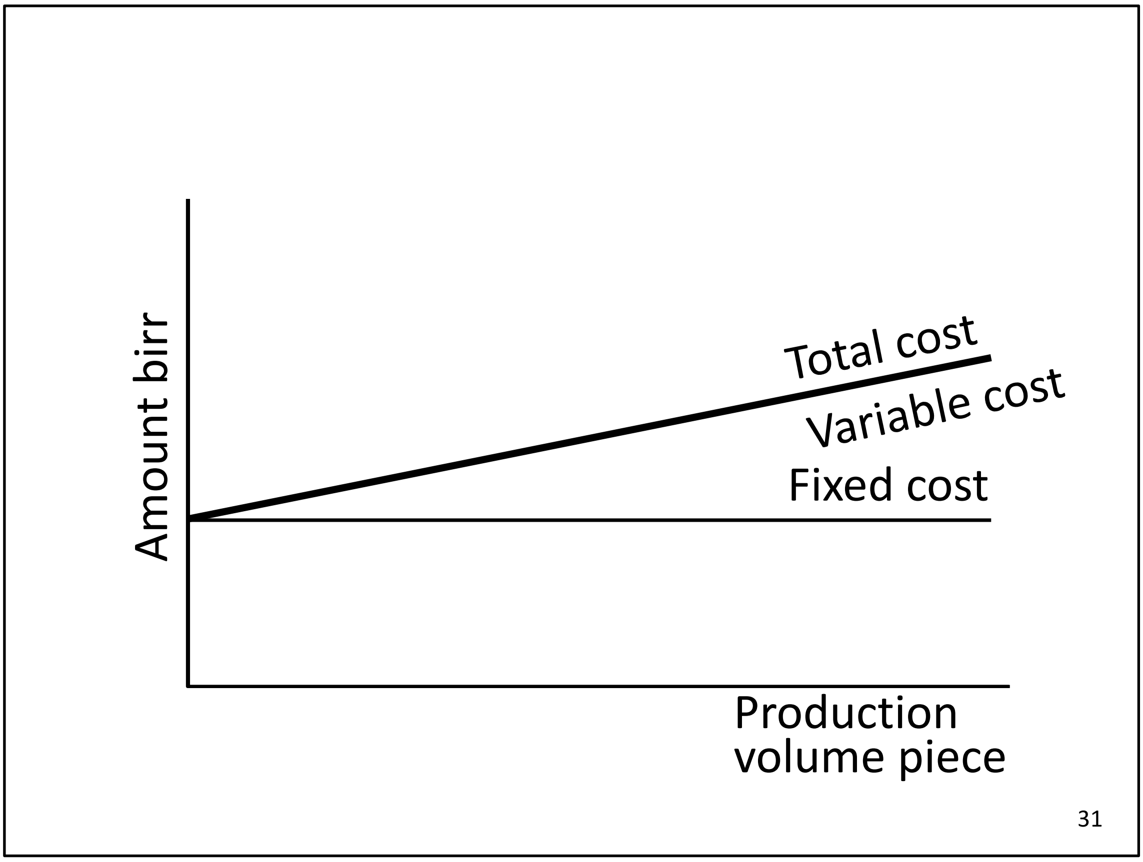



Fixed cost is not affected by sales or production volume.

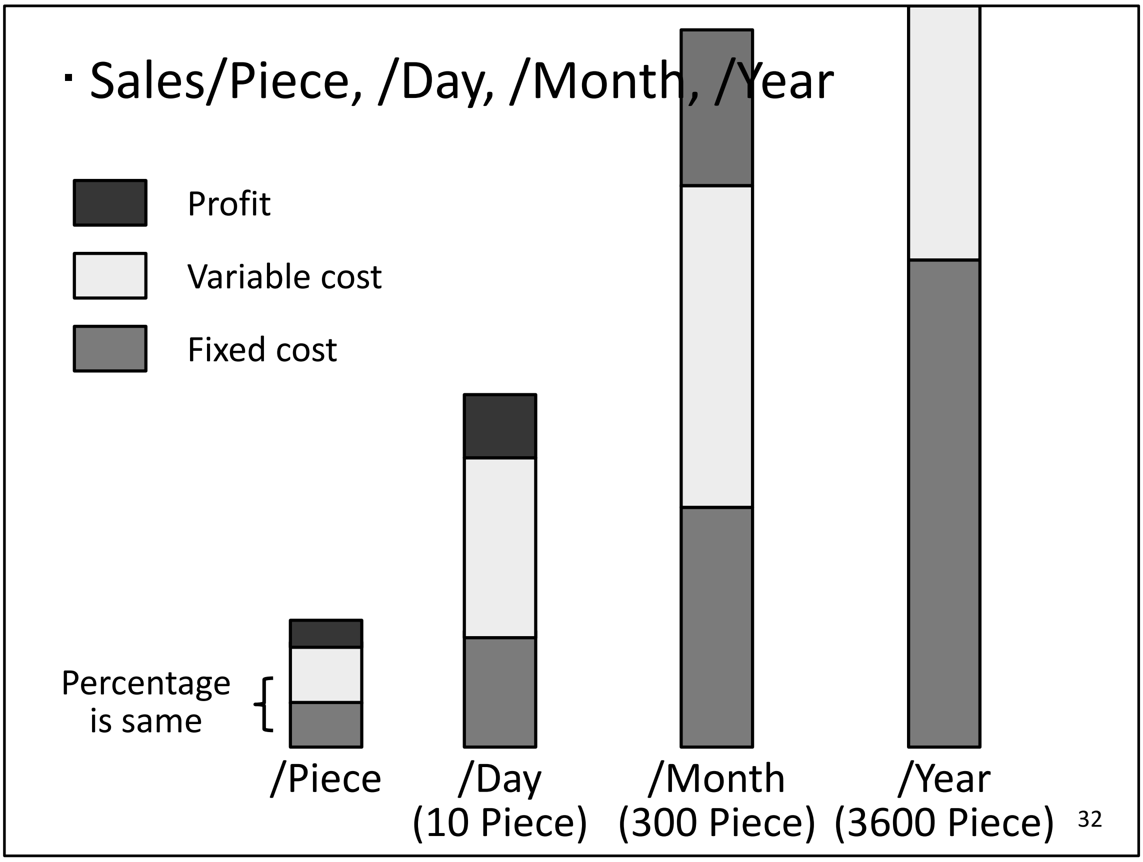
So, in the graph which has production volume as X-axis and cost amount in birr as Y-axis, the fixed cost is shown as constant horizontal.




Variable cost increase in proportion to production volume so in the graph, variable cost is illustrated by a line which slant from zero .



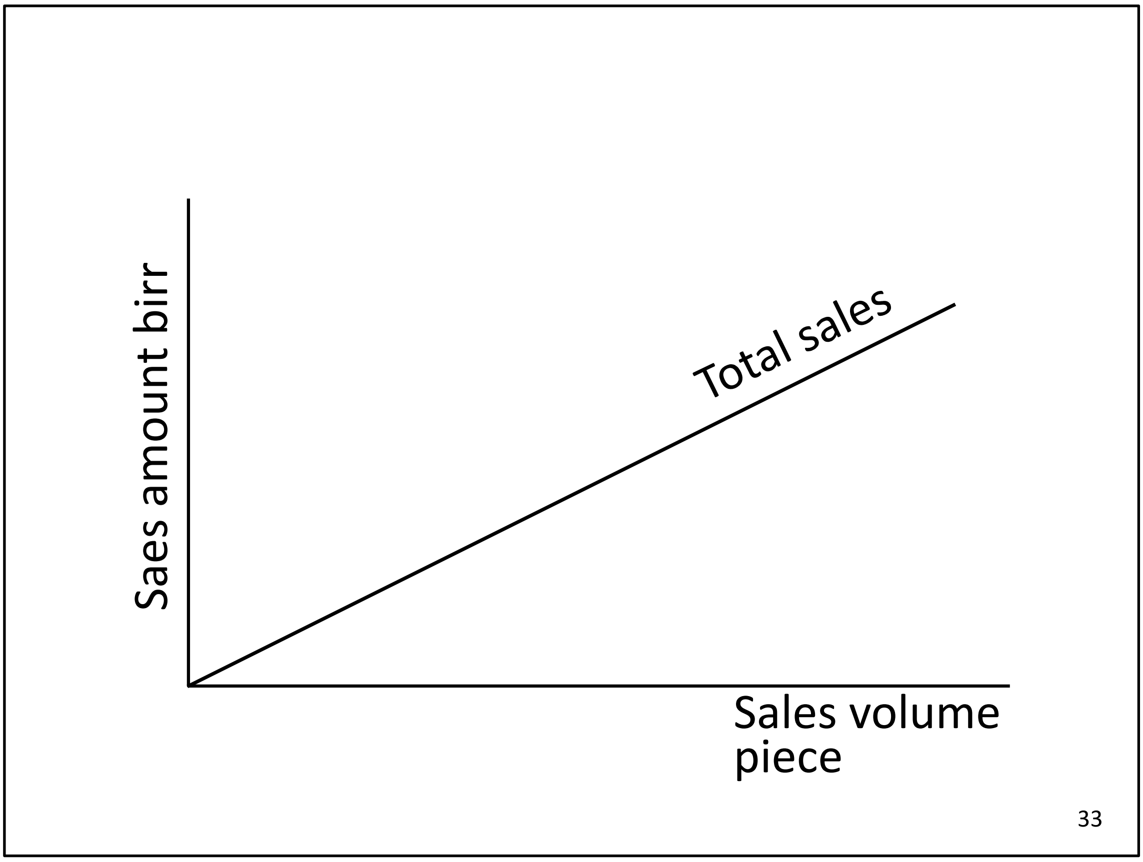

Total cost is graphically shown as the line that combines the fixed cost with the variable cost.




・**Sales/Piece, /Day, /Month, /Year**

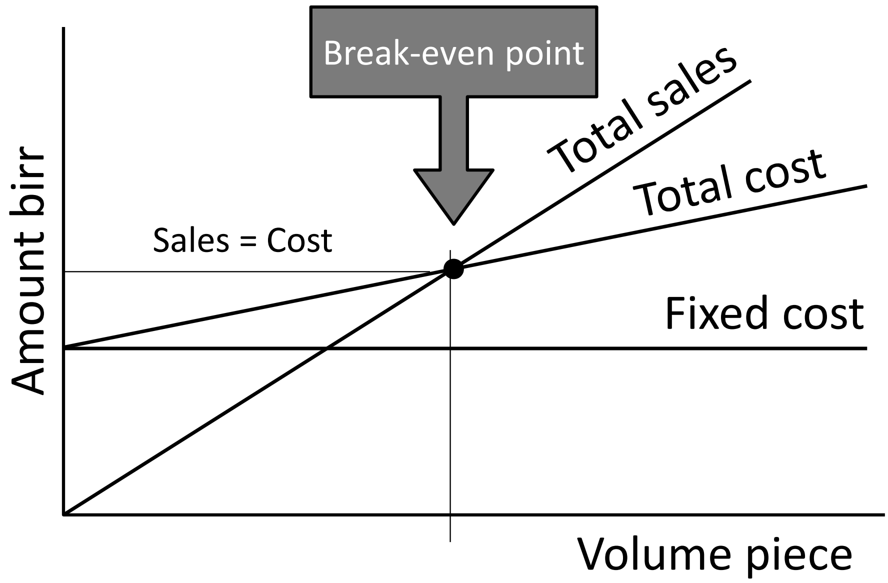
This slide shows sales price per piece, per month and per year.

Sales amount is consisted by Fixed cost, variable cost and profit.




This graph shows how the sales amount increases in proportion to the sales volume.

・Volume/ Amount

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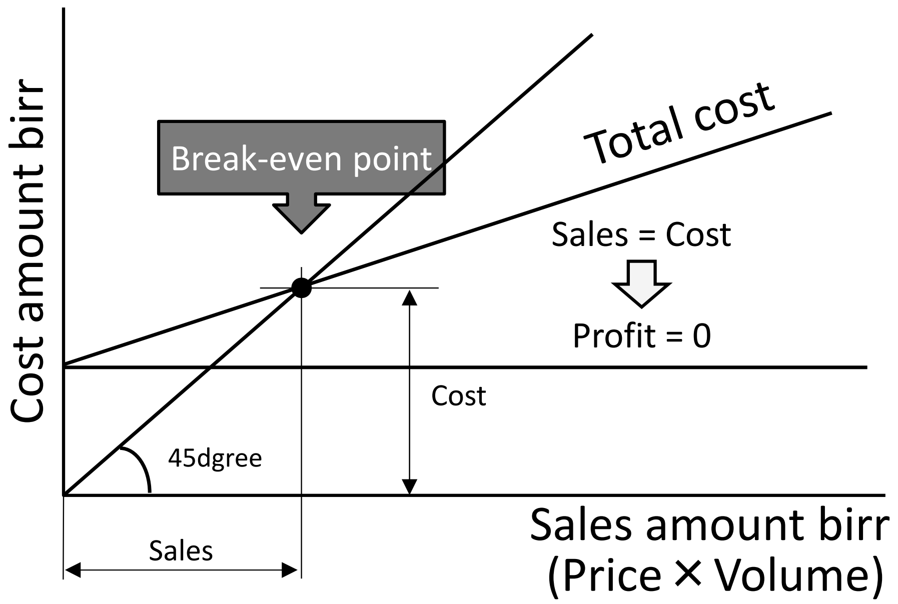
・**Volume/ Amount**

The point where the total cost line match the total sales line is the Break-even point.

Please note X-axis is the volume and Y-axis is the amount (birr)

・Amount/ Amount

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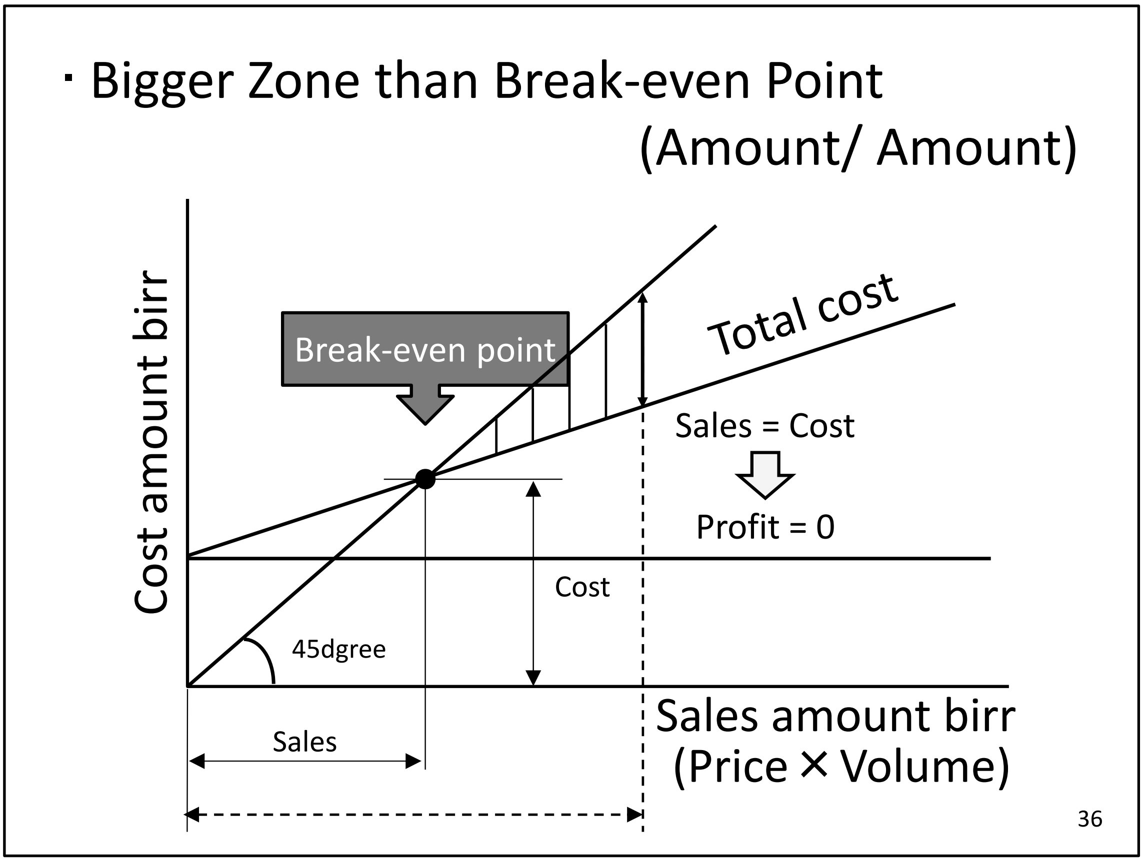
・**Amount/ Amount**

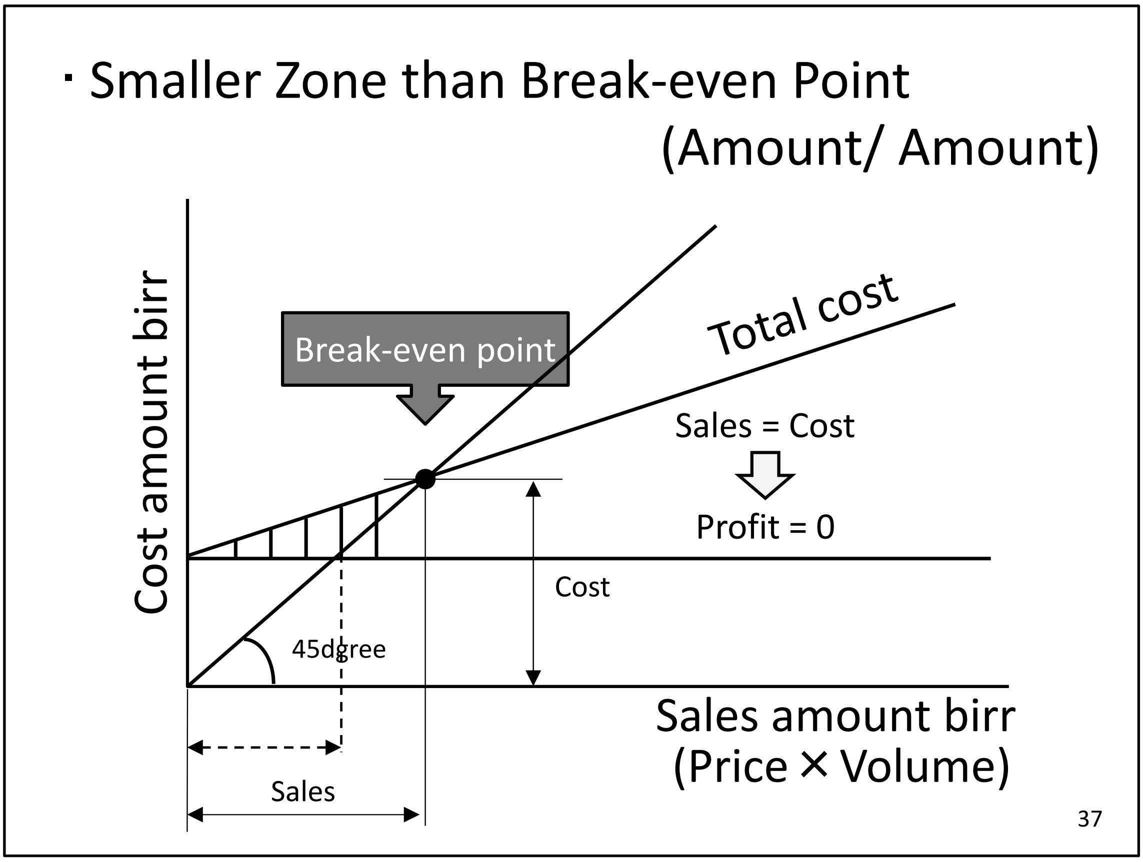
In this graph, X-axis is Sales amount in birr and Y-axis is Cost amount in birr.

You can see the Sales amount match the Cost amount in Break-even point.




**・Bigger Zone than Break-even Point (Amount/ Amount)**

From this graph you can understand profit becomes plus when the Sales amount is bigger than the Break-even point.




**・Smaller Zone than Break-even Point (Amount/ Amount)**

In the same way you can understand that the profit becomes minus when the Sales amount is smaller than Break-even point.

Let’s make break-even graph

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## Let's make break-even graph (Lesson)

1) Amount/ Volume graph

Sales Volume at Break-even point:
700birr

Fixed cost:
200birr

Variable cost at Break-even point:
300birr

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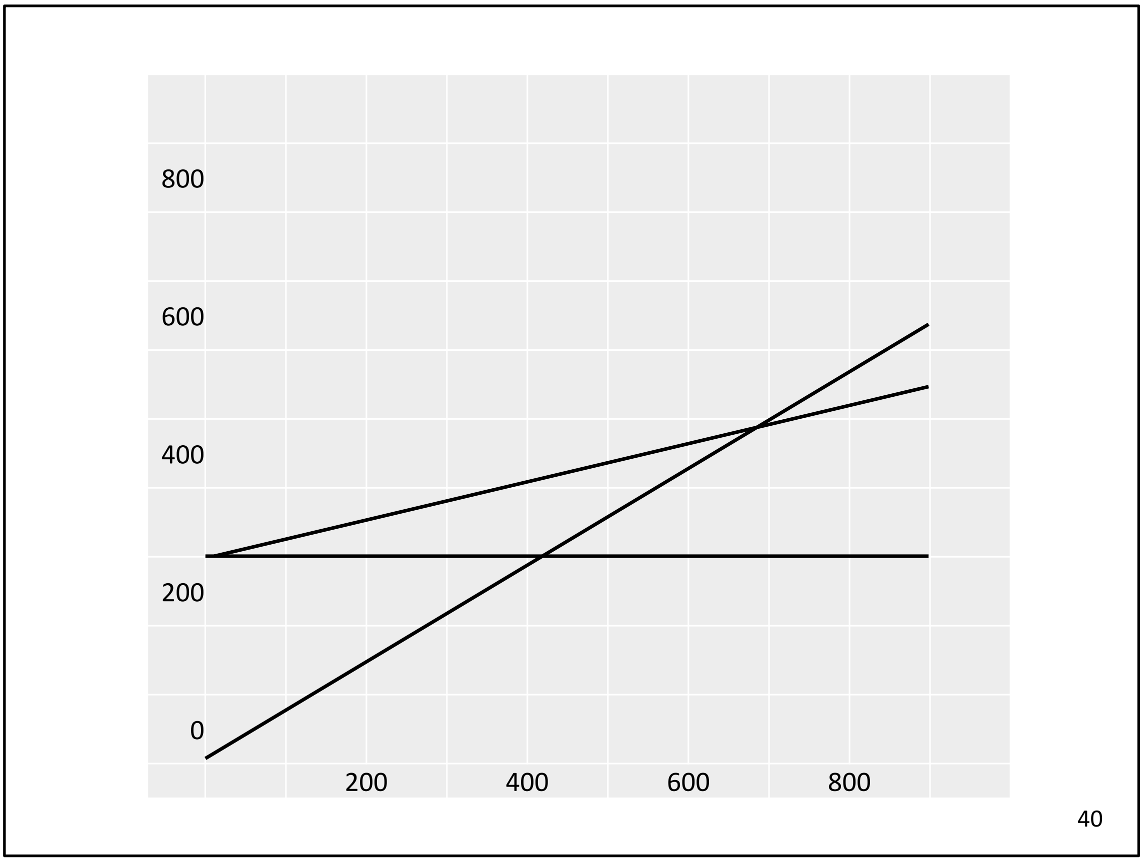
800
600
400
200
0
200
400
600
800
40

# Let's make break-even graph (Lesson)

2) Amount/ Amount graph

Sales amount at Break-even point:
600birr

Fixed cost:
300birr

Variable cost at Break-even point:
300birr

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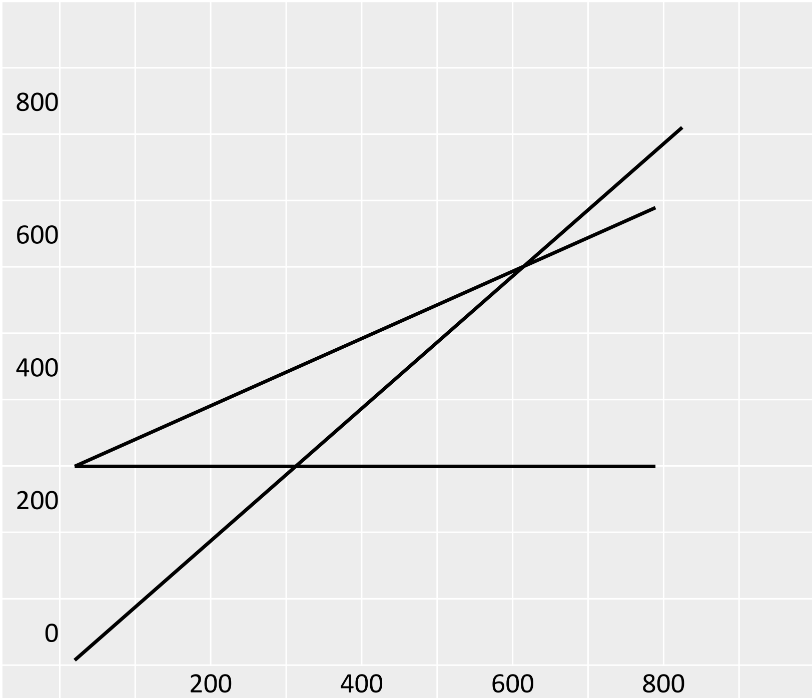


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# 2.2 Break-even Point Calculation

1. Sales amount (birr) at Break-even point

At Break-even point: Sales (birr) = Cost (birr)

Sales = p (unit price) × V (volume)

Sales = p × V

Cost = F (fixed cost) + variable cost

variable cost = V (volume) × v (unit variable cost)

Cost = F + V × v

Sales (p × V) = Cost (F+V × v)

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**2.2 Break-even Point Calculation**

Let's get Break-even point by calculation.

Break-even point＝Fixed cost / Marginal profit

Marginal profit = Selling price –Variable cost

$$p \times V = F + v \times V$$

Sales **volume** at Break-even point

$$V = \frac{F}{p-v}$$

$$\frac{\text{Fixed cost}}{\text{Unit price - unit variable cost}}$$

Sales **amount** (birr) at Break-even point

$$p \times V = p \times \frac{F}{p-v} = \frac{p \times F}{p-v} = \frac{F}{1-\frac{v}{p}}$$

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## Exercise 6

Calculate the Sales amount (birr) per day at break-even point with following conditions:

- Selling price per piece : 50 birr
- Variable cost per piece: 30 birr
- Fixed cost : 10,000 birr/day

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## Answer 6

$$\text{Sales amount (birr)} = \frac{F}{1 - \frac{v}{p}} = \frac{10{,}000}{1 - \frac{30}{50}}$$

$$= 25{,}000\text{birr}$$

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## Exercise 7

Calculate the Sales volume/day at break-even point with following conditions:

- Selling price per piece : 50 birr
- Variable cost per piece: 40 birr
- Fixed cost : 10,000 birr/day

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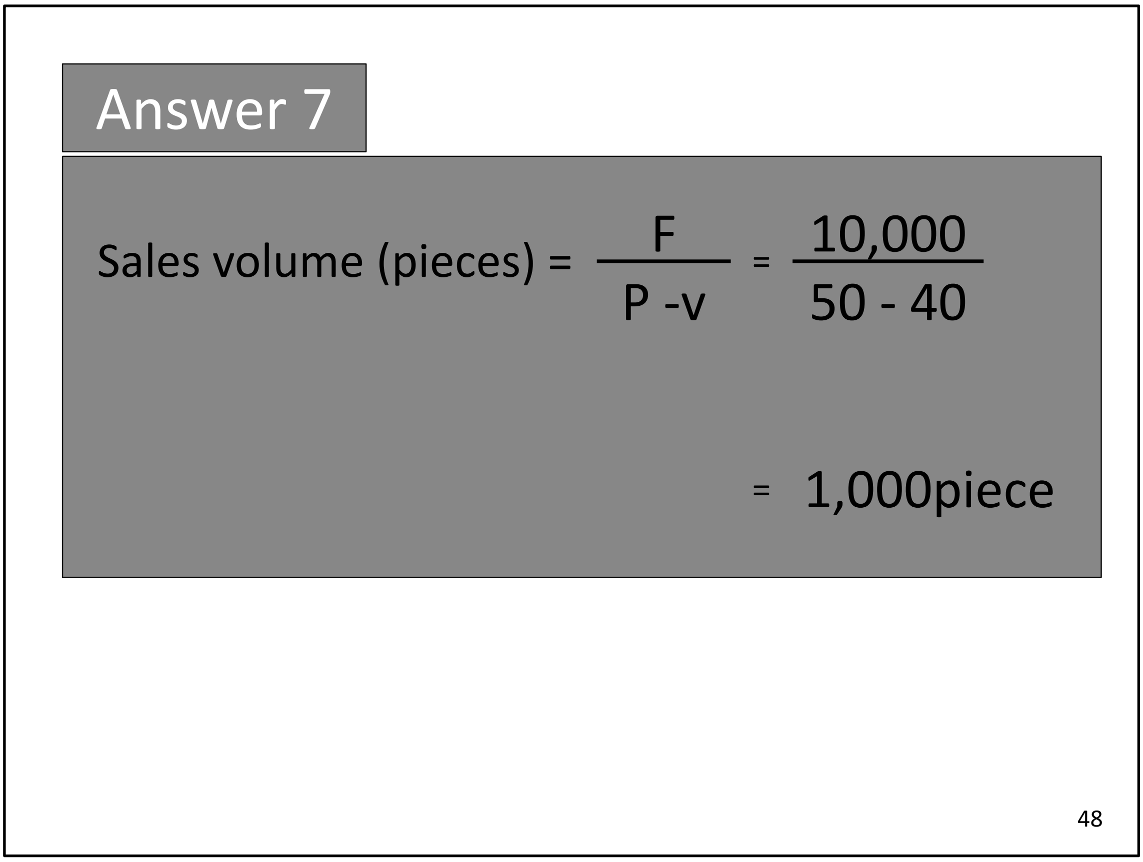



Now, here is an exercise.

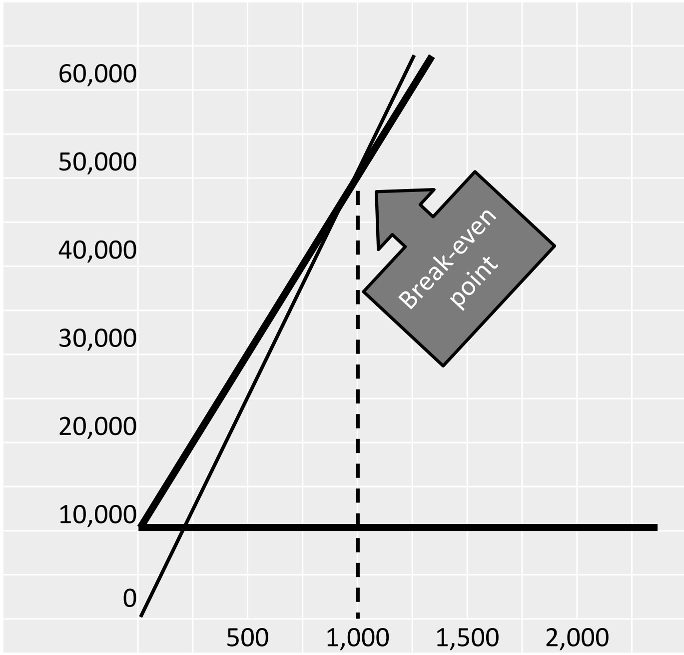
Find the break-even point in the following conditions.

・Selling price: 50birr

・Fixed cost : 10,000 birr/day

・Variable cost : 30,000 birr/1,000pcs

Please begin.


60,000
50,000
40,000
30,000
20,000
10,000
0
500
1,000
1,500
2,000
Break-even point

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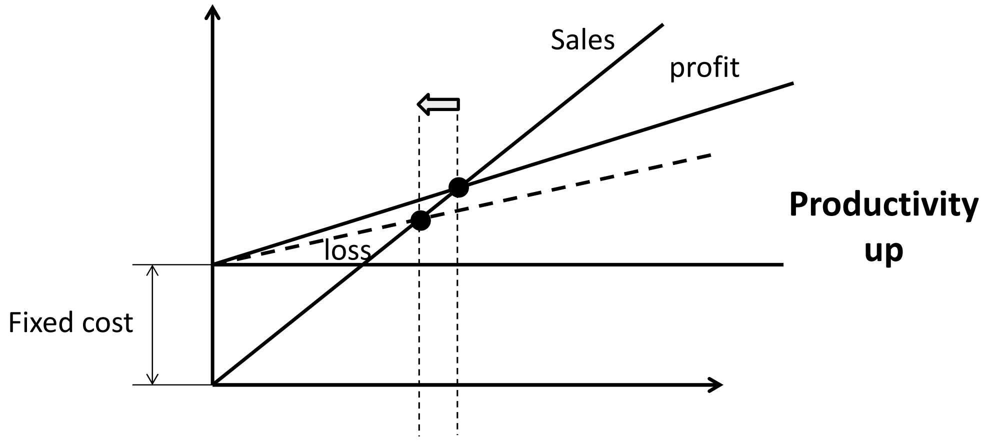
# 2.3 Improvement of Break-even Point

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**2.3 Improvement of Break-even Point**

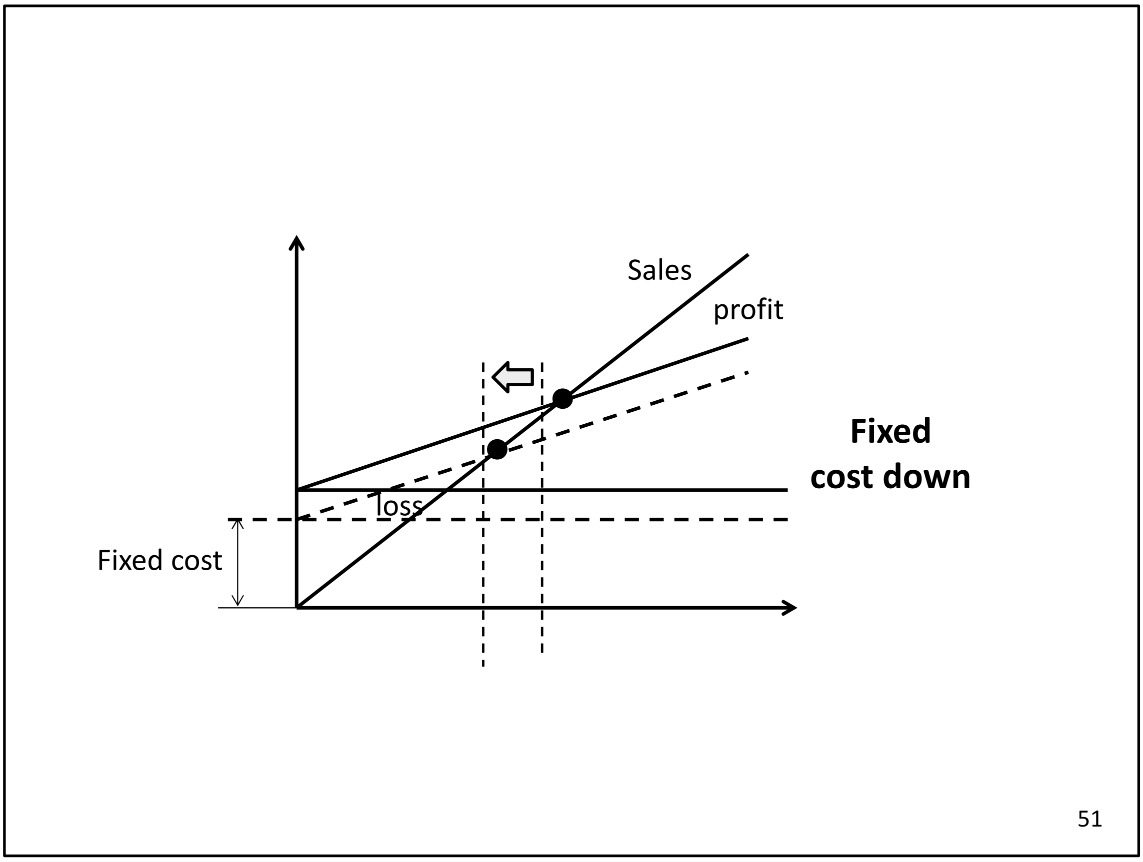
As was already explained, a Break-even point shows a point in the graph where the profit becomes zero (0).

If we can make the Break-even point smaller (Closer to zero in the graph), even though the sales volume is same, we can get more profit.

The “Improvement of Break-even point” means we can get more profit on the same sales.

There are two ways for improvement of Break-even point.

One is to reducing the variable cost (Lower the tilt angle) and it means increasing the productivity.




The second way is to reduce the Fixed cost as shown in the slide.

# Summary

| Item | Element | Method |
|---|---|---|
| Up Productivity<br>Less Variable cost | Less material | QC, IE |
| | Less energy | |
| | Minimum loss | |
| Down Fixed cost | Less labor | QC, IE, IT |
| | Less Depreciation | Rental |

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Tis slide shows the relation of two ways of “Improvement of Break-even point” and the method in business field.

QC and IE contribute in both ways.

Depreciation becomes smaller by not purchasing many new machines and/or not owning but rentalling.

## Exercise 8

Like to improve the Break-even point (Reduce the Sales amount (birr) at break-even point) by 10% .
If fixed cost can not reduced, we should reduce the Variable cost per piece. How much should we reduce?
Condition before improvement is given;

・Selling price per piece : 50 birr
・Variable cost per piece: 30 birr
・Fixed cost : 10,000 birr/day

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Now, here is an exercise.

We like to improve the Break-even point to get same profit when sales amount (volume) is reduced by 10%.

The given conditions are;

・Selling price: 50birr

・Fixed cost : 10,000 birr/day

・Variable cost : 30,000 birr/1,000pcs

# Answer 8

1[st] Calculate Break-even sales quo

$$\text{Sales} = \frac{\text{Fixed cost}}{1 - \frac{\text{Cost}}{\text{price}}} = \frac{10{,}000}{1 - \frac{30}{50}} = 25{,}000$$

2[nd] Calculate target Break-even sales amount (birr)

$$25{,}000 - 0.1\text{x } 25{,}000 = 22{,}500$$

3[rd] Calculate target cost/piece (birr)

$$22{,}500 = \frac{10{,}000}{1 - \frac{?}{50}} \qquad ? = 27.8$$

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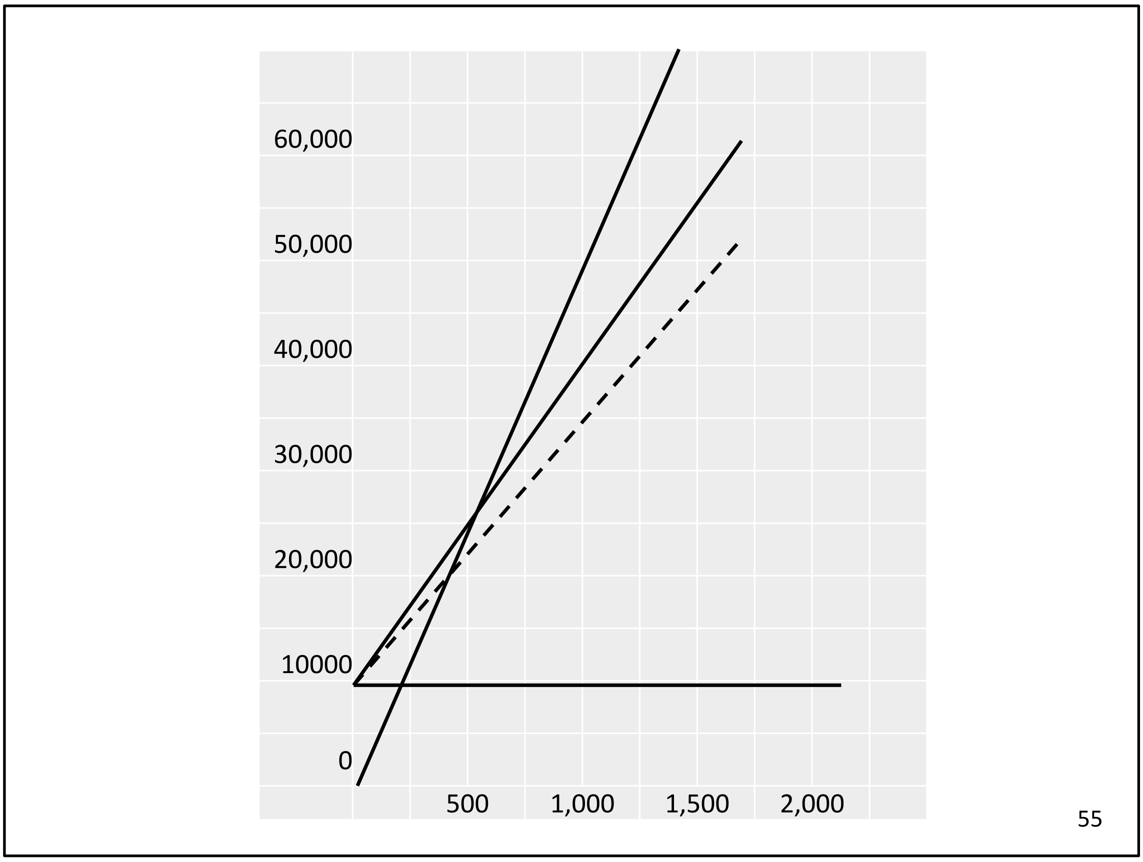
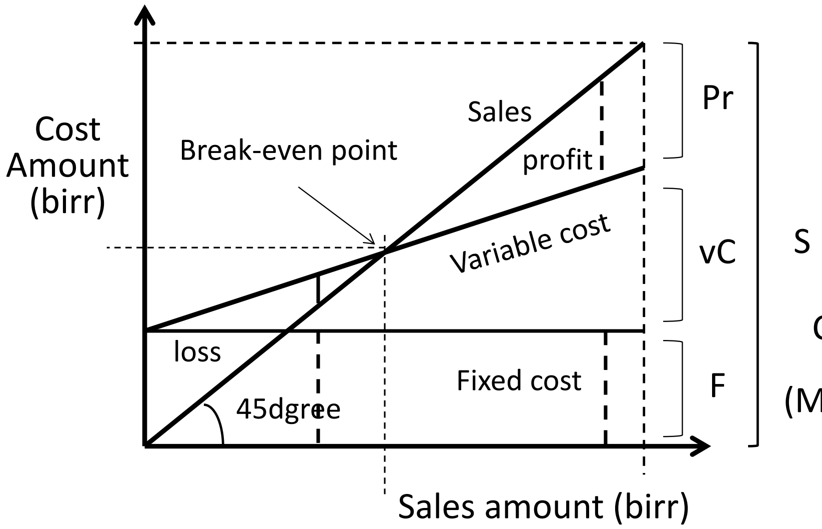



On the graph we can see how the Break-even point is improved.

# 2.4 CM & Marginal Profit Ratio




Contribution Margin (Marginal Profit)
CM
=S-vC
=F+Pr

Break-even point

Sales at Break-even point : Sb

Marginal profit ratio
=CM/S

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**2.4 CM & Marginal Profit Ratio**

We will learn about Contribution Margin (CM) and Marginal profit ratio.

Marginal profit ratio is very useful for a company to decide most profitable product from its assortment.

## Exercise 9

Birr

| | A | B | C | D | Total |
|---|---|---|---|---|---|
| Sales | 2,500 | 2,000 | 1,500 | 1,000 | 7,000 |
| Cost of goods sold | 2,300 | 1,900 | 1,400 | 1,100 | 6,700 |
| Profit | 200 | 100 | 100 | Δ100 | 300 |
| (Variable cost) | 1,600 | 1,400 | 900 | 500 | 4,400 |
| Contribution margin | | | | | |
| Marginal profit ratio | | | | | |

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Calculate the Contribution Margin and Marginal profit ratio.

# Answer 9

Birr

| | A | B | C | D | Total |
|---|---|---|---|---|---|
| Sales | 2,500 | 2,000 | 1,500 | 1,000 | 7,000 |
| Cost of goods sold | 2,300 | 1,900 | 1,400 | 1,100 | 6,700 |
| Profit | 200 | 100 | 100 | Δ100 | 300 |
| (Variable cost) | 1,600 | 1,400 | 900 | 500 | 4,400 |
| Contribution margin | 900 | 600 | 600 | 500 | 2,600 |
| Marginal profit ratio | 0.36 | 0.3 | 0.4 | 0.5 | 0.37 |

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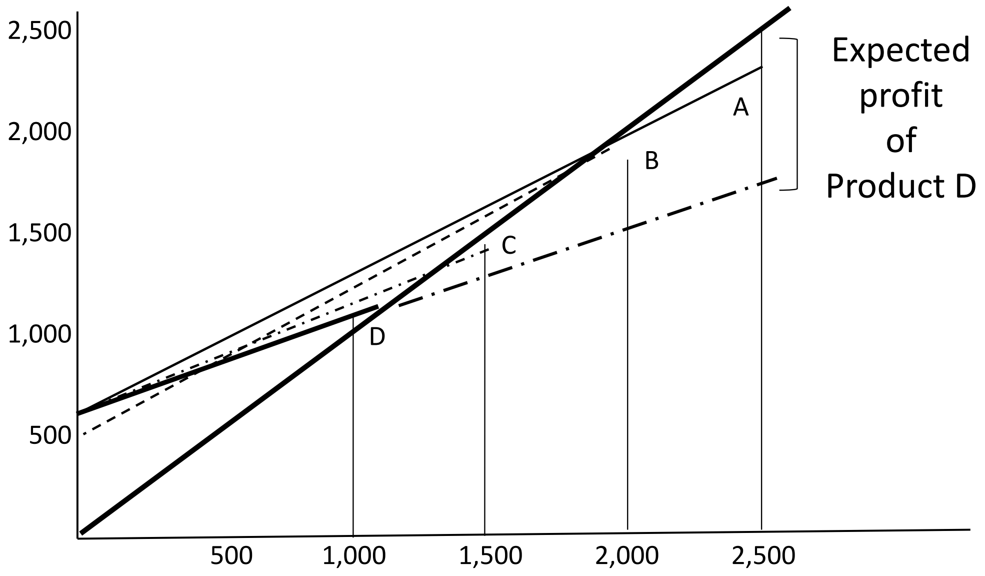
# Make goods more which has high Marginal profit ratio

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This graph shows Break-even points of product A to D.

Even though the current profit of product D is minus and that of product A is highest, product D gives largest profit if the company increase its production volume.

# 3. Accounting

- Legal financial accounting
- Management accounting

- Accounting shows the profit and loss and financial status in the certain period (1 or quarter fiscal year) of a company
- Legal financial accounting is made according the financial rule of the country
- Management accounting is made in more flexible manner to show the situation of the management

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**3. Accounting**

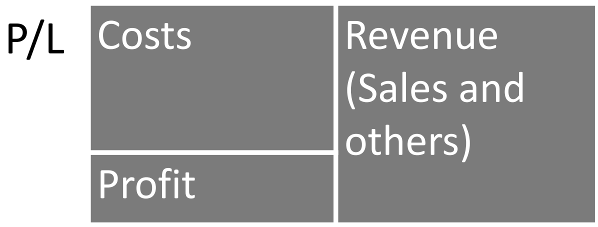
There are two types of Accounting . One is financial accounting and the other is management accounting.

Both show the company profit and loss and financial status.

Management accounting is more flexible.

## 3.1 Profit and Loss Statement (P/L)

A profit and loss statement (P/L) is a financial statement that summarizes the "Revenues", "Costs" and "Profit" incurred during a specific period of time.

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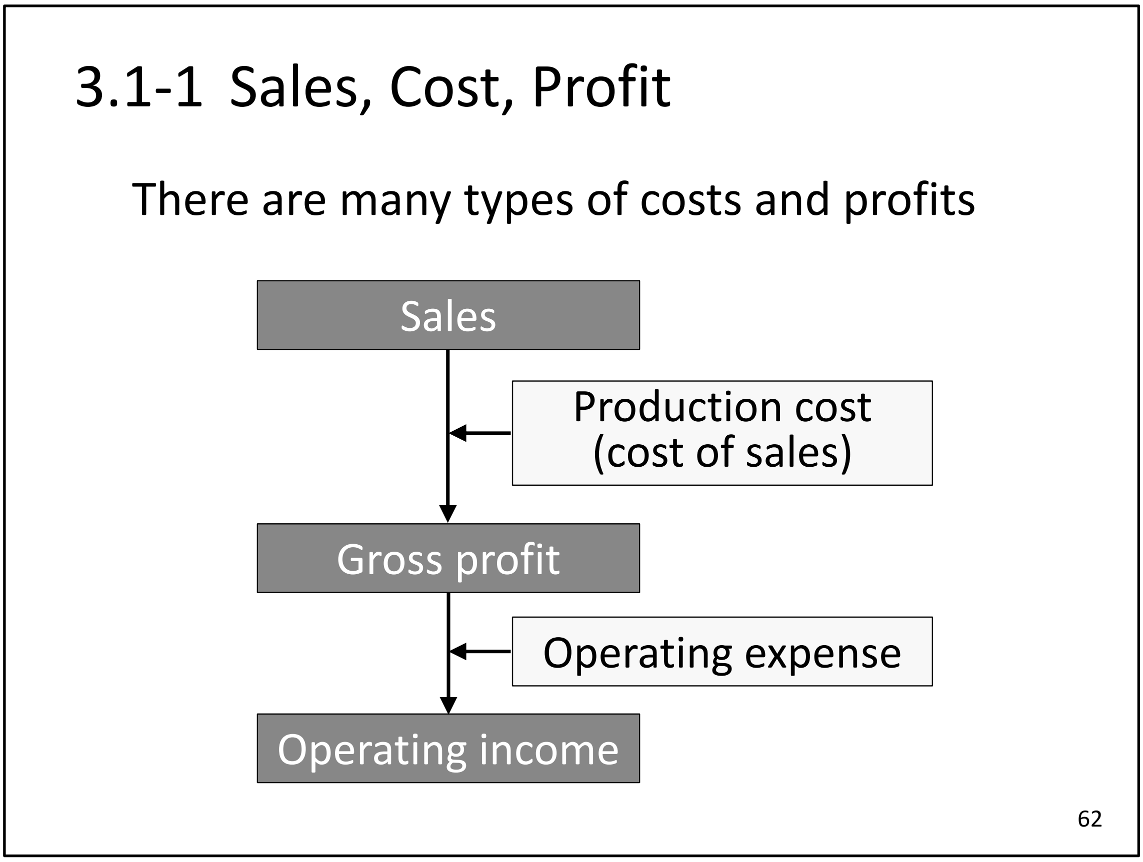
**3.1 Profit and Loss Statement (P/L)**

Next, we will learn about Profit and loss statement.

Profit and loss statement is a financial statement that summarizes company activities during a specific period of time in terms of "Revenues", "Costs" and "Profit."




**3.1-1 Sales, Cost, Profit**

If you look at the profit and loss statement, you will see Sales, Profit and Income.

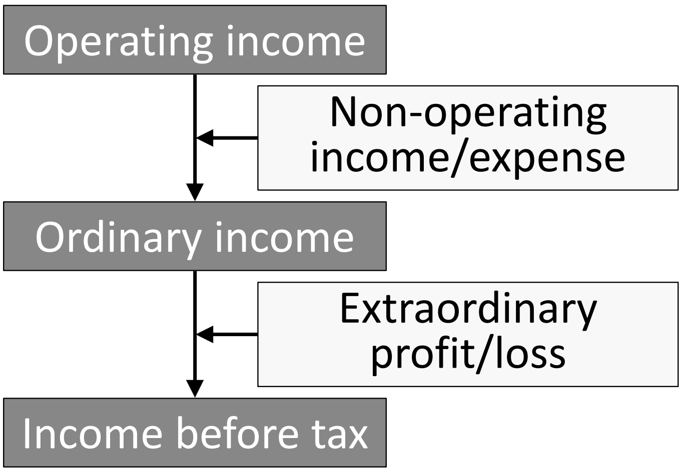
Start point is Sales which is the main income for company.

Next is Gross profit which is the Sales minus production costs. As already you know, production cost is consisted with variable cost such as material cost, and fixed cost such as labor cost and depreciation.

Third is Operating income which is Gross profit minus Operating expenses.

Operating expense includes indirect labor cost, rent and other indirect expenses.

## --- Cont.

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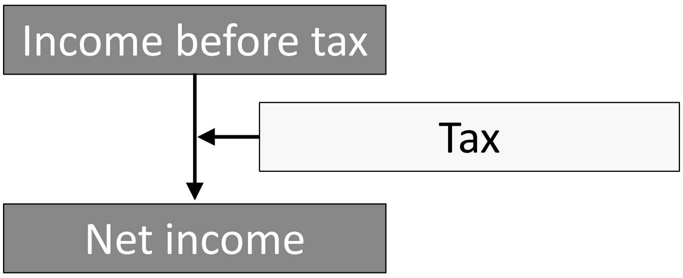
Ordinary Income is Operating income minus non-operating income and expense .

Non-operating income/expenses are profit from investment and interest of loan respectably.

Income before tax is Ordinary income minus Extraordinary profit/loss .

Extraordinary profit/loss are extraordinary items for example the income by selling fixed asset and cost for restructuring, respectably.

# --- Cont.

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Net income is Income before tax minus Tax.

# --- Cont.

| | |
|---|---|
| Production cost (Cost of sales) | Material, Direct labor |
| Operating expense | In-direct labor, Expenses |
| Non-operating income/expense | Interest of loan |
| Extraordinary profit/loss | Profit by selling fixed asset, restructuring cost, |

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This slide shows Cost, Expense and Profit/Loss.

# Example of P/ L

AAA Company
Income Statement
For the Year Ended December 31, 2018 thousand birr

| | |
|---|---|
| Net sales | 205,530 |
| Cost of goods sold | 167,140 |
| Gross profit | 38,390 |
| Operating expenses | 30,450 |
| Selling, general and administrative expenses | 30,300 |
| Salaries expense | |
| Travel expense | |
| Depreciation expense | 150 |
| Operating income | 7,940 |
| Non operating exposes | 1,120 |
| Ordinary income | 6,820 |
| Unordinary expense | 3,820 |
| Income before income tax | 3,000 |
| Income tax | 1,200 |
| Net income | 1,800 |

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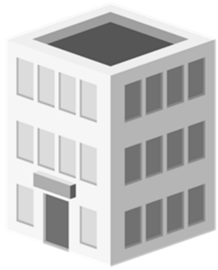
This is an example of Profit and Loss statement (P/L)

"For the Year Ended December 31,2018" means that this P/L shows the activities of AAA Company in one fiscal year which started January 1st 2018 and ended December 31,2018.

# 3.1-2 Operating Expenses

| Direct cost of manufacturing | Indirect cost of manufacturing |
|---|---|
| Production Dept. | Head office |
| Quality control Dept. | Sales Dept. |
| Purchase Dept. | Personnel Dept. |
| Material | Office consumption |
| Factory consumption | Depreciation of office |
| Depreciation of Equipment | |



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### 3.1-2 Operating Expenses

In the Operating expenses, Indirect costs of manufacturing are included.

# 3.1-3 Management Accounting

(1) Productivity
(2) Profitability

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### 3.1-3 Management Accounting

Management accounting provide the directors with information for how to steer the company.

There are indicators to show Productivity and Profitability.

(1) Productivity

I. Sales per person
= Sales / No. of employees

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First is the indicators for productivity.

Sales per person (Sales divided by No. of employee) is a typical indicator of the productivity.

## (2) Profitability

I. Gross profit on sales
   = Gross Profit/Sales
II. Operating income on sales
   = Operating income/Sales
III. Ordinary income on sales
   = Ordinary income/Sales
IV. Income before tax on sales
   = Income before tax /Sales

70

Next are the indicators for profitability.

The Profit on sales is obtained by dividing the gross profit, pre-tax profit, operating profit, etc. by sales.

These indicators are compared against other companies in the same sector or against the previous year in order to secure appropriate profits.

## Exercise

Sales and profit of company A and average of same sector are shown in next page.
Calculate

(1) Gross profit on sales,
(2) Operating income on sales, and compare these of average then explain the situation of company A.

71

(Unit : 1 Million birr)

| | Company A | Average in same sector |
|---|---|---|
| Sales | 522.3 | 612.5 |
| Sales cost | 431.5 | 526.7 |
| Gross profit | 90.8 | 85.8 |
| Operating expense | 76.5 | 65.7 |
| Operating income | 14.3 | 20.2 |

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## Answer

| | Company A | Average in same sector |
|---|---|---|
| Gross profit on sales | 17.4% | 14.0% |
| Operating income on sales | 2.7% | 3.3% |

Reason : Operating expenses like indirect labor, indirect expenses are much higher than average.

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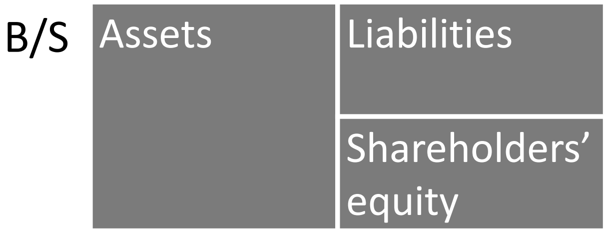
# 3.2 Balance Sheet (For Reference)

Balance sheet (B/S) is a financial statement that summarizes a company's "Assets", "Liabilities" and "Shareholders' equity" at a specific point in time.

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**3.2 Balance Sheet (For Reference)**

Balance sheet is a financial statement that summarizes a company's "Assets", "Liabilities" and "Shareholders' equity." Since the company conducts transactions every day, the Balance Sheet expresses the situation at a certain pre-determined point in time.

## 3.2-1 Balance Sheet

**Account titles** of B/S

| Assets | Liabilities |
|---|---|
| ・Cash | ・Account payable |
| ・Accounts receivable | ・Loans payable |
| ・Inventory | **Shareholders' equity** |
| ・Prepaid expenses | ・Capital |
| ・Fixed assets | ・Retained earning |
| ・Intangible assets, etc. | |

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### 3.2-1 Balance Sheet

So, what kinds of items are included on the Balance sheet?

Assets include cash, savings, accounts receivable, inventory, prepaid expenses, tangible fixed assets, intangible fixed assets and so on.

Liabilities include accounts payable, and short-term and long-term loans.

The Shareholders' equity includes capital, retained earnings and so on.

# 3.2-2 Example of Balance Sheet

AAA Company
Balance Sheet
As of December 31, 2013

| Assts | | Liabilities | |
|---|---|---|---|
| Current assets: | | Current liabilities: | |
| Cash | 3,210 | Notes payable | 11,110 |
| Notes receivable | 14,680 | Accounts payable | 7,350 |
| Accounts receivable | 9,160 | Short term loans | 18,250 |
| Inventory | 12,430 | Total current liabilities | 36,710 |
| Prepaid current assets | 660 | | |
| Total current assets | 40,140 | Non current liabilities: | |
| | | Long term loans | 40,030 |
| Non-current assets: | | Total non current Liabilities | 40,030 |
| Plant | 5,360 | | |
| Equipment (less accumulated depreciation) | 10,280 | Stockholders' equity: | |
| | | Common stock | 1,500 |
| Property | 17,880 | Retained earnings | 330 |
| Construction in progress | 4,910 | Total stockholders' equity | 1,830 |
| Total non-current assets | 38,430 | | |
| Total assets | 78,570 | Total liabilities and stockholders' equity | 78,570 |

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**3.2-2 Example of Balance Sheet**

# ECONOMIC ENGINEERING

Economic Engineering

1

**Economic Engineering**

Economic engineering is simply to determine if the Kaizen that you implement is profitable or non-profitable.

In this class, we have many exercises of profitability calculations and learn the way to evaluate profitability.

# Training Contents

1. How to Measure Kaizen Effect?
2. Economic Engineering
3. Which Idea is more Economical?
4. Calculate the Cost per Unit
5. Rule for Decision-making
6. Sunk Cost
7. Under Capacity and Over Capacity
8. Profit by Product
9. Cost of Failure
10. Kaizen Effect
11. Cost of Capital

2

# 1. How to Measure Kaizen Effect?

Question 1

Calculate improvement ratio.

| | Before | After | improve |
|---|---|---|---|
| 1) Defect rate | 5.3% | 3.6% | |
| 2) Productivity | 800 shoe/day | 950 Shoe/day | |

3

1. How to Measure Kaizen Effect?

- Basic Calculation

Answer 1

Calculate improvement ratio.

| | Before | After | improve |
|---|---|---|---|
| 1) Defect rate | 5.3% | 3.6% | 32.1% |
| 2) Productivity | 800 shoe/day | 950 Shoe/day | 18.8% |

4

- **Basic Calculation**

  The answer is this.

  The formula is (After-Before)/Before x 100%.

- Basic Calculation

## Question 2

Which country is the most competitive?

| COUNTRY | MATERIAL COST (%) | LABOR COST (%) | FOH COST (%) |
|---|---|---|---|
| INDIA | 55 | 13 | 32 |
| CHINA | 60 | 10 | 30 |
| VIETNAM | 55 | 33 | 12 |
| PAKISTAN | 45 | 13 | 42 |
| (SHEBA) | 84 | 6 | 10 |

FOH ;
Fixed Overhead

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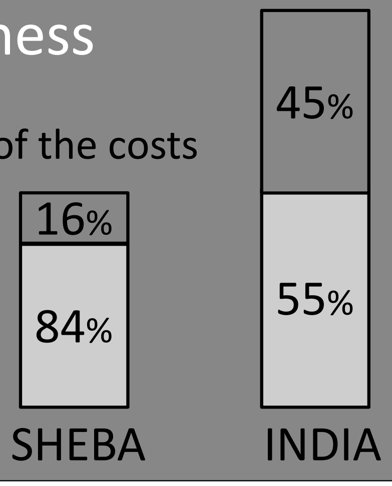
• Basic Calculation

Answer 2

Cost (%) can not determine the competitiveness

Need absolute values of the costs




6

**Cont.**

The answer is:

Percentage is not an absolute value but a relative value. If the denominators of two relative values are different, you cannot judge which one of the two is more competitive or not. You need the absolute values of those two to judge.

- Basic Calculation

Question 3

Calculate weekly defect rate.

| Day of wk | Production | Defects | % |
|---|---|---|---|
| Mon. | 1,200pcs | 18pcs | 1.5 |
| Tue. | 1,500pcs | 30pcs | 2.0 |
| Wed. | 2,000pcs | 10pcs | 0.5 |
| Thu. | 1,800pcs | 18pcs | 1.0 |
| Fri. | 2,400pcs | 12pcs | 0.5 |

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- Basic Calculation

Answer 3

Calculate weekly defect rate.

| Day of wk | Production | Defects | % |
|---|---|---|---|
| Mon. | 1,200pcs | 18pcs | 1.5 |
| Tue. | 1,500pcs | 30pcs | 2.0 |
| Wed. | 2,000pcs | 10pcs | 0.5 |
| Thu. | 1,800pcs | 18pcs | 1.0 |
| Fri. | 2,400pcs | 12pcs | 0.5 |
| Week | 8,900pcs | 88pcs | 1.0% |

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**Cont.**

The answer is this.

If the denominator of defect % changes by day, you need weekly total production quantity and total defect quantity to calculate weekly defect %.

- Basic Calculation

Question 4

How much money could you save?

▪ Cost is 500birr /shoes.

| | Before | After |
|---|---|---|
| Production volume | 20,000 shoes/month | 22,000 shoes/month |
| Defect rate | 5.3% | 3.6% |
| Money saving | | |

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- Basic Calculation

Answer 4

How much money could you save?

▪ Cost is 500birr /shoes.

| | Before | After |
|---|---|---|
| Production volume | 20,000 shoes/month | 22,000 shoes/month |
| Defect rate | 5.3% | 3.6% |
| Money saving | 187,000birr | |

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**Cont.**

The answer is;

22,000×0.053×500－22,000×0.036×500＝187,000

- How to Measure Kaizen Effect

Kaizen effect ･･･
“Work shop was cleaned up with 5S.”
“There were less work-in-process with line-balance.”
We need to know the cost reduced by the Kaizen.

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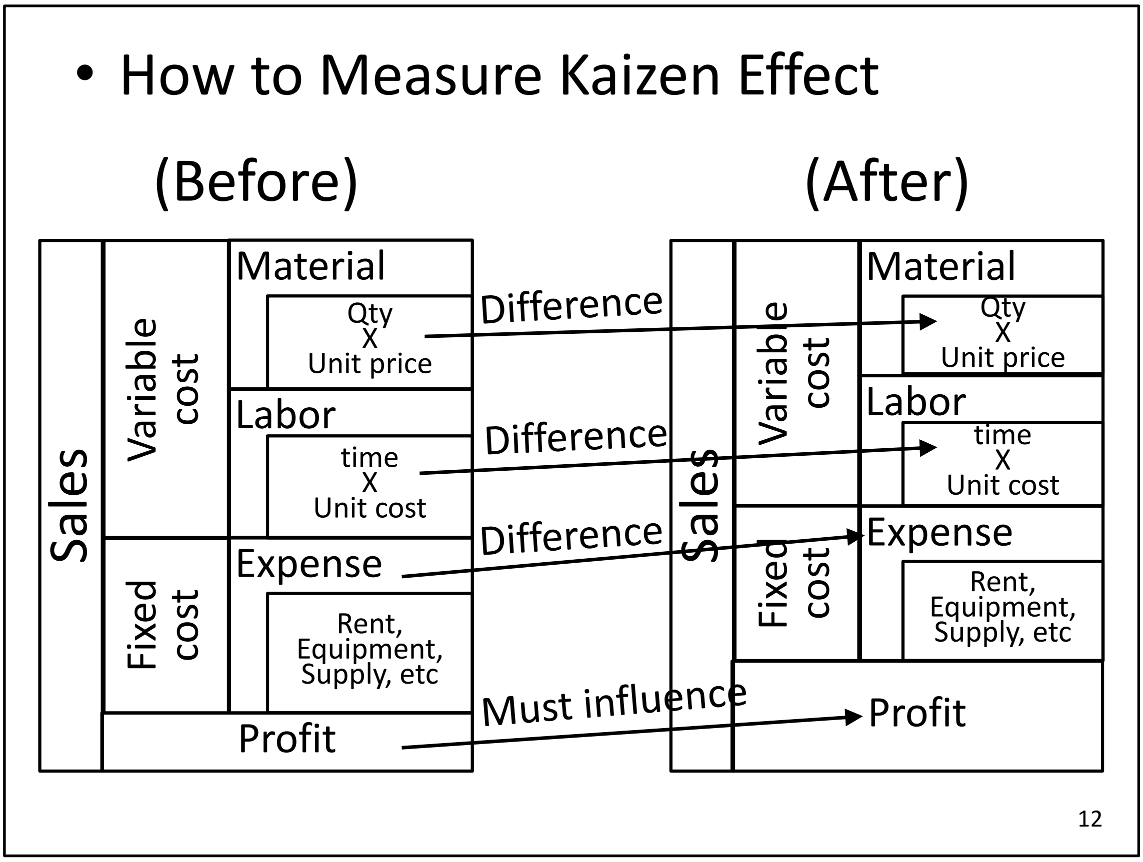
- **How to Measure Kaizen Effect**

  Some types of Kaizens are difficult to measure the effect like these two cases.




**Cont.**

You need to know the cost structure of production to evaluate Kaizen effect as this slide shows.

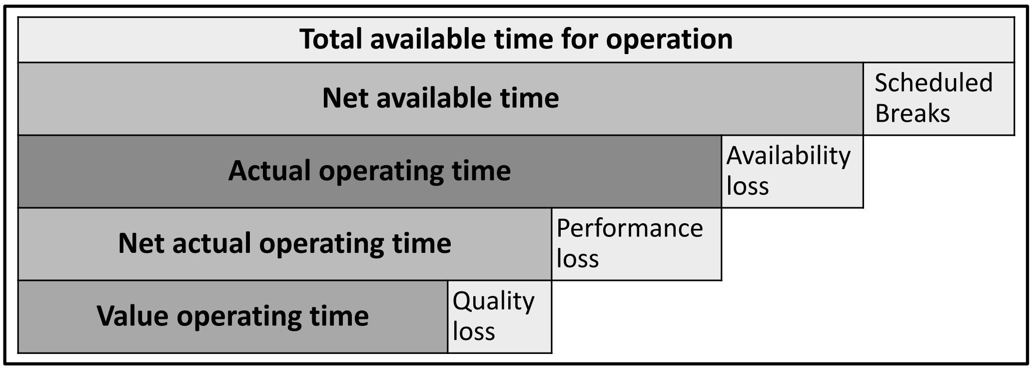
Then you can determine if the Kaizen reduces material cost, labor cost, or expense.

For example, if the Kaizen reduces the number of defective parts, the effect should be material cost and labor cost.

Then material cost is the difference between the number of defective parts before Kaizen and the number of defective parts after Kaizen multiplied by the material piece price.

And labor cost is the difference between the number of defective parts before Kaizen and the number of defective parts after Kaizen multiplied by production time per product and labor cost per hour.

## • Set a Clear Object




| Type | Six big losses | Tools and technics for improvement |
|---|---|---|
| Availability loss | Equipment failure | Preventive & autonomous maintenance, ECRS, 5S, etc |
| | Set-up and adjustments | |
| Performance loss | Idling and minor stops | Preventive & autonomous maintenance, QC approach, 5S, etc |
| | Slow cycles | |
| Quality loss | Defects | QC approach |
| | Start-up rejects | |

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- **Set a Clear Object**

  To evaluate the Kaizen effect, you should know what elements of the production you will improve, amount of material, number of operators, or production time. And set a clear object.

  For example, in the case of machine productivity Kaizen, you should know there are three types of time loss as this slide shows.

- Define a Formula

To evaluate the Kaizen effect, measurements are needed.

| Type | measure | Calculation |
|---|---|---|
| Productivity | qty. | Productivity = $\frac{\text{quantity}}{\text{no of operator}}$ |
| | cost | Productivity = $\frac{\text{Added value}}{\text{no of operator}}$ |
| Cost | % | Labor cost rate = $\frac{\text{Labor cost}}{\text{Cost of sales}}$ |
| Time | minute | Man hour = $\frac{\text{total operating time}}{\text{production quantity}}$ |

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- **Define a Formula**

  After you know the cost structure and set an object, you can define a formula to measure the Kaizen effect.

- Data for Kaizen Evaluation

To evaluate the Kaizen effect, fundamental data is needed.

| Item | Example |
|---|---|
| ① Sales | Actual figure of last year |
| ② Labor cost | Salary+welfare+insurance |
| ③ No. of direct labor | Operator+supervisor |
| ④ No. of all employees | Including security, cleaner |
| ⑤ Work days | |
| ⑥ Working hour | |

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- **Data for Kaizen Evaluation**

  Next thing you need is data. You need to collect data as this slide shows.

- Data for Kaizen Evaluation

To evaluate the Kaizen effect, fundamental data is needed.

| Item | Example |
|---|---|
| ⑦ Material cost | |
| ⑧ Depreciation | Investment/period |
| ⑨ Fived cost | Other fixed cost |

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- Evaluation

Question 5

How much was productivity improved?

| | Daily output | Number of labor |
|---|---|---|
| Before | 800pcs | 100 |
| After | 1,200pcs | 120 |

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- **Evaluation**

- Evaluation

Answer 5

How much was productivity improved?

| | Daily output | Number of labor | Output/ labor |
|---|---|---|---|
| Before | 800pcs | 100 | 8 |
| After | 1,200pcs | 120 | 10 |
| Change | 50% | 20% | 25% |

18

**Cont.**

This is the answer.

- Case Study ①

| Before | After (Made tool) |
|---|---|
|  |  |
| Daily : 7,000pcs<br>Remove seal : 2s/pc | Daily : 7,000pcs<br>Remove seal : 0.5s/pc |
| Effect : 175min/day (58hr/month)<br>2,900 birr/month (Labor cost : 50 birr/hr) | |

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- **Case Study①**

  In this case, before Kaizen, operators removed the seals on the sheet placed on the worktable.

  It took the operators 2 seconds to remove a seal. After Kaizen, a fixture to hold a sheet was made and the time to remove a seal from a sheet was reduced from 2 seconds to 0.5 seconds. As a result, 175 minutes is saved every day. Labor cost is 50birr/hr, so 2900birr is saved monthly.

- Case Study ①

Question 6

The cost of Case① was as follows.

How do you evaluate this Kaizen?

| Cost of the tool | Amount |
|---|---|
| Material | 2,000 birr |
| Machining | 4,000 birr |
| Total | 6,000 birr |

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**Cont.**

In this case, it costed 6,000 birr to make the fixture.

- Case Study ①

**Answer 6**

- Effect : 2,900 birr/month
- Cost of the tool: 6,000birr
- Payback period = 6,000/2,900  
  = 2.07 months

Judgement depend on a management decision.

But 2 months of payback period is short enough to justify

21

**Cont.**

This Kaizen effect is 2,900 birr per month. But the tool cost is 6,000 birr. So this Kaizen is a failure?

As a way to judge if this Kaizen is a failure or success, we can use payback time.

- Case Study ②

| Before | After (Conveyer) |
|---|---|
|  |  |
| Output: 2,000pcs/10man・hr | Output: 3,600pcs/12man・hr |
| Labor cost : 50 birr/hr, Demand : 36,000pcs/day | |
| Effect : | |

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- **Case Study②**

  Next case is

  By introducing a conveyor into the production line, the line can increase the output from 2,000pcs/10man・hr to 3,600pcs/12man・hr.

  How much is this Kaizen effect ?

- Case Study ②

Question 7

Calculate the effect of case②.

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- Case Study ②

Answer 7

Calculate the effect of case②.

| | Output | | To fulfil demand |
|---|---|---|---|
| Before | 2,000pcs/ 10man･hr | 0.3min /pc | 180man･hr/day |
| After | 3,600pcs/ 12man･hr | 0.2min /pc | 120man･hr/day |
| Effect : 3,000 birr/day (60,000 birr/month) | | | |

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**Cont.**

In this case, since the number of operator has changed, it is necessary to use the work time per one product.

Before Kaizen, the work time per product was 0.3 minutes, and it took 180 man-hours for daily production.

After Kaizen, the production time per piece was 0.2 minutes and 120 man-hours for daily production.

As a result, it can be said that 3,000 birr per day was reduced by spending 60 hours and labor costs.

- Case Study ②

Question 8

The cost of Case② was as follows.

How do you evaluate this Kaizen?

| Cost of the conveyor | Amount |
|---|---|
| Purchase price | 600,000 birr |
| Installation | 200,000 birr |
| Total | 800,000 birr |

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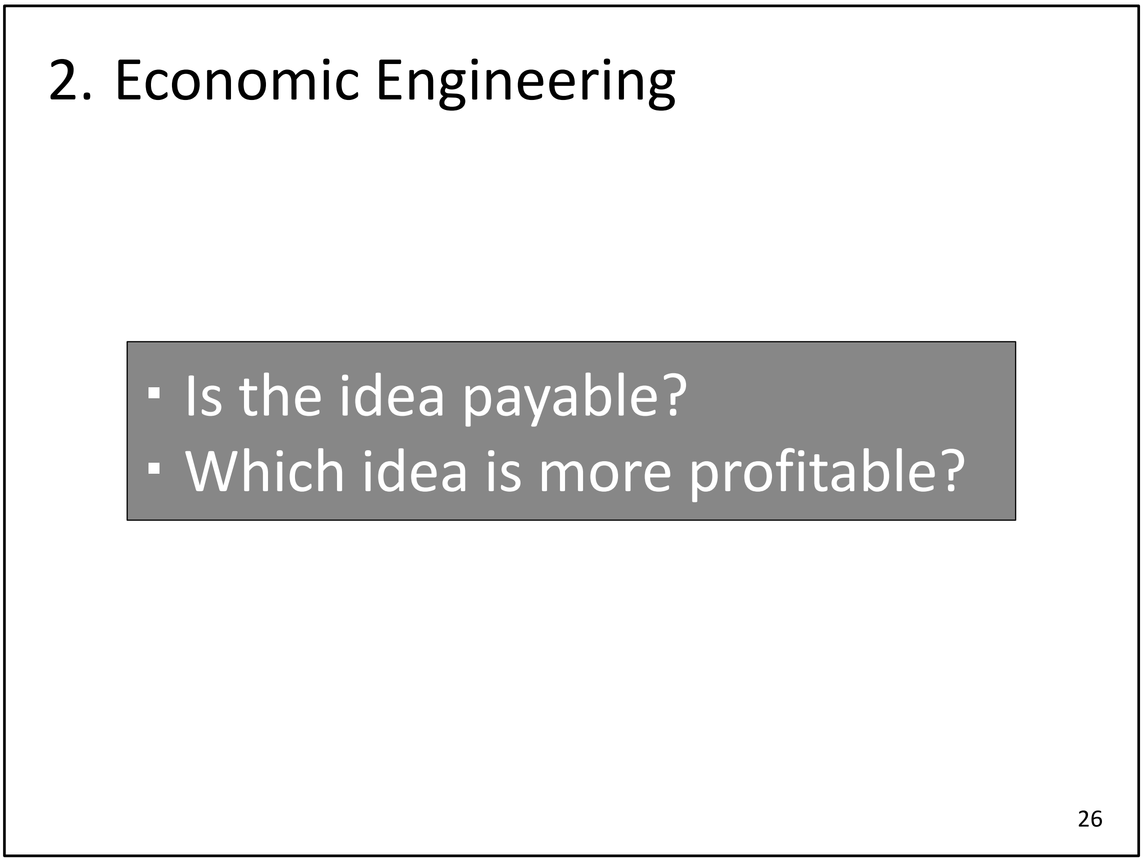
**Cont.**

Now, if it took 800,000 birr to install a belt conveyor, could this Kaizen be effective?

Please calculate the payback time using the same formula as the case study ① and explain us about your decision and reasons for the decision.




**2. Economic Engineering**

The basic idea of economic engineering is, “Can you pay for the plan?” or “Which plan is more profitable?”

# 3. Which Idea is more Economical?

Question 9

Which copy machine is better to rent?

- Usage : 8,000 copies/month

| | Rent (birr/month) | Per sheet |
|---|---|---|
| A | 10,000 | 2.0 birr |
| B | 18,000 | 1.2 birr |

27

**3. Which Idea is more Economical?**

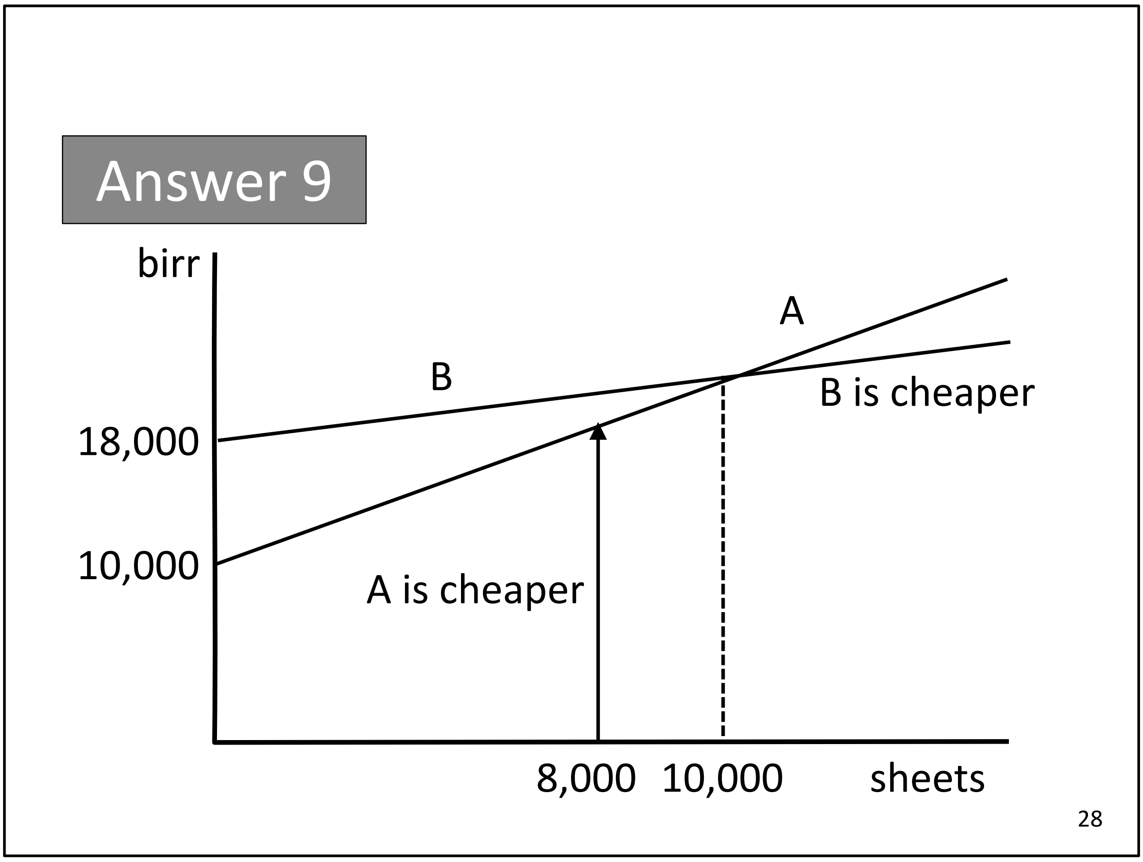
Now, exercise

A company is considering renting a copy machine.

There are two ideas.

If the monthly copy volume is 8,000 copies, which copy machine should the company borrow?

Think about 5 minutes for each person.




**Cont.**

The total cost is the fixed cost, which is the monthly rental fee, and the variable cost. On this graph, the line A is the total cost of plan A and the line B is the total cost of plan B. If your copy machine usage is less than 10,000 sheets, which is on the left side of the intersection of A and B, then you should select plan A. If your usage is above 10,000sheets, you should select plan B.

# 4. Calculate the Cost per Unit

## Question 10

Calculate the cost per sheet.

- Usage : 8,000 copies/month

| | Rent (birr/month) | Per sheet |
|---|---|---|
| A | 10,000 | 2.0 birr |

- Labor:200birr/hr. Speed:400sheet /hr.
- Space:4m$^2$, Room:1,000birr/m$^2$・month

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**4. Calculate the Cost per Unit**

Now, let’s think the cost per piece.

Additional information is given for labor costs, copying capabilities, and required space and space costs.

- Calculate the Cost per Unit

Answer 10

Calculate the cost per sheet.

- Usage : 8,000 copies/month
- Rent : 10,000/8,000 = 1.25birr/sheet
- Labor : 200/400 = 0.5birr/sheet
- Space : 4 × 1,000/8,000 = 0.5birr/sheet

Total : 2+1.25 (+0.5+0.5?)

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**Cont.**

This is the answer.

Each cost is converted to the cost per piece.

- Calculate the Cost per Unit

Answer 10

To calculate the cost per sheet, everybody can agree to add rental fee (1.25birr) and cost per sheet (2birr).

How about labor cost and space cost?

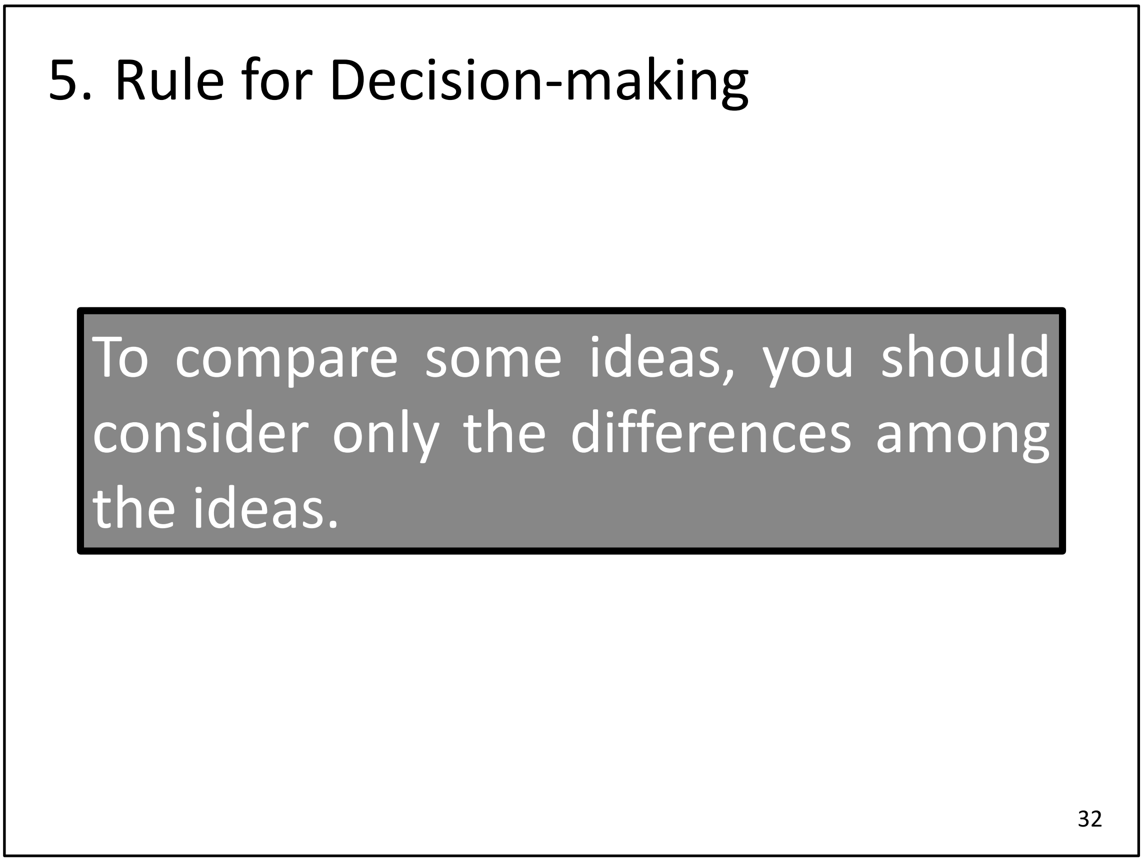
It is case by case.

You need to choose the most suitable one.

31

**Cont.**

Everyone agrees to include the rental fee and the cost per sheet, but whether the labor cost for copying and the space fee should be included or not is dependent on the problem. It is necessary to include the appropriate costs, depending on the type of problem.




**5. Rule for Decision-making**

Here, the rule for decision-making is explained.

**6. Sunk Cost**

This question is to learn what is sunk cost. Please try.

- Sunk cost

Answer 11

Mr. A thought ,

If he buys a car from Mr. B, he would need additional 80,000birr and 30,000birr deposit would not be returned. Then the total cost will be 110,000birr. That is higher than purchase from dealer X for 90,000birr.

Therefore, he bought from dealer X.

34

**Cont.**

Here is an answer.

What do you think his decision?

- Sunk cost

Answer 11

Deposit 30,000birr is not reimbursed whichever idea he chooses.

He should compare only 80,000birr for Mr. B and 90,000birr for dealer X.

He can save 10,000birr to buy from Mr. B.

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- Sunk cost

In economics and business decision-making, a **sunk cost** (also known as **retrospective cost**) is a cost that has already been incurred and cannot be recovered.
Sunk costs are contrasted with *prospective costs*, which are future costs that may be avoided if action is taken. In other words, a sunk cost is a sum paid in the past that is no longer relevant to decisions about the future

Deposit 30,000birr is paid already and can not be reimbursed in any way.
This is a "**Sunk cost**".

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**Cont.**

So, sunk cost is;

# 7. Under Capacity and Over Capacity

## Question 12

Company A has a following situation,

- Production capacity : 7,000pcs/month
- Current production : 5,000pcs/month
- Selling price : 9,000birr/pc

| | |
|---|---|
| ①Material cost | 4,000birr/pc |
| ②Variable expense | 1,000birr/pc |
| ③Direct Labor cost | 2,000birr/pc |
| ④Indirect expense | 1,500birr/pc |
| TOTAL cost | 8,500birr/pc |

* ③&④ are monthly costs divided by monthly production volume.

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**7. Under Capacity and Over Capacity**

Next exercise

• Under Capacity and Over Capacity

Question 12

Now, one European company offers a business of 1,500 pc a month for 7,000birr/pc.

Even if company A accepts this offer, there are no impact on the current business.

How company A shall decide?

38

- Under Capacity and Over Capacity

Answer 12

Cost : 8,500birr/pc

Price : 7,000birr/pc

Loss : 1,500birr/pc

=>Company A shall reject the offer.

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**Cont.**

This proposal is rejected because the selling price of 7,000 birr is below the manufacturing cost and is a loss.

Do you agree ?

- Under Capacity and Over Capacity

**Answer 12**

Current profit :

Sales : 45.0Mbirr/month

Cost : 42.5M birr/month

Profit : 2.5Mbirr/month

If accept the offer :

Sales : 55.5Mbirr/month

Cost : 50.0Mbirr/month

Profit : 5.5Mbirr/month ・・3M more

40

**Cont.**

Let's consider sales and cost as a whole.

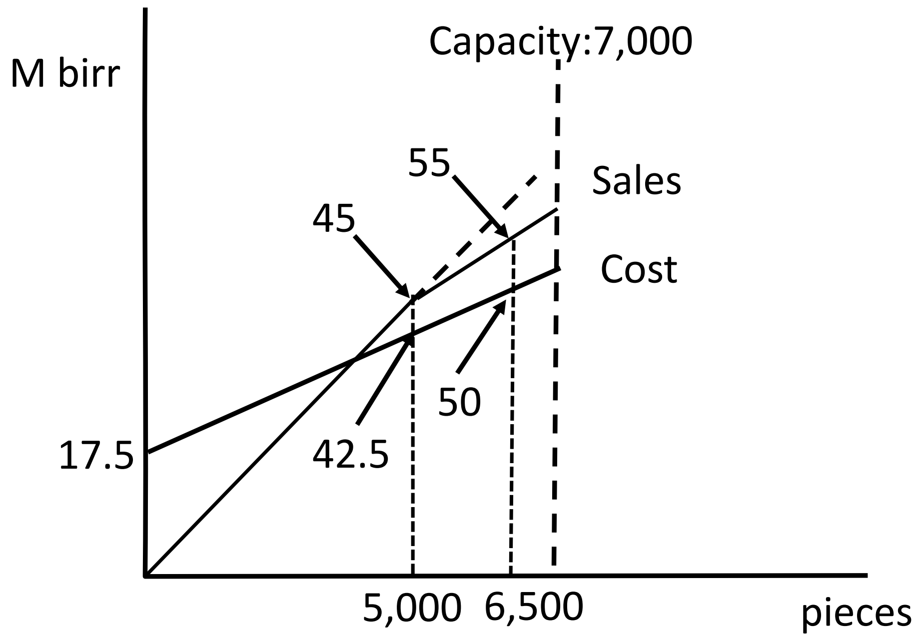
The current sales are 5,000 times 9,000 equals 45Mbirr. The cost is 42.5Mbirr when the variable cost is multiplied by the quantity and totaled with the fixed cost.

Therefore, the current profit is 2.5Mbirr per month.

What if you get this offer?

Sales will be 45Mbirr and 1,500 times 7,000birr equals 55.5mbirr. If the cost is calculated in the same way, it will be 50 Mbirr, which will increase the profit by 3 Mbirr than the current situation.

- Under Capacity and Over Capacity




41

**Cont.**

This situation can be explained by using sales and cost graph.

The difference between the two lines, sales and cost, is profit.

The dot line of 5,000 pcs is current business and The dot line of 6,500 pcs is the sales of current and new business.

As you can see, the profit of 6,500pcs line is bigger than the profit of 5,000pcs line.

- Under Capacity and Over Capacity

Question 13

Company A has following situation,

- Production capacity : 5,000pcs/month
- Current production : 5,000pcs/month
- Selling price : 9,000bill/pc

| | |
|---|---|
| ①Material cost | 4,000birr/pc |
| ②Variable expense | 1,000birr/pc |
| ③Direct Labor cost | 2,000birr/pc |
| ④Indirect expense | 1,500birr/pc |
| TOTAL cost | 8,500birr/pc |

* ③&④ are monthly cost divided by monthly production volume.

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**Cont.**

How about this case?
Only the production capacity has changed.

- Under Capacity and Over Capacity

Question 13

Now, one European company offers a business of 1,500 pc a month for 7,000birr/pc.

How company A shall decide?

43

- Under Capacity and Over Capacity

Answer 13

Current profit :

Sales : 45.0Mbirr/month

Cost : 42.5M birr/month

Profit : 2.5Mbirr/month

If accept the offer :

Sales : 42.0Mbirr/month

Cost : 42.5Mbirr/month

Loss : 0.5Mbirr/month ∵3M less

44

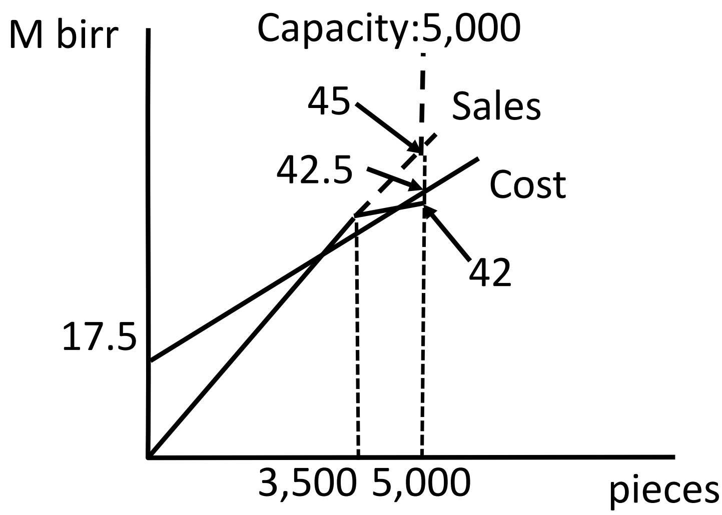
**Cont.**

If you accept this proposal, because of capacity constraint, you must cut some amount of current business that you can sell a product at 9,000 birr and make products for Europe business.

As a result, you lose the profit of 3Mbirr.

- Under Capacity and Over Capacity

Reduce current product by 1,500 pcs to accept Europe business




45

**Cont.**

The situation can be explained on this graph.

The dot line of 3,500pcs is current business that is reduced from 5,000pcs and the dot line of 5,000pcs is with new business of 1500 pcs. As you can see, the sales amount of 5,000pcs line is below the cost amount of 5,000pcs.

- Under Capacity and Over Capacity

Case of question 11・・・Under capacity
New price > Variable cost
makes more profit.
Case of question 12・・・Over capacity
New price > current price
is a must condition to make profit.

46

**Cont.**

In the case of Question 11, there is enough capacity to accept new business. In this case, fixed costs remain the same, and it is possible to increase production by adding variable costs only, so if the selling price is more than variable costs, profits can be increased.

In the case of Question12, production now is in full capacity, so current business must be reduced to accept more orders. In this case, the fixed costs remains the same, so profits cannot be increased unless the selling price is greater than the total cost.

These situations are called Under capacity and Over capacity.

# 8. Profit by Product

## Question 14

Company A has following products,

| | Product A | Product B |
|---|---|---|
| Sales (daily) | 4,000birr | 6,000birr |
| Variable cost (daily) | 800birr | 2,400birr |
| Labor cost (2,600birr/day) | 1,300birr | 1,300birr |
| Indirect cost (4,000birr/day) | 1,600birr | 2,400birr |
| Profit (daily) | 300birr | -100birr |

Shall company A produce product A only?

47

**8. Profit by Product**

Next, let's check the revenue for each product.

Revenue for each product of Company A is shown in the table. Fixed costs of labor cost and indirect cost are allocated in the piece cost for each product.

Looking at revenue by product, product A is profitable and product B is not profitable. The production quantity is the same.

Is it better for Company A to make only product A?

- Profit by Product

Answer 14

Making product A only,

| | Product A |
|---|---|
| Sales (daily) | 8,000birr |
| Variable cost (daily) | 1,600birr |
| Labor cost (2,600birr/day) | 2,600birr |
| Indirect cost (4,000birr/day) | 4,000birr |
| Profit (daily) | -200birr |

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**Cont.**

If you double the production quantity of A product, the profit will be like this.

If only A products are produced and sold, the profit will be negative.

- Profit by Product

Answer 14

Making product B only,

| | Product B |
|---|---|
| Sales (daily) | 12,000birr |
| Variable cost (daily) | 4,800birr |
| Labor cost (2,600birr/day) | 2,600birr |
| Indirect cost (4,000birr/day) | 4,000birr |
| Profit (daily) | 600birr |

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**Cont.**

But what if you double B production?

In this case, the profit is positive.

- Profit by Product

Answer 14

This table shows more clearly.

| | Product A | Product B | Total |
|---|---|---|---|
| Sales | 4,000birr/pc | 6,000birr/pc | 10,000birr/pc |
| Variable cost | 800birr/pc | 2,400birr/pc | 3,200birr/pc |
| Gross profit | 3,200birr/pc | 3,600birr/pc | 6,800birr/pc |
| Labor cost | | | 2,600birr/pc |
| Indirect cost | | | 4,000birr/pc |
| Profit | | | 200birr/pc |

50

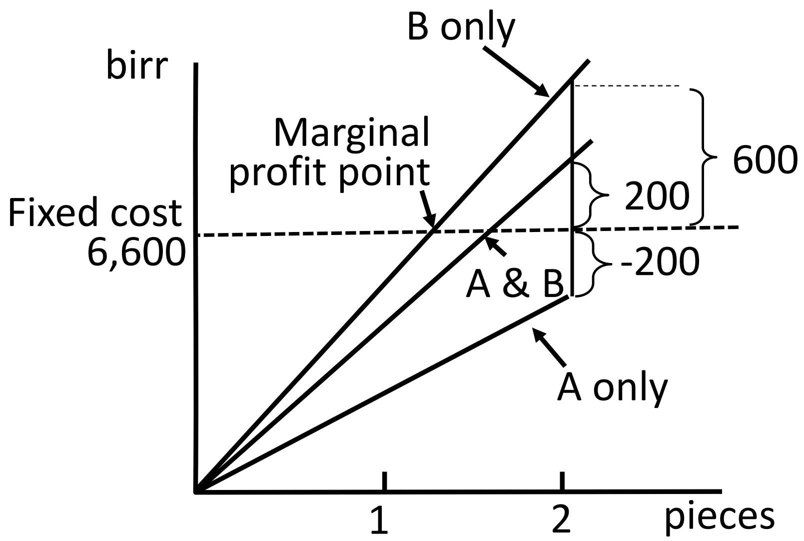
**Cont.**

The profitability difference on previous slides comes from the way of allocating the costs between product A and B.

When checking the profitability by product, the profitability will vary depending on the allocation method. As shown in this table, fixed costs should be considered separately from the product costs.

- Profit by Product

Gross profit by product




51

**Cont.**

The situation can be explained on this graph.

The A only line is the sales amount of A production only, the A & B line is the sales of A and B production, and the B only line is the sales of production B only.

The dot line shows 6,600 birr of fixed cost. The marginal profit point is the cross point between fixed cost and sales.

As you can see, the marginal profit of red line, B only is the highest.

# 9. Cost of Failure

## Question 15

There is a hamburger shop. The price and cost are as follows,

| | |
|---|---|
| Selling price | 40 birr/pc |
| Material & direct labor cost | 14 birr/pc |
| Indirect labor cost | 6 birr/pc |
| Indirect expenses | 7 birr/pc |
| Total cost | 27 birr/pc |
| Profit | 13 birr/pc |
| Monthly sales volume | 2,000pc/month |

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**9. Cost of Failure**

Next, let's study how much we could loose for a failure.

There is a hamburger shop.

The selling price and cost composition per hamburger is shown in the table.

- Cost of Failure

Question 15-a

One day, a server dropped one hamburger on the way to a customer table.

She dropped only hamburger, potato is not damaged.

The shop needed to cook a hamburger again. The material and direct labor cost of potato is 3 birr/pc.

How much did the shop lose for this failure?

53

- Cost of Failure

Answer 15-a

① The shop lost the “cost of sales”. Then the loss was 27 birr.

② The shop lost only “variable cost”. So the loss was 14 birr.

③ The shop lost only hamburger. So the loss was 14 birr – 3 birr = 11birr.

54

**Cont.**

Which one of these do you think is right answer?

- Cost of Failure

To compare some situations, you should consider only cost difference.

How much is the cost difference in this failure.

55

**Cont.**

The rule to know the cost of failure is the same as the rule for decision-making as previously explained.

- Cost of Failure

Answer 15-a

In this case, ③ is correct.

Indirect labor and indirect expenses are the same. And they could reuse the potato.

③ The shop lost only hamburger. So the loss was 14 birr – 3 birr = 11birr.

56

**Cont.**

In this case, the difference between “dropped” and “did not drop”, is only the variable cost to make a hamburger has changed. Therefore, ③ is the correct answer.

- Cost of Failure

Question 15-b

Same case with question16-a, the customer didn’t have time to wait for re-cooking. He cancelled his order and got out the shop.
In this case, how much did the shop lose ?

57

- Cost of Failure

Answer 15-b

In this case, the difference between situation A (did not drop) and B (dropped) is,

- Situation A: Sales (40B)-Variable (14B) =26B
- Situation B: Sales (0B)-Variable (14-3B) = -11B

So, Difference: 26B- (-11B) = 37birr

58

- Cost of Failure

Question 15-c

At the same shop  when a customer came, a server was talking over the telephone for long time. So the customer got out without ordering.

In this case, how much did the shop lose?

59

- Cost of Failure

Answer 15-c

In this case, the difference between situation C ( got an order) and D (got no order) is,

- Situation C: Sales (40B)-Variable (14B) =26B
- Situation D: Sales (0B)-Variable (0B) =0B

So, Difference: 26 birr

60

# 10. Kaizen Effect

Case 1;
Currently, product quality is unstable, and product price must be set lower because defective products are mixed. Kaizen is in progress to stabilize the quality and raise the selling price.

Case2;
Currently, defect ratio is around 20 % as monthly average. Kaizen is in progress to bring the defect ratio down to 5%.

Case3;
Currently, production downtime is around 30 hours per month for machine failures, change-overs, etc. Kaizen is in progress to reduce the downtime by 50% and increase net running time.

Case4;
Kaizen is in progress to increase production speed by changing the production system and reduce the total operation time.

Case5;
Kaizen is in progress to reduce material cost with Value Engineering activities.

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**10. Kaizen Effect**

Kaizen effect varies depending on the situations, like these cases.

- If Production Capacity > Demand

Case 1;
Price increase along with improved quality will increase total sale by the multiplication of price increase and sale volume.

Case2;
Defect reduction will decrease the variable cost of rework for defective products.

Case3 and 4;
These Kaizens could increase production capacity, but production will not be increased due to short demand. Therefore, profit will not go up. However, the variable cost, such as energy cost could be reduced along with the reduction of total operation time.

Case5;
Profit will increase by reducing material price or material usage.

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**Cont.**

If the production capacity is above demand, the Kaizen effect of each case is this,

- If Production Capacity > Demand

Case 1 and 5;

Price increase and material reduction will increase profit by the multiplication of unit price and quantity.

Case2;

Profit will go up by the multiplication of the number of good parts increased with the Kaizen and price.

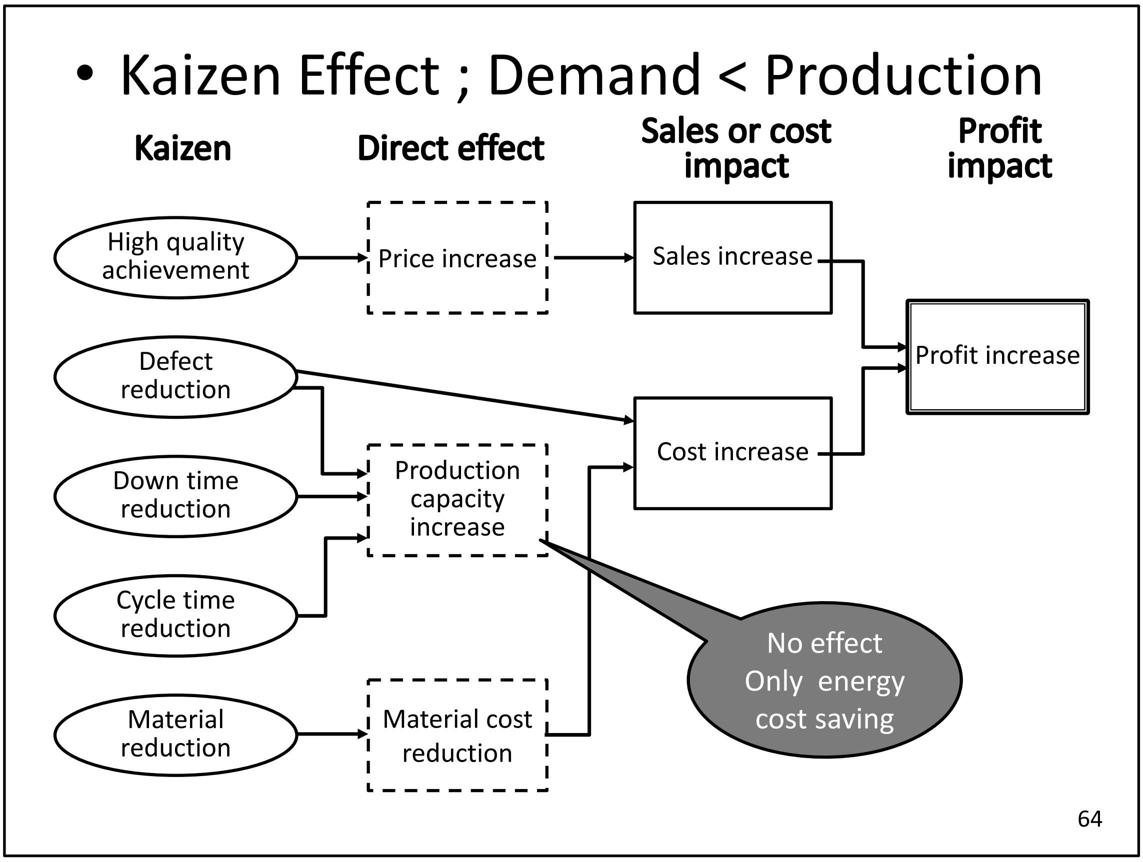
Case3 and 4;

These Kaizens could increase production capacity and increase the sales of goods with good quality. Profit will go up by the multiplication of the number of increase good parts and the reduced amount of variable cost with the Kaizen.

63

**Cont.**

If the demand is more than production capacity, the Kaizen effect of each case is this,

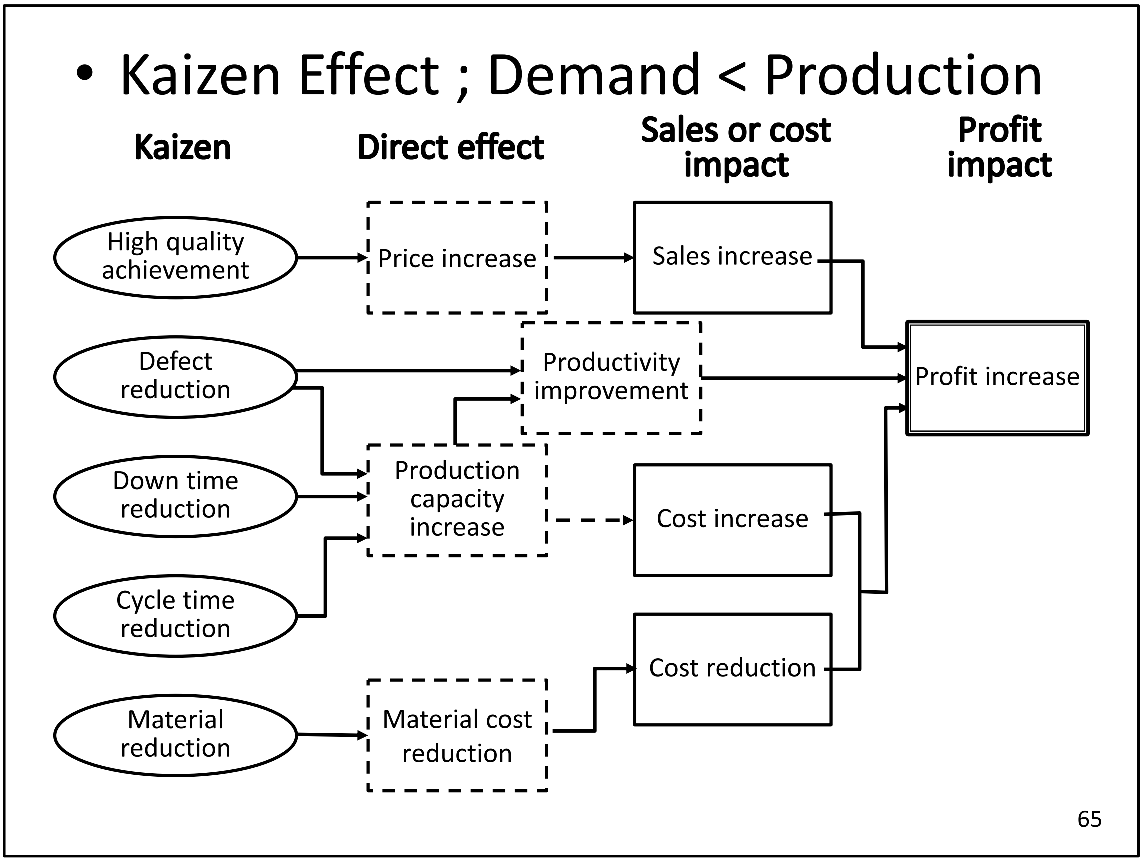



**Cont.**

If demand is below production capacity, Kaizen effect is like this.

The direct effects of Kaizen are price increase, production capacity increase, and material cost reduction.

These direct effects increase sales or decrease cost. The Kaizens like defect reduction, downtime reduction, or cycle time increase production capacity. But because the demand is below production capacity, the Kaizens do not increase sales nor reduce cost. Only some cases reduce energy cost.




**Cont.**

On the other hand, if demand is above production capacity, Kaizen effect is like this. In the previous slide, the Kaizens like defect reduction, downtime reduction, or cycle time do not increase profit. But in this case, those Kaizens enables us to produce more products ,increase sales, and increase profit. Some Kaizens for production capacity increase may increase cost for modifying machines, then you need cost and benefit study like we did earlier in this class.

- Comparison of Investments

Question 16

Two investment plans made by a company.

| Plan | Investment | Income (5years) |
|---|---|---|
| A | 20M birr | 7M birr × 5 |
| B | 30Mbirr | 9.5M birr × 5 |

Which plan do you choose?

66

- **Comparison of Investments**

  Now let's study about investments.

  There is a company that is considering two investment proposals.

  In Plan A, by investing 20Mbirr, the company will earn 7Mbirr annually over the next 5 years.

  Plan B will also generate 9.5Mbirr over 5 years by investing 30Mbirr as well.

  Which plan would the company choose?

- Comparison of Investments

As a principle, estimate the cash flow of revenue and cost arising from investment plan and evaluate net profit appropriately considering the time value of funds.

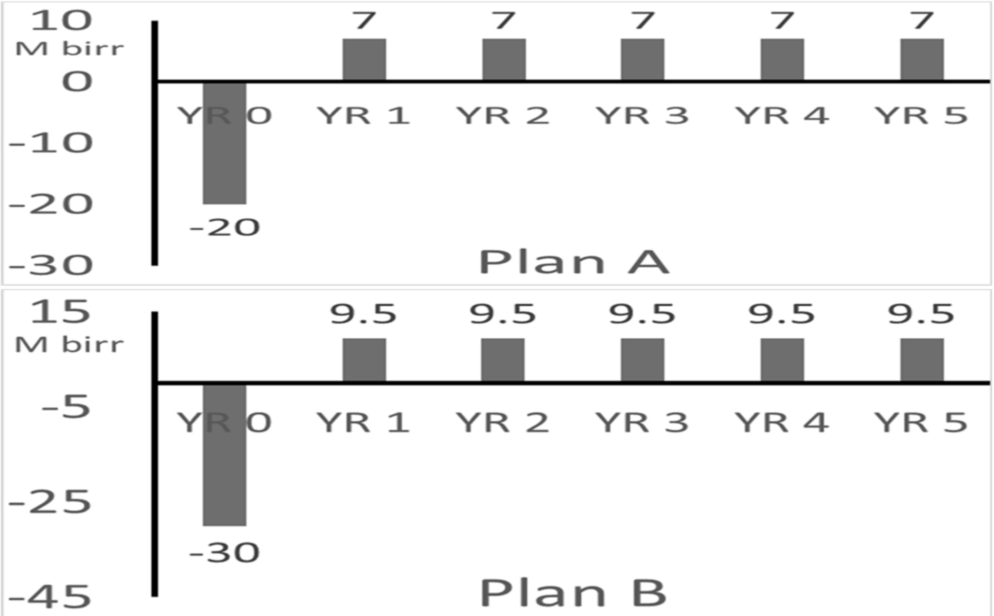
67

**Cont.**

One way to evaluate investment plans is;

- Comparison of Investments

## Question16; Cash flow stream chart




68

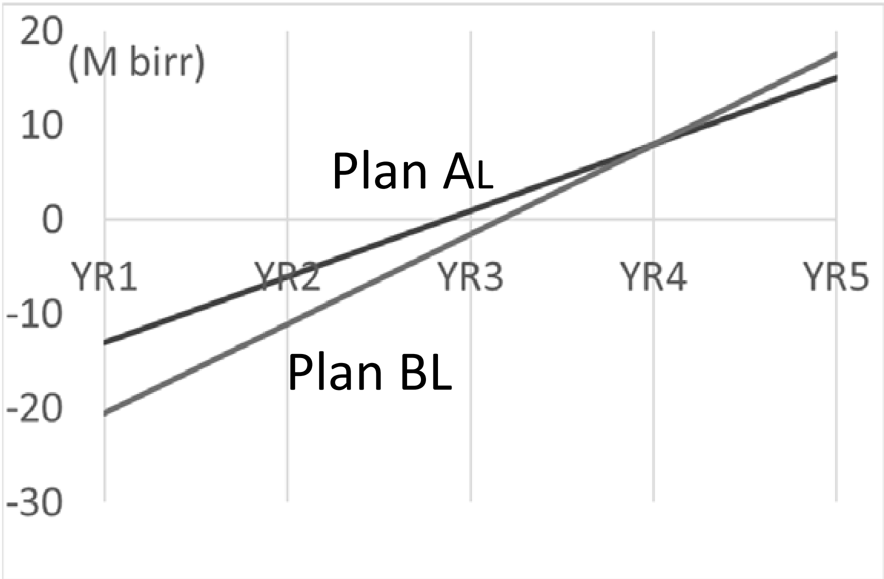
**Cont.**

This graph shows the revenue and cost of two plans.

It’s called cash flow stream chart that shows cash of investment and income by year.

• Comparison of Investments

## Question16; Investment payout curve




69

**Cont.**

This graph shows the profit of the two plans. The profit is the balance of revenue and cost on the previous graph.

As you can see, through the YR3, plan A has more profit then form YR4 plan B is more profitable.

This graph is called investment payout curve.

- Comparison of Investments

Answer 16

Plan B can make more profit in five years.

| Plan | Investment | Total income | Profit |
|---|---|---|---|
| A | 20M birr | 35M birr (7M birr × 5) | 15M birr |
| B | 30Mbirr | 47.5M birr (9.5M birr × 5) | 17.5M birr |

70

**Cont.**

You can simply put five years of profits like this and compare the two plans.

# 11. Cost of Capital

Think about "cost of capital".

Which one do you choose, 1M birr this year or 1.1M birr next year?

How about 1.5M birr next year?

71

**11. Cost of Capital**

Let's learn about Cost of capital.

- Cost of Capital

Think about "cost of capital".

Which one do you choose 1M birr this year or 1.1M birr next year?
How about 1.5M birr next year?

1M birr this year ≠ 1M birr next year

This is a basic idea of "cost of capital".

72

- Cost of Capital

If a company borrows money from a bank, it must pay a certain amount of interest year by year or if the company spends its own funds on the investment , it sacrifices a certain amount of return that its fund should bear if spent on others, saving account, equity, etc. The interest borne with procurement of such funds , Or the yield rate of fund management is called the capital cost.

73

**Cont.**

Here is the definition of capital cost.

- Cost of Capital

How much is the affordable cost of capital ?

74

- Cost of Capital

How much is the affordable cost of capital ?

It depends on the investor's expectation.

If company use their own capital, they can decide as they like.

One reference is loan interest of bank.

If the company invests using bank loan, “cost of capital” should be more than interest they pay.

75

- Cost of Capital

Question 17

In this case, “cost of capital” is set 10%.

| Year 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1M birr | 1.1M | 1.21M | 1.33M | 1.46M |
| 0.68M | 0.75M | 0.83M | 0.91M | 1M birr |

Please evaluate question17 using 10% of cost of capital.

76

**Cont.**

If the capital cost is 10%, let's see how it changes depending on the number of years.

This year's 1Mbirr is equivalent to 1.46Mbbirr four years later.

- Cost of Capital

Answer 17

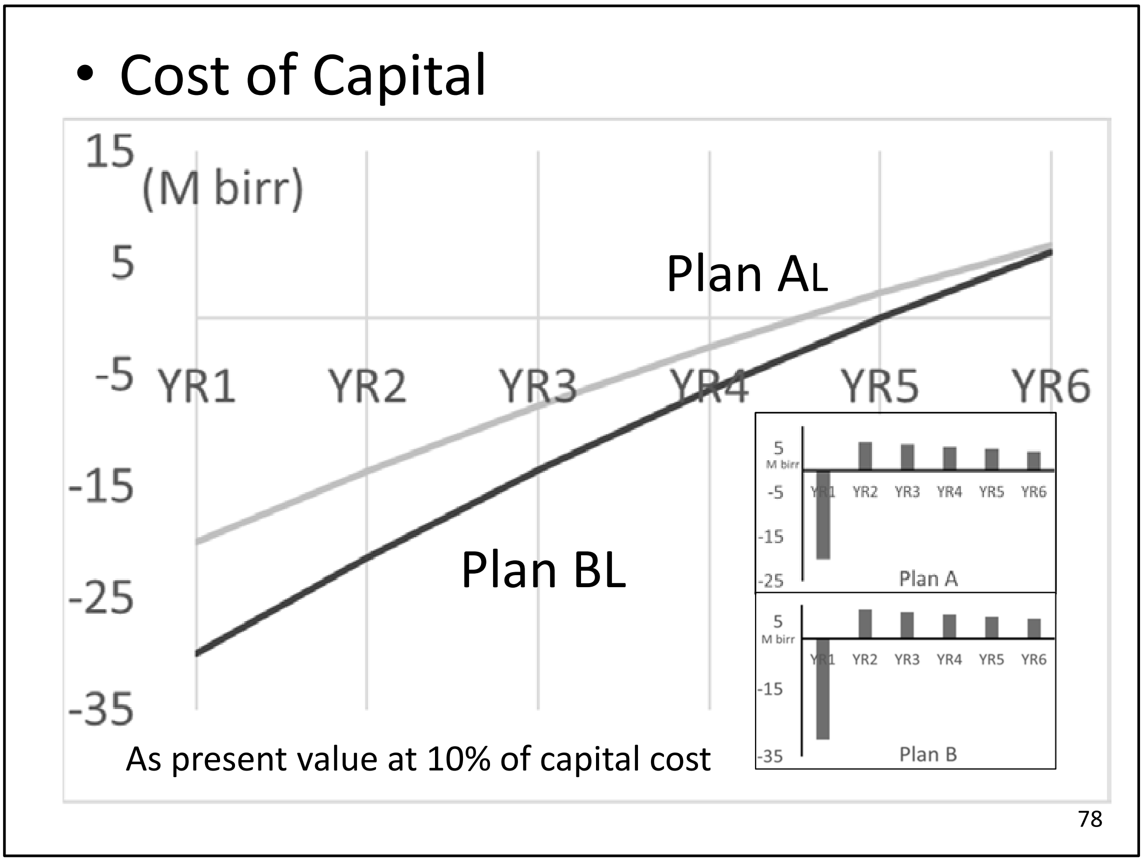
Calculate present value from future value.

| Year | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| PlanA | -20M | 7M | 7M | 7M | 7M | 7M |
| | -20M | 6.4M | 5.8M | 5.3M | 4.8M | 4.3M |
| PlanB | -30M | 9.5M | 9.5M | 9.5M | 9.5M | 9.5M |
| | -30M | 8.6M | 7.9M | 7.1M | 6.5M | 5.9M |

77

**Cont.**

The numbers in yellow are the value converted to the present value by the cost of capital.




**Cont.**

The investment payout curve and cashflow chart is like this.

- Cost of Capital

Answer 17

Calculate present value from future value.

| Plan | Investment | Income 1-5 | Profit |
|---|---|---|---|
| A | -20M | 35M | 15M |
| | -20M | 26.5M | 6.5M |
| B | -30M | 47.5M | 17.5M |
| | -30M | 34.1M | 4.1M |

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**Cont.**

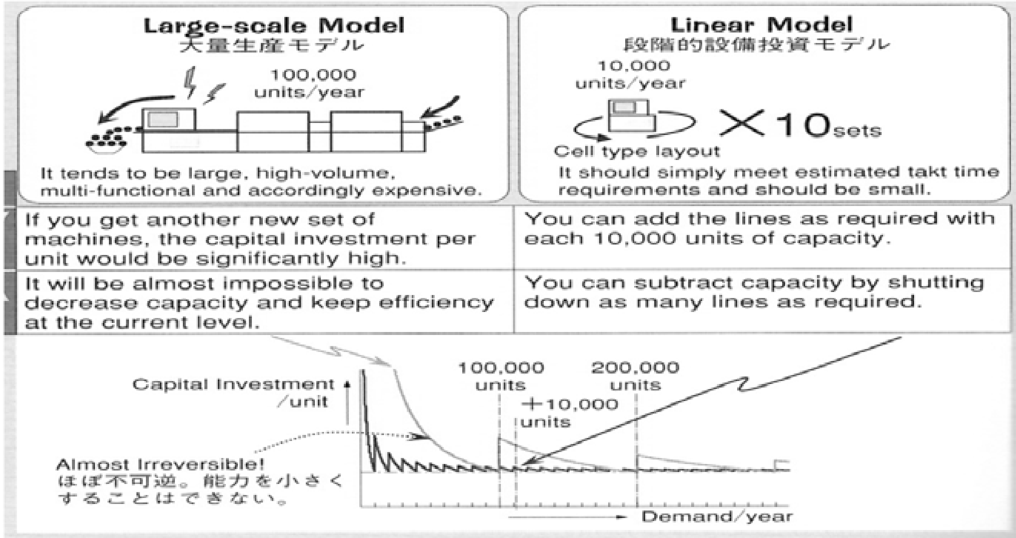
When combined with the total for five years, Plan A earned 6.5 Mbirr and Plan B earned 4.1 Mbirr.

Under this condition, Plan A should be adopted.

• Investment Planning

Advantage of Capital Linearity

Ex. Increase capacity up to 10,000units/ year




80

**Cont.**

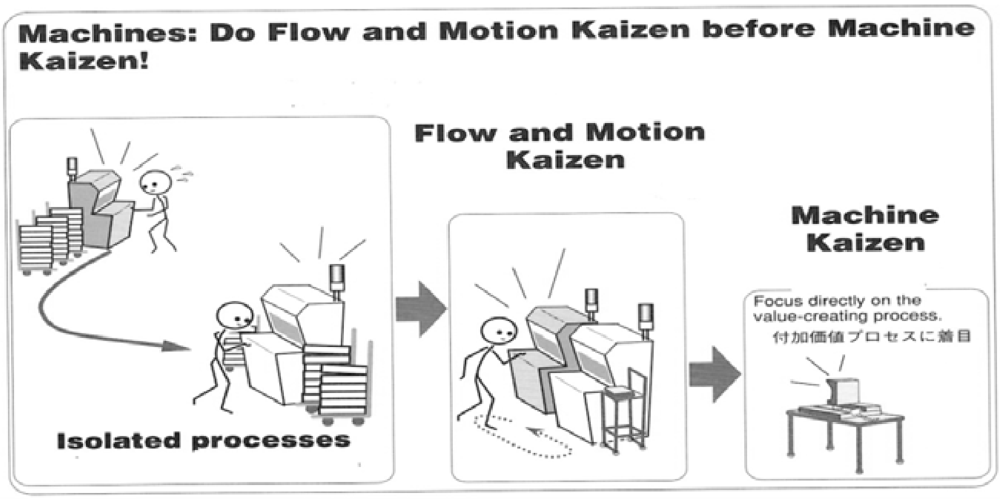
There is a philosophy called capital linearity. Capital linearity is for designing and buying production machinery so that small amounts of capacity can be added or subtracted as demand changes. In this way, the amount of capital needed per part produced can be very nearly level (linear).

For example, in capacitating for 100,000 units of annual output, a manufacturer might purchase a series of machines, each with an annual capacity of 100,000 units, and link them in one continuous flow production line (first alternative). Alternatively, the manufacturer might buy 10 sets of smaller machines to install in 10 cells, with each cell having annual capacity of 10,000 units (second alternative).

If the forecast of 100,000 units proved to be exactly correct, the single line with 100,000 units might be the most capital efficient. But if real demand is different, the second alternative offers distinct advantages:

- Investment Planning

No investment without Kaizen

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**Cont.**

At last, do not forget this.

Or the investment may become the waste of money.

# ETHICAL CODE

# ETHICAL CODE OF KAIZEN CONSULTANTS

This code is applicable for Kaizen consultants.

**(1) Confidentiality**

A consultant does not leak the work-related secret of a client to others, nor divert it to some other purpose without sufficient reason.

> When working as a consultant inside the company of a client, s/he has opportunities to know various information of the client, such as raw materials, machine and equipment, the way of processing, personnel, customers and market, and financial information of the client. In principle, the consultant should not leak any information to the outside or present it in a seminar. Only when the consultant obtains the permission from the client, s/he can do so.
>
> From point of view of Kaizen dissemination, it is very useful to share the kaizen practice of other companies. Thus, it is suggested to widen the scope of disclosing the information as much as possible and to get the permission from the companies in advance. When talking about the permission, there are several stages of opening the information, such as "Opening all information", "Opening all information except financial statements", "Opening information without announcing the name of company", or "Sharing photographs", etc.
>
> When the consultant is in charge of some clients of the same line of business, s/he shall get to know the company that employs an excellent way of processing among the companies. S/he may want to inform it to the other companies. But, it is the act of leaking information by consultant, if s/he does do so. Therefore, it must NOT happen. Note that it could be permitted that the consultant may provide a piece of advice to other companies, such as "Why does the company consider drying by using the wind, instead of natural drying in this process?"

**(2) Highest priority given to Kaizen needs**

A consultant puts top priority on problem solving/task achieving of client(s). S/he must not give priority to the use of the Kaizen technology in which s/he is interested.

> When a consultant learns new Kaizen technology, s/he wants to use it immediately. Then, s/he happens to find the problem/task that the new technology can be used and to make a trial of it, regardless of the request of a client. This is a wrong act of the consultant. For the consultant, the client is a customer that s/he provides the service of problem-solving/task achievement, but is not the field of experiment that s/he tries new technologies. Thus, it is suggested that for example, only when the consultant cannot make cause analysis or exploring the root cause done well with existing methods, new technologies can be used.
>
> It is common for enthusiastic consultants who study well that they make analysis with a difficult method and prepare a lengthy report, while it can be done with a simple method such as 7QC tools. This does not lead the consultants to find a proper countermeasure, nor to gain prestige on their proposal. What the client needs is a precise conclusion based on simple analysis, but not about how much the consultant studied, nor how long the consultant spent time for writing the report. It should not be a festival of the arts that the consultant shows his/her efforts made.
>
> The final goal of the consultant is to equip the client with ability of implementing Kaizen activity without the presence of the consultant. Therefore, it is recommendable that Kaizen

technologies to be used should be simple and easy to use. In order to establish the Kaizen in the company firmly, the consultant should figure out a good way, such as making data collection as less as possible, or finding out true cause with as a simple method as possible to make its countermeasure.

**(3) Serious consideration on work-site observation**

In making problem analysis and planning countermeasure(s), a consultant uses the information based on work-site observation and/or experiment. S/he must not make problem analysis or countermeasure planning only by a simple argument, a speculation and/or the opinion of a client.

There is a coined word "Lack syndrome". It is an attitude of a consultant to make a conclusion that there is lack of something, for instance, lack of skill, lack of knowledge, lack of attention, lack of time, lack of human resources as the root cause of a problem, after analyzing the causes that bring the problem. This syndrome then brings an aftereffect called "Fill up lack syndrome". That is, the consultant jumps to a conclusion that it is good to fill in the lacks and propose the provision of training, awakening of attention, increment of human resources, etc. These cannot be effective measures, as it is similar to the case that a poster "Beware of fires!" is put on to prevent the occurrences of fires.

In most cases, the cause of "Lack syndrome" is lack of something existing. It is lack of OEW, that is "Observation", "Experiment" and "Why-why analysis". The causes of a problem exist in Gemba (worksite), but the consultant repeatedly does discussion based on his/her guesswork in a meeting room. S/he cannot be confident about own conclusion, and then tends to make decision by following a person who has a big voice or who has been working in the company for longer time, as well as to implement all measures as s/he cannot narrow down the possible causes of a problem. This is a wrong way of implementing Kaizen.

The consultant should always discover things through observation in Gemba (workplace), rather than discuss in the meeting room.

**(4) Taking due consideration on human side in Kaizen**

A consultant takes special consideration on the human side of people influenced by Kaizen. The involved people shall be willing to understand it and give cooperation Kaizen positively.

Whether or not Kaizen can be sustained depends on whether or not the independency generates in a company, even though the Kaizen initiated with top-down way. Thus, Kaizen put value on the autonomy of bottom-up.

Kaizen is usually accompanied by change. However, most people tend to avoid the change. If there are 10 workers in a worksite, eight or nine of them refuse the change. Further, amongst them, two people become the stubborn forces of opposition to the change.

On the other hand, if asking whether or not there is someone who likes change, there certainly is. The number is only one or two though. One of them always gives agreement on any change, unless s/he loses something or becomes in a disadvantageous position due to the change. It is his/her character. The second one usually gives agreement after considering the case well. This person could be a strong Kaizen supporter. Thus, the consultant should see through who is such a person, gain him/her on the side of the consultant, and create the environment where sympathizers come to appear. The aforementioned "Consideration on human side of people" means creating such an environment.

To be specific, when initiating Kaizen, the consultant should explain to the workers to be involved why and for what Kaizen is needed by using familiar examples to obtain their consent. If the consultant carries out the activity of the creation of worker-friendly environment where less work-related accident cases occur or the workers feel comfortable in work at the beginning, the consultant can gain the followers of the Kaizen activity. From this point of view, it is reasonable to implement 5S at the beginning of Kaizen. In addition, it is necessary to collect the opinions of the workers in the critical stages of Kaizen (e.g. root cause analysis of a problem and countermeasure proposal). It is not necessarily to hold a formal meeting. If the consultant listens to the voice of the workers seriously, s/he will obtain helpful ideas from the workers.

**(5) Possession of trust**

A consultant keeps dignity and a promise. S/he must not do an act that loses trust, including receiving the unfair reward, which is not in a contract.

This article is easy to understand. What is written is something natural. However, there is one item that leaves question when asking whether it is executed properly or not. That is "keeps a promise".

The consulting is intangible service. The product of a maker is visible and touchable, and even can be operated. This is because it is a tangible material. It is easy to judge good or not on the tangible materials. On the other hand, Kaizen consulting service, a kind of intangible material, is difficult to evaluate. Thus, a client tends to evaluate the service not only by the result, but also by the process of the service provision. When it comes to the product, the majority of the consumers are not interested in the production process (how the product is produced under what kind of quality control process). This is because the consumers can confirm the degree of quality by the final product. On the other hand, in consulting service, not only "what was proposed", but also "how it was proposed (in what process)" are important.

The target of the evaluation in the process is whether or not "the consultant keeps a promise". Whether or not s/he visited the company on the promised date and time, whether or not s/he informed the client if s/he comes late, whether or not s/he prepared materials that were promised to bring, etc. The trust on the consultant can be established based on the accumulation of such small acts.

Whether the proposal of the consultant is accepted or not usually depends on the content of the proposal by half, and by what kind of person the proposal is made by half. "What kind of person" here means that whether s/he is the one who keeps a promise or not.

**(6) Mutual cooperation**

A consultant trusts mutually and makes an effort to cooperate with colleagues by respecting the points of view of others.

> A consultant usually works in team. The team is a kind of project team that has specific objective, limited period and available resources and is comprised of experts of different specialization.
>
> Sometimes, however, the consultants of different field have different way of thinking. For instance, when comparing the consultant whose specialization is QC and that of IE, the former may put more value on the quality of a product even though the productivity decreases. On the other hand, the latter one thinks that the competitiveness of the company depends on the productivity. The letter one often thinks that even though a good quality product is launched in the market, if it is produced without considering cost, the price of the product increases and then cannot be sold well, there is no way to take any measure. In this case, it is difficult to say which one is correct. There must be an optimal point that maximizes the long-term profit of the company in balancing quality and productivity.
>
> In order to find the optimal solution, it is dispensable to respect each other as experts of different fields and to collaborate each other. In such an atmosphere, respective consultants propose his/her ideas, make serious discussion and produce the recommendation that could bring greater contribution to the client (i.e. greater value added recommendation).

**(7) Continuous self-development**

A consultant recognizes the importance of the public mission of the certification. S/he always attempts at the development of technologies and self-development in her/his specialized field, and must execute his/her responsibility faithfully.

> There are not many Kaizen technologies that were invented for Kaizen. Most 7 QC tools have been used in Statistics, Economics and practical business as in the past. Venture to say, “cause and effect diagram” that arranges and summarizes the possible causes of a problem is only one tool devised for Kaizen.
>
> As shown in this example, most Kaizen technologies are the application of existing technologies. This means that any technologies that are useful to Kaizen can be utilized. Thus, it can be said that there are countless Kaizen technologies available. However, a consultant is not requested to acquire all of them to become the consultant. If so, his/her life time as consultant would be over before engaging in the service.
>
> Thus, it is important for the consultant to acquire the technologies of his/her area of specialization, in addition to the common and versatile Kaizen technologies. Needless to say, s/he should continue self-study. However, s/he may encounter the case that Kaizen technologies s/he possesses are not sufficient to solve the problem or to achieve the task in Gemba. What can the consultant do? S/he can inquire from colleagues, study by internet, but in a few case, s/he still cannot find the solution. What is important in this situation is not new technology, but one’s attitude, practice and skill of continuing to obtain it by self-education.
>
> To sum up, Kaizen technologies necessary to Kaizen consultant is fundamental Kaizen technologies and self-enlightenment (self-education) technology. That is, it is necessary to have both technologies related to “Know What” and that of “Know How”.

**(8) Fulfillment of independency**

A consultant always implements Kaizen consulting service with an appropriate attention and judgment. S/he maintains his/her independence in all Kaizen processes and must not cater to the request of a certain person.

> The former part of this article is easy to understand and thus no need to explain. But, the latter part needs some explanation.
>
> A consultant is often in middle position of two parties, such as between owner and employees; owner and managers; managers and front workers; or Department A and Department B. In such a case, the consultant should not support any one of the parties. This is described as "S/he maintains his/her independence in all Kaizen processes" and "must not cater to the request of a certain person".
>
> The owner and managers often request the consultant to give instruction that includes their intention to employees as well as to other department, instead of making direct communication. What the owner and manager intends to tell is usually a severe request or proposal. For instance, "Reducing the number of employees by half and increasing the productivity twice" and "If producing defects in quality, the salary would be reduced by 20 Birr per one defect" are the examples. The owner and managers want to know the reaction of the workers when such requests are made. Thus, they request the consultant to fly an observation balloon. From the workers, the consultant looks like "a running dog" of the owner if s/he does so. Then, the workers would not tell the consultant what they really think any more.
>
> If the consultant maintain his/her neutral position, s/he should attempt not to lean to one side, for example, by creating the position of reallocation of surplus workers as a result of the productivity improvement, by preparing and proposing to the owner a countermeasure of transferring the surplus workers to other growing section/department, or by making recommendation to the owner to establish the system of process control instead of making the penalty system that has only temporary effect.

**(9) Compliance with law**

A consultant implements his/her task by complying with the law and keeping the contribution to national growth strategy in mind.

> This Kaizen consultant CARS is the system that would contribute to the realization of GTP 2 through Kaizen activity. Kaizen consulting service is invisible and intangible asset, which is different from the tangible things such as a product. It has a unique characteristic of simultaneity of production and consumption, that is, when a consultant provides Kaizen service to client ("production"), the client receives and accepts the Kaizen service ("consumption").
>
> Due to such characteristics of Kaizen service, it is not easy to sustain and improve its quality. If it can be kept in stock, then, the quality inspection of the service can be done and only the service that have the quality of a certain level can be delivered. But it is not the case for consulting service.
>
> In order to disseminate the Kaizen consulting service, it is indispensable to level off the quality of the service, in parallel to the visualization of the service. From the point of view of the dissemination and expansion of Kaizen to bring contribution to GTP 2, this system is essential and important tool of quality management in sustaining and expanding the Kaizen contribution, not just certifying consultants.

### (10) Prohibition against facilitation of illegal act

A consultant must not facilitate any illegal act or anti-social behavior of client(s).

Most clients are business firms. The laws related to business administration include the one about estate lease, labor, trade and other field.

There are a few laws that may be a big issue in the future. One of them is the law on industrial safety and health; and the other one is law related to environmental pollution of the surroundings of a factory. In order to implement the countermeasure(s) to such issues, additional investment in plant and equipment is needed. Nonetheless, it would not increase the sales of the firm. There are managers who pursue the profit of the firm alone and overlook the issues. If the consultant also overlooks the issue, it would be taken as assisting anti-social act of the firm.

Thus, the consultant should be sensitive to safety and health of work place inside the factory; and be sensitive to the effect on environment (e.g. air, water, noise and vibration pollution) outside the factory. In addition, the consultant is expected to be a pioneer to encourage the Kaizen on the issues.

### (11) Serious violation of ethic code

When a consultant erodes the honor and/or the trust of Kaizen consultant certification by the violation of an ethic code stipulated in this paper, and/or brings a client the damage, the Secretariat (see 7-3) shall investigate and discuss the case to determine a certain punishment for the concerned consultant depending on the degree.

- Deprivation/cancellation of consultant certification
- Moratorium/suspension of consultant certification (for three months / for one year)
- Submission of letter of apology / warning

# INHERENT TECHNOLOGY

# Inherent Technology

1

**Inherent Technology**

Kaizen requires various technologies.

First, let’s think about Gemba Kaizen. Gemba means work-site.

For Gemba Kaizen,  there are basic technologies such as 5S;

7 QC tools such as Histogram, Pareto chart, Cause and effect diagram; and IE tools such as Flow diagram, Multi-activity analysis and Work sampling.

These technologies are used for analyzing actual situation and solving problem and/or achieving task.

These technologies are generally called as management technologies and are necessary for Kaizen of Gemba regardless the type of business of the target company.

Moreover, they can be applied not only to the manufacturing industry but also to Kaizen in other sector such as the service industry while product technology and production technology is to use in the specific industry.

# Contents

1. Three Categorized Technologies
2. Difficulty of Kaizen and Technology
3. Grasping what a Good Product is
4. What is Parameter?
5. Conclusion

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**Contents**

1. Three Categorized Technologies
2. Difficulty of Kaizen and Technology
3. Grasping what a Good Product is
4. What is Parameter?
5. Conclusion

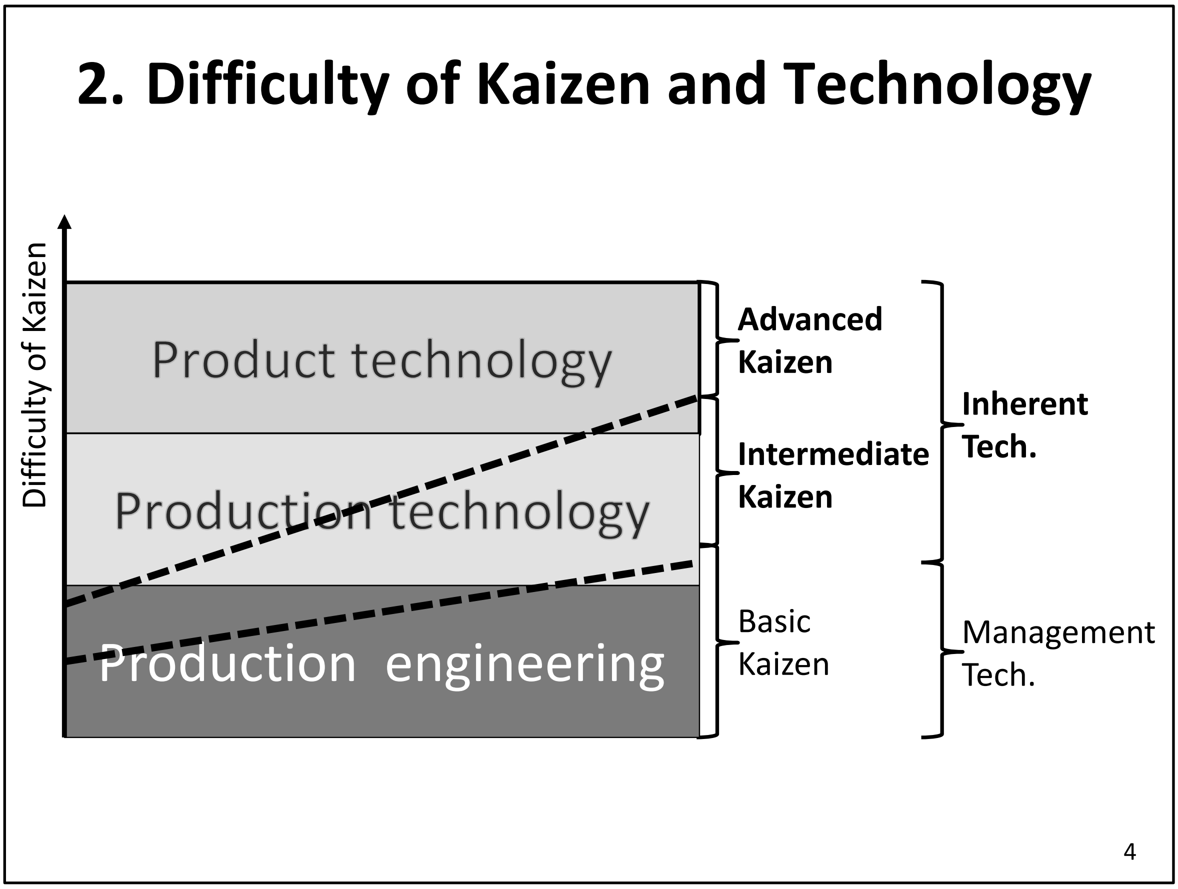
# 1. Three Categorized Technologies

The technologies are classified into following three by the objective of use:

- **Product technology**:
  Hybrid engine, self-drive: Technology built in the product and to play a role of product function
- **Production technology**:
  Press, vending, heat treatment, paining: technology necessary for processing of raw material or parts and/or assembling parts
- **Production engineering**:
  SMED, TPS, Kanban: Technology related to product with better quality, shorter lead time, cheaper cost

3

1. Three Categorized Technologies




**2. Difficulty of Kaizen and Technology**

This figure shows the difficulty of Kaizen and technology.

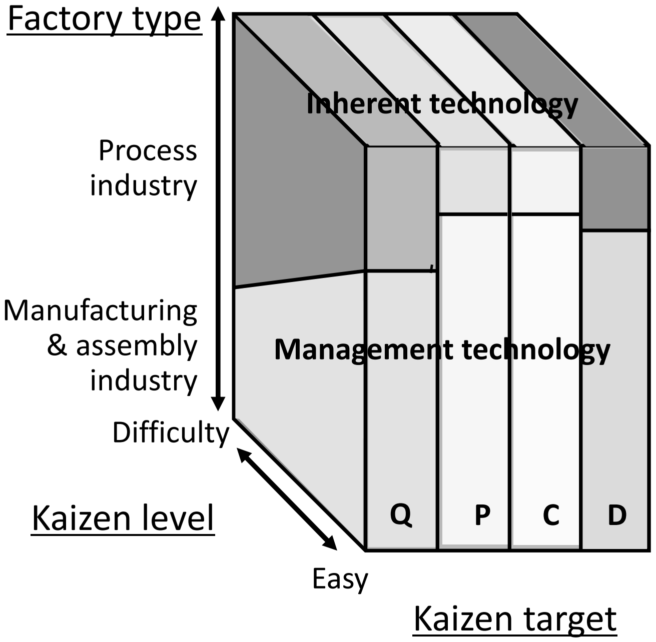
The three categories of technology are placed vertically from the bottom to the top as they go from simple to difficult.

Similarly, Kaizen technology is classified from Basic to Advanced, but in the case of Kaizen technology, the composition ratio of the technology is different as shown by the black dotted line.

For example, in Advanced Kaizen, Product technology is the main technology, but Production technology is also required.

Similarly, for Inherent technology, Product technology is the main technology, but Production technology will also be necessary.

## (Conti.)
## The image of the ratio of inherent technology and management technology in Kaizen




The image shows that:

- The ratio of using inherent technology depends on the Kaizen target, Kaizen level and factory type.
- One example of the easiest Kaizen:
  - Factory type: Combined with manufacturing and low assembling industry;
  - Level of Kaizen: Low
  - Kaizen target: Cost.

5

This figure is the image of the ratio of inherent technology and management technology in Kaizen.

The front side shows the composition ratio of Kaizen technology for each Kaizen target. Kaizen targets are listed from left to right: Q: Quality, P: Product, C: Cost, D: Delivery. Among them, when looking at Q, the ratio of inherent technology to Kaizen technology is high. This means that inherent technology is important for Kaizen of Quality.

On the other hand, it shows the ratio of inherent technology is small in Kaizen of Cost. This means that and it is easy to practice the Cost Kaizen even if consultant does not have much knowledge of related inherent technology.

The depth of the figure shows the difficulty of Kaizen level. When looking at Q, the deeper you go, the higher the ratio of inherent technology it requires.

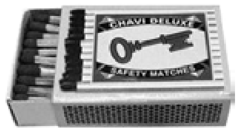
This means that in order to tackle advanced level Kaizen, more inherent knowledge is required.

On the contrary, although the depth of C is not shown from this figure, the Kaizen of C does not require the high ratio of inherent technology so much.

As described above, the importance of using inherent technology changes depending on Kaizen’s target and Kaizen's difficulty level. In order to solve the customer's problems/issues, inherent technology related to the problems is required as needed.

# 3. Grasping what a Good Product is

1) What is a good product?
2) Quality characteristic
3) Condition of safety food (next slide)
   - ◆ Grasping factors that represents quality characteristics.
   - ◆ What are defectives of match?



**Examples of answer ➙**
❶ Short number of march, ❷ quick drawdown of friction sides, ❸ broken match stick, ❹ no firing match, ❺ match without firing material, ❻ match with short firing material, ❼ fling head of match, ❽ movement of fire accelerated near finger, ❾ fluctuated blame size, ❿defective moving of blame from head to stick, ⓫ moist match, ⓬ broken match box

6

**3. Grasping what a Good Product is**

When asking what the purpose of Kaizen is, many people say that it is to make a good product. So, what is a good product?

There is a term “quality characteristic.”

The quality characteristic represents what kind of quality the product has.

Rather than generally saying it is a good product, we should say the product that has the quality characteristics.

Here is a match in a box. Now I want all of you think about the quality characteristics of this match.

As an exercise, check out what defect this match has.

(I have listed 12 types of defects for your reference)

# 4. What is Parameter?

Grasp the relationship among quality characteristic, parameter and operational condition

**Example (safety food)**

Quality characteristic
(Number of bacteria)

→ Grasping parameter
(Temperature, heating time, initial bacteria number, pH)

→ Finding processes and machines
(Sterilization process, retort equipment)

→ Degerming best condition
(Finding best condition by experimental design method)

7

**4. What is Parameter?**

Finally, in this slide, let’s determine the relationship among quality characteristics, operation conditions and parameters.

Let’s take food as an example.

One of the quality characteristics of food is the number of bacteria. The number of bacteria varies depending on parameters such as temperature and heating time during processing, number of bacteria before processing and ph (acidity and alkalinity). If you know this, then look into the actual machining procedure and machine.

Then, the optimal conditions (combination of parameters) are obtained by design of experiments.

# 5. Conclusion
## - For Customer Satisfaction -

- For customer satisfaction, it is very important to select problem/task and chose adequate Kaizen technology.
- Competent consultants tend to solve difficult problems by easy technology while poor competent consultants favor to apply the difficult technology for simple problems.
- A lengthy consulting report proves that the consultant spends long time on preparing it, but it never proves the consulting ability. Simple report impacts strongly to managers.

8

**5. Conclusion**

- For customer satisfaction -

## - Consulting Ability -

- It is recommended that you focus on the knowledge on quality characteristic, parameter, and its relationship regarding inherent technology in your learning.
- Once you get familiar with inherent technology of one industry, it gets easier for you to learn that of other industry.
- The half of consultant job is to serve for client companies; and the other half is to study new technologies (e.g. inherent technology).

***I sincerely hope your growth as a Kaizen consultant.***

9

- Consulting ability -

# CASE METHOD & CASE STUDY

## 1. TQM: Case Method (Sugar Factory)

### A. Introduction

The following is an introduction to the current status of management and production for Wonji / Shoa Sugar Factory, a representative sugar factory in Etama, located in Adama. You compare this situation with the aim and method of TQM, discuss whether this company is operating properly and the correct production method, point out if there is something to improve, and propose a desirable idea. Please practice.

### B. Case

The current Ethiopia's sugar business has a small production scale, and also a fewer small production volume. But the government positioned the sugar business as an important project in economic strategy, it has advanced in the direction to expand the number of plants from the current three (3) to thirteen (13).

All the plans are delayed, but currently, a large-scale factory is under construction in Tendaho area. (Please see Table-1)

Table-1 Construction Plan of Sugar Factories in Ethiopia

| | **Existing Factories** | **Construction** | **Crushing Capacity (ton per day)** | **Sugar (ton per year)** | **Ethanol as by-product (M3/y)** |
|---|---|---|---|---|---|
| A | Wonji/Shoa Sugar Factory | 1950s | 12,500 | 300,000 | - |
| B | Metahara | 1960s | - | - | - |
| C | Finechaa | ? | - | - | - |
| | **Expansion Projects** | **Construction Plan (Ending Time)** | **Crushing Capacity (ton per day)** | **Sugar (ton per year)** | **Ethanol as by-product (M3/y)** |
| 1 | Wonji/Shewa Expansion Project | June, 2012 | 6,250 | - | - |
| 2 | Finechaa Expansion Project | April, 2012 | 12,000 | - | - |
| 3 | Tendaho (total Building) | March, 2013 | 26,000 | - | - |
| | **New Projects** | **Construction Plan (Ending Time)** | **Cane (ton per day)** | **Sugar (ton per year)** | **Ethanol as by-product (M3/y)** |
| 4 | Belse-I Sugar Factory | December, 2012 | - | 242,000 | 20,827 |
| 5 | Belse-II Sugar Factory | January, 2013 | - | 242,000 | 20,827 |
| 6 | Kuraz-I Sugar Factory | September, 2013 | - | 278,000 | 26,162 |
| 7 | Kuraz-II Sugar Factory | November, 2013 | - | 278,000 | 26,162 |
| 8 | Kuraz-III Sugar Factory | November, 2013 | - | 278,000 | 26,162 |
| 9 | Kuraz-IV Sugar Factory | October, 2014 | - | 278,000 | 26,162 |
| 10 | Kuraz-V Sugar Factory | October, 2014 | - | 278,000 | 26,162 |
| 11 | Kuraz-VI Sugar Factory | October, 2014 | - | 278,000 | 26,162 |
| 12 | Welkait-VII Sugar Factory | May, 2014 | - | 242,000 | 20,827 |
| 13 | Kesem Sugar Factory | September, 2013 | 6,000 | 153,000 | 12,500 |
| | Kesem Sugar Factory | Extended | 10,000 | 126,000 | 30,000 |

Edition: June 17, 2012 by from other media

Each sugar corporate is expected to perform the high profitability of the business from Ethiopian government. There are a lot of challenges and problems that the top management must carry out in each corporate.

It will also need to have a solid vision and the policy over the coming future.

Ethiopia's sugar business ranks as 43th in the world when compared in sugar cane production volume scale (base 2013).

Table-2

| **Top ten sugarcane producers —** | | |
|---|---|---|
| | Production (thousand metric tons, TMT) | |
| Country | **2013** | **2015** |
| Brazil | 768,090 | 739 267 |
| India | 341,200 | 341 200 |
| China | 128,200 | *125 536 |
| Thailand | 100,096 | 100 096 |
| Pakistan | 63,749 | 63 750 |
| Mexico | 61,182 | 61 182 |
| Colombia | 34,876 | 34 876 |
| Indonesia | 33,700 | *33 700 |
| Philippines | 31,874 | 31 874 |
| United States | 27,905 | 27 906 |
| **Rank 43 Ethiopia** | 2,750 | |
| **World** | **1,911,179** | **1,877, 105** |
| Source: Food And Agricultural Organization of United Nations: Economic And Social Department: The Statistical Division | | |

Sugar manufacturing business of the world has been already crowded in by a number of large companies such as Brazil and India through the long history.

Although in recent years the sugar production volume of the world shows a trend of flat or slightly decreasing, but the consumption of sugar will inevitably come growth when living standards of African countries is going up in the future.

Sugar Cane in the Ethiopian fields has a very high concentration, 13.5 to 14.0 percent Sugar (as Sucrose), compared to 8-10% in India. It is a big advantage for the sugar business.

It was decided to carry out the improvement activities in Sugar A- Factory of Ethiopia. It is one of the state-owned corporates.

A- Factory has been manufacturing 200 tons per day from October, 2015 to June, 2016 by sugar cane harvested over in 1200 ha of the field.

Also the Factory has about 8,000 employees, and 70% of them are engaged in as sugarcane farmers.

The Factory under such a situation has a strong interest in enhancing profitability by improving activities, and already organized the 670 Kaizen Project Team in the factory (KPT). The members in KPTs have carried out discussions on improving every day and been implementing 5S activities for 2 times a day.

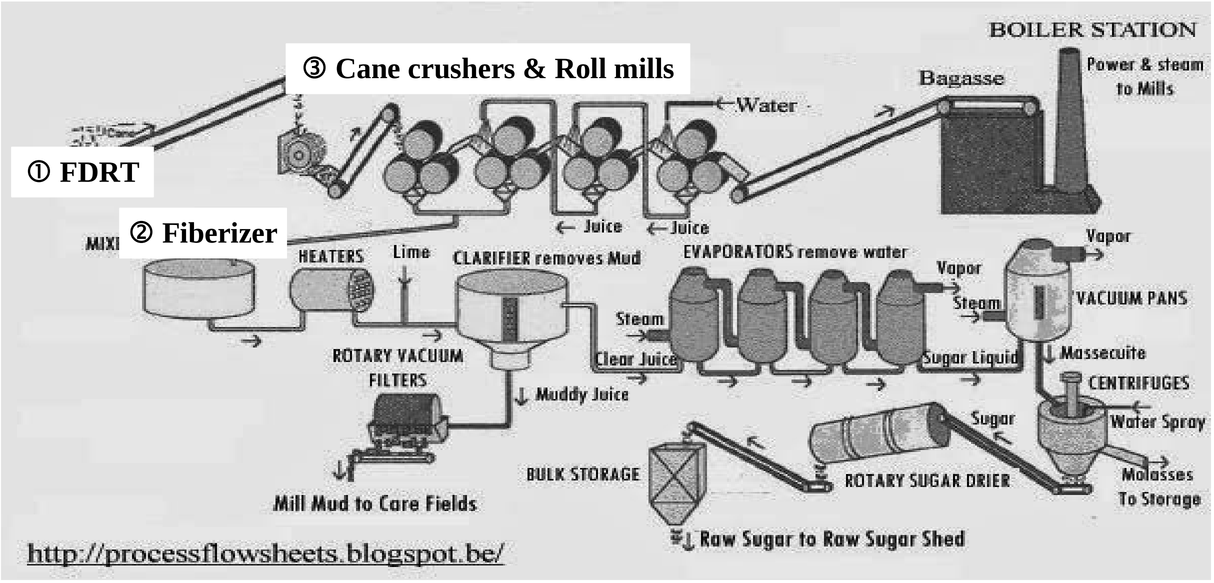



Figure-1 Sugar Production Scheme

**Description & Function of each Process**

① **Feeder Table (FDRT) -** Sugar Cane Supply

② **Fiberizer**

③ **Cane crushers & Roll mills -** Roll-mills that are can extract up to 80% of the available juice.

The pressure exerted by the mill on the cane is determined by the gap between the top roller and the bottom rollers. If the gap is too wide then poor extraction will result; if the gap is too small then the cane may not pass through it or may cause the rollers to jam. The correct setting of the rollers has to be determined at the site of crushing as it will be dependent upon the cane variety, size and quality.

Another important factor for efficient extraction is the operational speed of the crushers. Operating speeds are typically between 5 and 50 (round per minute).

It is important to remember that cane must be crushed within 24 hours of being cut. After this time the sugar begins to 'invert' into different sugars that will not set solid.

④ **Clarification -** Extract Juice is treated during the boiling process by adding a small amount of chemicals such as lime (CaO) and Sulphur dioxide (SO2) to reduce the acid component including in sugar cane.

⑤ **Filtration -** Juice should be filtered through a cloth before boiling in order to remove any solids such as dirt or particles of cane.

A filter press, if available, will give the best results. The reasonable levels of filtration can be achieved by allowing the juice to stand for a few hours to allow particulates to precipitate out.

⑥ **Evaporation -** The evaporation of moisture from the juice at temperatures of between 90 and 116ºC.

The massecuite is removed from the final boiling pan at about 84ºBrix, at a temperature of around 112ºC. (Massecuite is the mixture of crystal sugar and syrup)

(Brix: Solution is the mixture of sugar solid and other liquid, Percentage means the ratio of solid weight in solution)

For syrup production the juice is boiled until the required concentration is reached and the strike is made at around 105ºC when most of the moisture has been boiled off and just before crystallization occurs. (Syrup is the liquid with the concentrated sugar component and other impurities)

For lump sugars the juice is boiled for longer and the strike is made at between 116 and 120ºC. (Strike is sugar component just before crystallization)

The juice is then neutralized with Sulphur dioxide. Many producers also add 'hydros' (Sodium Hydrogen Sulphate) at the final stages of boiling. This releases Sulphur dioxide into the juice and lightens the color of the final product.

(Note: a high Sulphur content often remains in the final product.)

⑦ **Crystallization -** The massecuite is placed in U-shaped vessels where it is slowly rotated and allowed to cool for up to 48 hours.

Rotation promotes even cooling of the massecuite which helps to achieve uniform crystal growth.

⑧ **Centrifuge -** Separation of Crystal Sugar (Product)

## Material Balance of Sugar Recovery

In order to increase the profitability of company, it begins to first improve the productivity. To achieve this it is necessary to identify the material balance of raw materials.

Figure-2 generally represents the material balance when the raw sugar is produced in the approximately 10kg from sugar cane raw material 100 kg. Here, lowering the yield of the sugar process is a loss due to the Baggase and Molasses. Here, the losses lowering the yield of the sugar process are due to the Baggase and Molasses.

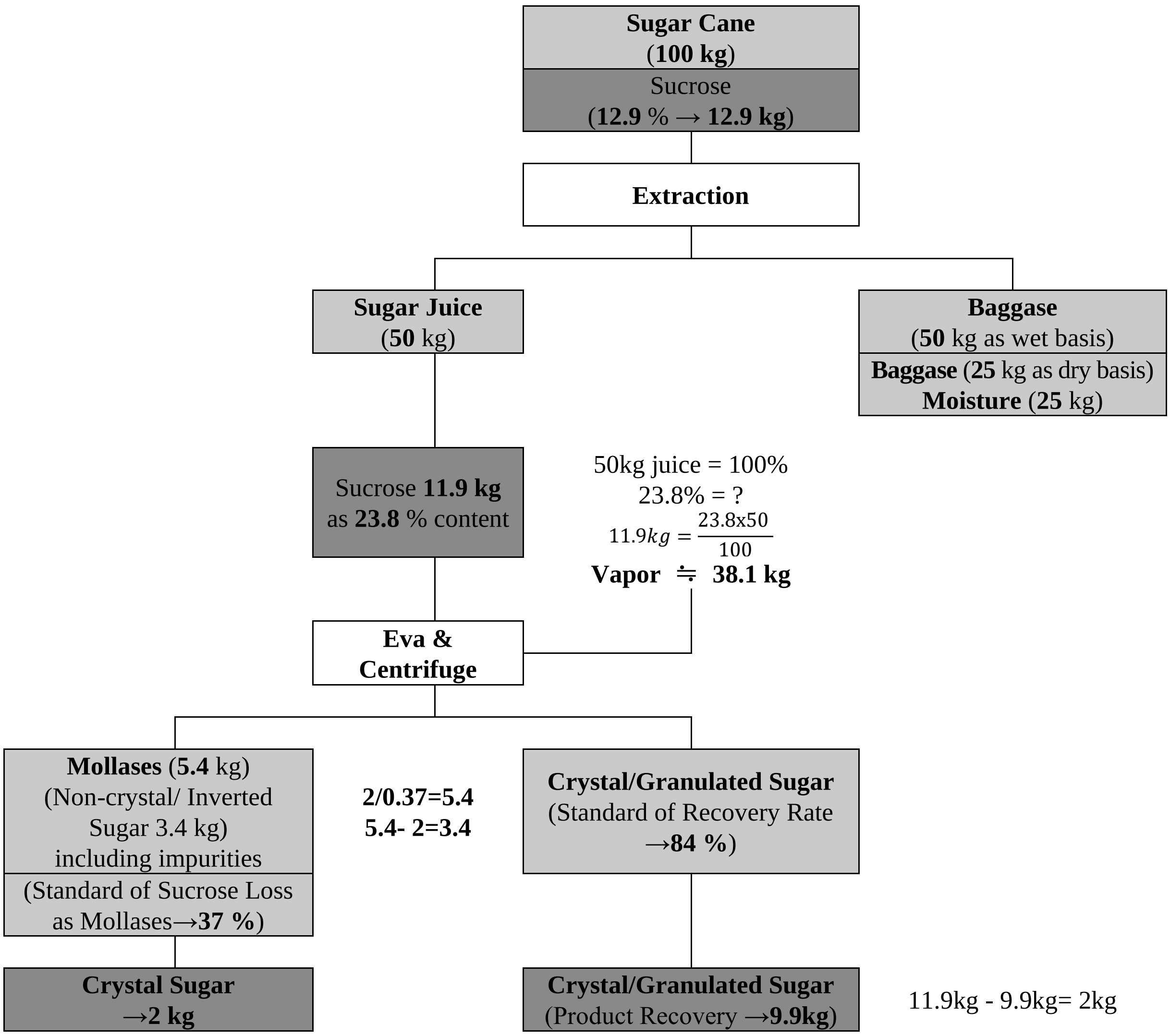



Figure-2

## A. Sugar Loss Identification

Here is the case of A Factory and B Factory as an example.

On the recovery of sugar the yield and loss are shown below by comparing a target value and the recent average of actual measurement values in Table-3 and Table-4.

Table-3 A- Factory Case

| Target (Standard) | Recovery Rate (A): 85 % | Loss Rate (B): 3.95 % | Loss Rate (C): 0.62 % | Loss Rate (D): 8.64 % |
|---|---|---|---|---|
| Current | 82 % | 5.38 % (in Bagasse) | 0.50 % (in Filter Mud Cake) | 10.26 % (in Molasses) |
| Difference | 2.73% | 1.43% | 0.12% | 1.62% |

In the case of A Factory, Fiberize Machine and FRDT equipment in Preparation Plant for sugarcane provision have low working operating rate because of frequent failure.

On the other hand, when the conditions such as temperature and time to crystallize the sugar component by boiling the Massecuite are not correct, it made the Crystal sugars too fine. And as a result, centrifuge machine cannot fully capture them in the final process.

The recovery rate of the sugar product is reduced as a whole by these problems.

So, this production line is equipped with a Sugar Recovery Circulation System.

The recovery rate is increased by again returning Molasses with new Syrup to Boiling process with mixing Molasses including a sugar component that could not become a crystal sugar and that could not be captured by the centrifuge machine after boiling process.

Incidentally, in the case of A Factory, the recovery loss of sugar is found how much it is reducing the sales amount by the following calculation.

- The above data results as the actual final purity of molasses was 40% but the world standard of purity of molasses was 30%. According to this results:
    1. Loss of sugar average 400 ton/month
    2. When the production is for 10 months in a year, the loss is 4,000 ton sugar
    3. One ton (1000kg) sugar price = 1,500 birr
    4. 4,000 x 1,500birr = 6,000,000 birr

Table-4 B Factory Case

| Target (Standard) | Recovery Rate (A): 84.25 % | Loss Rate (B): 5.50 % | Loss Rate (C): 0.65 % | Loss Rate (D): 9.26 % |
|---|---|---|---|---|
| Current | 79.39 % | 8.72 % (in Bagasse) | 0.96 % (in Filter Mud Cake) | 10.03 % (in Molasses) |
| Difference | 4.86 % | 3.22 % | 0.31 % | 0.83 % |

Whereas in the case of B Factory, the recovery rate of sugar products has been reduced by the failure of Mill equipment in the extraction plant of Sucrose.

Incidentally, in the case of the B Factory, it is reduced by Mill failure. The amount of 20 ton of sugar per the day in the bagasse.

The loss amount is 300,000 birr sales per the day by the assumption that one ton of sugar is sold at 15,000 birr, and 15,000birr × 20 tons = 300,000 birr.

**B. Sugar Color as Quality Problem (final Product )**

A content of impurities in the final sugar affects the quality level of the product. Especially the international standards are provided with the colored level for the raw sugar. In other words, it is defined as 400 or less as ICUMSA value.

Table 4 is showing the data of the past few years related to the coloring level of the products regarding B factory.

A few years ago the value showed to close to international standards, but in recent years it has a bad value. It would be taken little responsible for technical measures.

**1. Color Problem:**

- ✓ Measurement device of color of sugar is called Spectrophotometer.
- ✓ Quality condition that should be measured is unfiltered color.
- ✓ The current company's standard for color of sugar is <400 ICUMSA.
- ✓ Current average color of sugar is 692 ICUMSA

Table-5 Data on Sugar Color

| Mar 2011 | Mar 2013 | Mar 2014 | Mar 2015 | Jan- Feb 2016 |
|---|---|---|---|---|
| 415 | 545 | 542 | 664 | 692 |

Coloring problems is due to that it contains a variety of impurities in the Juice recovered from the extraction process. Especially chemical components of sugar-degraded do not crystallize. Also minerals absorbed from the soil are a major impurity.

When the treatment methods of the Extracted Juice in the next Clarification process, and further $SO_2$ treatment method in subsequent boiling process are not correct, the sugar product color is dark brown.

In the next clarification process it is technically treated by adding Lime ($CaO$) into the juice. It reacts with the metal ions and anions. The precipitates are separated by a filter after the addition of flocculants in the solution including the metal hydroxide and calcium-compound.

If the addition amount of the flocculants for the precipitate is small, it is not enough to become a big lump and leaks from the Filter.

The uncollected hydroxide can be seen like the cloud mixed in Syrup. Also if putting the excessive CaO into juice, its solution has too high alkaline. It leads to a lack of SO2 in the next acid treatment process ($SO_2$ addition), and it causes to have brown color.

Therefore, if these chemical processing is not correctly performed, the sugar product grades fall.

**2. The evaluation of color sugar:**

Customers such as manufacturing factories like soft drink, Beer factories, pharmaceuticals, etc. that use sugar as their input need sugar with a color below 450 ICUMSA and are willing to buy with a better price of 5,000 - 5,500 Birr. more per one ton than the high color. This increases the revenue of the company by 5,000 - 5,500 Birr. per ton.

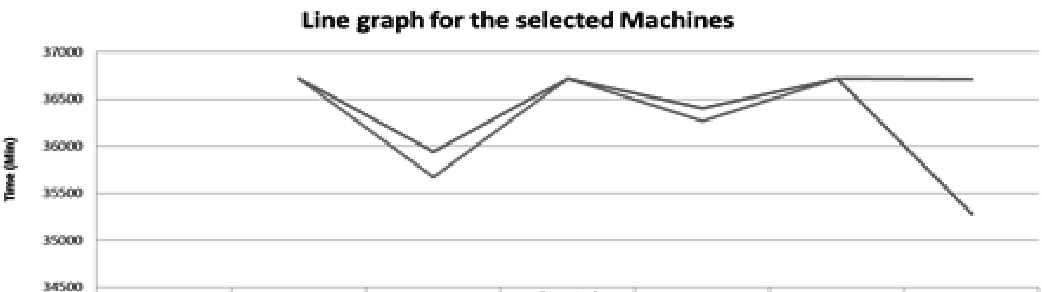
11,000 Birr. per ton for high color sugar.
16,000 Birr. per ton for low color (<450) sugar.

## C. Fiberize Machine and FRDT Breakdown in Preparation Plant

In A Factory the production often stops due to a failure of the machinery and equipment.

There is Fiberize Machine and FRDT equipment in sugar cane Preparation Plant which has the most failure frequency.

Graph -1




| | ExpectedNovmber | Actual Novmber | Expected December | ActualDecember | Expected January | Actual January |
|---|---|---|---|---|---|---|
| Fibrizer | 36720 | 35670 | 36720 | 36270 | 36720 | 36714 |
| FDRT | 36720 | 35940 | 36720 | 36405 | 36720 | 35280 |

❖ The figure shows the breakdown time in minutes for the month of November, December & January respectively.

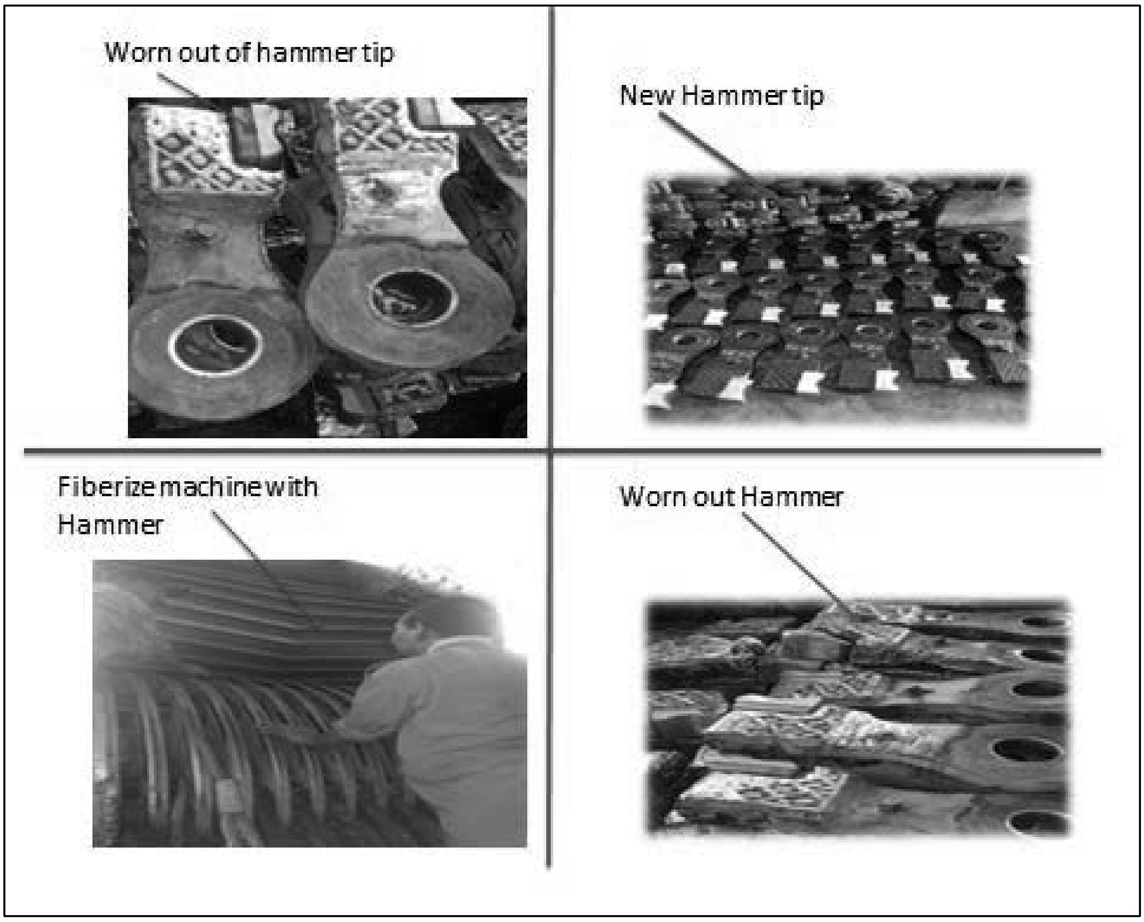



Photo-1

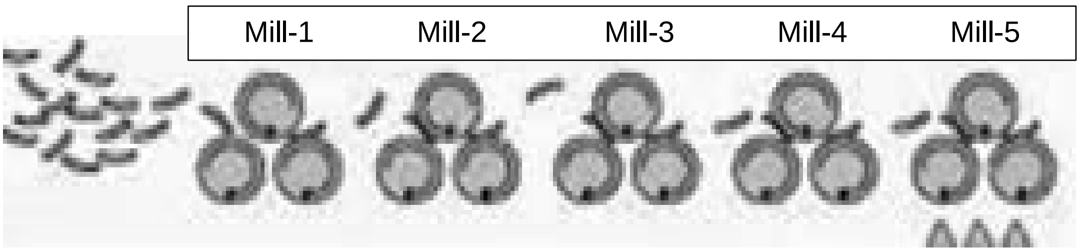
The sugar cane of raw materials has a mix of sand and stone that have been contaminated.

Since crushing the fiber of sugar cane by Fiberize Machine in the mechanical force, the problem has occurred.

The blade of Fiberize Machine is chipped also rounded by stones and metal pieces, and will not function.

**D. Mill Breakdown in Sugar Juice Extraction Plant**

In addition, in A Factory a few of five Mill Machines that make up the Sucrose Juice in the next extraction plant causes a failure in high frequency. Therefore it has been implemented as the by-pass working with the exception of the emergency to the failed Mill Machine.



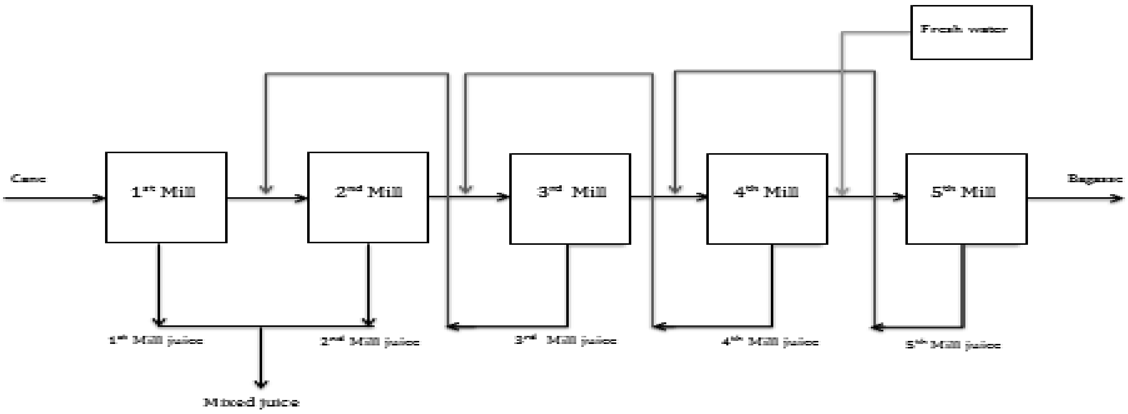
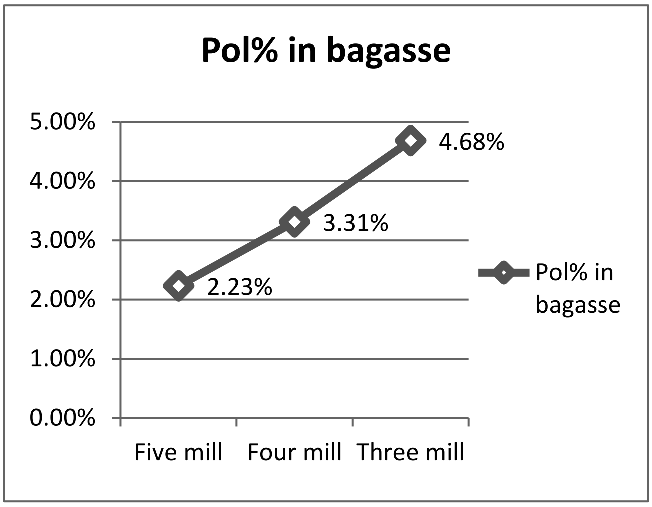



Figure-3

If any of Mill Machine fails, the Juice is collect with tentatively using the bypass of Juice recovery line, but it cannot be sufficient squeezing in that condition. As a result Sucrose with juice is remaining in Baggase and rid of. It will reduce the production of correspondingly sugar.

Right figure Graph-2 shows the percentage of Sucrose remaining in the Bagasse as the loss, compared to the cases, that is, the five of Mills running without any problem, and the case of three mills working with two failures and the case of four mills running with one failure.




Mill process is made to function to press the sugar cane in a mechanically strong force and squeeze out the Juice, and also move the sugar cane to the furnace.

Strong force by mills is efficient to extract the juice, but at the same time the machine is easily damaged. The conditions of moderate press and moving speed are determined.

<u>**Questions**</u>

**"Question-1"**

The Ethiopian government has strengthened the sugar industry in Ethiopia and has stated that it will not only rely on imports for domestic demand but also export it to the world for the future.

Factory A has been running a sugar factory since its early days and boasts decades of history. Please discuss and summarize how Company A should manage its business to meet government goals as a leading company in the sugar industry in Ethiopia.

(Answer)

Invest and increase sugar production facilities as planned as **a medium- to long-term Vision**. Even without importing sugar from abroad, it will be supplied by domestic production and exported to neighboring countries in the near future.

For example for **SWOT Analysis**;

Strength: ① Governmental Support ② Domestic Market ③ Has proper and vast sugarcane fields.

Weakness: ① Shortage of Governmental Budget ② Old manufacturing equipment and machinery ③ Low level of manufacturing technology and management technology.

Opportunity: ① Big African Market ② Africa is in the process of increasing population ③ Ethiopia becomes the center of industrialized nations in Africa.

Thread: ① Competitors of Kenya and South Africa ② Inexpensive sugar from South American countries and Southeast Asian countries Competitors flow in, etc. would be suggested.

Secondly, **the Business Policy** derived there from ① Increases the productivity of existing facilities. ② Improve the manufacturing process in comparison with the manufacturing technology and management technology of developed countries in Japan and Western Europe. ③ Investigate sugar consumption and plans for manufacturing plants in neighboring countries. ④ Analyze competitors in African, South American and Southeast Asian countries and so on.

**"Question-2"**

As a means to achieve a medium-to long-term vision proposed in the answer of Question-1, it seems that the following Business Policies are fairly important, that is, ① Increases the productivity of existing facilities. And ② Improve the manufacturing process in comparison with the manufacturing technology and management technology of developed countries in Japan and Western Europe. And it must be implemented first priority by Company A. Therefore, please propose each of the issues specifically to achieve the business policies of ① and ②. In addition, please explain the means to achieve those tasks concretely.

(Answer)

① Increase productivity of existing equipment.

Sugar's production facilities have an advantage of 1,000 ton per day, but the actual production situation has reached only 200 ton per day from 2015, October to 2016, June in recent years

This is mainly due to a decrease in the operation rate due to a power outage or failure of the Sugar Crusher & Roll Mill. First, carry out TPM activities to reduce the failure rate of Sugar Crusher & Roll Mill.

② Improve the manufacturing process in comparison with the manufacturing technology and management technology of developed countries in Japan and Western Europe.

The 10.26% of sugar escaping to Molasses is much higher than the global standard of 8.64%, thus it is important to find the optimal conditions in the sugar recycling process from Molasses liquor and increase sugar recovery.

## 2. TQM: Case Method (Shoe Maker)

I. Introduction

According to the Ethiopian economic situation survey report by the Japanese embassy in Ethiopia (March, 2008), the leather business in Ethiopia is positioned as one of the important fields in the government's economic policy. Among them, the shoe manufacturing industry is a typical business of increasing the added value of leather, and expectation for the future is great.

II. Case

The leather industry of Ethiopia has been around since a long time ago. It is now the number one in Africa and the world's largest number of livestock holdings, ranging from 7th to 9th. The export value of leather / leather products is fifth after coffee, oil seed, sight-seeing, chat (leaf with awakening effect) and plays an important role as a means of acquiring foreign currency.

Ethiopian leather trade is centered on exports of low value added 'tanned skin'. In order to effectively utilize abundant leather resources and obtain more foreign currency, the Ethiopian government is advancing a policy of shifting the center of gravity of exports from leather skin to leather goods.

Also, although leather shoe exports have only just begun ten years ago, their exports are growing steadily, and it is expected that the impact on the Ethiopian economy will be great in the future. Also, as the leather shoemaking factories that are increasing in the future are labor-intensive industries, they will create jobs for many skilled and unskilled workers and will have a major impact on poverty reduction.

However, despite being endowed with livestock like this, 2.5 million cattle hides (6.6% of livestock), 8.5 million sheepskins (31.7% same), and 7 million goat peels 32%) are only produced (see Table 1). Compared with the number of livestock, the amount of tanned skin production is overwhelmingly small, and it can be said that there is still room for resource utilization.

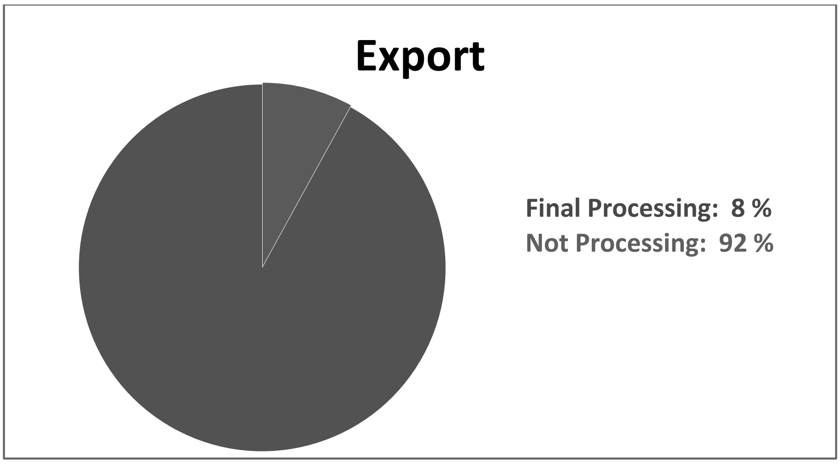
Table-1

| Raw Material | Population (Thousand Heads) | Rank of Livestock No in the world | Share in Total Population (%) | Raw Leather Production (Million Pieces) | Off-take Ratio (%) |
|---|---|---|---|---|---|
| Cattle | 40,877 | 7 th | 45.5 % | 2.7 | 6.6 % |
| Sheep | 25,497 | 9 th | 28.3 % | 8.1 | 31.7 % |
| Goat | 23,413 | 8 th | 26.0 % | 7.5 | 32.0 % |
| Source | MOTI, A Strategic Action Plan for the Development of the Ethiopian Leather and Leather Products Industry, vol. 1 March | | | | |

**Policy by Ethiopian Government**

In Ethiopia's national five-year development plan PASDEP, the leather and leather products industry is cited as a priority field of promotion of export industries. PASDEP aims to make the amount of leather shoes, which is 6.4 million pairs / day in 2005/06, about three times 20 million pairs in 2009/10 and the export value to 178 million dollars.

There are 22 leather tanning factories in Ethiopia, but there are only six factories with final treatment technology, the exported amount of finished processed leather trees with high added value is less than 10% of the total amount of leather tanned exports. (See Fig. 1)




Source: MOTI, A Strategic Action Plan for the Development of the Ethiopian Leather and Leather Products Industry, vol. 1 March

Fig.-1

High value-added leather shoes are listed as major export items as part of the top-down strategy advocated by the leather industry development plan. However, according to MOTI statistics, leather shoes are not exported until 2003, and in 2005/06 it is also 1.6 million dollars, accounting for only 2% of leather goods exports. (See Fig. 2)

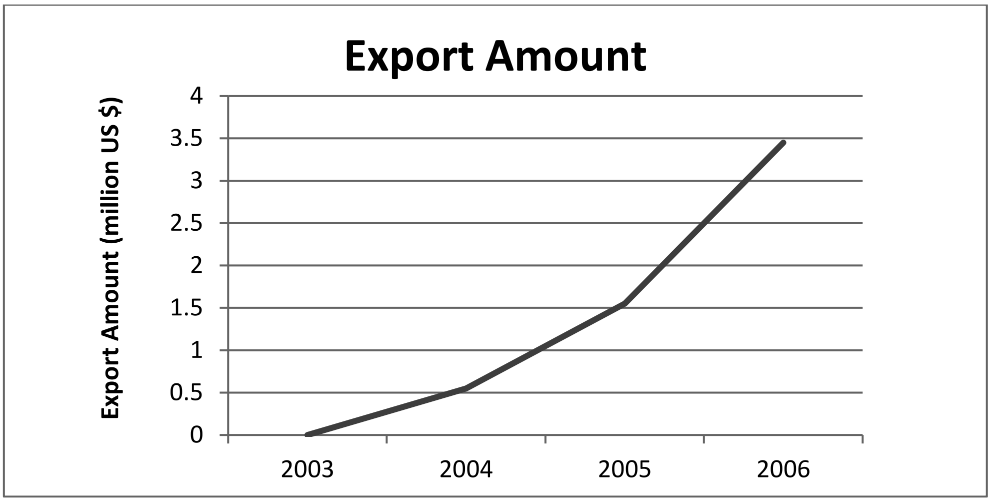



Fig.-2

Currently, Ethiopia has 12 mechanized leather shoemaking factories, but only a few are exporting factories. Also, throughout Ethiopia, leather shoes of 7,000 to 8,000 pairs / day can now be produced, but considering that China produces 3,000 - 4,000 pairs / day at one factory, production is insufficient. Furthermore, since Ethiopian leather shoes have been mainly focused on the domestic market, it is essential to develop products, develop markets, and strengthen productivity for export.

Specific target values (see Table 2) are listed in the Leather Industry Development Plan to improve this situation and increase the export volume of leather shoes.

Table-2 Leather shoes export target amount

| | 2005/06 | 2006/07 | 2007/08 | 2008/09 | 2009/10 |
|---|---|---|---|---|---|
| Leather shoes export target value | 4 | 16 | 50 | 95 | 177 |
| Source | MOTI, Strategic Action Plan for Development of the Ethiopian Leather And Leather Products Industry, vol. II March 2005 | | | | |

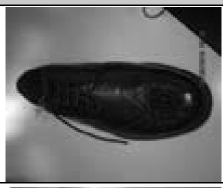
It is aimed to increase exports that had been zero from 2003 to 4 million dollars in 2005/06 and to 177 million dollars, which is more than four times stronger in 2009/10 in the next five years.

This is the summary of the report on the leather industry of the Japanese Embassy in Ethiopia.

In the background of this kind of leather shoemaker A company, the EKI team will instruct improvement activities.

Here, we introduce the model of representative leather shoes currently mass-produced in Table-3.

Table-3 Model Leather Shoe

| No. | Models | Pictures | Cutting | Stitching | Lasting |
|---|---|---|---|---|---|
| 1 | Simple (Simon 1605) |  | 815 | 721 | 101 |
| 2 | Moderate (Bades 6201) |  | 1,712 | 474 | 441 |
| 3 | Complicated (Revol 7201) |  | 90 | 103 | 117 |

Company A has a policy of exporting exports from 40% to 60% in line with PASDEP 's export industry promotion which is the Ethiopian government' s five - year development plan.

However, in order to achieve export expansion, it have various problems and problems at the moment.

First of all, many quality defects appear. Therefore, we examined data on defective products recorded from September 2014 to November 2015. The defective rate (including B - Grade) for the whole was about 2.5%.

Table-4 Defect Rate (2014 Sept ~ 2015 Nov, 12 months)

| | Total production | Good finished | B-Grade | Reject |
|---|---|---|---|---|
| 2014 Sept | 15,648 | 13,851 | 1,745 | 52 |
| Oct | 7,192 | 7,046 | 123 | 23 |
| Nov | 18,572 | 18,530 | 33 | 9 |
| Dec | 26,437 | 26,236 | 130 | 71 |
| 2015 Jan | 24,553 | 24,216 | 311 | 26 |
| Feb | 24,553 | 23,463 | 1,028 | 62 |
| Mar | 24,553 | 23,463 | 1,028 | 62 |
| July | 21,842 | 21,354 | 459 | 28 |
| Aug | 27,287 | 27,014 | 217 | 56 |
| Sep | 14,324 | 14,202 | 109 | 13 |
| Oct | 14,263 | 14,031 | 216 | 16 |
| Nov | 15,328 | 15,083 | 238 | 7 |
| Total | 244,553 | 238,491 | 5,637 | 425 |
| Defect Rate | | (Grade B + Reject)<br>= 6062/244553<br>=2.48% | | |

Grade B is not a defective item, but it can only be handed down to the domestic market at a cheap price.

Next, an example of a defective article is introduced in the photograph below.

| | |
|---|---|
| **1**<br>**Leather Defect** |   |
| **2**<br>**Variation** |  |

Photo-1 Poor leather (top) and bad color (bottom)

| | |
|---|---|
| **Leather Stretch** |   |
| **Back Part Problem Centering** |  |
| **Uneven Stitching** |  |

Photo-2 Inferior elongation (upper) and rear defect (middle) and uneven lamination (lower)

Meanwhile, the machinery of the manufacturing factory frequently fails. Used in the Stitching section About 23 machines collected failure data for 4 months at the end of 2015.

For machines with particularly high failure frequencies, the frequency is summarized in Fig. 3 by a bar graph.

✓ Have 23 machines in this section but Focused on Four critical machines.

In Stitching Section

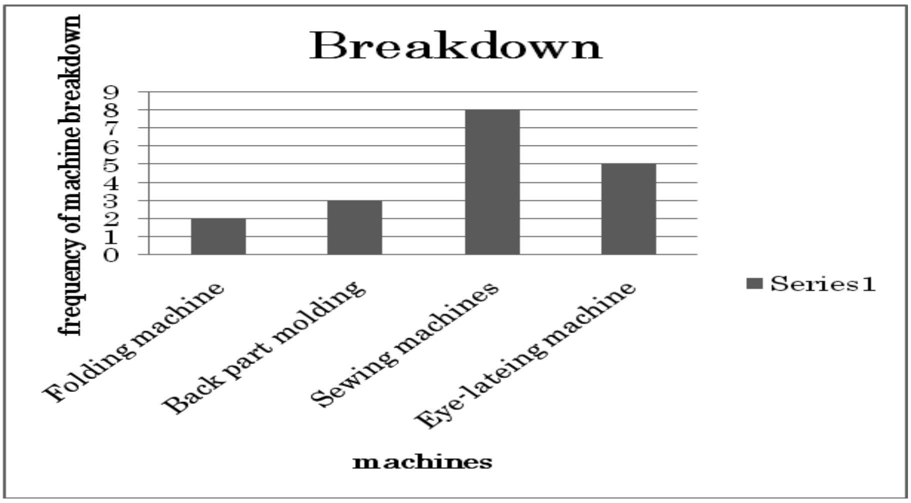



Fig.-3 Stitching section

| No. | Machine Name | Machine Picture |
|---|---|---|
| 1 | Double needle Machine |  |
| 2 | Flat bed (Typical) Machine |  |
| 3 | Binding (cylindrical) sewing machine |  |

Photo-3 Machine with the most breakdown frequency in Stitching Process

Similarly, the machine used in the Lasting section is also shown in Fig-4.

✓ Have 4 machines in this section but we Focused on one critical machine. Depend on TPM team experience and frequency of break down data

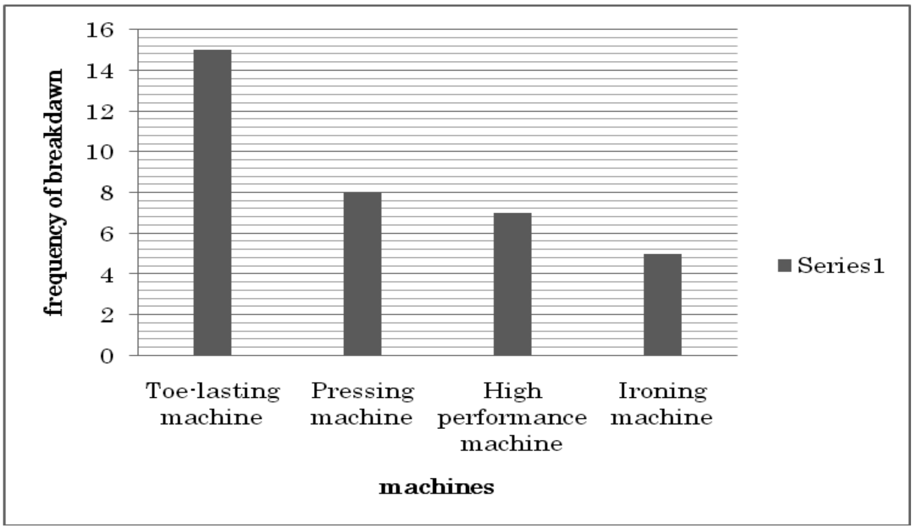



Fig-4 Lasting section

| | | |
|---|---|---|
| **1** | Toe lasting machine |  |

Photo-4 Machine with the most breakdown frequency in Lasting Process

This factory is roughly divided into a section to cut raw material leather, a section to assemble the raw material WIP and Lasting & Finishing to mold the semi-processed WIP.

There are four Processing in the first Cutting Section, and the working time per pair in each process is shown in Fig.-5

**Bar Graph on the cutting process**

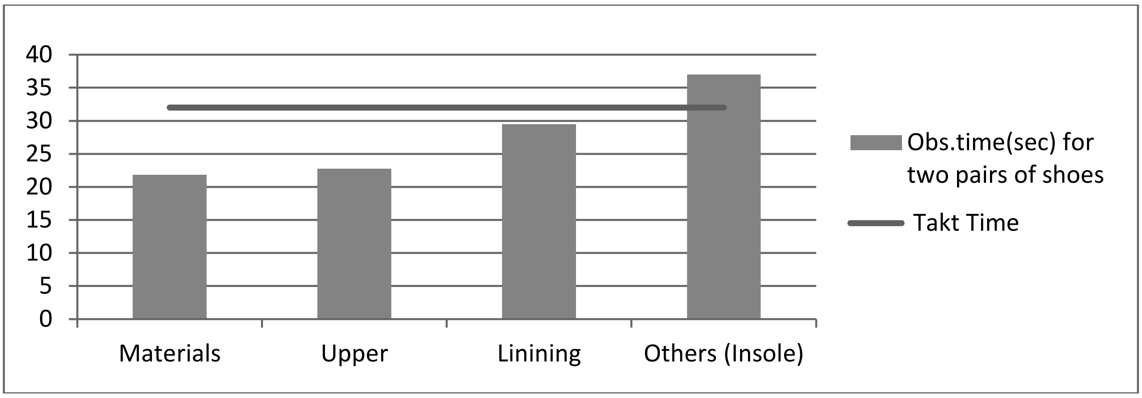



Fig.-5

From the above, upper, lining & material are under the longest time.

So, we will focus on Insole.

On the other hand, regarding the production of SIMON 1605, the operation time of each step in the next STITCHING section is shown in FIG-6.

Although each work time is shown by a bar graph, several red colored strips exceed the average time greatly and are what is called a so-called bottle neck. Incidentally, the LINE BALANCE of this process is calculated as 51.2%.

## SIMON 1605 PROCESS IN STITCHING

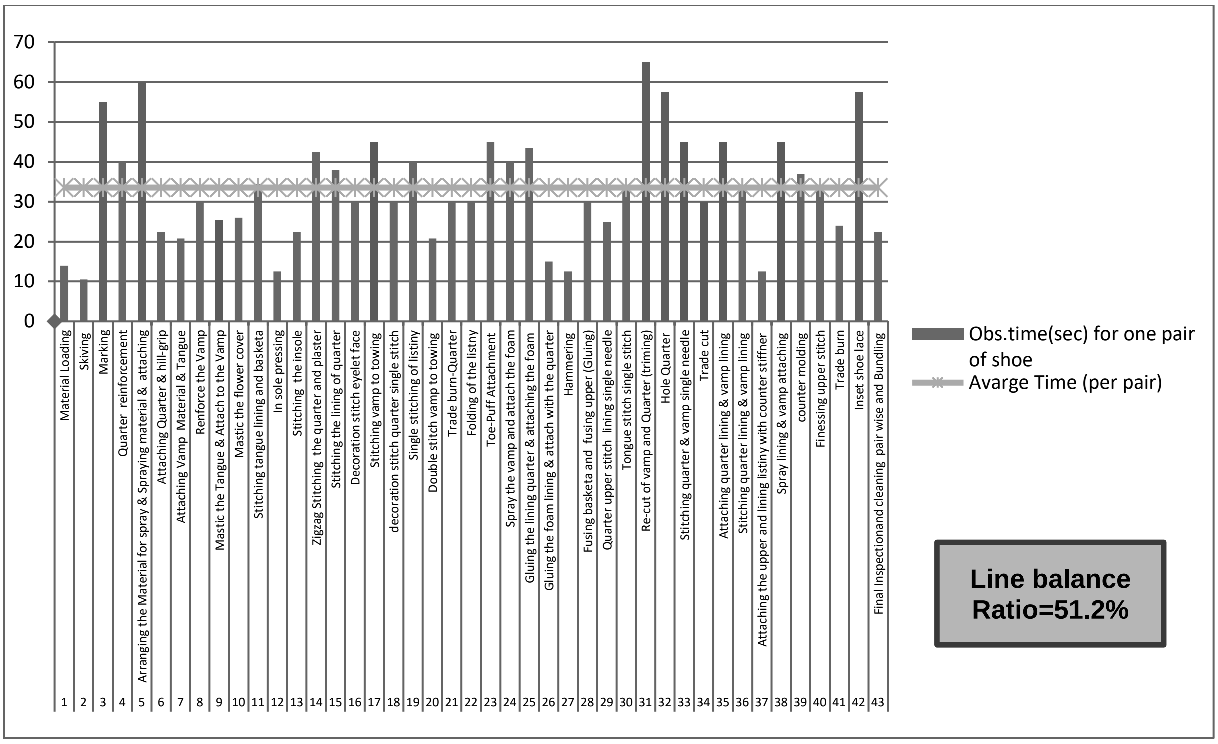



Fig.-6

Similarly regarding the manufacture of SIMON 1605, the working time of each step in the subsequent LASTING section is shown in Fig. 7. Incidentally, the LINE BALANCE of this process is calculated as 64.9%.

## SIMON 1605 PROCESS IN LASTING

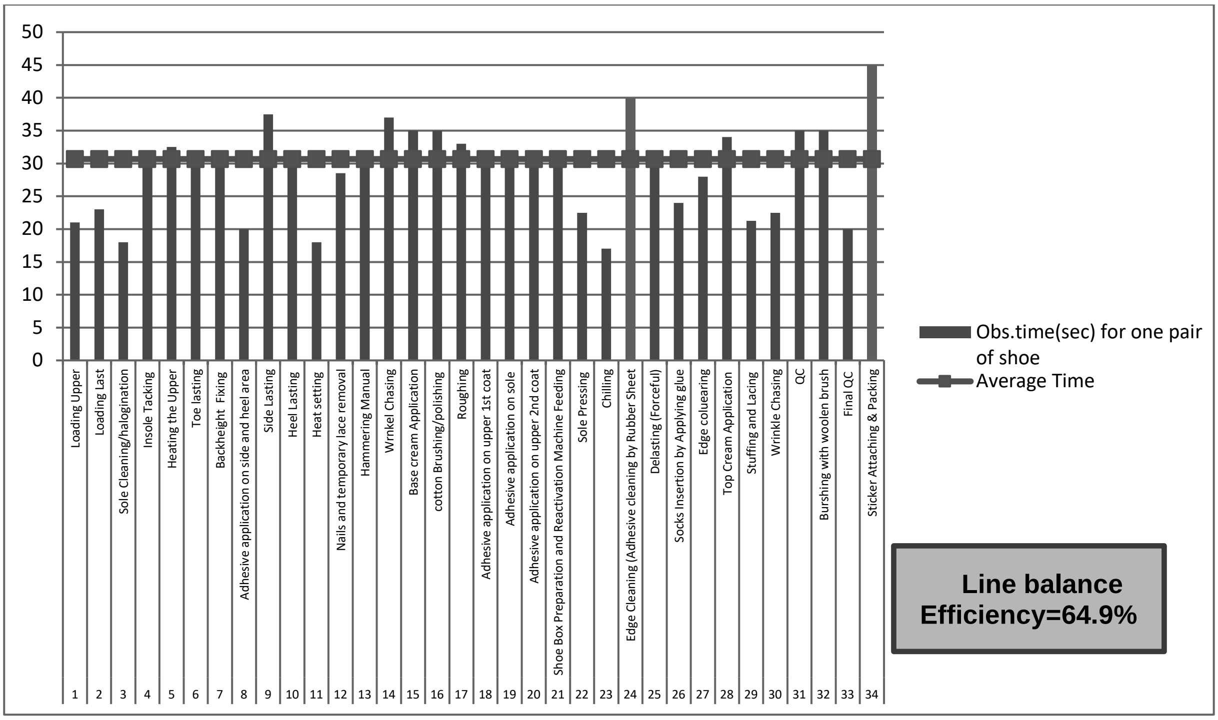



Fig-7

On the other hand, we will examine how the working time for BADES 6201 type is.

The operation time of each step of the STITCHING section is shown in Fig-8. LINE BALANCE is 46.8%, which is slightly bad.

**BADES 6201 PROCESS IN STITCHING**

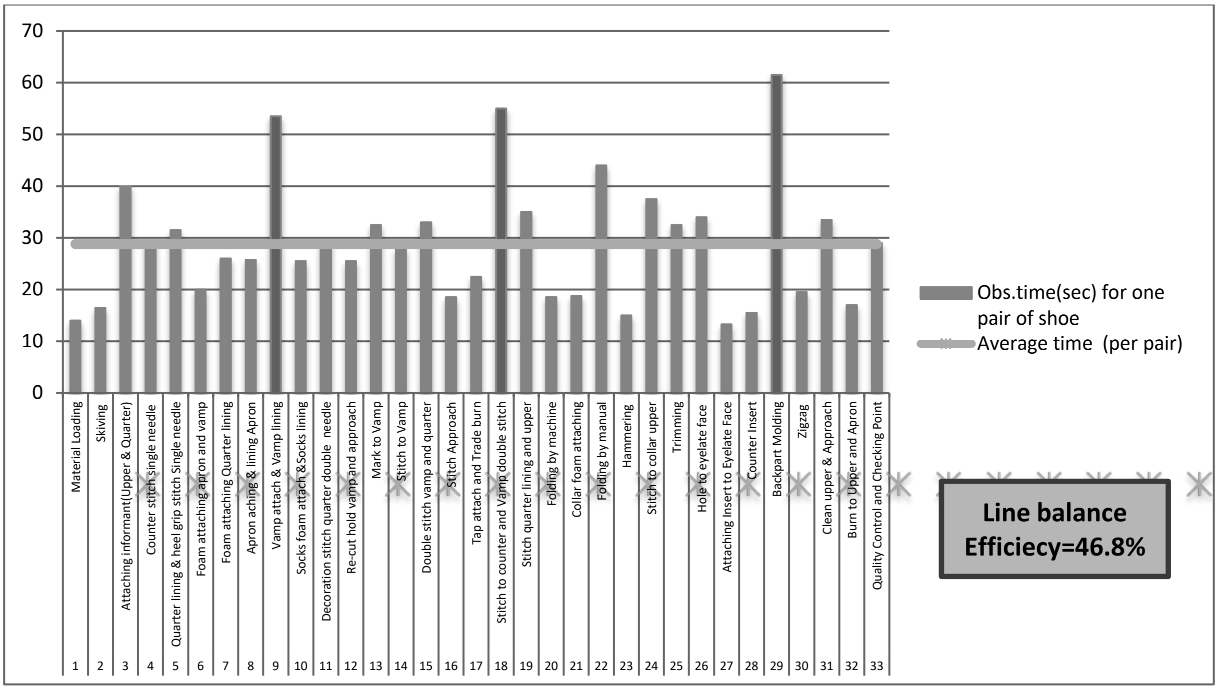



Fig.-8

**BADES 6201 PROCESS IN LASTING**

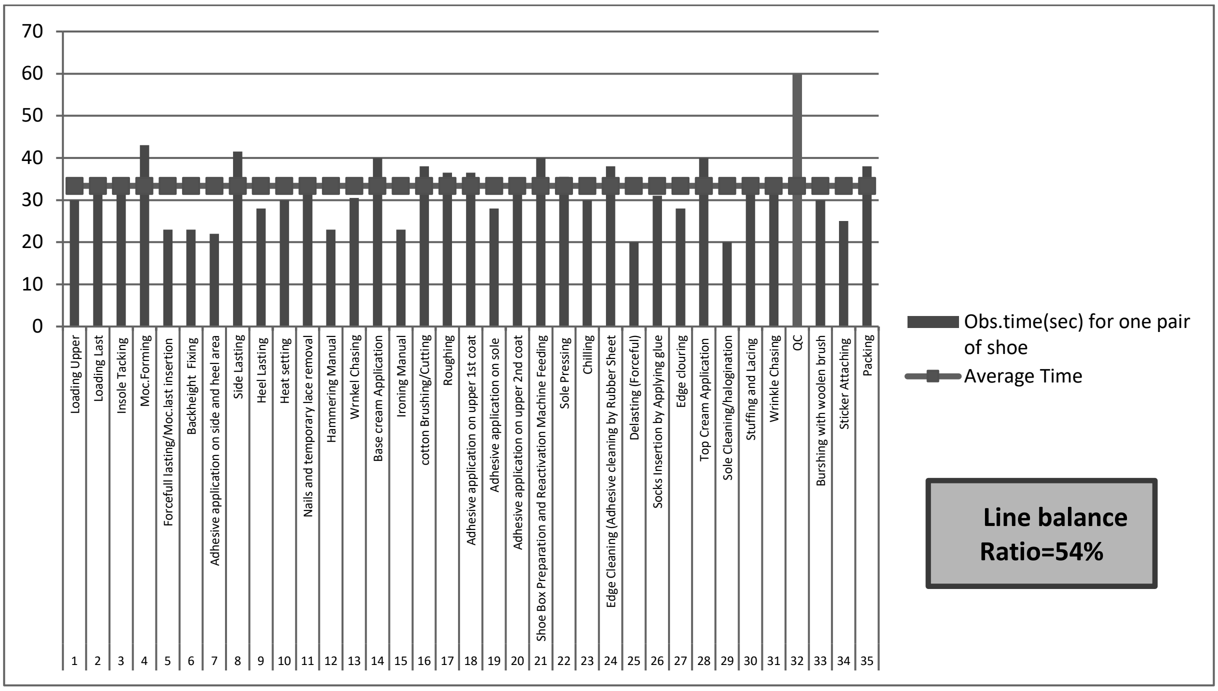



Fig.-9

As above, except for the Cutting section, the average value of work time in each section is distributed in about 30 seconds. In other words, we did not need to investigate bottleneck countermeasures for the Cutting section, and we only had to consider countermeasures only with a bottle neck in the Stitching and Lasting section.

When planning measures, I would like to respond by way of extreme capital investment and not introducing human resources. Also, I would like to propose some steps on how to deal with that.

## Problems of Decision Making

[Question 1]

What is the strategy of the Ethiopian government for the leather goods, please summarize the expectations and the position of the shoe manufacturing industry in the future.

(Answer)

It is recommended that the Ethiopian government's strategy is to increase the value added to leather shoes and bags in light of the domestic situation in which more than 90% of the leather industry is currently exported as raw materials, and to promote exports. I am aiming for. To do so, we will make use of high-quality leather raw materials, build brands in the design and functionality of leather products, increase competitiveness in the international market, and expand sales channels.

It will also make use of the abundant human resources of Ethiopians to enable mass production and reduce costs.

It also aims to provide Ethiopia with the opportunity to promote significant employment.

[Question 2]

Company A as a manufacturer of leather shoes must formulate a medium- to long-term vision and immediate business policy as a company in response to government policies and roll out its management policies to subordinate organizations and divisions. Please consider and propose the desired method concretely.

(Answer)

In light of the government's five-year policy, Company A has stated in its vision that its share of leather footwear exports will increase from the current 40% to 60%. In order to achieve that vision, it is necessary to reduce costs first, so improving productivity was made the top priority business policy.

On the other hand, the departments and divisions of the subordinate organizations that received the management policy set the theme of improving the line balance in the stitching line and reducing defective products in cooperation with the quality control section in the manufacturing department. Its Target value increases Line Balance improvement from about 50% to 65%. In terms of reducing defective products, it is set to reduce the reject and B-Grade by about 2.5% in half. In the equipment section, the theme is to prevent failure of mechanical equipment by TPM, and the frequency of failure is reduced by half.

# Case study

## Improve productivity in a garment company

**An example of Intermediate KAIZEN approach in a Garment company is provided.**

**Please discuss and exercise on the main steps of this case**

1


2

# Background

- Oromia Garment is a manufacturer of Men's shirt, Men's trousers.
- One of the company policy is to increase the sales amount by 5% by the fiscal year of 2019.
- The production Dept. deployed the company policy and set Dept. policy as increasing the production volume by 5%
- consultant was requested to organize KPT (CFT) and realize that policy.

3

# 1. Theme selection

- According to interview to the manager, analysis of existing data and study at Genba, the consultant decided to focus on some product

- Consultant organized CFT and ask them to gather more data

or Asked key person Basic data

4

# Example of data gathered

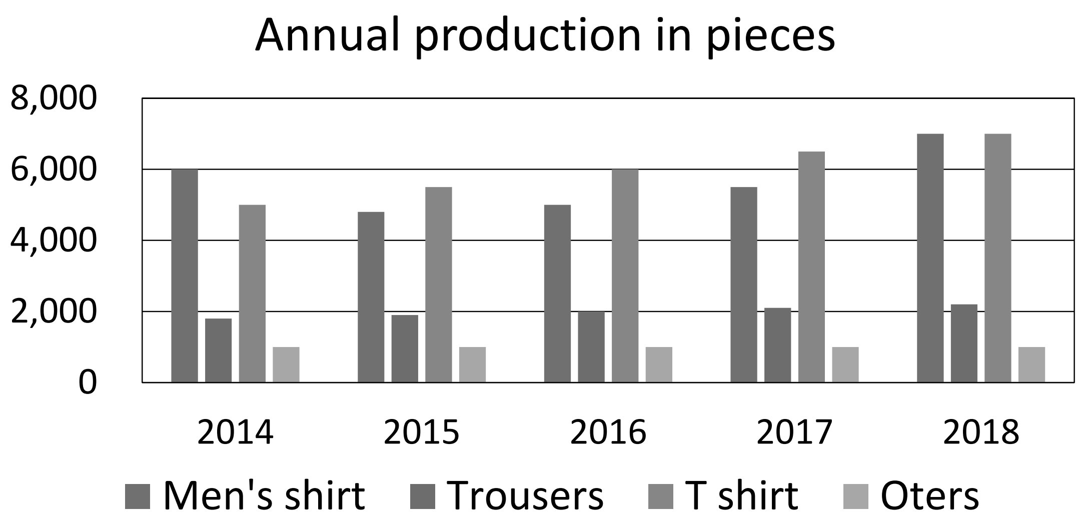
## Production volume in the past and the plan

The yellow ae the actual result, 2017 and 2018 are the plan

| | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| Men's shirt | 6,000 | 4,800 | 5,000 | 5,500 | 7,000 |
| Trousers | 1,800 | 1,900 | 2,000 | 2,100 | 2,200 |
| T shirt | 5,000 | 5,500 | 6,000 | 6,500 | 7,000 |
| Oters | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |

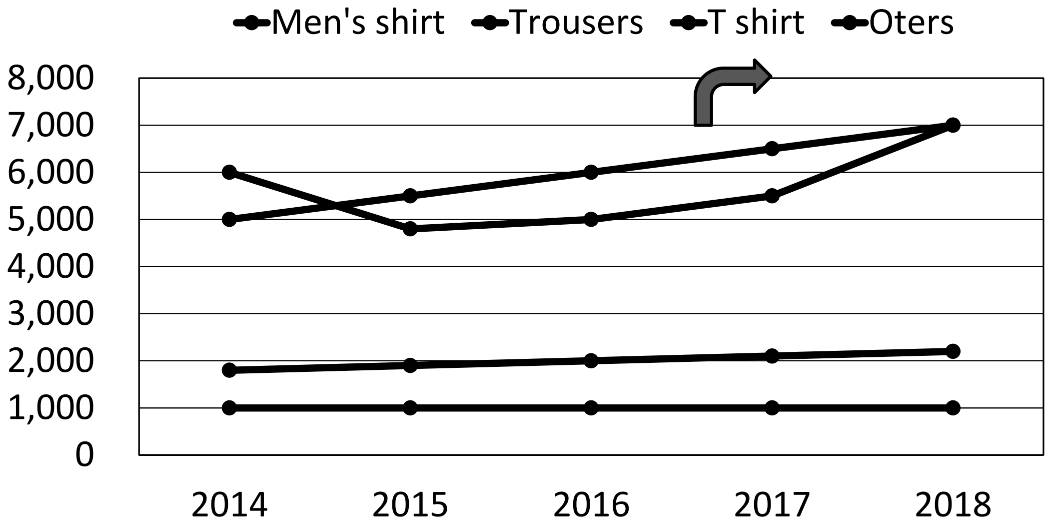
5

# ---cont.



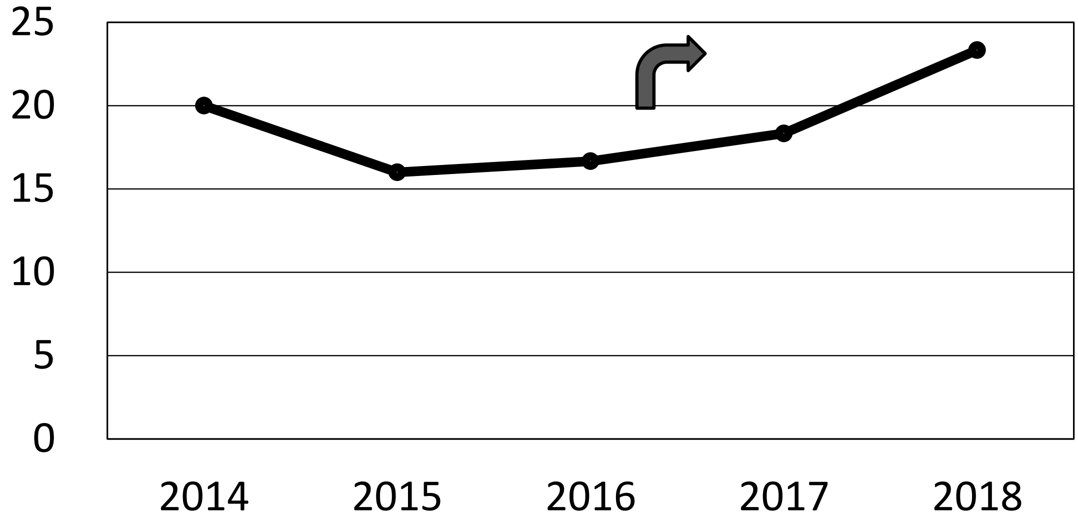

6

# ---cont.




7

# Productivity (Pieces per day) Men's shirt




8

**After discussion in CFT and with top management the main theme area was decided as " Increase the productivity of Men's shirts"**

Discussion 1

Why consultant and CFT selected this Theme

9

## 2. Select type of KAIZEN story

- **There are two types of Kaizen story. One is Problem solving and the other is Task achievement**
- **In this case, consultant selected Problem solving approach.**

Discussion 2

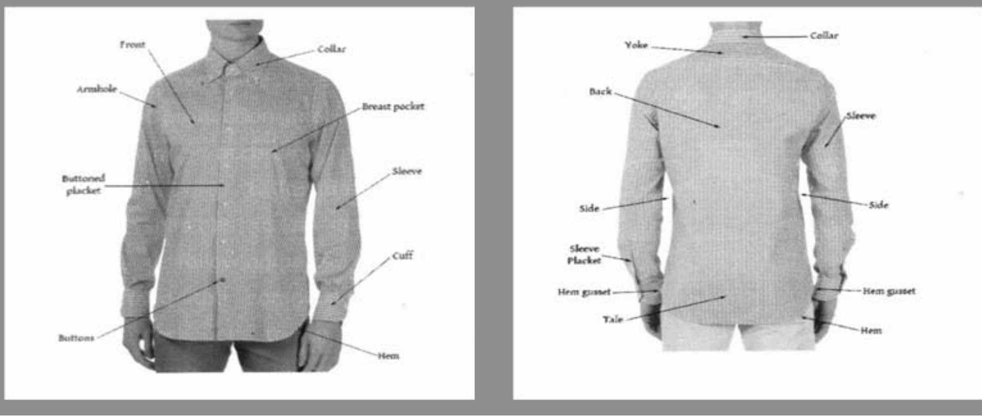
Why consultant and CFT selected the Problem solving approach

10

# 3. Comprehend current situation and target setting

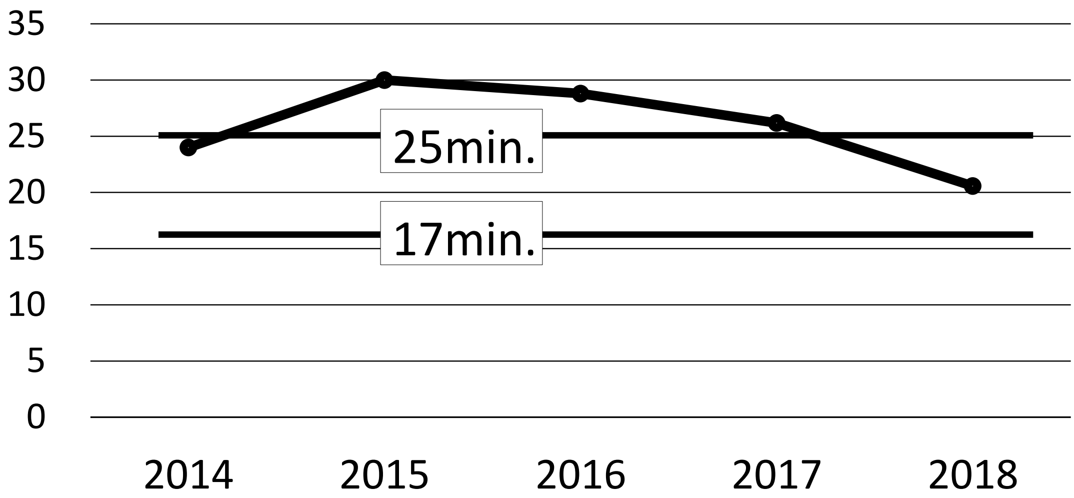
- Knowledge about the product (Inherent technology) was obtained through internet

**Parts name of Men's shirt (From Internet)**




11

# SAM in the company and standard



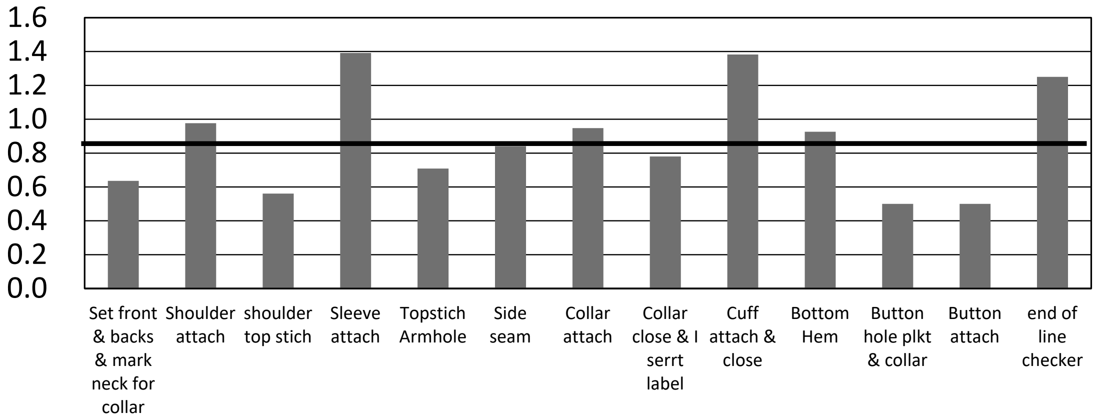

12

# Time study by Video camera


Take video
at GEMBA

13

# Line Balance

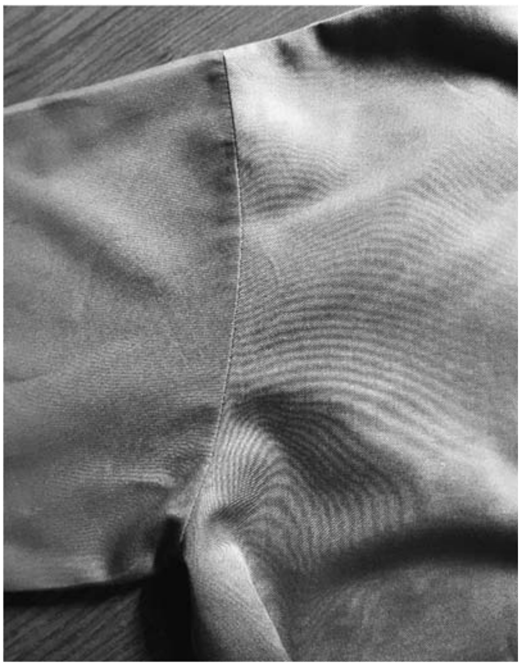



14

## Sewing line overview

15

## Sleeve attachment (Outside)



16

## Sleeve attachment (Inside)

17

# 4. Cause analysis

**From the Line balancing chart, we find the "Sleeve attach" takes the longest time**

Discussion 3

Discuss the possible cause why it takes so  long for sleeve attach
Make cause and effect diagram

18

# 5. Planning of Countermeasure

- "Think deeply" is essential
- There are some IE tools which help find solutions
  (1) 5W 1H
  (2) ECRS

Discussion 4

Analyze the root cause and try to find countermeasures using IE tools

19

# Reference Answer

**The purpose of Case study is to think deep by discussion.**
**So there could be different conclusion and answer.**
**The followings are for reference**

20

Sample answer 1

The production volume of men's shirts is the highest in this factory .

The productivity of men's shirts has dropped in the last few years.

So, improvement of the men’s shirt productivity is highly required

21

Sample answer 2

The productivity of men's shirts has dropped comparing to 3 years ago.

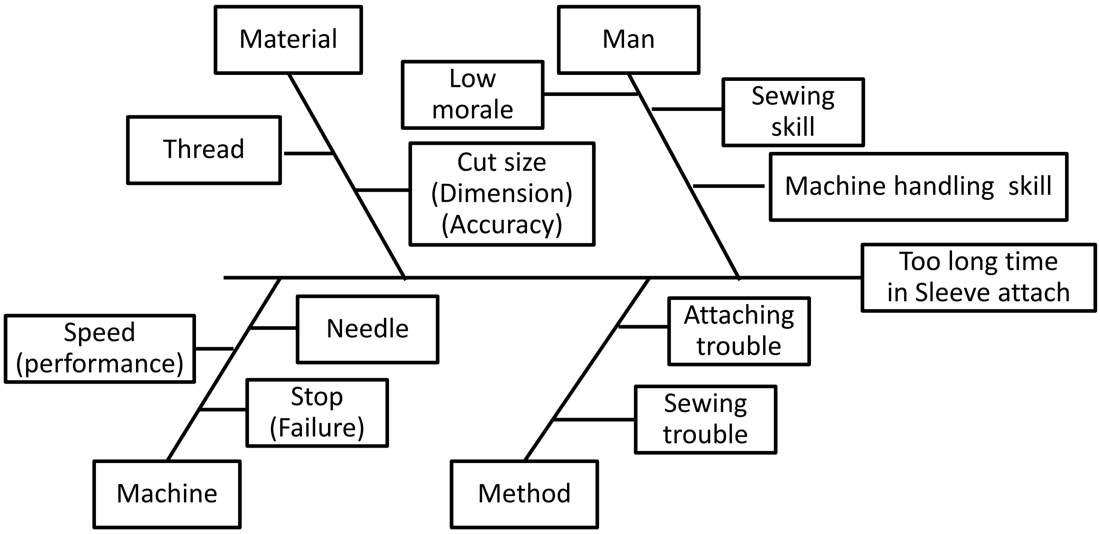
So, the task of CFT is finding the causes why the productivity has dropped and propose countermeasure.

This type of activity is called Problem solving approach.

22

Sample answer 3

# Example of Cause & effect diagram




23

Sample answer 4-1

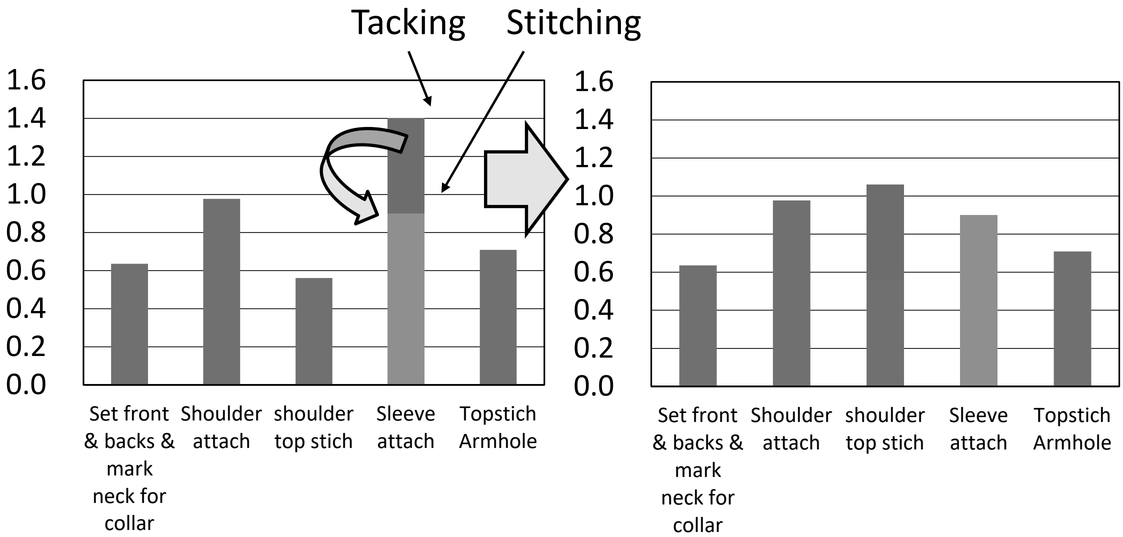
# 5 whys

1. “Why it takes too long time in Sleeve attach”?
   => The sewing speed is low
2. “Why sewing speed is low
   => The sewing skill is low
3. “Why the sewing skill is low?”
   => The training si not done sufficiently.
4. “Why is the training is not done sufficiently”?
   => There no SOP.
5. “Why is there no SOP?”
   => Because no one is aware what is the important step

24

Sample answer 4-2

## Move some element to other




**Tact time improve : 1.4s →1.1s (21% improve)**

25

# Case study

## Improve productivity in an Electric device manufacturer

**A consultant was given a task and after working with CFT, he proposed a success scenario (slide 17)**

**Please discuss and exercise on the main steps of this case**

1

# Background

- **Addis Electric is a manufacturer of Electric devices such as control panel.**
- **One of the company policy is to increase the sales amount by 20% by the fiscal year of 2019.**
- **The production Dept. deployed the company policy and set Dept. policy as increasing the production volume (pieces / month) by 20% by the middle of 2018.**
- **Consultant was requested at the end of 2017 to organize KPT (CFT) and achieve that policy (Business objectives).**

2

# 1. Theme selection

- **According to interview with the manager, analysis of data and study at Genba, the consultant focused on the production of the electric device " K"**

**Device "K"**

- **Consultant organized CFT and ask them gather data**

3

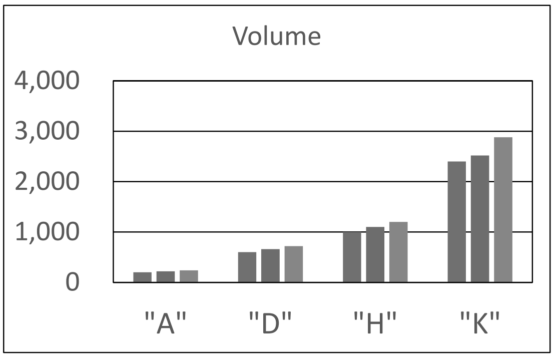
# Gathered data

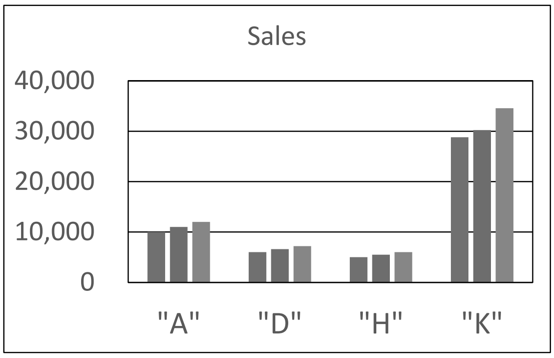
Sales in volume

| | 17 | 18 | 19 |
|---|---|---|---|
| "A" | 200 | 220 | 240 |
| "D" | 600 | 660 | 720 |
| "H" | 1,000 | 1,100 | 1,200 |
| "K" | 2,400 | 2,520 | 2,880 |

Sales in thousand Birr

| | 17 | 18 | 19 |
|---|---|---|---|
| "A" | 10,000 | 11,000 | 12,000 |
| "D" | 6,000 | 6,600 | 7,200 |
| "H" | 5,000 | 5,500 | 6,000 |
| "K" | 28,800 | 30,240 | 34,560 |




4

## Gathered data

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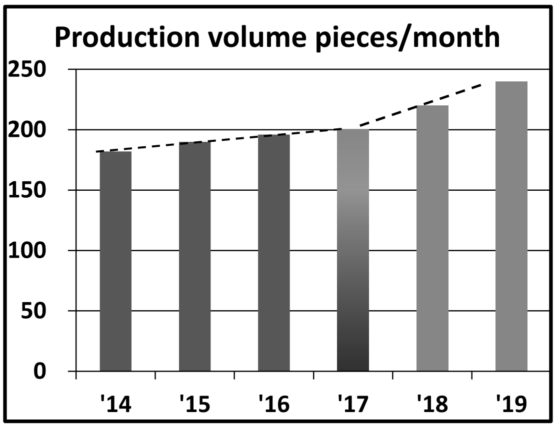
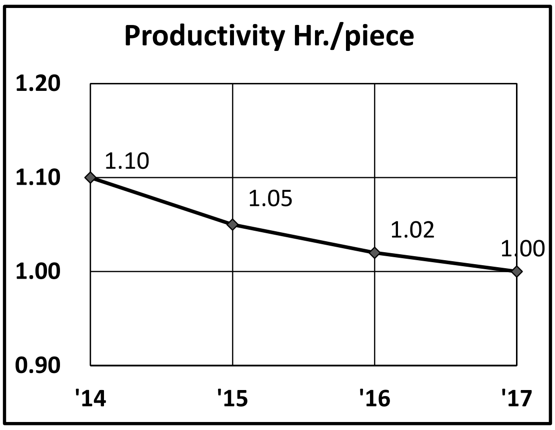



5

**After discussion in CFT and with top management the main theme area was decided as " Increase the productivity of "K" by 20%**

Discussion 1

Why consultant and CFT selected this Theme

Fill the evaluation sheet in the next slide

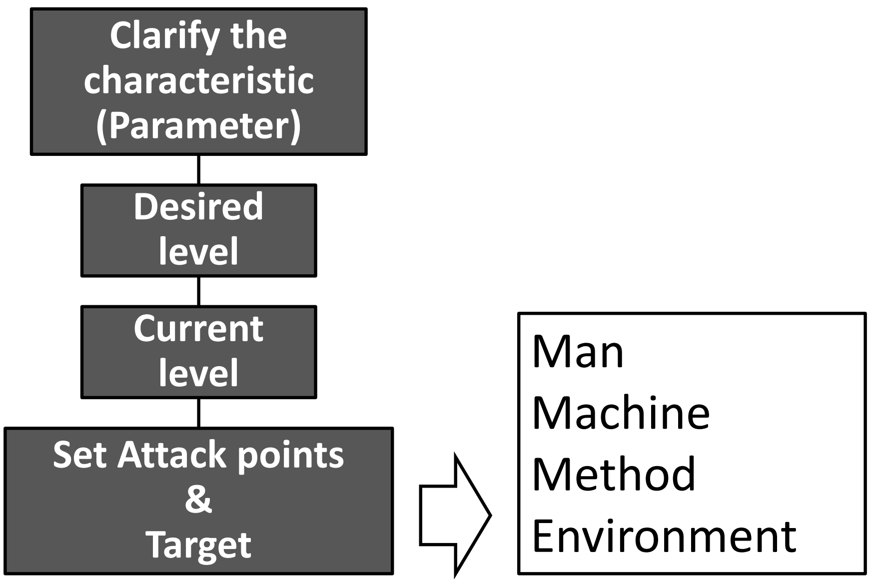
6

# Evaluation sheet of theme

| Evaluation items / Problems and tasks | Necessity | | | | KPT Capability | | | |
|---|---|---|---|---|---|---|---|---|
| | Importance | Urgency | Feasible for tackling | Upper Policy | Is the timing right? | Is the work possible to cope with ourselves? | Overall evaluation | Priority to table |
| Improve productivity ”A” | | | | | | | | |
| Improve productivity “K” | | | | | | | | |
| Improve productivity “H” | | | | | | | | |

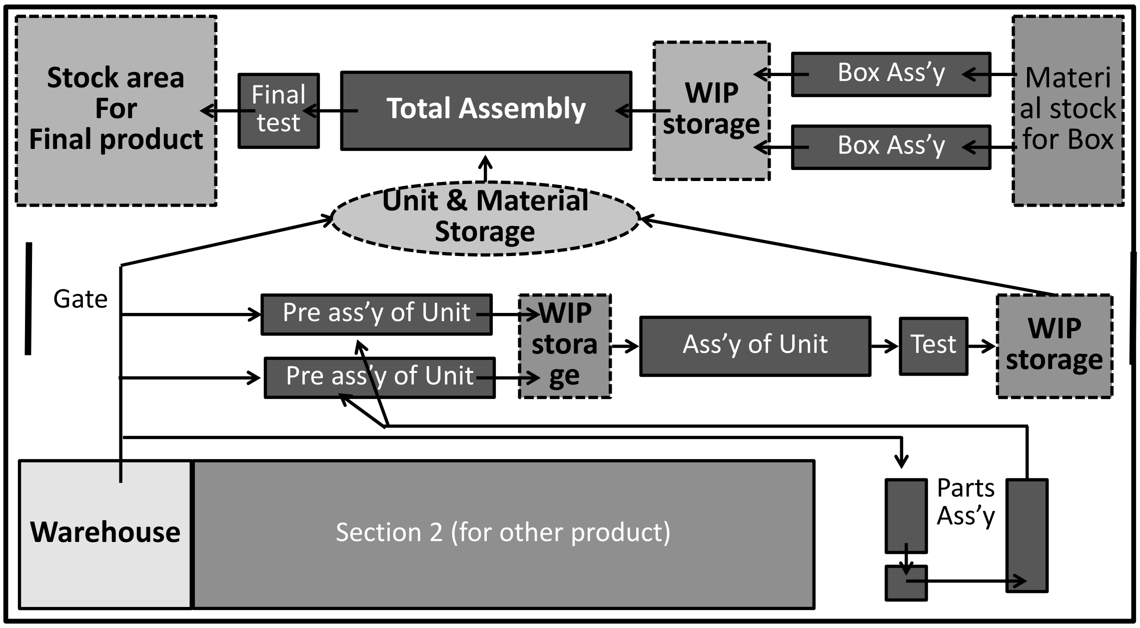
7

# 2. Clarification of attack points & Target setting




8

# Layout of the plant and flow diagram




9

# Attack points selection sheet

| Characteristic | | Desired level | Current level | Gap | Attack points | Effect | Obstacle | Adopt |
|---|---|---|---|---|---|---|---|---|
| Parameter | Product time | 0.8 Hr/piece | 1.0 Hr/piece | 0.2Hr/piece | | | | |
| Method | Man | Keep | 14 | No | Precondition | - | - | - |
| | Machine | No break down | down time: 5Hr. /Month. | No big gap | - | - | - | - |
| | | Good operation ability | No problem | No | - | - | - | - |
| | Method | No Muda | Complicated layout Long moving distance | 50m | Reduce moving distance | 0.1Hr | cost | ○ |
| | | | Waiting time : average 0.2Hr/Hr/operator | 0.1Hr | Reduce staying time of WIP and parts | 0.1Hr | | ○ |
| | Environment | Sorted and Set work space | Many storage area for WIP | 50 sqm | - | - | - | - |
| | | Safe | Narrow aisle, High shelf | Unsafe | Wide aisle | - | | - |

10

## --- cont.

| | | |
|---|---|---|
| Clarify the characteristic (Parameter) | No. of Piece/month | What |
| Desired level | 200piece | Gap |
| Current level | 240 piece | |
| Set Attack points & Target | Increase the monthly production of the product K by 20% by Aug. 2018 By Muda elimination | How & When |

11

# 3. Scenario Drafting (Planning of Measures)

- **List up potential measures for each attack point**
- **Start from the most effective expected attack point**
- **Use Brain storming method, Matrix table, Tree diagram (But never stick to use tools)**
- **Refer to practices of other companies**
- **Innovative idea is recommended**

12

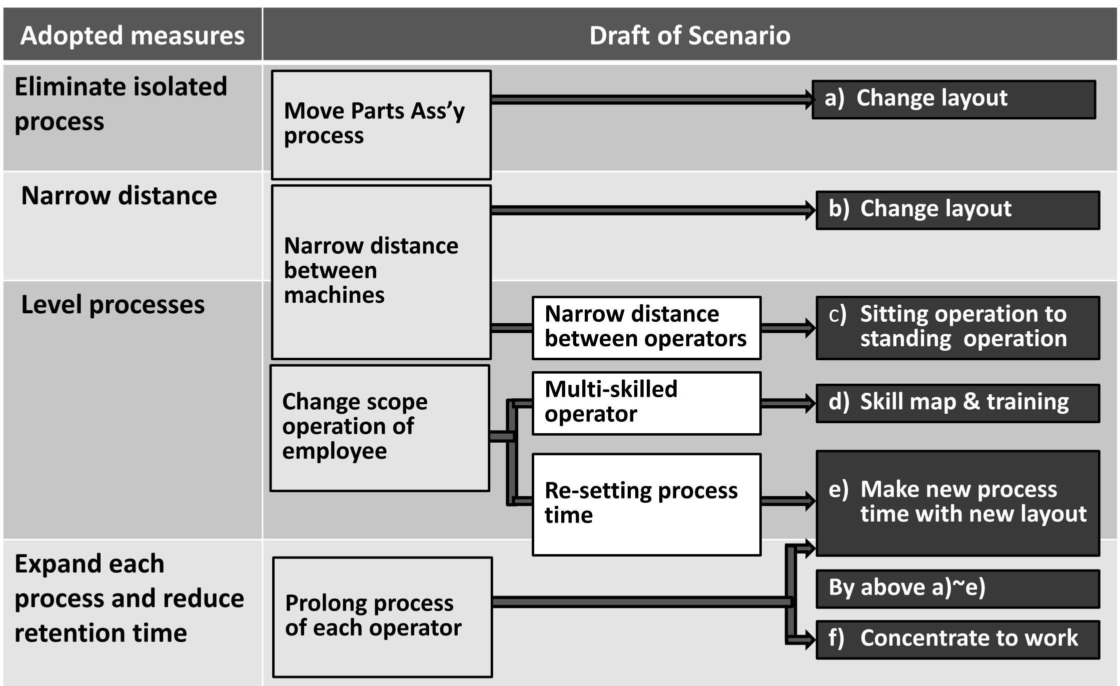
Discussion 2

# Scenario drafting

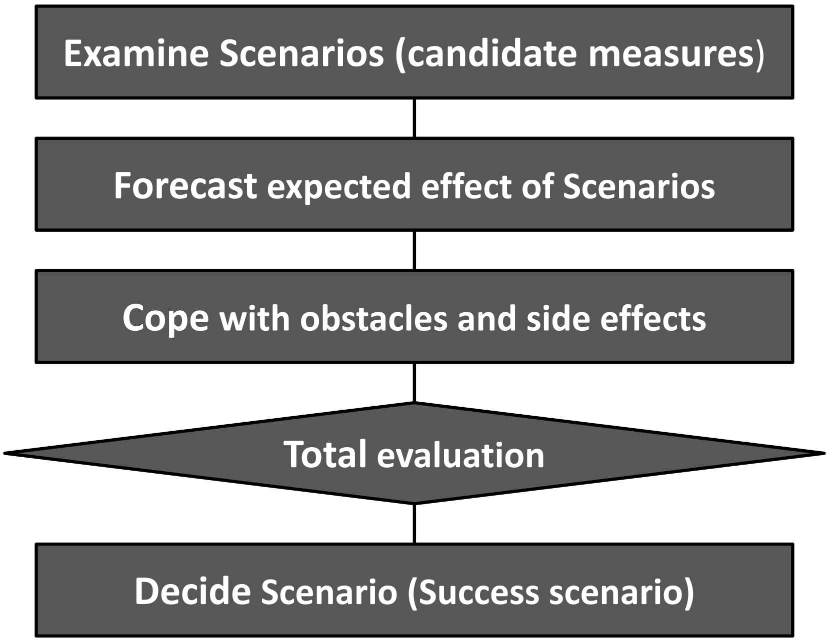
| Attack Points | Measures candidates | Expected effects | Evaluation point | Rank |
|---|---|---|---|---|
| Reduce moving distance | 1) Eliminate isolated process | 0.05Hr./piece | | |
| | 2) | 0.05Hr./piece | | |
| | 3) Implement AGV | 0.05Hr./piece | | |
| Reduce Staying time of WIP and parts | 1) Level the processes | 0.03Hr./piece | | |
| | 2) | 0.02Hr./piece | | |
| Reduce waiting time | 1) Improve Bottle neck | 0.05Hr./piece | | |
| | 2) Level the processes | (Included in above) | | |

Fill the blank





# 4. Pursuit of Success Scenario




15

Discussion 3

Fill the blank

## Pursuit of Scenario
## – Check Obstacle and secondary effect -

| Candidate Scenario | Obstacle<br>Secondary effect | Counter measure | Decision |
|---|---|---|---|
| a) Change layout | | Convince management by EE | Go |
| b) Sitting operation to standing operation | Physical Fatigue | | Go |
| c) Skill map & training | New process time with new layout | | Go |
| d) New process time with new layout | Mindset of operator | | Go |
| e) Concentrate to work process | Need operator for parts supply | Assign one operator | Go |

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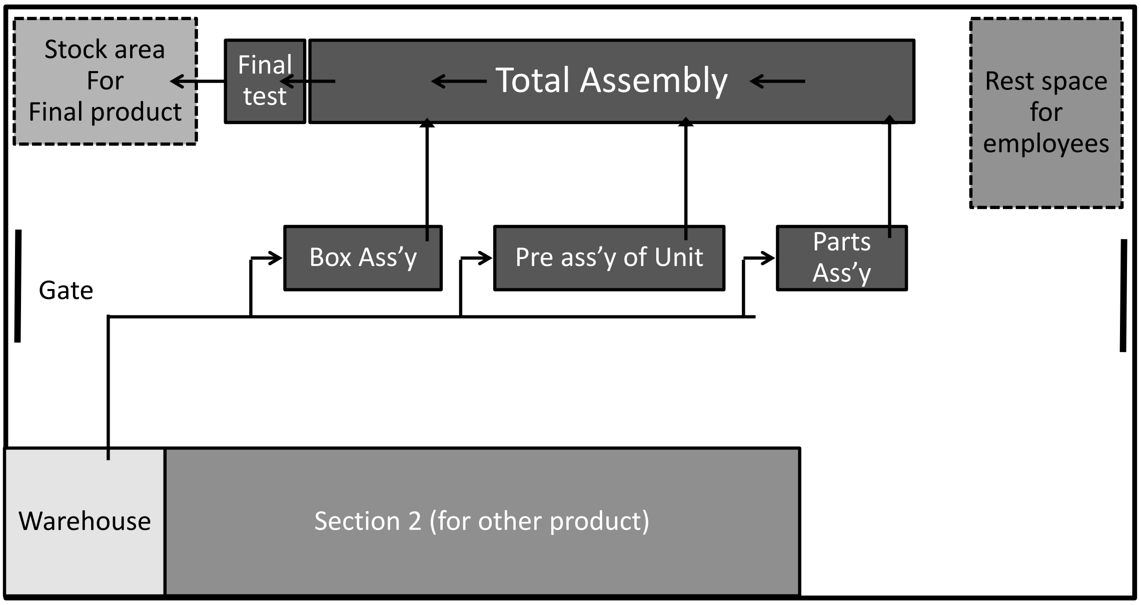
## Success Scenario (Rough idea of new layout)




17

# Reference Answer

**The purpose of Case study is to think deep by discussion.**
**So there could be different conclusion and answer.**
**The followings are for reference**

18

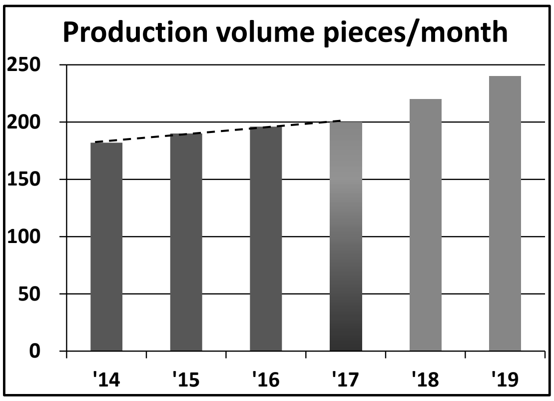
## Sample answer 1

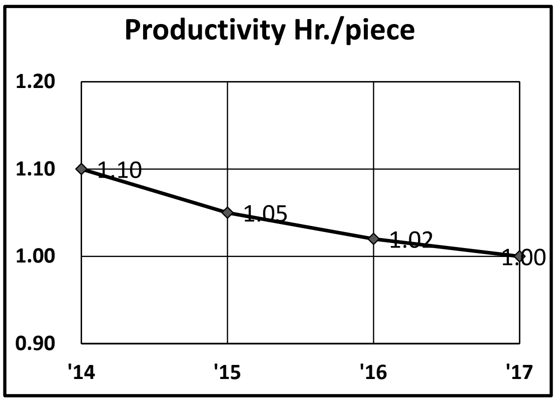
From the graph, we can see that this company has increased productivity every year till 2017.

The task is to increase the productivity more for year 18 and 19 to achieve the target production volume.

To do so, some drastic change is necessary.

For such case, Task achievement approach is most appropriate.




19

# Evaluation sheet of theme

| Evaluation items / Problems and tasks | Necessity | | | | KPT Capability | | Overall evaluation | Priority to table |
|---|---|---|---|---|---|---|---|---|
| | Importance | Urgency | Feasible for tackling | Upper Policy | Is the timing right? | Is the work possible to cope with ourselves? | | |
| Improve productivity ”A” | 2 | 3 | 1 | 5 | 4 | 5 | 20 | 3 rd |
| Improve productivity “K” | 5 | 5 | 3 | 5 | 5 | 4 | 27 | 1 st |
| Improve productivity “H” | 4 | 5 | 3 | 5 | 3 | 5 | 25 | 2 nd |

20

Sample answer 2

## Scenario drafting

| Attack Points | Measures candidates | Expected effects | Evaluation point | Rank |
|---|---|---|---|---|
| Reduce moving distance | 1) Eliminate isolated process | 0.05Hr./piece | 5 | 1 |
| | 2) Narrow distance | 0.05Hr./piece | 5 | 1 |
| | 3) Implement AGV | 0.05Hr./piece | 1 | - |
| Reduce Staying time of WIP and parts | 1) Level the processes | 0.03Hr./piece | 4 | 2 |
| | 2) Expand range of one process | 0.02Hr./piece | 4 | 2 |
| Reduce waiting time | 1) Improve Bottle neck | 0.05Hr./piece | 5 | 1 |
| | 2) Level the processes | (Included in above) | 4 | 2 |

21

Sample answer 3

## Pursuit of Scenario – Check Obstacle and secondary effect -

| Candidate Scenario | Obstacle Secondary effect | Counter measure | Decision |
|---|---|---|---|
| a) Change layout | Stop operation Budget | Convince management by EE | Go |
| b) Sitting operation to standing operation | Physical Fatigue | Adjust height of work table | Go |
| c) Skill map & training | New process time with new layout | Make SOP | Go |
| d) New process time with new layout | Mindset of operator | Meeting and award | Go |
| e) Concentrate to work process | Need operator for parts supply | Assign one operator | Go |

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## 5. TPS & Production Planning: Case Method (Bicycle)

### The Techniques of Flow

So, how do you make value flow? The first step, once value is defined and the entire value stream is identified, is to focus on the actual object, the specific design, the specific order, and the product itself (a "cure," a trip, a house, a bicycle) and never let it out of sight from beginning to completion. The second step, which makes the first step possible, is to ignore the traditional boundaries of jobs, careers, functions (often organized into departments), and firms to form a lean enterprise removing all impediments to the continuous flow of the specific product or product family. The third step is to rethink specific work practices and tools to eliminate backflows, scrap, and stoppages of all sorts so that the design, order, and production of the specific product can proceed continuously.

In fact, these three steps must be taken together. Most managers imagine that the requirements of efficiency dictate that designs, orders, and products go "through the system" and that good management consists of avoiding variances in the performance of the complex system handling a wide variety of products. The real need is to get rid of the system and start over, on a new basis. To make this approach clear and specific, let's take as a concrete example the design, ordering, and production of a bicycle.

### From Batch to Flow in Bicycles

We've chosen this example partly because the bicycle itself is simple and lacks glamour. You will not be distracted by novel product designs or exotic technologies. We've also chosen it because we happen to know something about the bicycle industry, one of us having resolved to test the methods we describe in this book by taking an ownership position in a real bicycle company. Finally, we have chosen bicycle manufacture because it is a deeply disintegrated industry, with most final-assembler firms making only the frame while buying the components, wheels, brakes, gears, seats, handle- bars, plus raw materials in the form of frame tubing, from a long list of supplier companies, many larger than the final assemblers themselves. The problems of value stream integration are present in abundance.

**DESIGN**

Product design in the bicycle industry was historically a classic batch-and- queue affair in which the marketing department determined a "need," the product engineers then designed a product to serve the need, the prototype department built a prototype to test the design, the tooling department designed tools to make a high-volume version of the approved prototype, and the production engineering group in the manufacturing department figured out how to use the tools to fabricate the frame and then assemble the component parts into a completed bike. Meanwhile, the purchasing department, once the design was finalized, arranged to buy the necessary component parts for delivery to the assembly hall.

A design for a new product, usually only one of many under development at a given time, moved from department to department, waiting in the queue in each department. Frequently it went back for rework to a previous department or was secretly reengineered at a point downstream to deal with incompatibilities between the perspectives of, say, the tool designers and the product designers who handled the design in the previous step. There was no flow.

In the late 1980s and early 1990s, most firms switched to “heavyweight” program management with a strong team leader and a few dedicated team members, but without changing the rest of the system. The product “team” was really just a committee with a staff that sent the great bulk of the actual development work back to the departments, where it still waited. in queues. What’s more, there was no effective methodology for carrying designs through the system without lots of rework and backflows. Even worse, no one was really responsible for the final results of development efforts because the accounting and reward systems never linked the success of a product through its production life with the original efforts of the design team. There was, therefore, a bias toward ingenious designs with admirable technical features which customers liked but which failed to return a profit due to excess costs and launch delays.

The lean approach is to create truly dedicated product teams with all the skills needed to conduct value specification, general design, detailed engineering, purchasing, tooling, and production planning in one room in a short period of time using a proved team decision-making methodology commonly called Quality Function Deployment (QFD).[2] This method permits development teams to *standardize work* so that a team follows the same approach every time. Because every team in a firm also follows. this approach, it’s possible to accurately measure throughput time and to continually improve the design methodology itself.

With a truly dedicated team in place, rigorously using QFD to correctly specify value and then eliminate rework and backflows, the design never stops moving forward until it’s fully in production. The result, as we will demonstrate in the examples in Part II, is to reduce development time by more than half and the amount of effort needed by more than half while getting a much higher “hit rate” of products which actually speak to the needs of customers.

In our experience, dedicated product teams do not need to be nearly as large as traditional managers would predict, and the smaller they can be kept the better all around. A host of narrowly skilled specialists are not needed because most marketing, engineering, purchasing, and production professionals actually have much broader skills than they have (1) ever realized, (2) ever admitted, or (3) ever been allowed to use. When a small team is given the mandate to “just do it,” we always find that the professionals suddenly discover that each can successfully cover a much broader scope of tasks than they have ever been allowed to previously. They do the job well and they enjoy it.

Moving most of the employees formerly in marketing, engineering, and production groups into dedicated teams for specific products does create problems for the functional needs of each firm along the value stream, a point we ·will address in Part III. Similarly, the need to include employees of key component and material supply firms as dedicated members of the product team raises difficult questions of where one firm stops and the next begins, the second major topic of Part Ill.

**ORDER -TAKING**

The historic practice in the bicycle industry has been to task the Sales Department with obtaining orders from retailers. In the United States, these range from the giant mass-marketers like Wal-Mart at one extreme.to thousands of tiny independent bicycle shops at the other. When the orders are fully processed to make sure that they are internally consistent and that the buyer is credit-worthy, they are sent to the Scheduling Department in Operations or Manufacturing to work into the complex production algorithm for a firm's many products. A shipment date is then set for communication back to Sales and on to the customer.

To check on the progress of orders, particularly in the event of late, delivery, the customer calls Sales, which then calls Scheduling. When orders are really late and important customers threaten to cancel, Sales and Scheduling undertake some form of expediting by going directly into the physical production system in both the assembler firm and the supply base to move-laggard orders forward. This is done by jumping them to the head of each queue in physical production.

Under the influence of the reengineering movement in the early 1990s, a number of firms integrated Sales and Scheduling into a single department so that the orders themselves can be processed much more quickly-often by one person tied in to the firm's electronic information management system so that orders never need to be handed off, placed in waiting lines, or put down. (They now flow.) As a result, orders can be scheduled for production in a few minutes rather than the days or even weeks previously required; at the same time, order information can be transmitted electronically to suppliers. Similarly, expediting procedures are tightened up to eliminate the confusion which often arose between Sales and Scheduling.

These innovations certainly helped, but a fully implemented lean approach can go much further. In the lean enterprise, Sales and Production Scheduling are core members of the product team, in a position to plan the sales campaign as the product design is being developed and to sell with a clear eye to the capabilities of the production system so that both orders and the product can flow smoothly from sale to delivery. And because there are no stoppages in the production system and products are built to order, with only a few hours elapsed between the first operation on raw materials and shipment of the finished item, orders can be sought and accepted with a clear and precise knowledge of the system's capabilities. *There is no expediting.*

A key technique in implementing this approach is the concept of *takt* time, which precisely synchronizes the rate of production to the rate of sales to customers. For example, for a bicycle firm's high-end titanium- framed bike, let's assume that customers are placing orders at the rate of forty-eight per day. Le t's also assume that the bike factory works a single eight-hour shift. Dividing the number of bikes by the available hours of production tells the production time per bicycle, the *takt* time, which is ten minutes. (Sixty minutes in an hour divided by demand of six bikes per hour.)

Obviously, the aggregate volume of orders may increase or decrease over time and *takt* time will need

Question.1

In the lean enterprise, the production slots created by the *takt* time calculation-perhaps ten per hour for high-end bicycles (for a *takt* time of six minutes) and one per minute for low-end models (for a *takt* time of sixty seconds)-are clearly posted. This can be done with a simple whiteboard in the product team area at the final assembler but will probably also involve electronic displays (often called *andon* boards) in the assembler firm and electronic transmission for display in supplier and customer facilities as well. Complete display, so everyone can see where production stands at every moment, is an excellent example of another critical lean technique, *transparency* or *visual control*. Transparency facilitates consistently producing to *takt* time and alerts the whole team immediately to the need either for additional orders or to think of ways to remove waste if *takt* time needs to be reduced to accommodate an increase in orders.

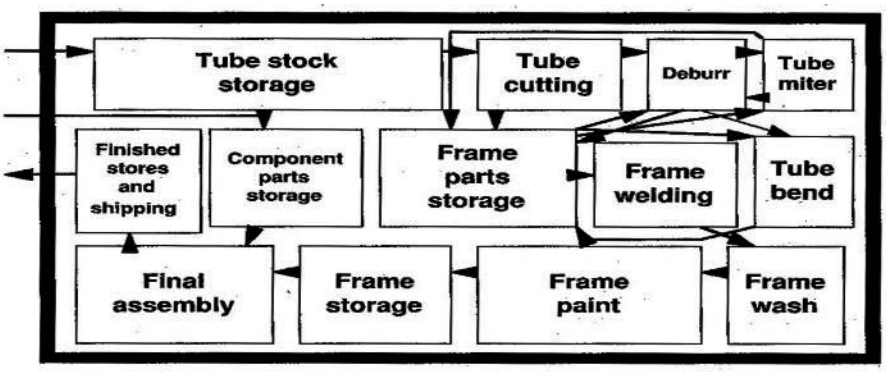
Raising awareness of the tight connection between sales and production also helps guard against one of the great evils of traditional selling and order-taking systems, namely the resort to bonus systems to motivate a sales force working with no real knowledge of or concern about the capabilities of the production system. These methods produce periodic surges in orders at the end of each bonus period (even though underlying demand hasn't changed) and an occasional "order of the century" drummed up by a bonus- hungry sales staff, which the production system can't possibly accommodate. Both lead to late deliveries and bad will from the customer. In other words, they magically generate muda.

**PRODUCTION**

The historic practice in the bicycle industry was to differentiate production activities by type and to create departments for each type of activity: tube cutting, tube bending, mitering, welding, washing and painting for the frame and handle bars, and final assembly of the complete bike. Over time, higher-speed machines with higher levels of automation were developed for tasks ranging from cutting and bending to welding and painting. Assembly lines were also installed to assemble a mix of high-volume models in dedicated assembly halls.

All bike makers produced a wide range of models using the same production equipment, and part fabrication tools typically ran at much higher speeds (expressed as pieces per minute) than the final assembly line. Because changing over part fabrication tools to make a different part was typically quite time-consuming, it made sense to make large batches of each part before changing over to run the next part. The typical final assembly plant layout and materials flow looked as shown in Figure-1.

**FIGURE-1: BICYCLE PLANT LAYOUT AND FLOW**




As batches of parts were created; an obvious problem arose how to keep track of the inventory and make sure that the right parts were sent to the right operation at the right time. In the early days of the bicycle industry- an activity dating back to the 1880s and a key precursor to the auto industry

-scheduling was handled by means of a master schedule and daily hand- written orders to each department to make the parts final assembly would need.

After nearly a hundred years, these manual scheduling methods were replaced in the 1970s by computerized Material Requirements Planning systems, or MRPs. A good MRP system was at least 99 percent accurate in keeping track of inventory, ordering materials, and sending instructions to each department on what to make next. As a group, these systems were a clear improvement on older manual systems for controlling batch-and- queue operations and became progressively more complex over time. Eventually capacity planning tools" were added to evaluate the capacity of machines at every step in the production process and to guard against the emergence of bottlenecks and capacity constraints.

MRP, however, had a number of problems. If even one part was not properly logged into the system as it proceeded from one production stage to the next, errors began to accumulate that played havoc with the reorder "triggers" telling a department when to switch over to the next type of part. *As* a result, downstream manufacturing operations often had too many parts (the *muda* of overproduction) or too few parts to meet the production schedule (producing the *muda* of waiting).

A worse problem was that total lead times in batch-and-queue systems were usually quite lengthy- typically a few weeks to a few months between the point in time when the earliest upstream part was produced and the moment when a bike containing that part was shipped to the retailer. This would have been fine if orders had been perfectly smooth, but in fact orders received by the bike manufacturer changed all the time, partly due to the bonus-driven selling system, partly due to the substantial inventories in the retail channel, and partly due to seasonal demand patterns, particularly for low-end bikes. What's more, there were often engineering changes in bicycle designs, even for mature products, meaning that

Question. 2

MRP systems which were very simple in concept therefore became exceedingly complex in practice. In the bicycle industry, every firm's MRP system was supplemented by a backup system of expediters moving through the production system to move parts in urgent shortage downstream to the head of the queue in every department and at every machine. Their efforts, while essential to avoiding cancellations or large penalties on overdue orders, played havoc with the internal logic of the MRP system-often causing it to generate absurd orders-and with inventory accuracy as well. In the end, most MRP applications were better than manual systems, but they operated day to day at a level of performance far below what was theoretically possible and what had been widely expected when MRP was first introduced.

Just-in-Time, an innovation pioneered at Toyota in the 1950s and first embraced by Western firms in the early 1980s, was designed to deal with many of these problems. This technique was envisioned by Taiichi Ohno as a method for facilitating smooth flow, but JIT can only work effectively if machine changeovers are dramatically slashed so that upstream manufacturing operations produce tiny amounts of each part and then produce another tiny amount as soon as the amount already produced is summoned by the next process downstream. JIT is also helpless unless downstream production steps practice level scheduling *(heijunka* in Toyota-speak) to smooth out the perturbations in day-to-day order flow unrelated to actual customer demand. Otherwise, bottlenecks will quickly emerge upstream and buffers ("safety stocks") will be introduced everywhere to prevent them.

The actual application of JIT in the bicycle industry largely ignored the need to reduce setup times and smooth the schedule. Instead, it concentrated on suppliers, making sure that they only delivered parts to the final assemblers "just in time" to meet the erratic production schedule. In practice, most suppliers did this by shipping small amounts daily or even several times a day from a vast inventory of finished goods they kept near their shipping docks. Some final assemblers even specified the existence of these safety stocks and periodically sent around their purchasing staffs to inspect them. In the end, "just in time" was little more than a once-and-for-all shift of massive amounts of work-in-process from the final assembler to the first-tier supplier and, in turn, from first-tier supplier to firms farther up- stream.

To get manufactured goods to flow, the lean enterprise takes the critical concepts of JIT and level scheduling and carries them all the way to their logical conclusion by putting products into continuous flow wherever possible. For example, in the case of the bicycle plant shown in Figure-1, flow thinking calls for the creation of production areas by product family, which includes every fabrication and assembly step. (Product families can be defined in various ways, but in this industry, they would logically be defined by the base material used for the frame, specifically titanium, aluminum, steel, or carbon-fiber. This classification makes sense because the fabrication steps and processing techniques are quite different in each case.)

Better yet, if noise problems can be managed, the lean enterprise groups the product manager, the parts buyer, the manufacturing engineer, and the production scheduler in the team area immediately next to the actual production equipment and in close contact with the product and tool engineers in the nearby design area dedicated to that product family, The old- fashioned and destructive distinction between the office (where people work with their minds) and the plant (where people work with their hands) is eliminated.

(We're often struck that in the old world of mass production, the factory workforce really had no need to talk to each other. They were supposed to keep their heads down and keep working and professionals rarely went near the scene of the action. So production machinery could make a lot of noise. The isolated workers simply donned their ear protection and shut out the world. In the lean enterprise, however, the workforce of the plant floor needs to talk constantly to solve production problems and implement improvements in the process. What's more, they need to have their professional support staff right by their side and everyone needs to be able to see the status of the entire production system. Many machine builders are still oblivious to the fact that a lean machine needs to be a quiet machine.)

In the continuous-flow layout, the production steps are arranged in a sequence, usually within a single cell, and the product moves from one step to the next, one bike at a time, with no buffer of work-in-process in between, using a range of techniques generically labeled "single-piece flow." To achieve single-piece flow in the normal situation when each product family includes many product variants, in this case, touring and mountain bike designs in a wide range of sizes, it is essential that each machine can be converted almost instantly from one product specification to the next. It's also essential that many traditionally massive machines, paint systems being the most critical in the bike case-be "right-sized" to fit directly into the production process. This, in tum, often means using machines which are simpler, less automated, and slower (but perhaps even more accurate and "repeatable") than traditional designs. We will look in detail in Chapter 8 at the Pratt & Whitney example of simplified blade grinding machinery that we mentioned in the Introduction.

This approach seems completely backward to traditional managers who have been told all their lives that competitive advantage in manufacture is obtained from automating, linking, and speeding up massive machinery to increase throughput and remove direct labor. It also seems like common sense that good production management involves keeping every employee busy and every machine fully utilized, to justify the capital invested in the expensive machines. What traditional managers fail to grasp is the cost of maintaining and coordinating a complicated network of high-speed machines making batches. This is the *muda* of complexity.

Because conventional "standard-cost" accounting systems make machine utilization and employee utilization their key performance measures while treating in-process inventories as an asset, even if no one will ever want them, it's not surprising that managers also fail to grasp that machines rapidly making unwanted parts during 100 percent of their available hours and employees earnestly performing unneeded tasks during every available minute are only producing *muda*.

To get continuous-flow systems to flow for more than a minute or two at a time, every machine and every worker must be completely "capable." That is, they must always be in proper condition to run precisely when needed and every part made must be exactly right. By design, flow systems have an everything-works-or-nothing-works quality which must be respected and anticipated. This means that the production team must be Question. 3 (in case someone is absent or needed for another task) and that the machinery must be made 100 percent available and accurate through a series of techniques called Total Productive Maintenance (TPM). It also means that work must be rigorously Question. 4 (by the work team, not by some remote industrial engineering group) and that employees and machines must be taught to monitor their own work through a series of techniques commonly called poka-yoke, or mistake-proofing, which make it impossible for even one defective part to be sent ahead to the next step.7

A simple example of a poka-yoke is installing photo cells across the opening of each parts bin at a workstation. When a product of a given description enters the area, the worker must reach into the boxes to get parts, breaking the light beam from the photo cells on each box. If worker attempts to move the product on to the next station without obtaining the right parts, light flashes to indicate that a part has been left out.

These techniques need to be coupled with *visual controls*, as mentioned earlier, ranging from the 5S (where all debris and unnecessary items are removed and every tool has a clearly marked storage place visible from the work area) to status indicators (often in the form of *andon* boards), and from clearly posted, up-to-date standard work charts to displays of key measurables and financial information on the costs of the process; The precise techniques will vary with the application, but the key principle does not: Everyone involved must be able to see and must understand every aspect of the operation and its status at all times.

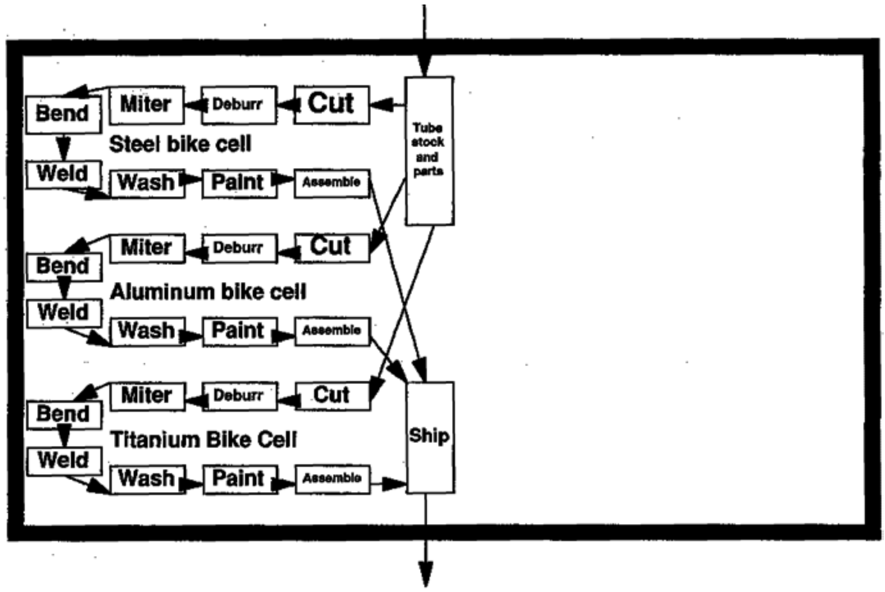
Once the commitment is made to convert to a flow system, striking progress. can be made very quickly in the initial *kaikaku* exercise. However, some tools (for example, massive paint booths with elaborate emission control equipment) will be unsuited for continuous-flow production and won't be easy to modify quickly. It will be necessary to operate them for an extended period in a batch mode, with intermediate buffers of parts between the previous and the next production step. The key technique here is to think through tool changes to reduce Question. 5 that existing machinery will permit. This typically can be done very quickly and almost never requires major capital investments. Indeed, if you think you need to spend large sums to convert equipment from large batches to small batches or single pieces, you don't yet understand lean thinking.

The original small-lot, quick-change techniques pioneered at Toyota in the 1960s are a striking achievement, but we caution readers not to take quick-change machines still producing batches, however small, as an end in themselves. Any changeover requiring any loss in production time and any machine which must run at a rate far out of step with the rest of the production sequence can still create *muda*.

The end objective of flow thinking is to totally eliminate all stoppages in an entire production process and not to rest in the area of tool design until this has been achieved.

Let's tie all of these techniques together by showing what a lean bicycle production process looks like, as shown in Figure-2. First, note that the same number of bikes are being produced but that the plant is more than half empty, in large part because all of the in-process storage areas have disappeared. Although the diagram cannot show this, the human effort needed to produce a bicycle has been cut in half as well; and time through the system has been reduced from four weeks to four hours. (We'll talk in Part II about what to do with people no longer needed for their traditional tasks as. *muda* is eliminated. Protecting their jobs by finding them other productive tasks is a central part of any successful lean transition.)

**FIGURE-2: LEAN BICYCLE PLANT LAYOUT AND FLOW**




The diagram does show that single large machines have been broken down into multiple small machines, in particular the washing systems and paint booths, so that bikes can proceed continuously, one at a time, from tube cutting to mitering to bending to welding to washing to painting to final assembly without ever stopping. In this arrangement the inventory between workstations can be zero and the size of the work team can be geared to the production volume of the cell, with high-volume cells having more workers than low-volume cells. Finally, note that the track assembly operations have been eliminated. When production is broken into product families, it is often the case that no family accounts for the kind of volume needed for track assembly. Remarkably, manual advancing of the product through assembly is often cheaper.

Because the work flow has been so drastically simplified, the MRP system and the accompanying expediters are no longer needed to get parts from step to step. (MRP still has a use for long-term capacity planning for the assembler firm and its suppliers.) When the sequence is initiated at the end of final assembly, work progresses from each station to the next in accordance with *takt* time and at the same rate as final assembly.

The entire product team including the team leader, the production engineer, the planner/ buyer, the TPM/ maintenance expert, and the operators (collectively the heart of the lean enterprise) can be located immediately adjacent to the machinery for each product cell. Because the process machinery currently available for these operations in the bicycle industry either makes very little noise inherently- for example, paint or can be shielded so that very little noise escapes into the team area-the mitering step - it's possible to lay out activities so everyone can see the whole operation and its status at a quick glance.

A final point about the cells which is hard to illustrate with a diagram is that the work in each step has been very carefully balanced with the work in every other step so that everyone is working to a cycle time equal to *takt* time. When it's necessary to speed up or slow down production, the size of the team may be increased or shrunk (contracting or expanding job scope), but the actual pace of physical effort is never changed. And when the specification of the product changes, the right-sized machines can be added or subtracted and adjusted or rearranged so that continuous. flow is always, maintained.

**Question. 1 to 5**

Discuss what the author said in the blanks and express it in a paragraph

Question1 : in 50 words
Question2 : in 30 words
Question3 : in 10 words
Question4 : One word
Question5 : in 10 words

Answer 1

to be adjusted so that production is always precisely synchronized with demand. The point is always to define *takt* time precisely at a given point in time in relation to demand and to run the whole production sequence precisely to *takt* time.

Answer 2

a considerable fraction of the parts piled up alongside the value stream were suddenly either completely obsolete or in need of rework.6

Answer 3

cross-skilled or multi-skilled in every task

Answer 4

*Standardized*

Answer 5

changeover times and batch size to the absolute minimum

These are examples.

If the team's answer includes key words in red and the meaning is the same as these examples, the answer is accepted.

## 6. TPM: Case Method (Ethiopia Iron and Steel Factory)

**Company's Situation**

Ethiopia Iron and Steel Factory was originally a state-run enterprise, but it was privatized around 10 years ago.

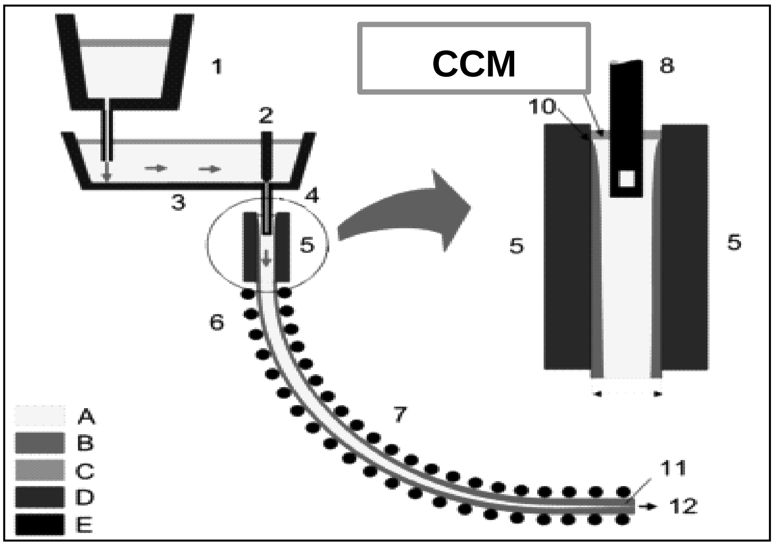
It manufactures and retails mainly R-bars (reinforced steel construction bars) and iron and steel products such as fence wire and nails. As is often the case in developing countries, there is a large market for R-bars due to the construction boom, and the factory is able to sell all the R-bars it makes.

The Ethiopia Iron and Steel Factory plant is old, and so are the work machines and equipment it uses. However, it has also introduced some modern equipment such as a high-frequency fusion furnace.

Moreover, the company produces R-bars using a continuous casting machine (CCM) purchased from a South Korean maker.

(See the figure)

**Continuous Casting Machine**




| | | | |
|---|---|---|---|
| **1.** | **Ladle** | **10.** | **Meniscus** |
| **2.** | **Stopper** | **11.** | **Withdrawal unit** |
| **3.** | **Tundish** | **12.** | **Slab.** |
| **4.** | **Shroud** | **A:** | **Liquid metal** |
| **5.** | **Mold** | **B:** | **Solidified metal** |
| **6.** | **Roll support** | **C:** | **Slag** |
| **7.** | **Turning zone** | **D:** | **Water-cooled copper plates** |
| **8.** | **Shroud** | **E:** | **Refractory material.** |
| **9.** | **Bath level** | | |

**Products made-in Ethiopia Iron and Steel Factory**

**R - Bar**

**Fence**

The R-bar production process is as follows:

(CCM process)

① Scrap iron is melted down in the high-frequency furnace.
② The molten steel is transferred to the ladle and then held in the tundish.
③ Before the molten steel cools down, a clay stopper is hammered with an iron bar in order to open a hole in the nozzle at the bottom, and the molten steel is quickly poured into the CCM.
④ The billets are produced through extruding from the CCM while cooling and cutting to dimensions of 100mm × 100mm × 2000mm.

(Extruder process)

The said billets are reheated to around 900°C and are then pushed into corrugated molds by extruder for processing into bars.

**Problems**

However, Ethiopia Iron and Steel Factory experiences frequent trouble in operation of the CCM process, and the equipment is rendered idle for long periods. In other words, the operating rate is extremely low. In the CCM process, billets are made by pouring molten steel that is more than 1,000°C into molds and then gradually solidifying it from the outside with cooling water, however, if this cooling treatment is not properly controlled, the billets rupture and the molten steel spills out.

When spill-out occurs, not only extremely heavy and hot molten steel lost but nonconforming billets are produced and a lot of time is wasted on dealing with them. The overall operating rate of Ethiopia Iron and Steel Factory is reported to be around 40%.

Moreover, such troubles have an impact on the quality of products and contribute to the high ratio of nonconforming products.

Therefore, the good quality rate is also very low, which makes productivity even worse than the above figure suggests.

The top management of the company are desperate to resolve this problem and improve the company's business performance, and they have asked EKI to provide support for KAIZEN activities.

[Question]

Assuming you are appointed as manager of the manufacturing department in Ethiopia Iron and Steel Factory, think about what kind of KAIZEN measures you would implement in the plant.

Give consideration to TPM techniques in your answer.

(Answer)

R-Bar production can be broadly divided into the process of melting steel scrap in a high-frequency furnace and the continuous casting process of changing molten steel into Billet. To consider. That is, the time when the molten steel is transported to the continuous casting machine by Tundish is defined as the start of the operation, and the time when the molten steel is cooled and solidified into a rod shape and cut into 1,000 mm billet is defined as the end. In the meantime, the process includes a human operation and a continuous casting machine operation. So EKI consultants have to do the following work with company engineers:

① Identify all operations and measure times about each operation from a day’s work.

② Express the items on a bar graph with a time axis.

③ Compile the times of the 7 big losses.

④ Calculate indicators of machine efficiency, such as the Availability Rate, Performance Rate and the O.E.E. on Status-quo.

⑤ Discuss the source of causes based upon Fish Bone, or PM analysis and identify the root cause.

⑥ Then target at the serious causes, and tackle to make the countermeasures to solve them.

⑦ After the countermeasures are implemented, calculate the improved Rates such as Availability, Performance and the O.E.E. on After Kaizen to confirm the effectiveness.

⑧ Compare the difference between each Rate before and after the improvement, and especially for Rate where no difference is seen, reconsider Countermeasure to correct errors or try another Countermeasure.

## 7. TPM: Case Method (Electric Appliance Manufacturer in Egypt)

**Company's Situation**

This is the case of an electric appliance manufacturer in Egypt. This is one of the biggest corporations in Egypt, having more than 10,000 employees. It produces gas oven ranges, refrigerators, rice cookers, electric fans and so on, and it mainly exports to Europe and America but also conducts sales in Egypt. In Egypt, the company's products have a reputation for being inexpensive but poor in quality.

The plant's organization comprises the metal parts processing department, the assembly department, the plastic case making department, and the quality control department.

You are approached by the company as a consultant.

According to the president, he wants to solve problems such as poor precision of parts, weld defects, flash in plastic parts and so on.

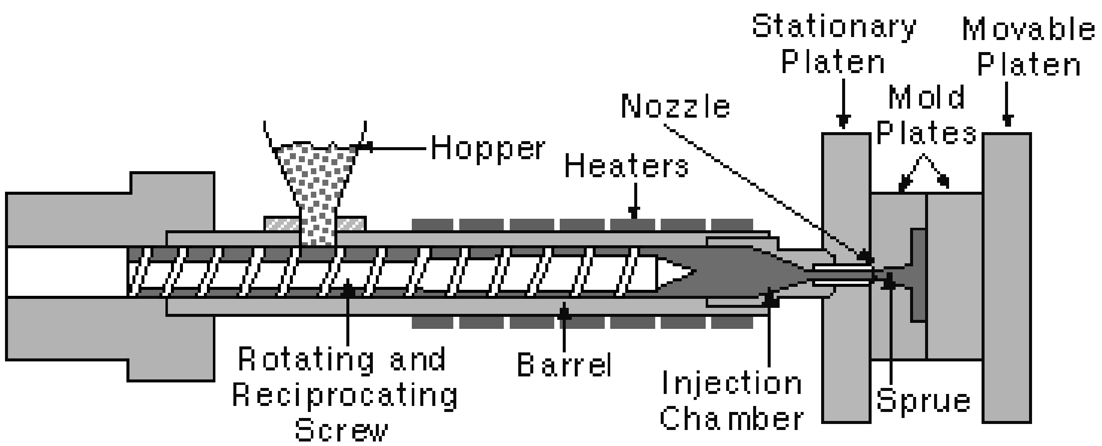
**Problem-1.**

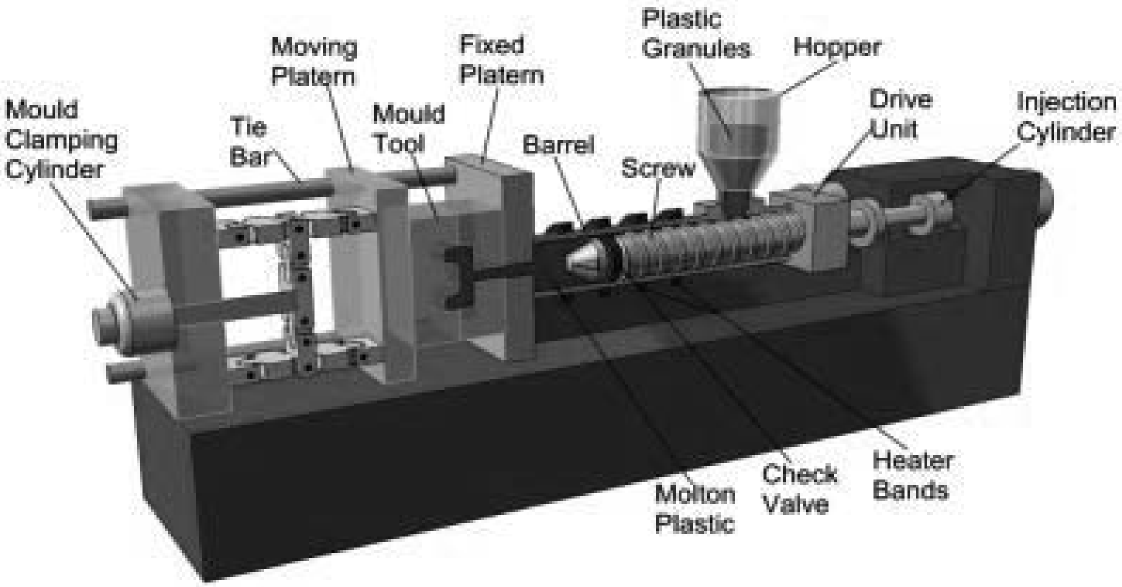
The nonconformity rate is around 3~5%. Such problems are commonly seen in the electric appliances sector in developing countries, however, this company's nonconformity rates are rather high. Moreover, according to the vice-president, the company also wants to improve productivity with a view to preventing product delivery delays.

You notice the following points in observation of the factory.

There are many dies lying around the processing shop. Most are stored on racks, however, they are not covered with plastic sheet. None of the dies are purged with nitrogen gas. Not only are the dies covered in dust, but many of them show signs of rust.

The plastic workshop has 45 injection molding machines ranging from a large 4,000-ton unit to small units weighing a few hundred tons, however, a lot of the equipment is idle.






**Problem-2.**

Even so, the company places great emphasis on the role of the plastic workshop. Every Monday morning, dies are fitted to the injection molding machines and resin materials are inserted into the melting devices.

Then, the electric power is turned on to the molding machines; the materials are heated; a few trial shots are tried when the temperature reaches around 200℃; the resin temperature is adjusted and then continuous production is started. Production is continuously implemented day and night in a three-shift system. Finally, the power for heating is turned off every Friday evening.

Cycle times during production range from around 1 minute for small items to a few minutes for large items. Cycle time here refers to the time taken from pouring of the molten resin into the die to separation from the die after cooling. The cycle time is controlled by computer, however, in order to improve the molding speed without turning out any nonconformities, the most important thing is to grasp the appropriate cycle time for each product.

However, this factory has not established any data concerning the appropriate cycle times for each product. Accordingly, it is faced with critically high nonconformity rates of 5~7%. It is also sometimes unable to deliver products on schedule because production takes so long time.

**Problem-3.**

Another problem is the large amount of flash that arises in large plastic products. This is perhaps caused by poor die design or lack of experience with the manufacturing technology.

**[Question]**

| |
|---|
| Sort out the serious problems that exist in this electric appliances manufacturer and sum up the KAIZEN measures that you think should be taken.<br><br>In giving your answer, indicate what and where TPM should be implemented as autonomous maintenance. Also, describe KAIZEN measures from the viewpoint of OEE for shortening time losses. |

(Answer)

**Autonomous Maintenance Issue**

The mold in the factory is stored without sheets. Daily inspection and cleaning activities are not performed. There is also a lot of unused injection machines. Muda(wastes) in 3M has not been implemented.

**Quality Rate in TPM Issue**

In developing countries, the ratio of defective products by injection molding is about 3-5%, but this company is slightly higher at about 5-7%. This lower good quality rate decreases O.E.E.

Defects with the large amount of flash are clearly visible among defective products. As a countermeasure, it is necessary to consider, as a condition at the time of injection, such as lowering the discharge pressure to reduce excessive molten Resin or lowering the temperature to suppress the fluidity.

**Performance Rate in TPM Issue**

In addition, delays in delivery have been pointed out. This factory has not established any data concerning the appropriate cycle times for each product. The manufacturing department must measure the exact cycle time for each product to reduce the speed loss time for Performance Rate in O.E.E..

## 8. TPM: Case Method (Bekas Chemicals Private Limited Company)

**Company's Situation:**

Bekas Chemicals private limited company (hereinafter abbreviated as Bekas) is a small and medium enterprise of detergent manufacturer.

At the factory in Bekas' Adama it produces plastic containers containing detergent together with detergent production at the same time

There are two kinds of product bottles, 1 kg of detergent weight and 0.5 kg, and there are three colors of red, blue and yellow. Some of the products are shown in Fig-1.

Fig.-1

The detergent container is made of polyethylene or polypropylene pellets as a raw material and is molded by a Blow Molding Machine.

Blow Molding Machine is roughly divided into Extruder part and Blow Molding part. Figures 2 and 3 show the image of parts.

Main functions of the main parts are as follows.

The function of the Extruder section is aimed at building a parison. First insert plastic pellets into the Extruder Hopper. When the temperature of the pellet is elevated to a hundred and several degrees by a heating cylinder, it is melted and led to Die. The molten resin extruded from Die is cooled to become a parison (pipe made of thermoplastic resin).

## Extruder Mechanism & Function

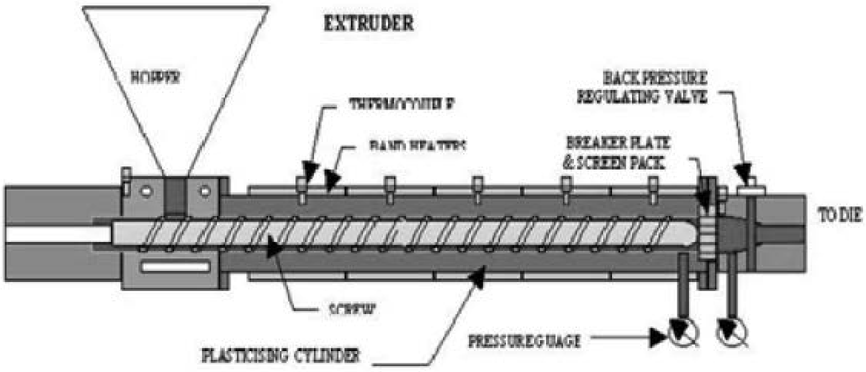



Fig.-2

The function of the Blow Molding section sandwiches the parison together, and inflates the product bottle by Air Blow.

It plays a role of bringing it into close contact with the inner surface of the mold, cooling it, solidifying it and taking it out.

## Extrusion Blow Moulding

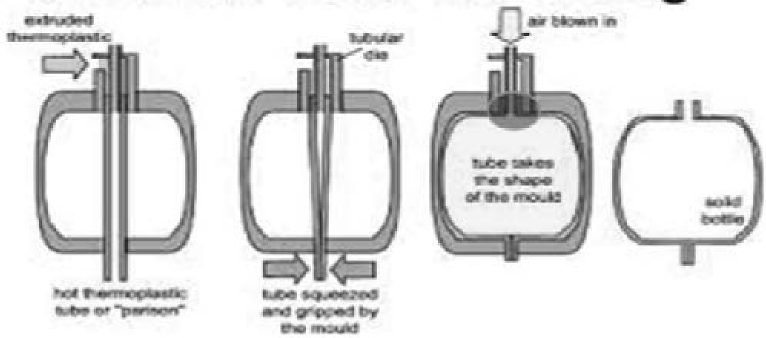



Fig.-3

On the other hand, the chemical detergent formulated in advance is temporarily stored in Mixing Vessel, and when a predetermined plastic container is prepared, it is filled in a certain amount by the following process and becomes a product through the process of Capping and Labelling.

Figure 4 shows the detergent manufacturing process.

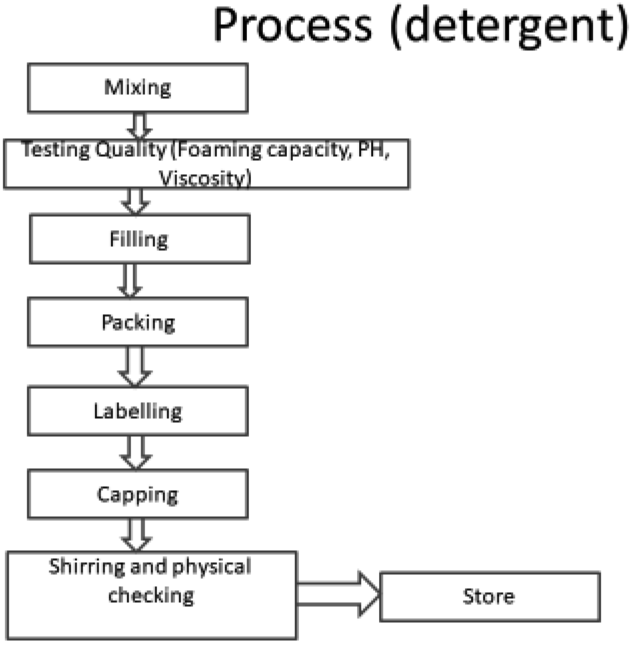



Fig.-4

Bekas's factory operates 24 hours a day continuously for two shifts when demand is high. When the demand declines, it controls the amount of production with weekday operation only except Saturday and Sunday.

An example of production volume is listed in Table 1.

Table-1. The production amount of 3 months' data until Jan.7/2018 by selected machines

| | Actual Production (1st quarter) | | | | |
|---|---|---|---|---|---|
| S.N | Product Type | Month | | | |
| | | 3 Month Data | | | |
| | | 1Kg (Pieces) | 1/2 Kg (Pieces) | Actual production Volume | Number of working days per month= 26 days |
| 1 | Bright | 910440 | 453924 | | |
| 2 | Special | 318564 | 444504 | | Number of working days per Week= 6 days |
| 3 | SIGHN | 39384 | 8604 | | |
| | TOTAL | 1268388 | 907032 | | Number of shifts per day= 3 shifts |
| | TOTAL (Actual Production per 3month) | | 2175420 | | |
| | Actual Production per month | | 725140 | | |
| | Actual Production per day | | 27890 | | |
| | Actual production per shift | | 9296.666667 | | |
| | Planned production per shift | | 28800 | | |
| | | | 26000 | | |
| | Planned Production Per Shift | | 21600 | | |
| | Production Loss | | 12304 | | |
| | Production Loss | | 56.96% | | |

Bekas's factory owns several Molding Machines, but it has a long period of inactivity.

As an example, Production capacity of Blow Mold No. 5 is 5760 pieces / shift, while Actual Production is 4043 pieces / shift. Production Loss is as high as 18.6%.

When looking at the Loss, there are firstly preparation of plastic raw materials (including recycled materials) and machine equipment setup before the production line is in operation. It is usually one day or two days in case of one month operation.

And start up. Approximately 10 hours is required for the Extruder line to be heated and stable thermally / thermally (170 to 185 ° C.). After that, we tried several parisons' tests and it will start production if there is no problem, but if it seems to be bad, it will re-temperature the Extruder system. Subsequently, even in Blow Molding Machines, it will continue to produce continuous in correct thermal conditions.

However, production will not continue without any problems for a month, certainly defective products as described below will occur and Lead to stopping.

Also, since the machinery facilities of the Bekas factory are just using old machines, they break down frequently. At that time, operators stopped the operation and inspected it and given first aid measures. To make matters worse, spare of parts are missing at any moment, so operators use parts from the next facility and divert them. It is a situation in Bekas that can have only one or two things that can work well in Blow Molding Machines

Moreover, the problem is the management attitude of the factory. Even in this situation, leaders and managerial level employees are not actively responding.

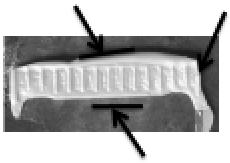
EKI consultants who were in charge of improving project of Bekas plant last year decided the theme of kaizen, but Kaizen's appraisal had difficulty making progress as they expected.

In addition, it is difficult if there is at least no data base to improve it, but generally it can be said that there is nothing at small factories.

Note) Last year the Bekas factory was unable to purchase plastic materials due to the shortage of the dollar, making it impossible to operate full. So, Saturdays and Sundays stopped, they had to respond to driving only on weekdays.

On the other hand, when examining the quality of plastic containers, there are very many defective products. Examples of representative defective products are shown in Figures 5 and 6.

**Thickness Variation of Bottle Mouse Hole (1kg old Type)**



| S. No | Mouse hole | | | Ave. | Flash | T. Scrape length | Internal thickness |
|---|---|---|---|---|---|---|---|
| 1 | 2.89 | 3.09 | 2.59 | 2.856666667 | 7.63mm | 47.02mm | 0.87mm |
| 2 | 2.96 | 2.61 | 2.62 | 2.73 | 7.48mm | 45.70mm | 1.00mm |
| 3 | 2.63 | 2.78 | 3.07 | 2.826666667 | 7.80mm | 46.29mm | 1.30mm |
| | | | | Ave. | 7.64mm | 46.34mm | 1.05mm |
| Max – Min/Ave. (%) | | | | | | | |

Fig.-5

## Prioritized defect types

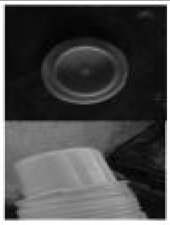
| Types of defects which happen in blow molding and injection ma | | | |
|---|---|---|---|
| Defect photo | Description of the problem | Probable causes of defect | Quantified amount of defect |
|  | For 5kg &1/2 kg (100%) Unclear | High melt temper ature | • No. of Defects per Production Volume |
|  | 100% Internal lock mismatch | Too much Resin Volume | • Bottle |

Fig.-6

Besides this, even in the process of filling plastic containers with detergent, small troubles also occurred, The time to stop is also long. For the reasons mentioned above, Bekas's factory productivity is rather low.

[Question]

If you are asked to instruct productivity improvement at this factory, please show how to tackle the activities from the TPM perspective.

Discuss how to do it in groups.

(Answer)

In TPM, when evaluating the productivity of machinery and equipment, improvements are made from the viewpoints of Availability Rate, Performance Rate and Good Quality Rate. Here, the focus is on improving the Good Quality Rate.

First, reduce the number of defective bottles. The problem of detergent leaking from the container is due to poor sealing of the cap and bottle mouse. Most of the defects are that the mouse is not flat, but other than that, it can be presumed that the cause is that the screw portion is inaccurate due to poor precision and the meshing is not enough to close tightly.

In order to solve this problem, it is important to control the temperature, pressure, discharge amount of molten resin, etc. in the extruder part of the blow molding machine and to carry out the optimal conditions regarding the holding time in the mold as Manual. If you do not have Manual, you need to change each condition to find the optimal range until you can make a good product.

## 9. Cost Accounting: Case Study (PL and Break-even Point)

### Case:

A Co. is an electronic parts manufacturer with headquarters on the outskirts of Addis Ababa. It has sales of approximately 800 million birr/year, and 180 permanent employees. It produces switches and other electronic parts.

The factory and the company's headquarter (Sales and administration) are in a same place, and this makes the close links between the production and the administration and reduce the administration costs.

Through carrying out vigorous technical development and plant investment, A Co. has realized more compact and high-performance products and stable quality, thereby securing the trust of major manufacturers as its customers.

As a result, the company has stable orders and good profits.

Z Co., a major manufacturer of information devices, is an important customer of A. Co, and Part Q for Z Co. accounts for a large share of A Co.'s production.

A Co. forecasts that orders for Part Q will increase over the long term, and it has room to spare in its current production capacity.

However, due to a major fall in the prices of Z Co.'s final products, Z Co. has requested recently that the price of Part Q be significantly reduced.

A Co.'s board of directors is discussing how to respond to this request

---

The financial statements of A Co. and those of another company in the same sector for 2018 are shown below.

Profit and Loss Statement

(Unit: 1 million Birr)

| | A Co. | Other company in same sector |
|---|---|---|
| Sales<br>Sales cost | 799.8<br>686.0 | 612.5<br>526.7 |
| Gross profit | 113.8 | 85.8 |
| Operating expense<br>(Selling cost and general administration expenses) | 63.8 | 65.7 |
| Operating income | 50.0 | 20.2 |
| Non-operating income<br>Non-operating expenses | 10.3<br>24.7 | 7.3<br>17.2 |
| Ordinary income | 35.6 | 10.3 |
| Extraordinary profit<br>Extraordinary loss | 3.7<br>35.0 | 3.0<br>7.5 |
| Income before tax | 4.3 | 5.8 |
| Corporation tax, etc. | 1.7 | 2.3 |
| Net income for the term | 2.6 | 3.5 |

(Unit: persons)

| | A Co. | Other company in same sector |
|---|---|---|
| Number of employees | 180 | 209 |

Discussion & work 1

(1) Using A Co.'s financial statements for 2018 and using that of the other company in same sector, calculate five (5) management indicators (one productivity, and four profitability) which demonstrate the situation of this company.

(2) State the situation of A Co. briefly

Discussion & work 2

According to the marketing department, Z Co. is requesting two options.

(1) The supply price of Part Q be reduced by 20% from the present price, and the purchase volume is same.

(2) The supply price of Part Q be reduced by 30% from the present price but purchase only from A Co. and increase orders twofold.

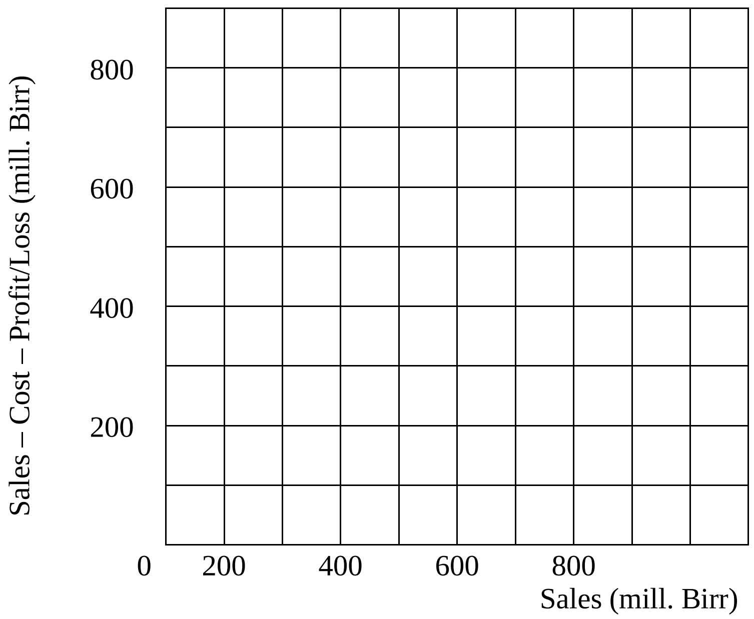
You must advise the company management which option should be adopted.

Conditions

1. Current sales of Part Q amount to 400 million birr, variable costs are 80 million birr, and fixed costs are 300 million birr.
2. Incidentally, A Co. has room to spare in its production capacity, and the production technology department reports that even if supplies of Part Q were doubled, the cost structure would be no different from at present.
3. Since the company has only just implemented large-scale restructuring, it cannot expect to reduce fixed costs any further. Moreover, the production technology department has reported that it will be difficult to achieve major reductions in variable costs with the current equipment.

Steps of discussion (decision making step)

1. Calculate and make current break-even point graph of Part Q.




2. Calculate break-even points and or put points on the break-even graph drawn in the step 1 under the following conditions.

   ① When the supply price is reduced by 20% and supply volume isn’t change.

   ② When the supply price is reduced by 30% and supply volume becomes double.

3. State which option is more profitable for A Co.

**Answer:**

Instruction 1.

1) Using A Co.'s financial statements for 2018 and using that of the other company in same sector, calculate three management indicators which demonstrate the situation of this company.

Answer (1)

<u>Indicator Productivity No.1</u>

| | | | |
|---|---|---|---|
| Sales per Employee A CO. | : | 799.8/180 = 4.4 | 152% |
| Sales per Employee Average | : | 612.5/209 = 2.9 | |

<u>Indicator Profitability No.1</u>

| | | | |
|---|---|---|---|
| Gross profit on Sales of A CO. | : | 113.8/799.8 = 14.2% | Almost same |
| Gross profit on Sales of Average | : | 85.8/612.5 = 14.0% | |

<u>Indicator Profitability No.2</u>

| | | | |
|---|---|---|---|
| Operating income on Sales of A CO. | : | 50.0/799.8 = 6.3% | 191% |
| Operating income on Sales of Average | : | 20.2/612.5 = 3.3% | |

<u>Indicator Profitability No.3</u>

| | | | |
|---|---|---|---|
| Ordinary income on Sales of A CO. | : | 35.6/799.8 = 4.5% | 265% |
| Ordinary income on Sales of Average | : | 10.3/612.5 = 1.7% | |

<u>Indicator Profitability No.4</u>

| | | | |
|---|---|---|---|
| Income before tax on Sales of A CO. | : | 4.3/799.8 = 0.5% | 56% |
| Income before tax on Sales of Average | : | 5.8/612.5 = 0.9% | |

Answer (2)

The sales per employee of A CO. is 152% higher to average. This means the Productivity of A CO. is high. It is the result of vigorous technical development and plant investment.

The Gross profit on Sales of A CO. is almost same as Average, while the Operating income on Sales of A CO. is 152% higher than the Average. This means that the A CO. has the strong point in location of the headquarter which is close to the factory and which enable the reduction of sales and administration cost Income before tax on Sales of A CO. is almost half of the average company.

This is the result of extraordinary loss.

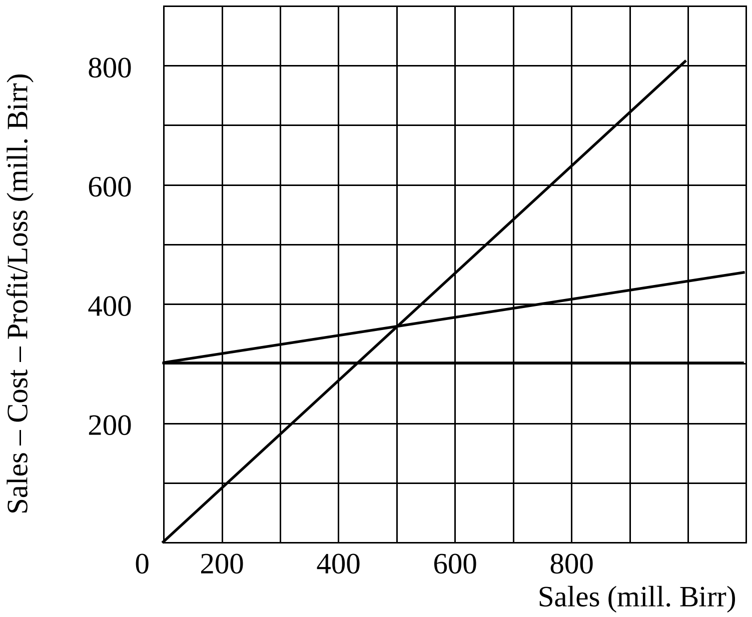
The extraordinary loss is for the restructuring (Ex. Severance pay) and it will make the company stronger.

Instruction 2.

According to the marketing department, Z Co. is requesting that the supply price of Part Q be reduced by 20%. Z Co. has also indicated that if the supply price of Part Q can be reduced by 30% from the present price, in future it will purchase only from A Co. and increase orders twofold. Current sales of Part Q amount to 400 million birr, variable costs are 80 million birr, and fixed costs are 300 million birr.

Incidentally, A Co. has room to spare in its production capacity, and the production technology department reports that even if supplies of Part Q were doubled, the cost structure would be no different from at present.

2-1) The break-even graph of Part Q is as follows.

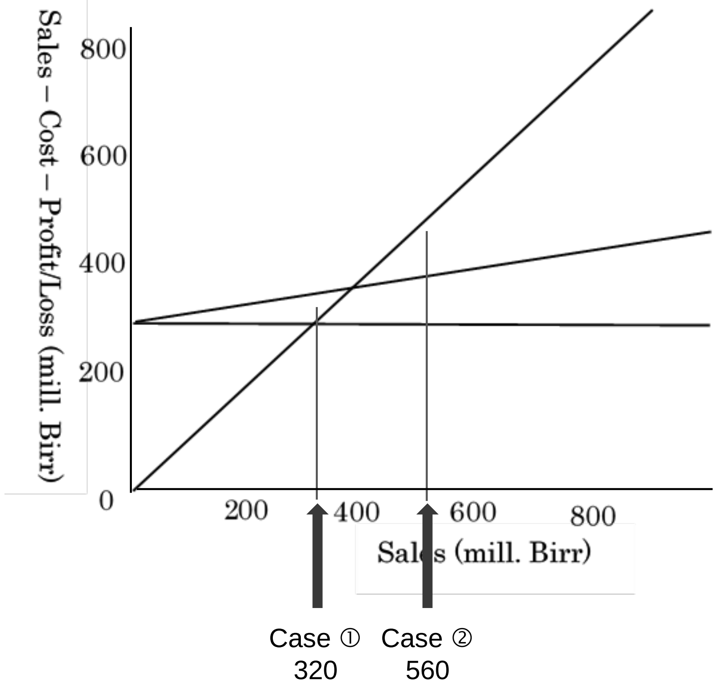



$$\text{Break} - \text{even sales} = \frac{300}{\dfrac{1 - 800}{400}} = 375$$

2-2) The situation of condition 1 and 2 are followings

① Unit price reduced 20%, so the sales amount is 400x0.8=320

② Unit price reduced 30% and sales volume become double, so the sales amount is 400x0.7x2=560




2-3) If accept option 1, then profit becomes minus.

If accept option 2, then profit becomes plus

So, Option 2 is more profitable for A Co.

## 10. Economic Engineering: Case Method (Trading Company)

### Trading company's distribution center expansion plan

### 1. Background

A Company., in Addis Ababa, is a trading company that imports mechanical parts from overseas and sells it to domestic manufacturers. With the recent business expansion of the company, the storage space of the existing distribution center has become short, and the work of receiving imported products and shipping to domestic customers has sometimes delayed, so capacity expansion is becoming necessary.

In the distribution center, after unloading the imported parts that arrived in large lots of one-cubic-meter pallets from overseas, unpacking them into cartons and inspecting them. Then they are stored on shelves and kept. When an order is received from a domestic manufacturer, workers pick the cartons from the shelf according to the order, unpack the cartons and take the parts to inspect, re-pack them and load them to truck for shipping. The total parts numbers are over 5,000, shipping more than 300 parts every day.

### 2. Direction of capacity expansion

The management of A Company let the planning department and the logistics department make a plan for capacity expansion respectively.

The planning department presented a draft of a large-scale semi-automated investment plan (initial investment of 200 million Birr) and the logistic department presented a distribution plan of small investment (40 million birr).

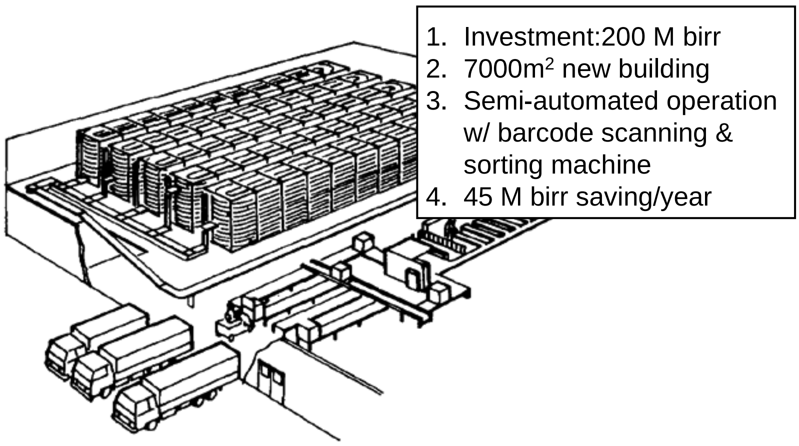



Fig1; large-scale semi-automated investment

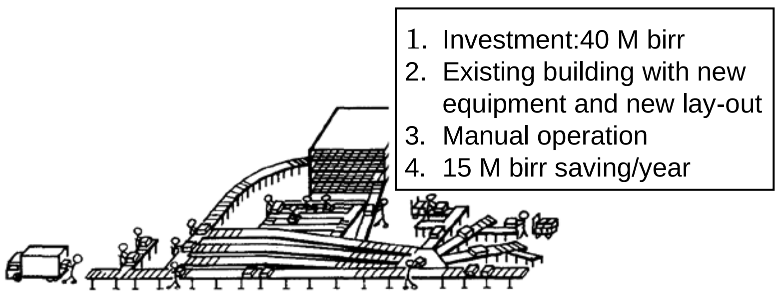



Fig 2; small-scale investment plan

Plan 1 (large-scale semi-automated investment plan) Outline

Because the expenses have become large part of total cost at existing distribution centers. The planning department aimed to reduce warehouse rent, truck transportation fare, etc. To that end, they proposed a new distribution center construction plan (see Fig 1)

Plan 2 (Small scale investment plan) Outline

The logistics department has initiated the "IE Improvement Activity" 10 years ago.

The activity has started seeing the waste of logistics, for example

- Waste of unpacking,
- Waste of counting the parts
- Waste of much space for parts in process,
- Waste of attaching and removing several types of slips,
- Waste of loading and unloading parts many times by hand

And so on. For improving the poor workability, they have been boiling up improvement proposals based mainly on hand-made equipment (see Figure 2)

## 2.1 Economic comparison of two proposals

The two plans cannot be thrown out, especially about the first plan, five project members were assigned with a manager of the planning department as leader, and planning for concretization started. So, the management decided to compare economic merits of both proposals (see Figure 3). From the figure, the first plan shows that the advantage is inversed with the second plan over 6 years, the first plan is advantageous in the long term. Many talks were held at their office on which to choose, over two months passed

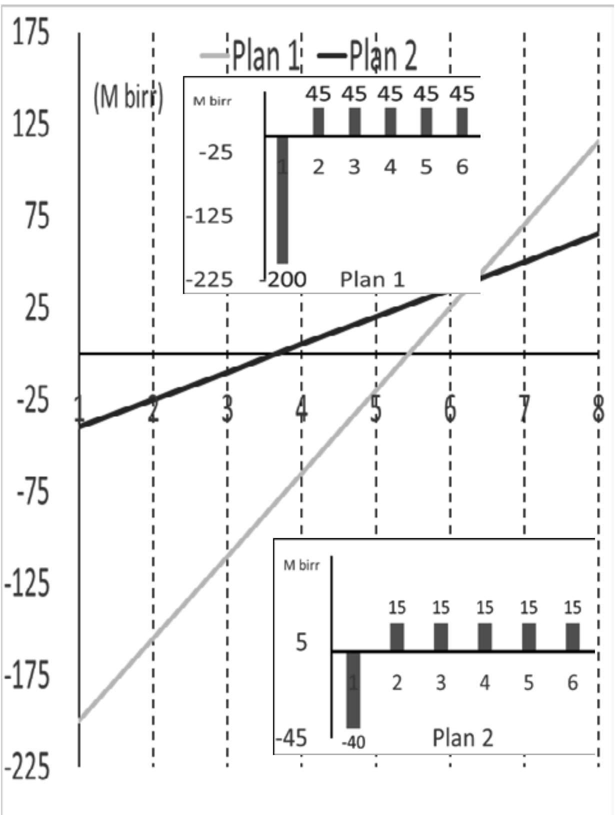


Fig 3; Cash flow stream and investment payout charts

## 2.2 More discussion

To decide which of the first plan or the second plan should be chosen, it was necessary to further clarify the problem situation. By reviewing the basic functions of the distribution center, the fundamental waste in the present situation can be classified as follows

(1) Waste caused by parts themselves

Poor parts quality, wrong packaging, incorrect quantity of parts, unreasonable packaging. Lot size is too big.

(2) Waste caused by poor handling

Work procedure· space · equipment · layout · working method etc.

(3) Waste caused by poor information that controls (1) and (2) processes

There is excess or deficiency of information on slips with low accuracy.
Its system is also bad.

Particularly about (1), the following countermeasures are required.

- Improve quality and try to eliminate inspection
- Package should be changed to eliminate repacking.
- Determine quantity in container to minimize stocks.
- Proper delivery form such as delivery lot size and delivery time from overseas manufacturer

Distribution center is where parts delivered from overseas manufacturers are being converted into packing style, quantity and timing specified by customers. For this reason, although it fulfills the functions of sorting, transportation, storage, etc. If large-scale semi-automated investment is made with the condition (1) as it is, if the logistics conditions are improved and some works related to (1) become unnecessary.

However, it will remain in semi-automated process.

This equals to waste and waste. Then the management starts deeply considering what would be the best way to invest.

<u>Discussion1;</u>

What would be your conclusion as the management of A Company,

<u>The answer 1</u>

A Co., management conclusion

(1) To be able to keep up with environmental changes around the market.
(2) It is not only the investment to eliminate waste but to merge with manual work and continue to uphold,
(3) Even if equipment trouble occurs, we can respond promptly by ourselves.

Looking at this, the second plan seemed to be a desirable one. However, from figure 3 plan 2 is less profitable than plan 1. The best is to find optimal condition of capital investment at first and find out the plan that is comparable to plan 1 economically, a new way (the third way) came into view. It is “the idea that large-scale semi-automated investment like plan 1 should be implemented after improving the conditions of parts flow”. At the initial stage, small investment of the 2nd plan is carried out and improvement is accumulated and various knowledge and know-how are obtained. After that, proceed with an advanced automated process with less expensive investment than first plan

Plan 3

Initially it proceeds with a small-scale kaizen investment. Make a large semi-automated investment some years (n years) later.

The result of the investment of 40 million birr and improvement activity in the first year will greatly affect the next large-scale investment. We decided after clarifying the conditions that make the third plan economically advantageous from the first plan. Based on that assumption, we calculated the allowable investment amount after n years as below. This is to decide whether it is cost effective even if we invest in an allowable amount after taking the necessary time, n years, to eliminate basic waste of logistics.

| | | | | | |
|---|---|---|---|---|---|
| **Investment timing(n year after)** | **1** | **2** | **3** | **4** | **5** |
| **Allowable investment(M birr)** | **200** | **155** | **110** | **65** | **20** |

- It will be easy to spend five years on improvement activity, but after five years it is uncertain to invest less than 20 million birrs and gain the same effect as plan 1.
- After one year it will be possible to invest less than 155 million birrs, but it is impossible to improve all in a year.
- Implementation with investment of 65 million birrs or less in three years is likely to be possible because the investment amount is almost half,

Through this judgment, it was decided to put it on the third plan. In other words, “In the beginning, we will make capital investments of 40 million birr for logistic department to implement plan 2 and improve logistic conditions at the same time as accumulating our know-how. And introduce semi-automated process with investment of 65 million birr or less three years after. The project team of plan 1 from the planning department joined the logistic department team of plan 2 and implemented together plan 3.

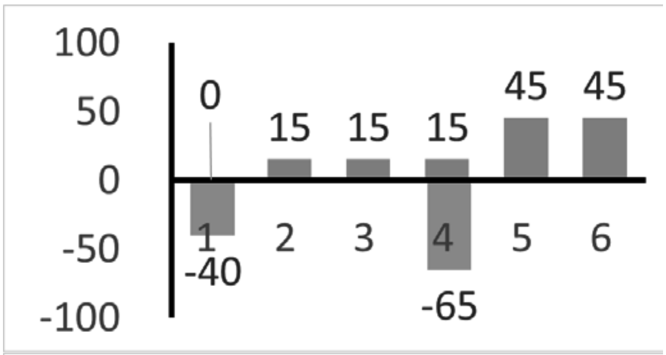
The trainee’s answer needs to have the idea of taking both advantages of plan 1 and 2 and making a third plan.

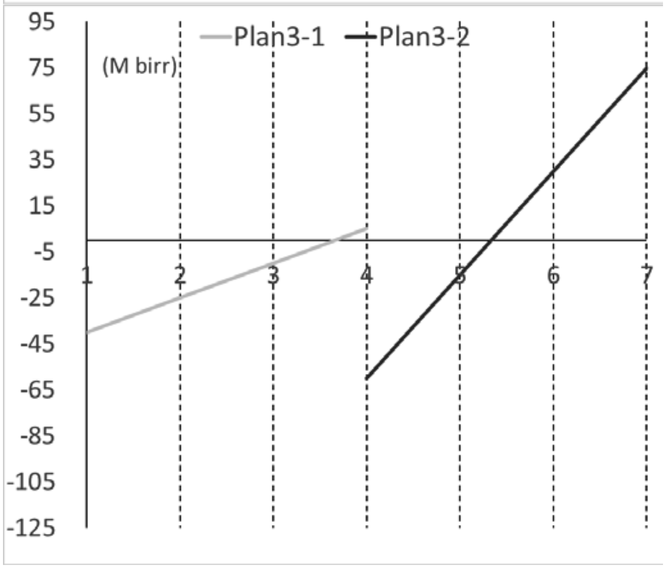
Discussion 2;

- From above information, make cashflow stream chart and investment payout chart for plan 3.
- Discuss the economic effectiveness of plan 3 based on the charts

The answer 2:

| | | YR1 | YR2 | YR3 | YR4 | YR5 | YR6 | YR7 |
|---|---|---|---|---|---|---|---|---|
| Plan3-1 | Cashflow | -40 | 15 | 15 | 15 | 0 | 0 | 0 |
| | Payout | −40 | −25 | −10 | 5 | | | |
| Plan3-2 | Cashflow | 0 | 0 | 0 | -65 | 45 | 45 | 45 |
| | Payout | | | | −60 | -15 | 30 | 75 |




The effectiveness of plan3 is;
The company will gain 30m Birr in 6th year with 105m Birr investment.

The gain is 5m Birr more than plan1 and the investment is 95m Birr less than plan1.

## 11. Ethical Code: Case Method (Consultant Ethics)

### 1. Case 1

Mrs. A, who is a Kaizen Consultant, has been providing Kaizen support for three years to Company F that produces "Kolo". At the beginning, the working environment was not good; the place was full of smoky due to roasting barley, which is the raw material. To this problem, she proposed to put a duct over the roasting iron pan, which can exhaust the smoke through a chimney pipe connected with the duct. This brought good result and there were no longer much smoke. Because of this, she obtained the credit from the Company. After that, she proposed the layout change and installation of a worktable in the work place. As a result, the productivity of the Company was improved by 9%; and the fatigue of the workers was reduced since there was no longer the work of half-sitting unnatural posture. Due to this, Mrs. A received appreciation not only from the owner but also from the workers of the Company.

In the first visit to the company, Mrs. A and another accompanied consultant received one 200-gram package of Kolo each. She understood that the Kolo were distributed to them because the Company wants them to know about the Company product. She brought back the Kolo at home and ate it with her family. At that time, she was very surprised at the outstanding taste, which was very different from others. Thus, in the second visit, she asked the Company to sell her three packages of Kolo. At the time, she knew that she can buy one package at 40 birr, instead of the retail price of 60 birr per package. Then, she had a thought: If I can purchase the Kolo at this price, I would add 8 birr as a profit; and distribute it to the retailer of her acquaintance at the wholesale price of 48 birr. She is now thinking that she can do it as a side job.

**Task**: Examine which ethical code the act of Mrs. A is strongly related to; and by what degree her act is accepted.

### 2. Case 2

The rubber factory that Mr. B, Kaizen Consultant, visits regularly produces all kinds of rubber packing that are used for the joints of pipes. The packing is produced by: cutting off a certain amount of rubber from thick rubber sheet; and filling it in a heated die to form by pressing for a certain time. As the way of production is manufacturing of a wide variety of products in small quantities, it requires frequent change of dies. The time required for changing a die in press is 15min; and that of heating a newly-set die up to a designated temperature is 20min. Thus, not only factory head but also site workers think that it is more effective to produce one type of product in big quantities with one die at once. Due to this, the total amount of production stock is equivalent to three-month sales, while salable products are often out of stock.

Mr. B thought that it is necessary to employ the frequent small lot production in order to reduce the amount of stock without having stock-out of some products. Because he has the knowledge of

SMED, he paid attention to the heating time of a die and thought that this process could be done by external set-up, so as to shorten the entire time of die change. The external set-up is to make other work possible while the press is under operation. Based on his idea, he and the factory members repeated the test in the factory to put it to practical use.

The point of attention in his idea is that a die is to be heated before setting in to a press, instead of heating it after setting. This could shorten the entire time of die change, including the heating time of a die, from 35min to 15 min. The idea is very simple, but what about disseminating this technique to other companies in the same business?

**Task**: Which article of the ethical code should you consider in this case? Examine and organize your thoughts about the dissemination referring to the article you select.

## 3. Case 3

Ms. C, Kaizen Consultant, became a leader of the consultant team of introducing Kaizen in a garment factory. She always thinks that it is necessary to have participation of as many site workers as possible for the implementation of Kaizen, instead of implementing it only by consultants or one group of a factory. In addition, she thinks that the Kaizen would not be successful even though the countermeasure is good, if the workers don't get motivated.

**Task**: Put yourself on a shoe of Ms. C, who is introducing 5S into the garment company. In this case, what aspect and what point should you make consideration from the perspective of human side? Summarize your idea on what the human side is and what measures should be taken according to the procedure of introducing 5S.

(end)