REPORT ON THE STUDY ON ENERGY CONSERVATION PROJECT IN THE KINGDOM OF THAILAND

VOL. 2

— TEXTILE, METAL —

JUNE, 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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I. GENERAL REPORT

1. Objectives of the Second Study

This study was undertaken in accordance with the Scope of Work for the Study on the Energy Conservation Project in the Kingdom of Thailand (hereinafter referred to as "the Scope of Work") signed between the National Energy Administration (NEA) of the Kingdom of Thailand and the Japan International Cooperation Agency (JICA) in March, 1982.

The framework of the study agreed upon in the Scope of Work is shown in Fig. 1. The second study undertaken recently represents a part of Phase I in the framework and has the objectives as shown in the following.

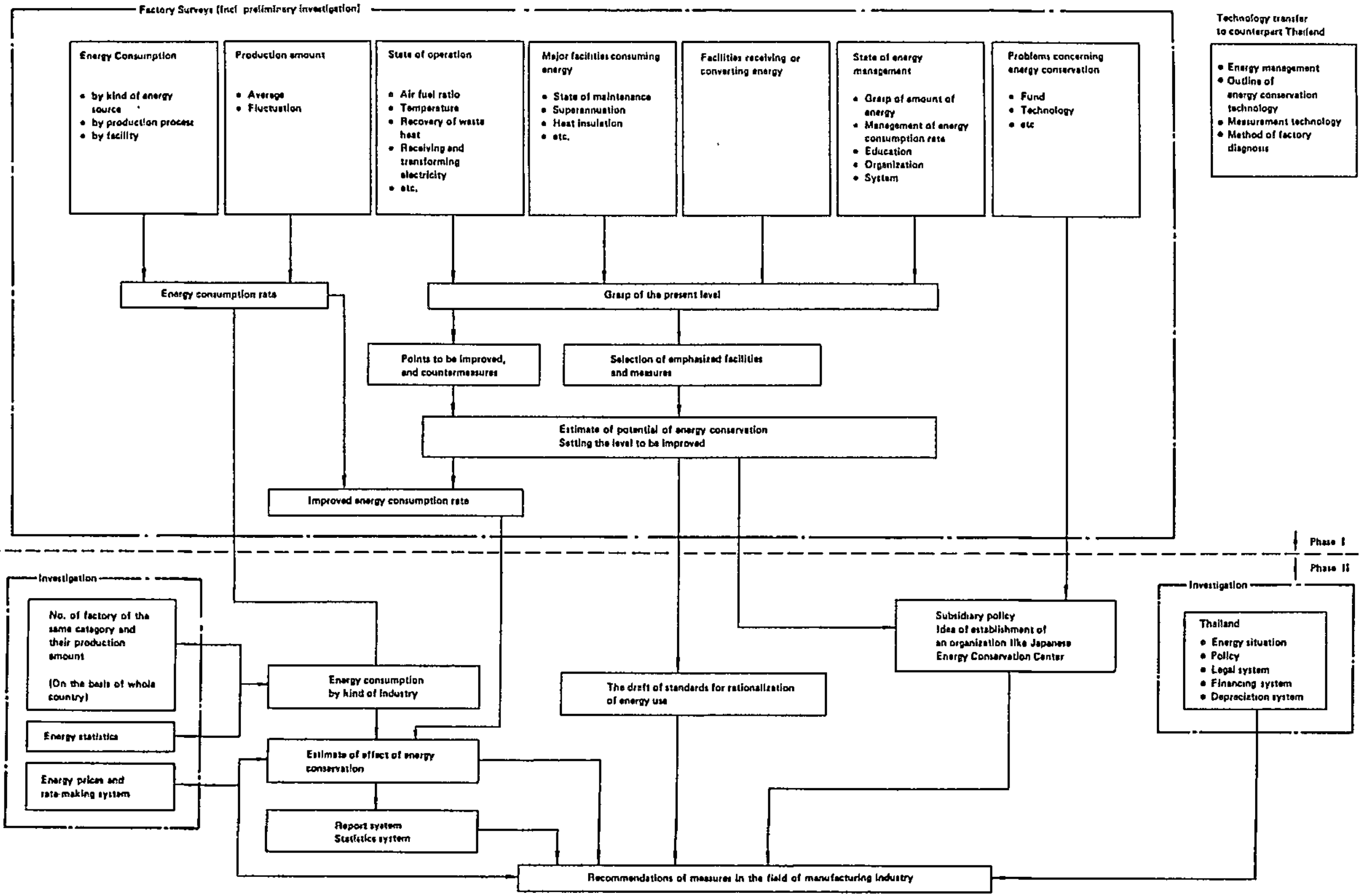
(1) Factory diagnosis covering nine each textile and metal factories.

(2) Transfer of energy conservation measurement and diagnostic technology to the counterparts in the Kingdom of Thailand.

(3) Gathering of general information related to energy in the industrial sector in Thailand.

The field study was made for a period of 35 days beginning on January 9, 1983 by the study team shown in Appendix 1 in accordance with the schedule shown in Appendix 2.

Fig. 1 Framework of Thailand's Manufacturing Industry Energy Conservation Investigation



2. Study Method

2.1 Factory Diagnosis

2.1.1 Preliminary Study through Questionnaire

Prior to undertaking the field study, a questionnaire (Appendix 3) was distributed to the factories concerned through the NEA asking that the following items be filled out.

a. Outline of the factory (factory name, address, names of officers, type of industry, capital, annual sales, number of employees and engineers, principal products, and production capacity)

b. Energy consumption (fuel, electric power, and water)

c. Principal energy consuming equipment (name, model, year installed, capacity, fuel used, and operating hours)

d. Production process chart

e. Energy flowchart

f. One-line diagram

g. Factory layout

h. Problems encountered in promoting energy conservation activities

2.1.2 Interviews with Executives and Managers

Referring to the returned questionnaires and energy management check lists (Appendix 4), interviews were held centering on the items shown in the following.

a. Current state of production and sales

b. Energy conservation countermeasures implemented in the past

c. State of energy management

d. Production problems

2.1.3 Overall Inspection of Factory

Overall inspection of the factory was made following the manufacturing processes to grasp the following items.

a. Overall management state

b. Layout

c. Priority facilities for surveys and measurements

2.1.4 Surveys and Measurement

Surveys and measurements were taken on the following items covering the priority facilities in accordance with the items given in the check list.

a. Measurement of facility dimensions

b. Data gathering utilizing factory records and meters

c. Measurement by measuring instruments (Appendix 5)

— Fuel combustion state

— Heating, cooling, and heat transfer state

—State of heat reliese prevention
—State of waste heat recovery
—State of conversion of heat into motive power
—State of electric power losses by resistance, etc.
—State of conversion of electric power into motive power and heat

2.1.5 Discussion

The outline of the survey and measurement results were explained to the executives and managers, and the points that were considered as problems were discussed.

2.2 Technology Transfer to Counterparts

2.2.1 Handling of Measuring Instruments

In the factories diagnosed, the study team showed how to handle the measuring instruments.

2.2.2 Guidance on Diagnostic Techniques

At the begining the study team explained to the conterparts the check list items and their meanings at NEA and thereafter guided them during the factory diagnosis on how to fill in the check list. On the days data were sorted after the factory diagnosis, the processes and diagnostic points for the diagnosed factories were explained to them. Guidance on diagnostic techniques was given through sorting of gathered data and descriptions of information that could be obtained from the data.

2.3 Gathering of Related Information

Information related to energy policies, the energy situation, production state of manufacturing industries, and other items in Thailand was gathered through NEA and the Thai-Japan Technological Promotion Association (TPA).

3. Diagnosed Factories

Table I shows the factories diagnosed in the study. All factories are located near Bangkok.

Of the factories diagnosed, four textile factories and three metal factories are joint venture companies with foreign capital. Of the pure Thai capital factories, five factories belong to large capital groups. Nearly all of the factories were capitalized at more than 10 million Bt. The study covered relatively large factories.

Table I Factories Diagnosed

Industry Type	Factory	Products	Dates
Textile	The Thai Durable Textile Co., Ltd.	Spun yarn and woven fabrics	Jan. 13~14
	Union Thread Industries Co., Ltd.	〃	Jan. 24~25
	The Thai Textile Co., Ltd.	〃	Jan. 27~28
	The Phiphatanakit Textile Co., Ltd.	〃	Jan. 31~Feb. 1
	Siam Synthetic Weaving Co., Ltd.	〃	Feb. 3~4
	Thai Warp Knitting Co., Ltd.	〃	Feb. 7
	Hantex Corporation Ltd.	Nylon filament	Jan. 17~18
	Toray Nylon Thai Ltd.	〃	Jan. 20~21
	The Bangkok Nylon Co., Ltd.	Socks	Feb. 8~9
Metal	Bangkok Steel Industry Co., Ltd.	Steel bar for concrete	Jan. 20~21
	Sahaviriya Metal Industries Co., Ltd.	〃	FEb. 3~4
	Union Metal Co., Ltd.	〃	Feb. 7~8
	Thai Special Wire Co., Ltd.	PC Wire	Jan. 17~18
	Sinthani Industry Co., Ltd.	Wire rods	Jan. 24~25
	Thai Malleable Iron and Steel Co., Ltd.	Castings	Jan. 27~28
	Thai Special Steel Co., Ltd.	〃	Feb. 9
	BIS Asia Equipment Industry Co., Ltd.	Tractor parts	Jan. 14
	Kang Yong Manufacturing Co., Ltd.	Nails, screws, bolts, and nuts	Jan. 31~Feb. 1

4. Results of Factory Diagnosis

4.1 State of Energy Management

4.1.1 General

In every factory, the attention of executives and managers to energy conservation was strong due to the very high cost of energy, particularly of electric power. However, when examining how their attention was translated into concrete activities, as shown in Table 2, there was a difference in the state of their activities. Generally, the textile factories were large in scale and had a well-organized management system, and their activities were conducted systematically. Some of them had already achieved substantial results.

Table 2 State of Energy conservation Activites

State of Activity	Textile	Metal
Systematic activities	5 Factories	2 Factories
Non-systematic case-by-case counter-measures	2	3
Underpreparation, or not yet implemented	2	4

4.1.2 Participation by All Employees

The first prerequisite for effective energy conservation activity in a factory is to motivate all the employees to recognize the necessity for energy conservation and participate in such activities. During the process of factory diagnosis, the disgnosers noticed that only factory executives and staff participated in the activities without including all employees. The following items will become possible only when all employees participate in the activities.

a. To make a thorough search for energy conservation items without overlooking small items.

b. To produce ideas for effective and economical countermeasures.

c. To accurately and completely carry out countermeasures once a decision has been made.

A variety of methodes can be considered for motivation. The principal methods of motivation that were observed in the factories diagnosed are summarized in the following.

(1) Appeal by Executives

In many instances, the appeal was made through the organization or through posters. In some cases the appeal was also directed toward correct operation as well as energy conservation. A factory solicited employees to design stickers for these drives in order to further increase employee interest. There were some opinions that the government would help in supplying necessary media such as posters.

(2) Target Setting by Executives

In asking the employees to cooperate, it is necessary to show them concrete targets such as to save a certain percentage by a certain time as well as to set clear investment criteria as means to achieve such targets. This method also shows that company executives are considering energy conservation as an important factor in company management, which naturally motivates the employees to take a more serious view.

In the diagnoses made, about 1/3 of the factories were trying to save energy by approximately 10%. Only two of them had shown their employees clear targets. Some of the factories had set no targets as they were of the opinion that they would tackle the question whenever problems are found out. This attitude may be effective at primitive stage. However, when some progress is made, it will be difficult to find problems thoroughly.

(3) Committee Organizaiton

Energy conservation activities concern not only energy consumption, but also other wide areas such as quality control, productivity, and equipment and facility maintenance. Therefore, full communication and coordination among the various departments and process is necessary to reduce losses as a whole. Excellent solutions are unexpectedly found by gathering opinions from various viewpoints on one problem. Moreover every person taking part in energy management can get clear understanding on the situation by exchanging information on the progress of measures as well as what is being implemented in each department and process. For these reasons, committees made up of executives and staff personnel will be effective in promoting energy conservation.

The following items are often taken up on the committee agenda:

a. Energy conservation targets

b. Study of accomplishments, problems, and improvement plans in energy conservation

c. Report on specific successful cases

d. Investment plans and budget distribution

The committee should be chaired by the factory superintendent or his substitute, and a coordinator is needed to make preparations and to expedite the proceedings.

Nearly half of the factories visited had energy conservation on their executive meeting agenda. In some factories, the committee system for energy conservation had failed. The reasons given were "Did not know how to proceed", "Could not understand about other departments", "A committee was formed with a university professor as the chairman, but the improvement plans did not suit the actual conditions of the factory", and others.

(4) Small Group Activities

Through their routine work, operators are well acquainted with the situation in which energy is used, and in many instances, effective improvement plans are made through their cooperation. However, it is difficult for individual operators to produce improvement plans. The most effective method will be for small groups consisting of several persons each, to voice their opinions and to shape the plans. In Japan, a large number of such small groups are formed contributing not only to energy conservation and quality control, but also the enhancing the ability of the employees themselves, a positive approach to work, and better human relations in the work place.

Of the diagnosed factories, six factories had QC circle activities. All of these QC circles were formed by staff personnel and foremen; operators were not participating in these activities. It is hoped these activities will take root and expand further.

(5) Other

Awarding of prizes is one method of answering effective improvement suggestions and improved performance. Only a few factories had an award system, and some factories had discontinued it thinking it would cause a problem. In other factories, incentives were given to groups or section instead of to individuals.

4.1.3 Determining the Actual Situation of Energy consumption

Constant determination of the level of energy consumption rate in the factory, processes and facilities which produce large losses, and comparison with previous levels is needed to plan for energy conservation. To do this, energy consumption data segmented by process and time whenever possible have to be gathered to check variations compared with the production situation. And whenever data show anomalous variations prompt action should be taken. It is also important to show the results of data analysis to the operators and to guide them to pay attentiion to energy consumption.

The bulk of the factories visited had energy consumption data recorded monthly for the entire factory. Nearly half of these factories also calculated energy consumption rate. Some of the factories figured serial change of them in the shape of management charts, which were also shown to their employees for guidance. However, in almost all instances, records were kept within executives hand. Only a few factories analyzed the change factors considering the difference in production conditions and product types (e.g. yarn count) for use in making improvements based on such data.

Because there were few available meters, consumption by process could not be determined even though the total consumption for the entire factory was known, and this made data analysis difficult. For this reason, some factories were planning to purchase portable measuring instruments.

Lack of information exchange in the industry is one reason why there was less stimulation because the factories did not disclose their energy consumption rate and no comparison could be made.

4.1.4 Improvement of Technical Level

Parallel with the motivation of employees, technical knowledge should be given such as what should be watched and how problems could be solved.

Of the factories diagnosed, eleven factories sent their staff to seminars held by the Thai-Japan Technological Promotion Association (TPA) and others. Training of operators has rarely been undertaken, saying that operators would be trained after staff personnel had finished their training. However, some excellent cases were observed such as showing slides on trap handling and distributing leaflets which appeals careful use of insulating materials and has material price on it.

In many cases, facility maintenance, quality control, and safety countermeasures were observed insufficient during the survey. The supply of information should preferably be strengthened by holding training meetings and issuing publications on overall plant management technology without restricting the area to energy conservation only.

4.1.5 Items which Factories Consider as Problems in Carrying Out Energy Conservation (Answers to Questionnaire)

Table 3 shows the results of the questionnaires distributed to the factories in advance.

The following questions attracted the most replies.

(1) Prospect of energy price is not clear.
(6) Difficulty in obtaining good energy conservation equipment
(8) System of research and development is not sufficient
(11) Employees consciousness is low
(13) Shortage of measuring equipment

Compared with the results of the first study, replies to the question (3) — Increase of energy cost can be covered by raising the prices of products — decreased reflecting the severe economic situation, while (5) — Shortage of engineers—and (12) — No personnel are available who can educate the employees — also decreased as the enterprise scales of the factories were larger than the last time. Replies to the question (8) — System of research and development is not sufficient and (13) — Shortage of measuring equipment — were many, indicating that energy management has reached a certain level. In the metal industry in particular, (6) — Difficulty in obtaining good energy conservation equipment — was prominent. No investigation has been made on exact equipment name, however, equipment for waste heat recovery, combustion control, and other purposes can be considered.

Table 3 Replies to Questionnaire "Problems Encountered in The Promotion of Energy Conservation"

Question	Textile	Metal	Total	Results, 1st Study
(1) Prospect of energy price is not clear.	4	5	9	9
(2) The proportion of energy cost in the whole cost of enterprise is small.	2	1	3	1
(3) Increase of energy cost can be covered by raising the prices of products.	0	3	3	10
(4) Instability of energy supply. (power stoppage, etc.)	2	1	3	5
(5) Shortage of engineers.	2	0	2	6
(6) Difficulty in obtaining good energy conservation equipment.	1	7	8	2
(7) Information such as active cases is not easy to obtain.	3	1	4	3
(8) System of research and development is not sufficient.	5	5	10	2
(9) Shortage of fund for facility improvement.	1	3	4	2
(10) The facilities are superannuated.	2	1	3	1
(11) Employee consciousness is low.	7	5	12	10
(12) No personnel are available who can educate the employees.	0	2	2	9
(13) Shortage of measuring equipment.	5	6	11	5
(14) No time to analyze energy consumption rate.	1	0	1	1
(15) Shortage of information on government's measures.	1	2	3	2
(16) Shortage of government's subsidiary measures.	2	1	3	5
(17) Others	1	1	2	3
Total	39	44	83	76

4.2 State of Energy Consumption

4.2.1 Fuel Combustion

(1) Several burners were not properly maintained. Corrosion and blockage of nozzles were caused and fuel atomizing was not sufficient. Oil was dripping from some burner nozzle tips.

(2) Some burners had their loads extremely low due to control problems, causing incomplete combustion.

(3) Several burners had an controller for the air-to-fuel ratio. However, setting was not finely adjusted after analyzing oxygen in exhaust gases.

(4) In some instances, the air ratio was abnormally high due to poor carriage car sealing and other reasons.

(5) Preheating to an unnecessarily high temperature was performed in spite of the light fuel oil used.

(6) There were excellent factories that accurately checked both quantity and quality of fuels on recivings. Some factories complained of variation in the of fuel oil.

4.2.2 Heating, Cooling, and Heat Transfer

(1) A billet heating furnace in a rerolling factory was used improperly. In high temperature furnaces as those for steel, heat transmission is performed almost entirely by radiation. In this furnace, billets were heaped high inside the furnace, blocking radiation from the furnace walls and combustion gases. Flames were blown directly onto the billet heap to heat it, causing incomplete combustion and scale formation.

(2) Hot charge is extremely effective in energy conservation as it prevents loss of the heat the material hold when it come out of the earlier process and as it charges the material into the heating furnace at as high temperature as possible. A factory diagnosed have possibility to this use technology.

(3) Some of the heating furnaces had defects in equipment such as insufficient capacities as they were used for purposes other than those originally intended, flues not properly installed, and extraction outlet positions not appropriate.

4.2.3 Heat Loss by Radiation, Conduction, etc.

(1) There were large number of steam pipelines and steam consuming equipment that had insufficient heat insulation.

(2) A large number of steam traps did not operate properly.

(3) There were gaps between lids and metal melting furnaces causing a large amount of heat radiation.

4.2.4 Waste Heat Recovery and Reutilization

(1) Only one heating furnace was recovering waste heat exhaust gases for reutilization.

(2) Some factories were recovering steam condensate.
There is room for improvement and expanded utilization by others.

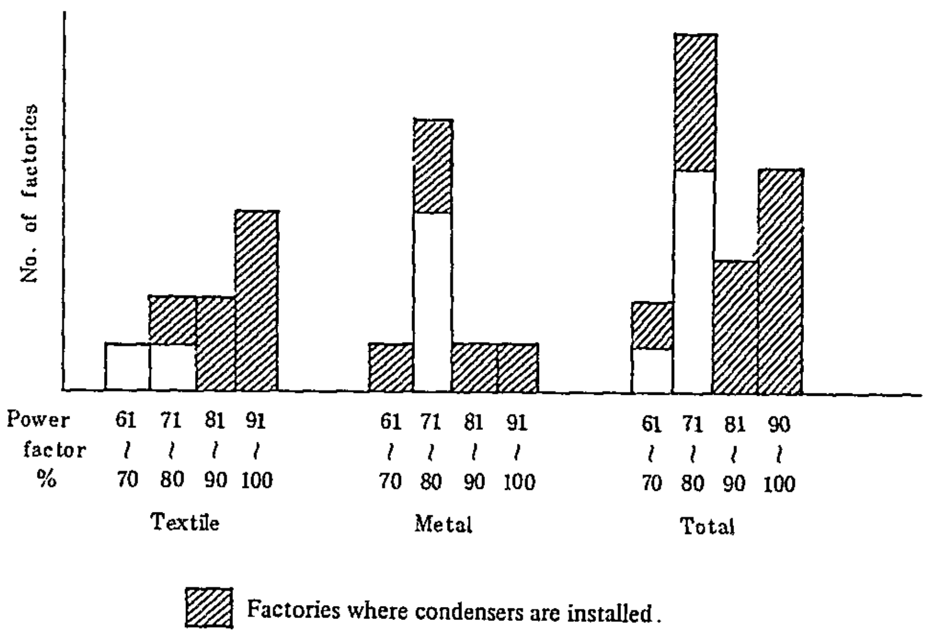
4.2.5 Heat Conversion into Motive Power, etc.

Some of the textile factories were always running diesel power generators to prevent damage by cut yarn caused during a power failure. Unless the heat generated at that time is also utilized, the overall efficiency would not be further improved.

4.2.6 Loss of Electric Power by Resistance, etc.

(1) Fig. 2 shows the distribution of power factors of the factories diagnosed by the study team. In the textile factories in particular, many condensers were installed to improve the power factor. A metal factory having low power factor in spite of condensers installed was one which had installed them only for induction heating furnaces. Two factories were contemplating condenser installation.

Fig. 2 Distribution of power factory by branches of industry



(2) Approximately half of the factories had low load factors (average demand/peak demand x 100).

The fact that the load factor is low means, in other words, that the peak demand is high. A factory with this proportion has increased distribution losses and requires excessively large receiving facilities. In the final analysis, this results in increases in both distribution loss and in capacities of power generators for the country. By reducing the peak demand, the demand charge for the factories can be reduced. The peak demand can be lowered by recording the power every hour, checking what are the reasons that cause the peak, and by taking measures such as shifting the starting times of machines.

(3) Transformers

As the operating ratio of the metal industry had decreased, the transformer load has also lowered. Transformers should be united or be cut off during the night.

4.2.7 Conversion of Electric Power into Motive Power, Heat, etc.

(1) In textile factories, a large number of machines are belt-driven. Many belts of an energy-conservation type with less slippage were observed. On the other hand, there were also machines with loose belts, or with fewer belts than were required.

(2) Some factories replaced their daylight fluorescent lamps with white-light ones. The change to high-efficiency lamps should be encouraged.

(3) In textile factories, the proportion in power consumption for air conditioning is high. Efforts were made to lower the air conditioning load by raising the setting level of temperature and humidity. Improvements are possible by reducing spaces requiring air conditioning, by sealing out the open air, by cleaning filters, and by other means.

(4) Damper closing ratio on blowers were large in some instances. Power can be saved by reducing the revolution speed.

(5) Some motors were seen operating with light load. Although replacement of these motors with smaller ones would result in reduction of power loss, it seems no good economy to do so immediately. It is more preferable to replace them when renewal time comes or spare motors with proper capacity are available.

4.3 Textile Industry

4.3.1 Outline of the Industry and Relative Positions of the Factories Diagnosed

Textile production is the largest industry in Thailand, and there are as many as approximately 120 manufacturers which are members of the Thai Textile Manufacturer Association (TTMA). The depression after the oil crisis has been recovering slowly, and production is now at almost full capacity.

Of three nylon filament producers in synthetic fibers, two were subject to the diagnosis, and their capacity covered nearly 2/3 of Thailand's total production capacity.

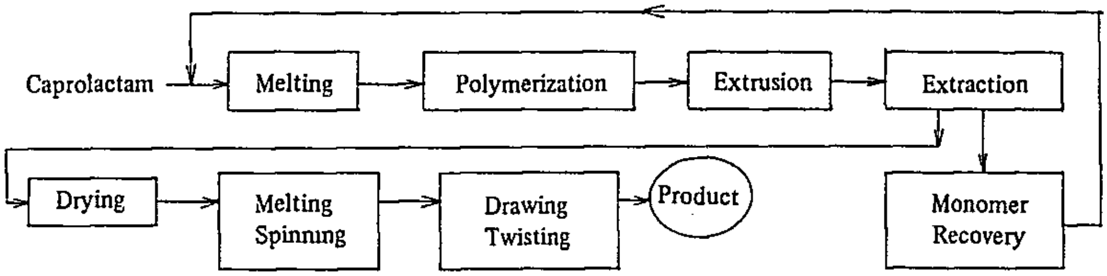
Four cotton spinning factories were diagnosed, and these four spinning factories have a total of approximately 200,000 spindles. The total number of spindles of the manufacturers which are the members of the TTMA is about 1.5 million, and the study covered approximately 13% of these spindles.

The socks factory surveyed is the largest one in Southeast Asia, and two other factories are medium or large factories in their respective product areas.

4.3.2 Manufacturing Process

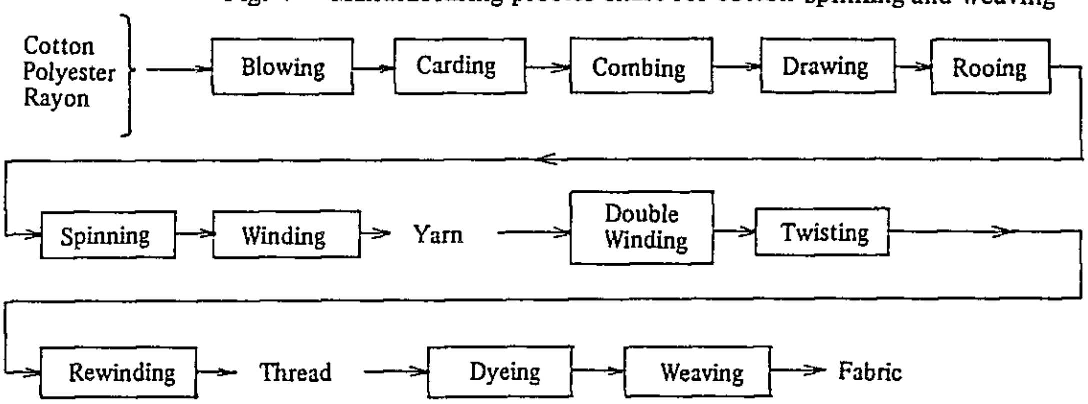
(1) Nylon Filament

Fig. 3 Manufacturing process chart for nylon filament



(2) Cotton Spinning and Weaving

Fig. 4 Manufacturing process chart for cotton spinning and weaving



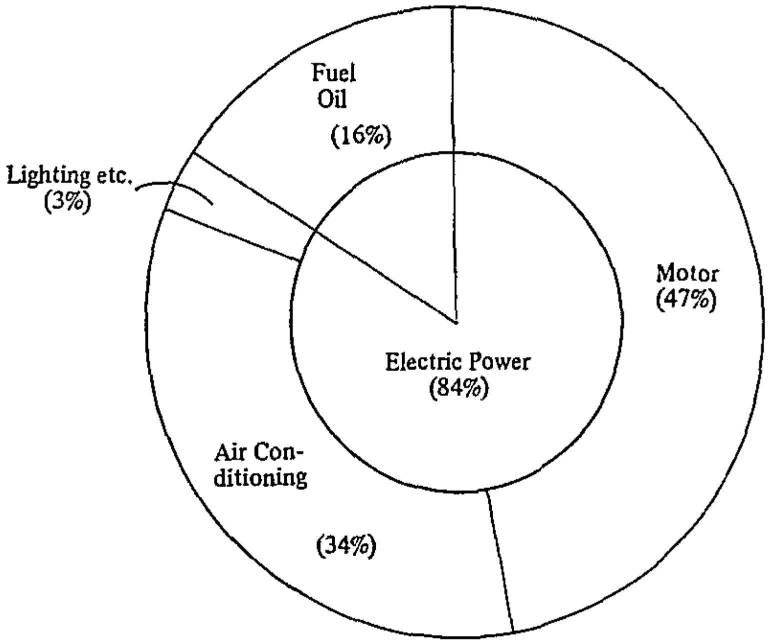
4.3.3 States of Energy Consumption

(1) In textile factories, energy is utilized in the following forms.

Purpose	Facility	Energy Source
Steam generation	Boilers	Fuel oil
Melting	Melters	
Drying	Sizing machines, dryers	
Evaporation, Distillation	Evaporators, distillation towers	Steam
Heating	Glue cookers, setters, dyeing machines	
Pressure reduction	Ejector	
Heating	Nylon polymer spinning machines, false twisters	Electrical heating, heating medium oil
Air conditioning	Chillers, blowers	Electric power
Motive power	Motors	
Lighting, others		

(2) The energy consumption proportion differs depending on the facility composition. The following is the typical proportion for the four cotton spinning factories diagnosed.

Fig. 5 Percentage of energy consumption of cotton spinning



Notes: 1. Power is distributed for machine capacity
2. Unit of power is 860 Kcal/kWh

The proportion of the electric power is high, and the energy consumption for motive power, including that for air conditioning, accounts for the bulk. In terms of unit price per kcal, the power is approximately 4 times higher than fuel oils, and the electric power accounts for nearly 95% of total energy costs.

4.3.4 Major Points of Energy Management

(1) Air Conditioning

Spinning factories require air conditioning for the following purposes, and their consumption of energy for air conditioning is high.

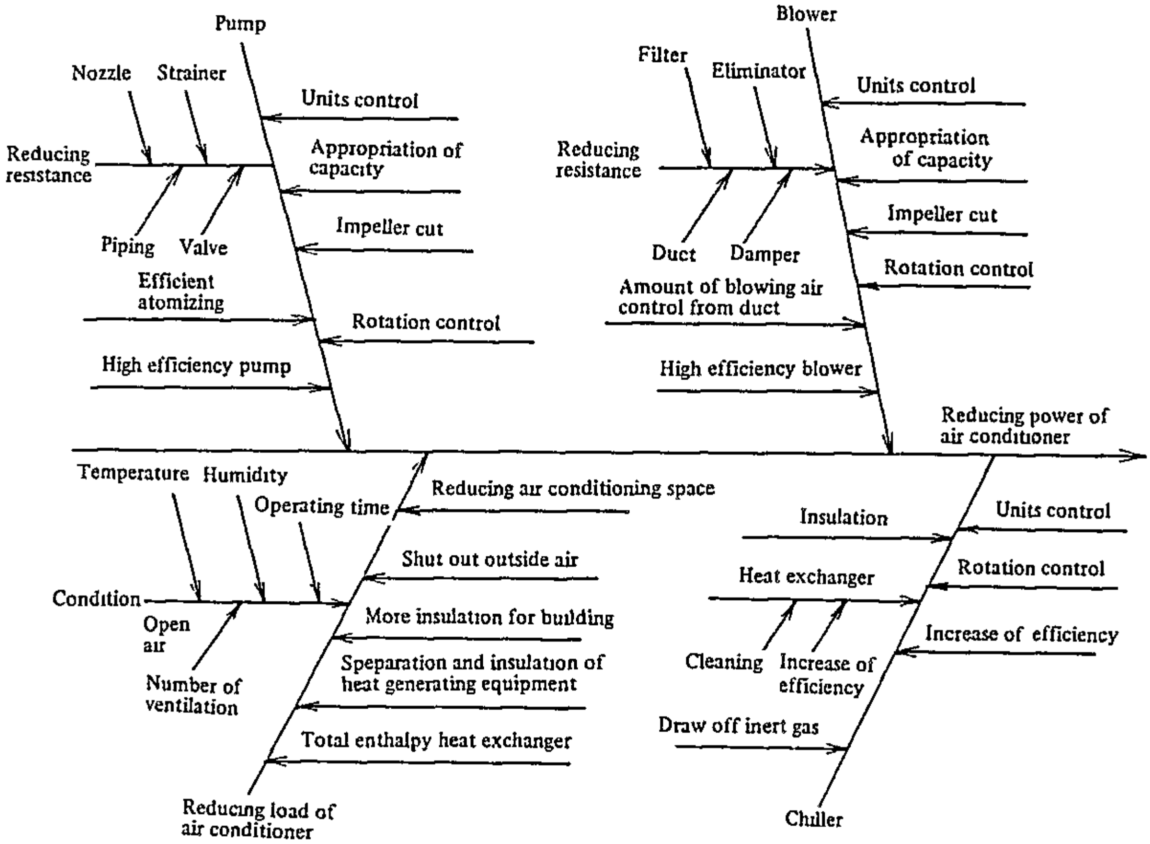
a. To secure temperature and humidity conditions to maintain product quality.

b. To remove shag cotton which is produced in large quantity.

c. To secure a good working environment.

A characteristic factor chart for a reduction in power for air conditioning is shown in Fig. 6.

Fig. 6 Characteristic diagram of reducing power of air conditioner



A reduction in the air conditioning load is the most effective application. The allowable ranges of the temperature and humidity conditions are determined by yarn properties, processes, and factory facilities and technology levels.

The conditions should be gradually relaxed while checking product quality, and efforts to standardize them are repeated. In our study, some factories had low set temperatures, while there were other instances where processes that did not seem to require air conditioning had air conditioning. In some factories, entrances were no double entrances, allowing open air to freely flow in, while other factories had not partitioning with spaces that were used as product warehouses. The heights of ceilings in the control rooms of a factory were lowered to reduce air conditioning cubic volumes.

With respect to blowers, the discharged air amounts from ducts were uneven in some factories, while in other factories, filters were loading badly and drive belts were loose. In other factories, openess of damper were little. Power can be saved by changing pulleys or by lowering the revolution speed by installing inverters.

With respect to pumps, the water spray nozzles can be changed to larger ones with good efficiency, to lower both pressure and water quantity. Some of the factories were already studying them.

(2) Motors

Many of the spinning factories were using energy conservation type drive belts with little slipping. However, many belts had insufficient tension. Loose belts do not transfer force effectively, and not only shorten belt life, but also cause uneven rotation adversely affecting quality. When the belt tension is too tight, a lateral force is applied to the motor shaft sometimes burning bearings. Belt tension is considered adequate when the belt can be depressed by only its thickness when pushed down under normal finger pressure.

In some factories, end breakage was reduced to a minimum by changing spinning machine pulleys and by adjusting the spinning machine speed. This method also saved energy.

Many motors were operating at low load factors. Replacing them does not assure immediate economical results. However, these motors should be replaced with those having appropriate capacities at an opportune time.

(3) Lighting

Fig. 7 shows a characteristic factor chart regarding energy conservation for lighting.

Fig. 7 Characteristic diagram of reducing power of lighting

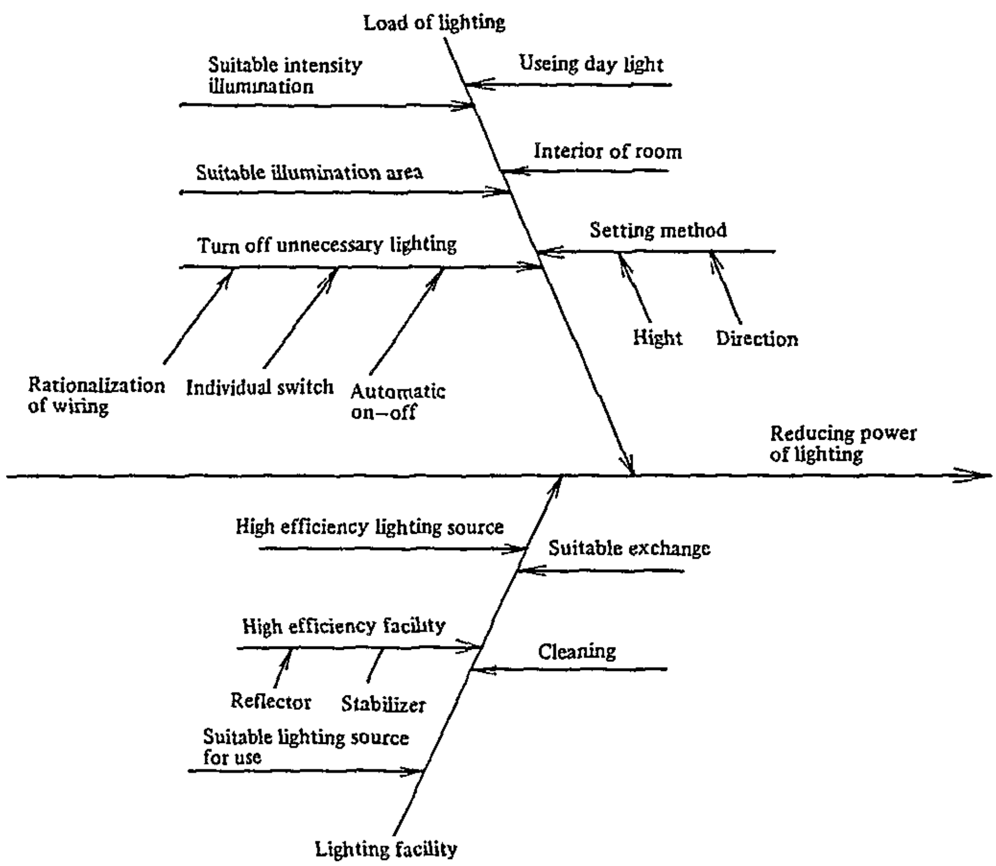
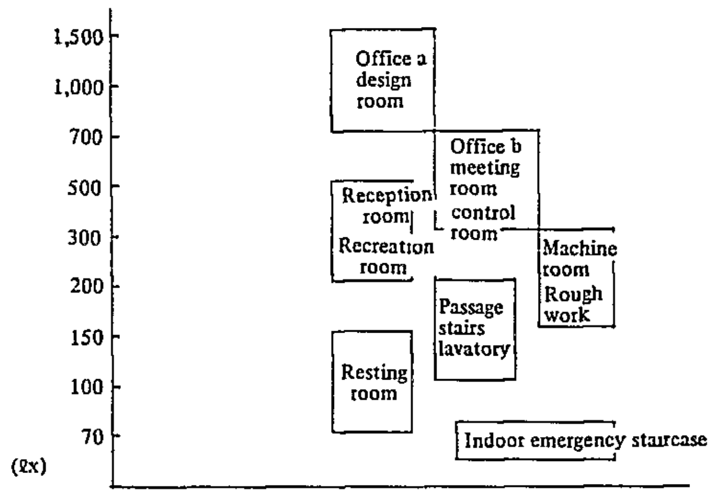


Fig. 8 Selection standard of luminous intensity



Source: Japanese Industrial Standard

Compared with the Japanese standard for illumination shown in Fig. 8, illumination in the diagnosed factories was generally low. In particular, illumination in some control and inspection rooms was not sufficient. In some factories, fluorescent lights were installed at the position too high.

White fluorescent lamps are more efficient than daylight color fluorescent lamps. Some factories were using white fluorescent lamps. The manufacture of energy-conservation type fluorescent lamps, which are about 10% more efficient, will be begun in Thailand, and it is hoped that these lamps will be used.

(4) Power Factor

Of nine factories diagnosed, seven factories had condensers installed (see Fig. 2). However, four factories were operating with power factors below 85%, and improvements are required.

(5) Power Receiving and Distribution Equipment

The loads of the transformers in the diagnosed factories were generally appropriate. Excessive transformers were disconnected.

Repairs and adjustments of meters were not satisfactory in many instances. Each process should have watt-hour meters to control electric power.

(6) Boilers

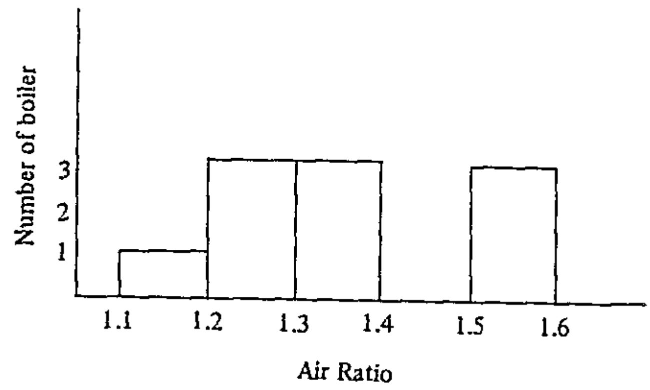
a. Control by evaporation ratio

For daily control of boiler performance, the ratio between feedwater amount and fuel amount, that is, an evaporation ratio, should be calculated and its trends should be checked. The diagnosed factories did not have control by evaporation ratios. In most of the factories, feedwater meters were not installed, or the meters were out of order, even when such meters were installed. Feedwater amounts could be determined in only two of nine factories.

b. Lower combustion air ratio

The boiler air ratios of the diagnosed factories are shown in Fig. 9. Air-fuel-ratio regulators were installed, and only a few of them showed high values. The difference between high and low loads was large, requiring an exchange and rearrangement of nozzle tips and linkages.

Fig. 9 Air ratio of boiler



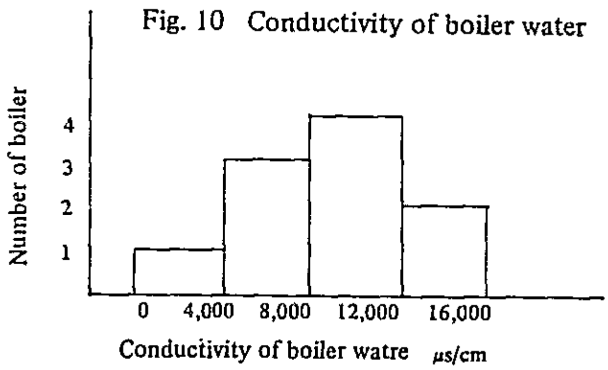
c. Boiler heat release

The heat insulation condition was good.

d. Optimization of blow amount

Fig. 10 shows measurement of boiler water electrical conductivity. The value should be below 6,000 μS/cm with flue boilers in order to prevent scale formation. The values were slightly high, indicating that the blow amount was insufficient.

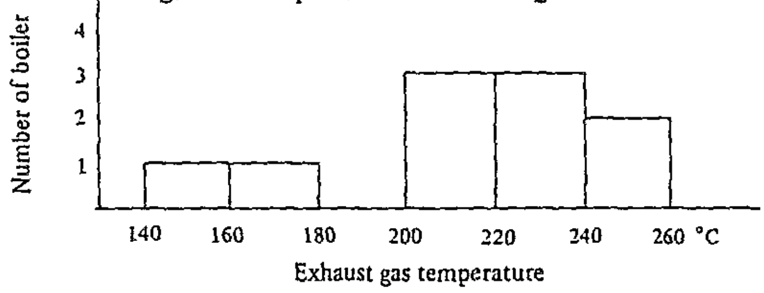
Fig. 10 Conductivity of boiler water



e. Exhaust gas temperature

Fig. 11 shows the distribution of exhaust gas temperatures, indicating that the temperatures are mostly in satisfactory range.

Fig. 11 Temperature of exhaust gas from boiler



(7) Waste Heat Utilization

Steam in textile factories is used mostly for indirect heating. Even though it depends on the distance between a boiler and the equipment using steam, condensate should be recovered. Condensate recovery permits utilization of the sensible heat of the condensate and lowers the load of feedwater treatment facilities because it contains less impurities. Nevertheless, periodic checking of water is needed to detect leakage from dyeing machines and increases in iron ions caused by the corrosion of recovery pipes. Of the nine factories diagnosed, six factories were recovering steam condensate. However, the recovery rate can still be increased. When recovering steam condensate some of the heat of the condensate is lost as flash steam if released to the atmosphere. Therefore, waste heat recovery will be more efficient by directly feeding it to the boilers using a recovery pump without lowering the pressure, or by utilizing flash steam to heat low temperature equipment. Of the nine factories one factory was even utilizing flash steam.

Dyeing factories use a large amount of steam to heat a liquid 10 to 20 times the volume of yarn to approximately 120 to 130°. Except for one factory, which recovered waste cooling water and led it into a boiler feedwater tank, this heat was discarded. One utilization example of this heat is to recover waste cooling water and reutilize it in the dyeing process. Next, the hot water thus obtained is heat-exchanged with waste dyeing solution for reutilization after raising its temperature. A new tank, pump, and heat exchanger will have to be installed. However, it is estimated that the investment will be able to be recovered in about three years.

(8) Heat Insulation

The equipment was generally well insulated. However, flanges and valves were hardly insulated. Dyeing machines were not insulated because the insulation could easily become wet. However, they should be insulated using water-proof material such as from polypropylene or polyethylene.

(9) Steam Traps

Some steam traps were leaking steam. Malfunctions can be detected using even simple stethoscopes when enough experience is gained in using them well. Periodic checking should be made and data should be recorded in a ledger. Pipes should be installed or reinstalled to ensure smooth flow of condensate.

(10) Steam Pressure

The portion of steam enthalpy that moves to condensate increases when the steam pressure increases. So, it will be more efficient to use steam at as low a pressure as to keep a temperature difference. Some factories were using steam at excessively high pressures for cooking or glue cooking.

4.3.5. Targets for Improvement and Projected Effects

A. Targets for Improvement

Major control items (1) to (3), (5), (7), (9) and (10) are the results of various countermeasures, therefore quantitative target values cannot be set.

(4) Power Factor

Power factor of more than 85%.

(6) Boiler

Air ratio of less than 1.3 and exhaust gas temperature of less than 250°C.

(8) Insulation

Surface temperature of steam equipment and piping at less than 60°C.

B. Projected Effects

As a result of totalling the proposed counter-measures for each factory diagnosed this time, the projected effects become as follows:

Fuel Conservation

Item	Projected conservation	Ratio to amount used
	kl/year	%
Improvement of air ratio and dropping of exhaust gas temperature	209.4	1.6
Reinforced insulation	439.5	3.3
Recovery of condensate	536.6	4.0
Heat recovery from Waste solution	130.4	1.0
Other	55.8	0.4
Total	1,371.7	10.2
Amount of fuel consumption	13,460	(excepting fuel for power generation)

Electric Power Conservation

Item	Projected conservation	Ratio to amount used
	10^3 kWh/year	%
Improvement of air conditioning	4,609.0	2.1
Optimization of motor load	3,010.8	1.4
Effective lighting	663.6	0.3
Optimization of belt	469.7	0.2
Insulation of electric heater	250.3	0.1
Integration of transformer	180.5	0.1
Improvement of power factor	51.7	—
Other	525.4	0.2
Total	9,761.0	4.4
Amount of electric power consumption	219,610	

The number of spindles in the factories diagnosed this time occupies about 13% of the total in Thailand. Assuming that this sampling is representative, fuel conservation of about 10,600 kl/year and electric power conservation of about 75,000 x 10^3 kWh/year is projected for the entire textile industry in Thailand.

4.4 Metal Industry

4.4.1 Outline of the Industry and Relative Positions of the Factories Diagnosed

Nearly all of the products produced by the factories diagnosed in this study were steel products. The demand for steel products in Thailand is estimated at about 1,800,000 tons per year. But now the business depression is continuing, and the operating ratio has decreased considerably.

Five companies using electric furnace have a production capacity of approximately 530,000 tons per year. Of them, the second largest manufacturer was diagnosed.

There are several tens of reroll manufacturers, and some of them are not operating. Of them, two reroll manufacturers, including the largest one were diagnosed.

The production of steel bars, shapes, etc. by electric furnace and reroll manufacturers is estimated at about 300,000 tons per year, and the three factories diagnosed are estimated to cover about 1/4 of the entire production.

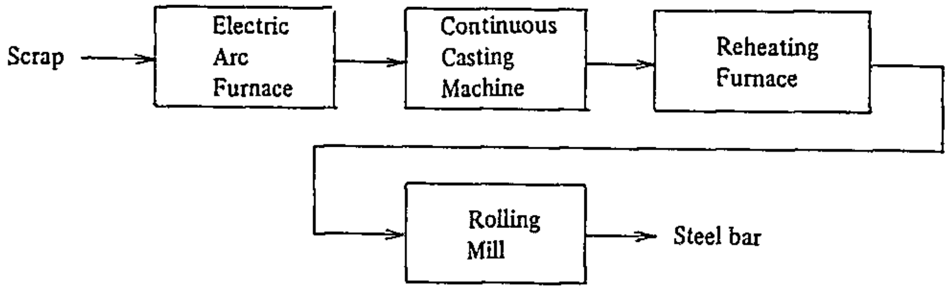
In the production of secondary products such as wire and nails from wire rods, the three factories diagnosed are producing 34,000 tons per year, representing about 1/3 of the entire production. In addition to them, two casting foundries and a tractor parts manufacturing plant were included in the study.

4.4.2 Manufacturing Process and Outline of Facilities

(1) Steel Bars (Electric Furnaces)

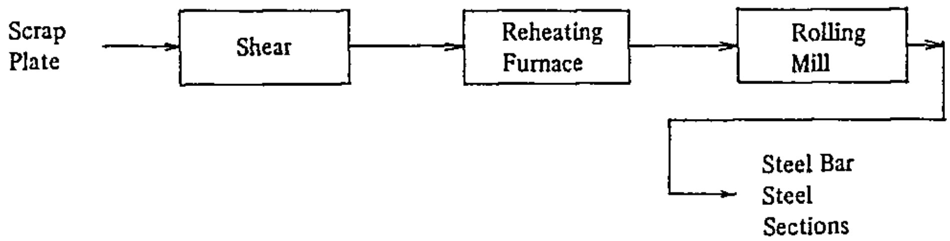
Electric-arc furnaces had no dust collector, and furnace walls, etc. were not water-cooled.

Fig. 12 Manufacturing process chart for steel bar (electric-arc furnace)



(2) Steel Bars and Shapes (Rerolling)

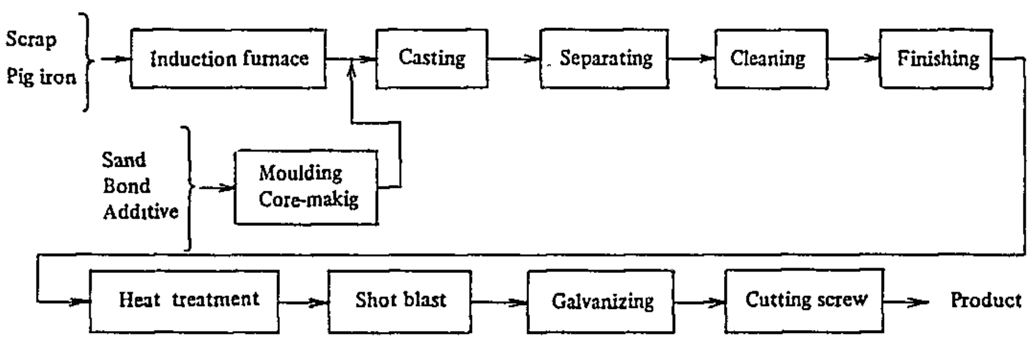
Fig. 13 Manufacturing process chart for steel bar and steel sections (rerolled)



(3) Castings

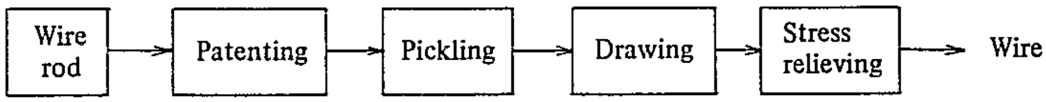
Induction furnaces (low or high frequency) were used as melting furnaces, and no cupolas were used. Channel-type induction furnaces were installed as retention furnaces, but were not operating.

Fig. 14 Manufacturing process chart for casting



(4) Wires

Fig. 15 Manufacturing process chart for wire



4.4.3 State of Energy Consumption

In the metal industry, manufacturing processes and facilities are diverse and energy consumption modes differ accordingly. Examples of energy consumption proportion in the metal industry are shown in Table 4.

Except for the rerolling process, electric power has a larger proportion in terms of cost.

The fuel consumption rate of a new heating furnace with a recuperator for steel bar billets was 53 l/t, compared with 100 to 120 l/t for an old furnace. A one-shift operation which needs heat retention during the night worsens the fuel consumption rate.

The power consumption rate for scrap melting was 600 kWh/t for an electric-arc furnace operating 24 hours a day and was 700 to 750 kWh/t for an induction furnace operating on only one shift. Both levels were generally satisfactory.

Table 4. Actual condition of energy consumption of metal industries

Produce	Manufacturing method	Ratio of energy consumption (calory based)		Major energy consumption equipment
		Fuel	Power	
Bar steel	Electric arc	42%	58%	Reheating furnace Electric arc furnace Rolling mill
Bar steel Section steel	Rerolled	86%	14%	Reheating furnace Rolling mill, Shear
Casting	Electric arc induction	59%	41%	Induction furnace electric arc furnace, Heat treatment furnace
Wire		68%	32%	Heat treatment furnace Drawing machine
Parts of car screw, nail	by machine	–	100%	Electric heater Machine tool

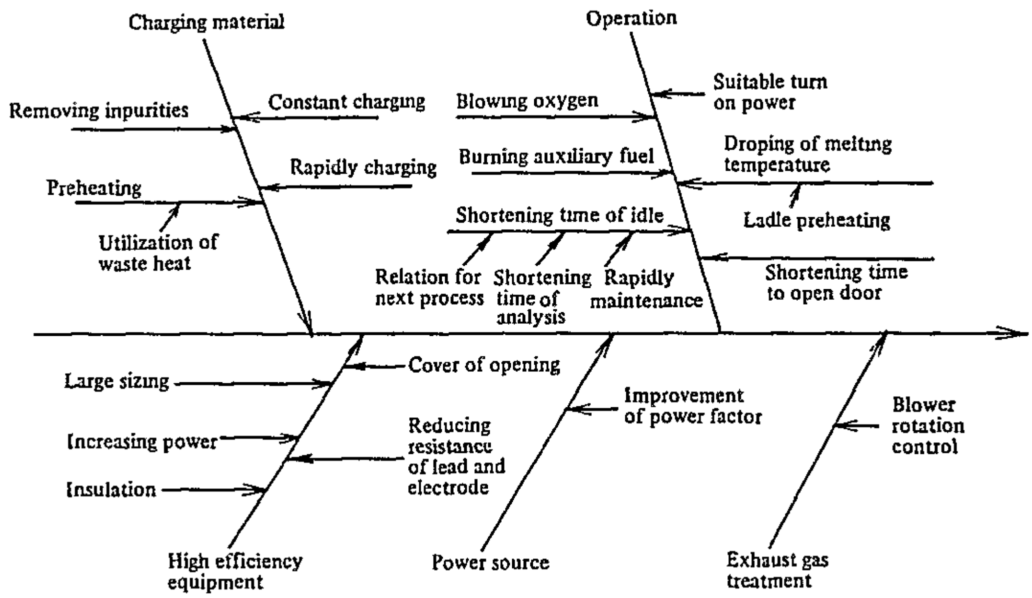
Note: Power is converted on the basis of 860 kcal/kWh.

4.4.4 Major Points of Energy Management

(1) Electric-Arc Furnaces

Fig. 16 shows energy-conservation characteristic factors for electric-arc furnaces.

Fig. 16 Characteristic diagram of electric arc furnace



Energy conservation of 30 to 50 kWh/t by preheating scrap using electric-arc furnace exhaust gases has become a common practice. New ducts and blowers will have to be installed on furnaces that have no dust collectors, as in the factories diagnosed recently, and this will present both space and cost problems. However, it is a very effective means to save energy.

Fuel oil and oxygen are blown into furnaces, instead of using expensive electricity. In this instance, the melting time can be shortened. This should be investigated when studying plans to increase capacity.

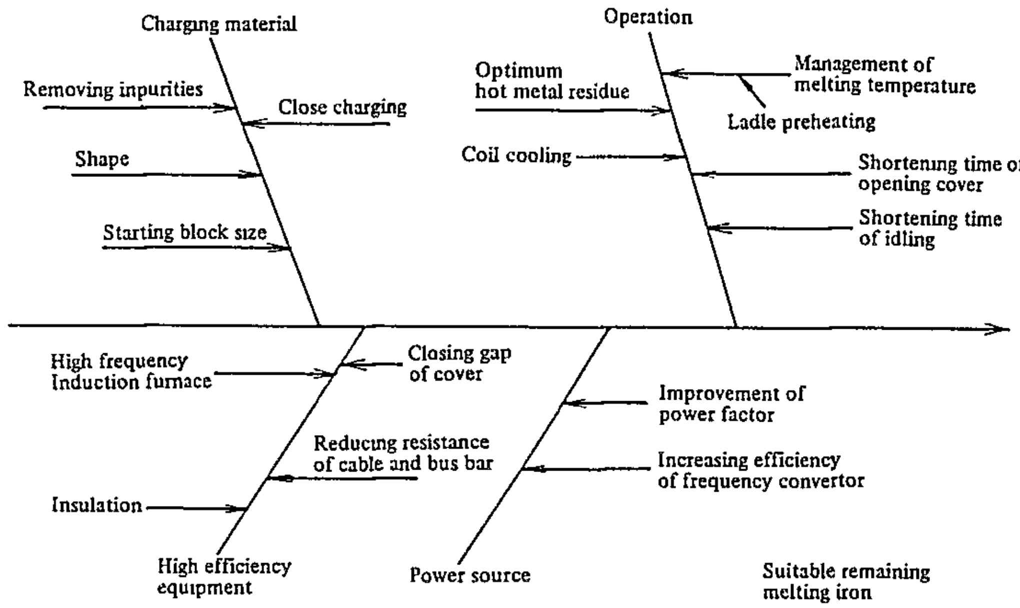
The power charging method also greatly affects the power consumption rate. It is considered advantageous to melt as quickly as possible without damaging the furnace walls. The optimal charging pattern differs depending on the scrap blending ratio and the furnace. Improvements should be made by repeating the process of accumulating operation data and analyzing it. After melting scrap iron, the voltage should be lowered to operate with short electric-arcs in order to reduce energy loss through the furnace walls.

Due to high temperature in furnaces, heat loss from the open sections were great. Doors with good sealing should be installed at the open sections, and the time of opening door should be reduced to a minimum. It is also important to prepare well for the work and to shorten the time for charging, analyzing, standing by, repairs, etc. as much as possible.

(2) Induction Melting Furnaces

Energy conservation characteristic factors for induction melting furnaces are shown in Fig. 17.

Fig. 17 Characteristic diagram of induction melting furnace



The blending ratio of return scraps is high in casting foundries. Accompanied molding sand increases power consumption, and life of refractories is also decreased. It is necessary to thoroughly remove molding sand. Molding sand was well separated in the diagnosed factories.

The speed of temperture rising is very high in induction furnaces, and tends to heat excessively. Proper control of the temperature to avoid overheating is required. In one factory, engineers were present during tapping, instructing the operators when to tap, and this is a good practice.

Much radiation losses, proportionate to the fourth power of the absolute temperature of hot metal, result when there is a gap between furnace and furnace opening cover, or when the furnace covers stay open for a long time. The loss amount for hot metal of 1500°C will reach as much as 220 kW/m^2. The cover clearance should be reduced to a minimum and the opening time, when charging scraps and alloys, should be shortened as much as possible. In the study, two factories had no covers on the furnaces, and gaps were seen around the covers in two factories. One factory was using a cover that assured tight sealing after work. In a low-frequency induction furnace, the starting block size and amount of remaining hot metal affect the efficiency. The furnaces should be operated in various modes to obtain data and to locate optimal amounts.

Cases using high-frequency melting furnaces have increased parallel with advances made by frequency converter equipment. In these cases power density can be increased, rapid melting is possible, and the power consumption rate is reduced by approximately 5%. They are suitable for intermittent operation as they do not require hot metal residue or a starting block. Of the factories diagnosed, one factory was using high-frequency furnaces.

(3) Heating and Heat-Treatment Furnaces

Energy-conservation characteristic factors for heating and heat treatment furnaces are shown in Fig. 18.

Judging from the diagnostic results, the major items to be implemented can be summarized as shown in the following.

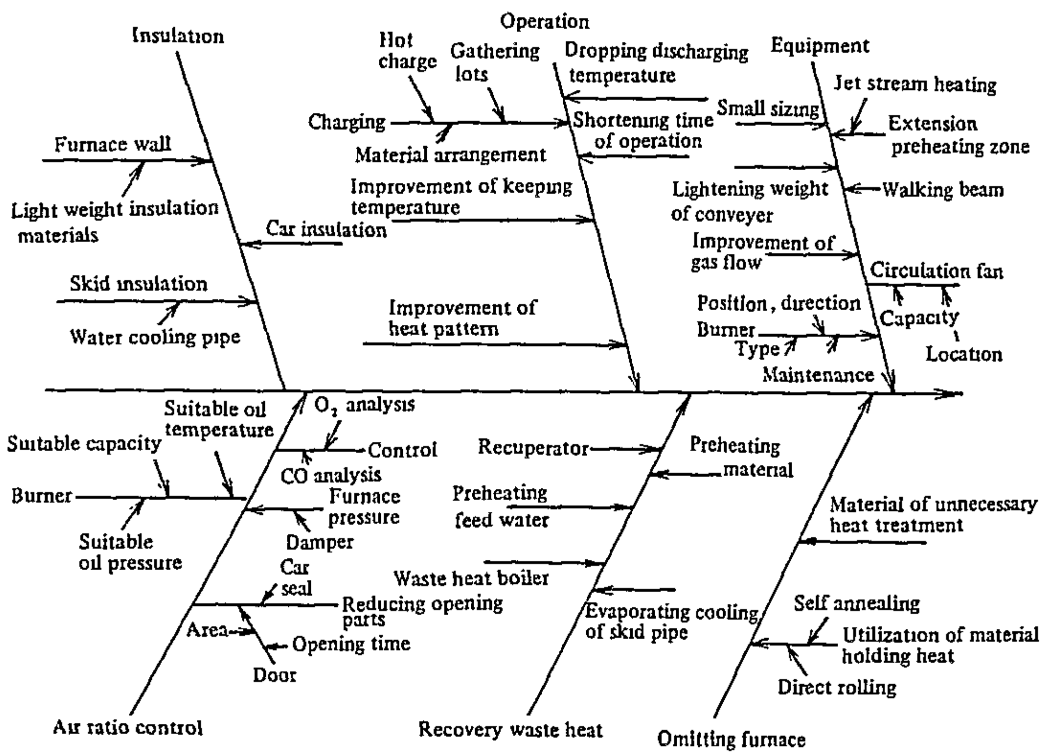
a. Burner Maintenance

It is required to clean burners periodically (about once a week) and to replace them when nozzle diameters expand more than 20%. These will improve oil atomizing and eliminate oil dripping and sparking, permitting low air ratio combustion. Generally, burner maintenance was not adequate. Burners unmatched to the furnace size were used. Poor combustion caused by insufficient preheating of oil could also be observed.

b. Hot Charging

Charging of hot billets extracted from continuous casting equipment into a heating furnace without cooling them is most effective for energy conservation in

Fig. 18 Characteristic diagram of energy conservation for reheating furnace and heat treatment furnace



heating furnaces. When standing by due to unavoidable reasons, such as performing an analysis, hot billets should be placed in insulated pits, etc. to prevent cooling. A factory with continuous casting operations had no layout problems, and hot charging is possible with it.

c. Heat Transfer Improvements in Heating Furnaces

The direction of the movement of heating objects and the flow of combustion gases should be made opposite to each other, and the surplus heat of combustion gases should be utilized to adequately preheat the heating objects. The arrangement of heating objects should be improved so as to make the heat transmission by radiation from the furnace walls and combustion gases in the high temperature sections efficient. Burner layout and direction should also be adjusted. In some factories, chimney locations were not appropriate, and charging of materials into furnaces was inappropriate.

d. Lower Heat Capacity of those other than Heating Objects and Furnace Insulation

In furnaces where heating is performed intermittently, a large portion of heat energy is consumed to heat the furnaces themselves. For this reason, it will be effective to line the interiors of furnaces with fire-resistant insulation materials, as lightweight as possible (ceramic fibers), to minimize the heat capacity.

The heat capacities of the buckets and mesh conveyors used in heat treatment furnaces should also be reduced. Insulation of the carriage upper surfaces will also have a large effect.

e. Waste Heat Utilization

It will be effective to recover the waste heat of combustion exhaust gases from heating furnaces and to utilize it to preheat combustion air. Waste heat recovery equipment should be installed after introducing the foregoing measures and improving the fuel consumption rate. Otherwise, such equipment may become redundant. During the study one factory was seen preheating air utilizing waste heat.

f. Air Ratio

In some factories, gaps caused by improper carriage seal or insufficient structure of doors were large, causing the air ratio to be excessive. Some of the furnaces operating at a low air ratio to prevent decarburization showed incomplete combustion due to an excessively low air ratio. One factory had an air ratio controller. Furnace pressure control was generally inappropriate, and the air ratio control was disturbed.

(4) Motors

Many motors had loose drive belts or fewer belts than required. The foundations of some motors were not fixed. Many motors were operating with a low load. Though the saving is not large enough to justify buying new motors and replacing the present ones, motors with appropriate loads should replace those with low loads when they are due for replacement or at other opportune times.

(5) Power Factor

The power factor was generally low, and large penalties were paid.

The following are the reasons why the power factor is low.

a. Condensers to improve the power factor are not installed.

b. Condensers only for some facilities, such as electric furnaces are installed.

c. A speed control system with a low power factor is employed, and the condensers capacity becomes inadequate when facilities of that system are in operation.

By installing condensers in these plants, penalties can be saved and transformer losses can be reduced to permit recovery of the installation costs in a short time.

(6) Transformers

Generally, the transformer load factor was low, and iron losses can be reduced by integrating transformers. Some transformers can be disconnected during the night or on holidays.

(7) Suppression of Peak Demand

Some factories showed an extreme level of high peak demand compared with mean power. Resistance losses of the power proportionately vary to the square of the current, and the peak demand should be suppressed as much as possible. Excessively large transformers have to be installed when the peak demand is large resulting in increased iron losses.

The load trends should be recorded hourly to suppress the peak demand, and the causes responsible for generating the peak have to be checked and appropriate steps should be taken accordingly. One effective measure will be to stagger the starting times of all machines at the beginning of operations. Otherwise, by installing demand controllers, the peak demand every hour can be forecast based on the electric power that changes from time to time. Facilities that least affect production should be temporarily stopped to suppress the peak demand, when it is likely to exceed targets.

(8) Repairs and Adjustments of Meters

In order to achieve excellent power control, the state of power consumption of the factory should be recognizable every hour. All of the factories diagnosed failed to have adequate meters for this purpose. Voltmeters, ammeters, wattmeters, and reactive power meters (or power factor meters) should be installed on the incoming panels and their readings should be recorded so that necessary steps can be taken as required.

4.4.5. Targets for Improvement and Projected Effects

A. Targets for Improvement

Most major control items are difficult to express quantitatively, therefore, target values are set only for the following two items:

(1) Air ratio Less than 1.3

(2) Power factor More than 85%

B. Projected Effects

As a result of totalling the proposed countermeasures for each factory diagnosed this time, the projected effects become as follows:

Fuel Conservation

Item	Projected conservation	Ratio to amount used
	kl/year	%
Improvement of air ratio and internal pressure of furnace	165.2	2.0
Rationalization of heat transfer	1,495.0	18.0
Reinforced insulation	209.9	2.5
Total	1,870.1	22.5
Amount of fuel consumption	8,310	(excepting LPG)

Electric Power Conservation

Item	Projected conservation	Ratio to amount used
	10^3 kWh/year	%
Improvement of power factor	169.4	0.2
Integration of transformer	514.2	0.7
Improvement of cover on electric arc furnace	337.5	0.5
Effective lighting	48.8	0.1
Other	206.5	0.3
Total	1,276.4	1.7
Amount of electirc power consumption	73,292	

Assuming that the factories diagnosed this time comprise about one fourth of the entire metal industry in Thailand, and that they are representative of the overall situation, fuel conservation of about 7,500 kl/year and electric power conservation of about 5,100 x 10^3 kWh/year is projected for the entire metal industry in Thailand.

II. SEPARATE REPORT
ON
THE INDIVIDUAL FACTORIES

— TEXTILE, METAL —

CONTENTS

Report No. 1: Textile

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

— The Thai Durable Textile Co., Ltd. —

June, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

— The Thai Durable Textile Co., Ltd. —

1. Outline of the Factory

Address	33 Moo 4 Suksawat Rd. A. Prapradaeng	
Capital	650 million Bt	
Type of industry	Textile	
Major products	Blended yarn, Cotton yarn and Textile	
Annual output	Yarn 26.26 million lb, Fabric 40.7 million yard	
No. of employees	4000	
Annual energy consumption	Electric Power	81,684,000 kWh/year
	Fuel	Fuel oil 1,318 kℓ/year
Interviewees	Mr. Jarin President Mr. Boonying Factory Manager Mr. Chaart Assistant Spinning Manager A2 Mr. Pravet Assistant Spinning Manager A1	
Date of diagnosis	Jan. 13 ~ 14, 1983	
Diagnosers	K. Nakao, Y. Ohno, M. Matsuo	

The factory is an enterprise with 100% Thailand capital. Having 100,000 spindles, the factory ranks in the top ten textile factories in Thailand. Its products are sold only in Thailand, and its share of the domestic market is approximatley 15%.

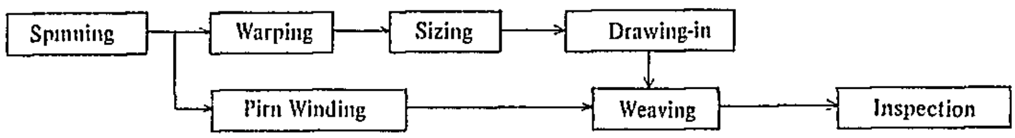
The factory manufactures polyester-cotton and rayon-cotton mix spinning yarn, cotton yarn, and woven fabrics.

The factory is divided into two plants, A1 and A2, each having processes from raw material treatment to woven fabrics. The A1 factory is about 20 years old, and the A2 factory about 11 years old.

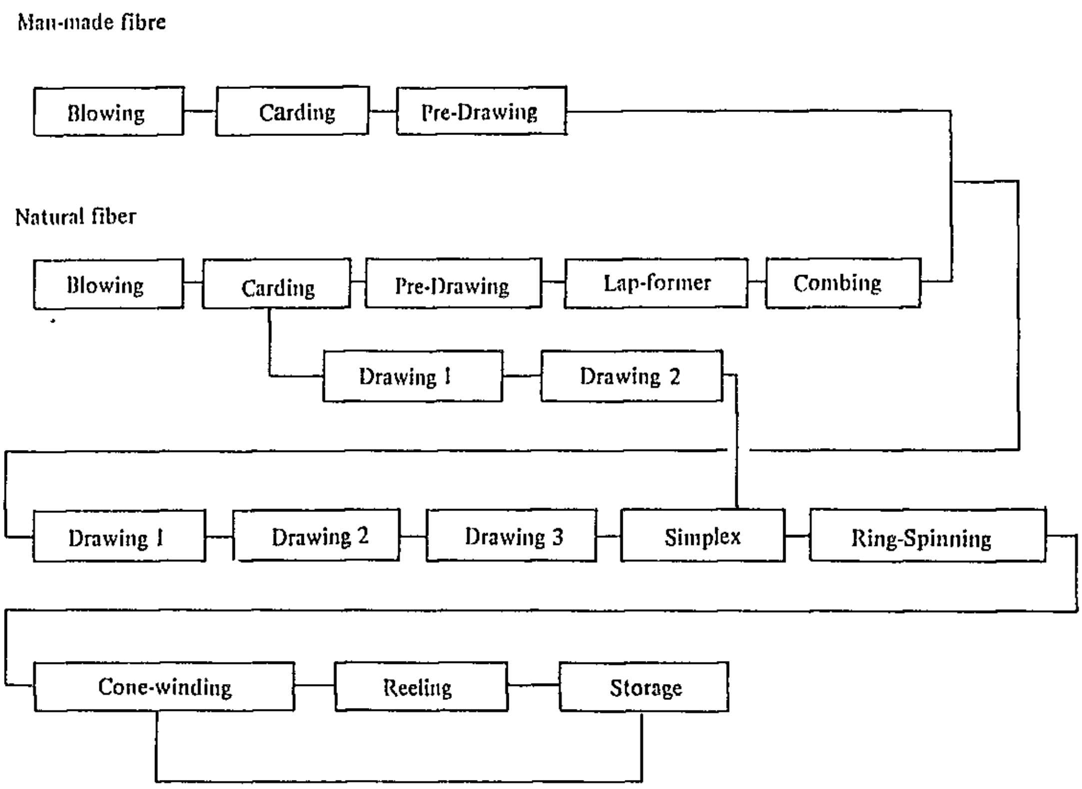
The factory were operating at full capacity.

2. Manufacturing Process

Weaving Process



Spinning Process

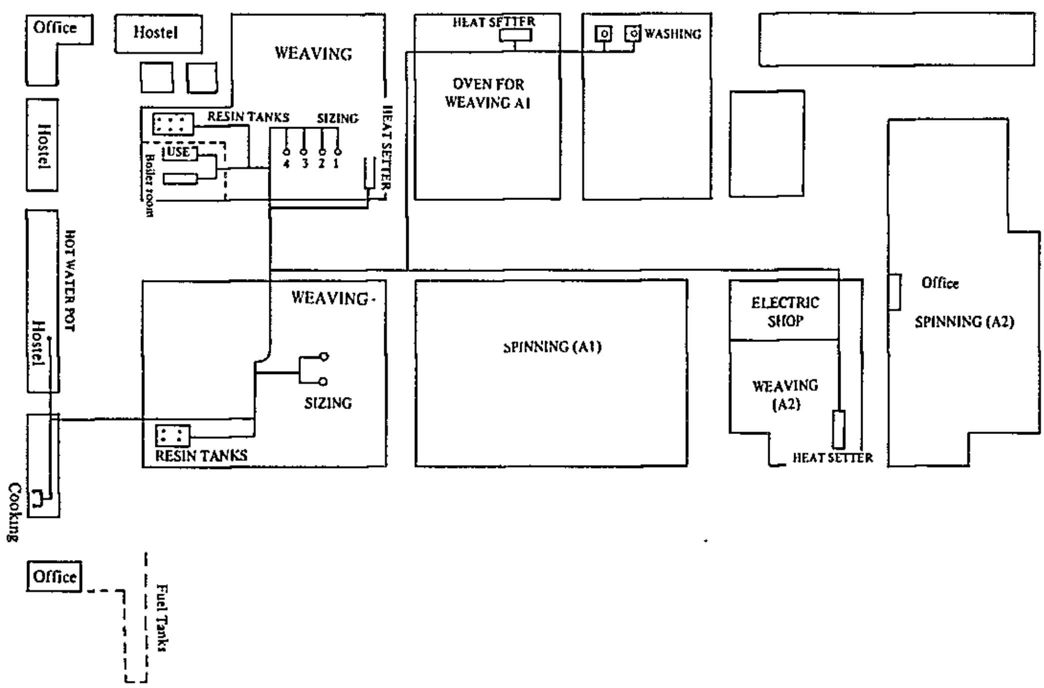


3. Major Equipment

3.1. Major Equipment

Name	No. of unit installed	Specification
Tenter	6	Horizontal drum, Steaming under vacuum (Made by Weeker, W. Germany)
Sizing machine	6	Drum type dryer (Made by Zell, W. Germany)
Boiler (on service)	1	Rated evaporation 4.7 t/h Working pressure 6 kg/cm^2 (Made by Cleaver Brocks, U.S.A.)
Boiler (Stand-by)	1	Rated evaporation 6.3 t/h Working pressure 6 kg/cm^2 (Made by Thompson Boiler, U.K.)

3.2. Layout



4. State of Energy Management

Since last year, training has been undertaken at the TPA to which members staff have been sent. The stage is for preparation before starting specific activities.

4.1. Targets and Investments

Management desires to save about 10% of its monthly electricity bills which total about 11 million Bt. In order to acocmplish this, the factory has already placed its order for portable meters (power factor meters, kWh meters and ammeters etc.). Specific policies and target levels should be explained and shown to all employees after setting concrete target levels.

4.2. QC circle and Energy Conservation Organization

QC circle activities have already been started by staff members. The activities should be now spread to the lower echelons.

Regarding an organization to promote energy conservation, it is discussed at weekly meetings of department managers headed by management director as a matter concerning the entire factory. To further promote energy conservation, a committee specifically set up for this purpose is needed. The committee composition should be expanded to include factory foremen and leaders to demonstrate that everyone is participating in the drive.

4.3. Grasping Energy Consumption

Power consumption is measured daily and fuel consumption once a month. Power consumption rates are calculated and distribution of power consumption is broken down by processes. Good overall energy management is enforced, particularly for electric power.

Records and data are valuable assets and should be utilized more, such as for calculation of consumption rates for yarn count conversion and data analysis, which would result in more thorough management in order to make further improvements.

5. State of Fuel Consumption

Fuel is used to produce boiler steam, which is used in heat setters, sizing machines, glue cookers, dormitory cafeterias, hot water for washing, etc.

Bunker A was used as fuel oil. The factory began to use bunker C beginning in

January for testing purposes. The factory consumes 1,318 kl of fuel oil a year. Boiler feed water is fed after deaerating in an open heating type deaerator (95 to 100° C). Condensate is recovered only from the sizing machine and glue cooker in the A1 Factory for return to the deaerator.

5.1. Efficiency Calculations Based on Performance Values

(1) The fuel consumption and feedwater quantity for three months October ~ December, 1982, are shown in the following.

Quantity of feedwater	5,164.9 t	2,418 kg/h
Quantity of blow water	5%	121 kg/h
Evaporative amount of steam		2,297 kg/h
Fuel consumption	361,255 l	169.13 l/h (157.88 kg/h)
Days worked	89 days	
Operating Hours	24 h	

(2) Boiler Efficiency

$$\eta = \frac{(W - B)(E_S - E_F)}{F \times Hl + Q_S} \times 100$$

$$= \frac{2{,}297 \text{ kg/h} \times (659.5 \text{ kcal/kg} - 70 \text{ kcal/kg})}{157.88 \text{ kg/h} \times 9{,}802 \text{ kcal/kg} + 4{,}973 \text{ kcal/h}} \times 100 = 87.2\%$$

Note 1: Bases for Boiler Efficiency

Fuel type		Fuel oil A
Fuel consumption	(F)	157.88 kg/h
Heat content of fuel (Low level)	(Hl)	9,802 kcal/kg
Specific gravity of fuel	(S_G)	0.9335
Specific heat of fuel	(C_P)	0.45 kcal/kg
Temperature of fuel	(T_F)	100°C
Reference temperature	(T_O)	30°C
Quantity of blow water	(B) 5%	121 kg/h
Temperature of blow water	(T_B)	165°C
Quantity of feed water	(W)	2418 kg/h
Temperature of feedwater (Softened water + condensate)	(T_W') (Estimate)	70°C
Temperature of feedwater after deaeration	(T_W)	95°C
Steam pressure	(P)	6 kg/cm^{2}G

Note 2: Quantity of Evaporation (S)

$S = W - B = 2{,}297$ kg/h

Enthalpy of Steam	(E_S)	659.5 kcal/kg
Enthalpy of Feedwater	(E_F)	70 kcal/kg

5.2. Boiler Heat Balance

- Measurements of Fuel Consumption

The boiler heat balance was calculated based on values measured in two hours between 11:12 a.m. and 1:12 p.m. on the day the survey was made. The steam quantity was counted back as the feedwater meter was out of order.

Input			Output		
Item	10^3 Kcal/h	%	Item	10^3 Kcal/h	%
Heat of fuel combustion	1,761.4	99.7	Heat of steam	1,564.1	88.5
Sensible heat of fuel	5.7	0.3	Heat loss in exhaust gas	163.7	9.3
			Heat loss in blow water	0	0
			Heat release from boiler body	39.3	2.2
Total	1,767.1	100.0	Total	1,767.1	100.0

Note 3: Heat Balance Calculations

Fuel type		Fuel oil A
Fuel consumption	(F)	179.7 kg/h
Heat content of fuel (Low level)	(Hl)	9,802 kcal/kg
Specific gravity of fuel	(S_G)	0.9335
Oxygen content in exhaust gas	(O_2)	4.6%
Exhaust gas temperature	(T_G)	230°C
Quantity of blow water	(B)	None

Other (Same as in Note 1)

Note 4: Equations for Calculating the Heat Balance

Input

Heat of Fuel Combustion (Q_e)

$$Q_e = F \times Hl = 1{,}761.4 \times 10^3 \text{ kcal/h}$$

Sensible Heat of Fuel

$$Q_S = F \times C_P(T_F - T_O) = 5.7 \times 10^3 \text{ kcal/h}$$

Output

Heat Loss in Exhaust gas (Q_E)

Theoretical amount of air

$$A_O = 0.85\ Hl/1{,}000 + 2.0 = 10.35 \text{ Nm}^3/\text{kg}$$

Theoretical amount of exhaust gas

$$G_O = 1.11\ Hl/1{,}000 = 10.90 \text{ Nm}^3/\text{kg}$$

Air ratio

$$m = 21/(21 - O_2) = 1.28$$

Actual amount of exhaust gas

$G = G_O + A_O(m - 1) = 13.80\ Nm^3/kg$

$Q_E = F \times G \times 0.33\,(T_G - T_O) = 163.7 \times 10^3\ kcal/h$

Heat Loss in Blow Water (Q_B)

$Q_B = 0$

Heat release from boiler body and other heat losses (Q_R)

Heat release from boiler body (Q_r)

$Q_r = 12.7 \times 10^3\ kcal/h$

Other heat losses (Q_O)

$Q_O =$ Heat Input x 1.5% $= 26.6 \times 10^3\ kcal/h$

$Q_R = Q_r + Q_O = 39.3 \times 10^3\ kcal/h$

Heat of Steam (Q_V)

$Q_V = Q_e + Q_S - Q_E - Q_B - Q_R = 1{,}564.1 \times 10^3\ kcal/h$

Quantity of Evaporation (S)

$S = Q_V \div (E_S - E_F) = 2{,}653\ kg/h$

6. Problems in Heat Contorl and Potential Solutions

6.1. Reinforced Heat Insulation

(1) Steam piping is long and its support sections are not insulated.

Facilities in the factory consuming steam (6 sizing machines and 3 heat setters are the main facilities) are scattered over an area measuring 40 acres. The total length of steam piping connecting the boiler room with these facilities counting only the main pipes, is 450 m. (See Plant layout)

More than 90% of these main pipes are insulated. In particular, the outdoor portions of the piping were carefully racked using galvanized steel sheet. However, no consideration was given to supported parts and flanges to insulate them.

(2) Sizing Machines

Dished plates on the sides of the drying cylinder, bottom and side surfaces the sizing tanks, steam pipes inside buildings and by the machines, headers, pressure contorl valves, valves, and recovery condensate pipes needed insulation.

(3) Glue Cooker

All dissolving tanks are not yet insulated. Measures to prevent heat loss such as insulating tank side walls and installing lids are needed.

All six storage tanks are insulated. In the A1 factory, the external steel plate of the tanks was severely corroded, and some of these needed replacement.

Surface temperature of the cooker was high in the A1 factory, and steam was leaking from the agitator glands in the A2 factory. Some steam pipes had no insulation.

(4) Boiler

The following sections related to the boiler needed insulation: Header and main steam valve, 1-1/2" conecting pipes (approx. 3.5 m) between 2 sets of float-type water level meters and the boiler condensate return pipes to deaerators, and 2" boiler feedwater pipes (approx. 13 m) between deaerators and the boiler.

(5) Steam leakage was not so much but from the union of heat setter valves in the kitchen, valve glands of sizing machine , etc.

Generally speaking, management of insulation and steam leakage was good. Table hereunder shows results which may be obtained by insulating the foregoing sections.

Effects of Insulation

Plant or facility	Specification of equipment for insulation	Skin temp °C		Heat loss Kcal/h m²		Save by insulation		Fuel cost to be saved (Bt/y)	Insulation cost (Bt)
		before Insu	after Insu	before Insu.	after Insu	Hourly	Yearly x 10³ Kcal		
Steam piping (5 Kg/cm²)	Pipe support 90 pcs Pipe flange 90 sets	130 130	51 51	1,484 1,484	214 214		36,300 65,900	20,300 36,800	5,000 6,000
Sizing machine	Shell plate of dryer drum	120	48	1,287	178	40,257 Kcal/h 6 sets	340,000	190,200	3,000
	Glue tank 1,300W x 2,000L Depth = 300 mm Surface area 4 6 m²	90	40	760	90	18,490 Kcal/h 6 sets	156,200	87,400	18,000
	Steam piping 2½" pipe 4 mL x 6 pcs 2" pipe 3 5 mL x 6 pcs 2" press regulator 3 units x 4 (eqv length = 18 6 m) 2" strainer 4 units 2½" press regulator 5 units 2½" globe valve 4 units (total eqv. length = 17.5 m)	120	48	1,287	178	10,800 Kcal/h 6 units 14,880 Kcal/h total 25,680 Kcal/h 6 units	216,900	121,300	26,000
	Piping of recovered condensate 1" x 16 mL/6 units	90	40	760	90	2,830 Kcal/h 6 units	23,900	13,400	4,000
Steam condensate piping to boiler	1" x 20 mL 1½" x 80 mL	90	40	760	90	20,140 Kcal/h	170,100	95,100	25,000
Glue cooker (A – 1)	Solution tank 1,100φ x 1,530H x 2 units Surface area 5.7 m² x 2	88	40	728	90	7,340 Kcal/h 2 units	62,000	34,700	12,000
	Cooker 1,300φ x 1,900H Surface area 9 1 m²	85	40	680	90	5,370 Kcal/h unit	45,400	25,400	8,000
Boiler plant	Feed water pipe 2" x 13 mL/valves on steam header/main block valve/ connecting pipe of level gage to boiler drum 1½"x 3 5 m					5,060 Kcal/h	42,800	23,700	

Remark The glass wool with thickness 25mm is availed as insulation material.

6.2. Effective Utilizaiton of Condensate

Condensate was recovered only from the sizing machines, which were relatively close to the boiler. Condensate generated by other machines was discarded in the pits. Condensate from the 3 heat setters and from the double rice cooker in the kitchen should be utilized as hot water for washing because the return distance to the boiler is long and because only a small quantity of condensate is generated.

Condensate discharged by the drying cylinders of the sizing machines can be utilized better in effective utilization of steam by collecting it in a flash tank, instead of returning directly to the boiler as it is, and by using steam re-evaporated in it as part of the glue solution process steam. When flashing condensate of 2 kg/cm^{2}G at a pressure of 0.5

kg/cm^{2}G, 22% of its heat is transferred to flash steam.

$$\text{Flash evaporation rate } \frac{133.4 - 109.5}{533.0} = 0.045$$

$$\text{Heat of flash steam } \frac{642.5 \times 0.045}{133.4} = 0.22$$

6.3. Heat Setters (3 Units)

The doors were left open after work was over and before the next cycle started. Unnecessary opening of the doors only accelerates body cooling and increases the energy needed to reheat the body. The operators should be told not to open the doors unnecessarily. Insulation of steam pipe and body were good for the 3 heat setters. The valve of setter No. 2 in particular was insulated, and the valves for setters No. 1 and 3 should also be insulated in the same manner.

6.4. Boiler

(1) Fuel Combustion

Air ratio control was relatively good with satisfactory values of a 4.6% oxygen content in the exhaust gas and an air ratio of m = 1.28.

(2) Feedwater Flowmeter

The feedwater flowmeter was out of order. It needs to be repaired immediately. It is essential for efficient operation of the boiler to monitor variations in the ratio between the feedwater quantity and fuel quantity, that is, evaporation ratio. If possible, a flowmeter solely for softened water should be installed to check condensate recovery.

(3) Temperature of Exhaust Gas

The exhaust gas temperature was 230°C. A high exhaust gas temperature indicates low heat transfer due to a soiled smoke tube. The exhaust gas temperature should be measured at all times to monitor its variations.

(4) Boiler Water and Blow Quantity

Records of analysis of water quality were as follows.

	Softened Water	Feedwater	Boiler Water
PH	6.75	7.0	11.5
Electrical conductivity	800	700	4,000
Total dissolved solid	1,244	1,008	5,424
Total hardness	3	5	19
Chlorine ions	800	600	3,000

Phosphoric acid ions, sulfuric acid ions, and silica should also be analyzed.

Boiler water PH and electrical conductivity were good. Total dissolved solids must be maintained at a level of approximately 3,500 ppm. The level of chlorine ions should be maintained at about 500 ppm. The measured value was anomalously high. The level of chlorine ions in softened water was high, and it should be checked whether washing of reclaimed salts in the softner was actually done.

If the cause can be traced to raw water chlorine ions in the analysis, permeation of seawater in the well can be suspected. The raw water well should be changed, or dechlorination by a basic ion exchanging resin should be considered in the future.

We understood that boiler compounds were used. To prevent rusting on th boiler inner surfaces, a sodium phosphate chemical will be needed. A residual quantity of 20 to 40 ppm of phosphoric acid ions is needed in the boiler water.

(5) Boiler Load Factor

The boiler load factor was low, approximately 60%. It is recommended that the load states such as the hot water utilizaiton rate be studied on a long range basis and exchanging the boiler for one with a capacity suiting the load should also be studied.

7. State of Electric Power Consumption

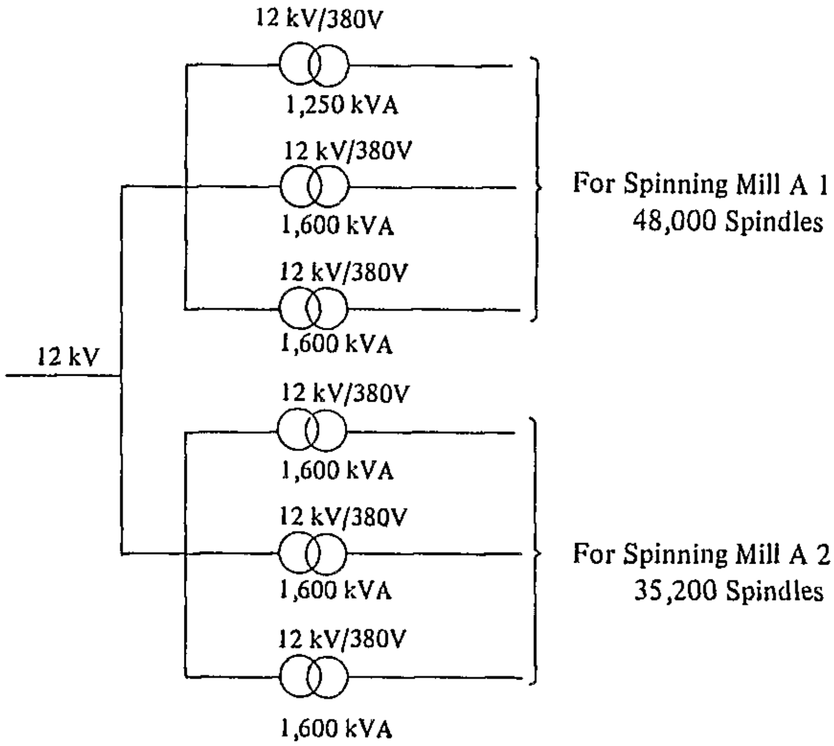
7.1. The Principal Data Relating to Power Consumption

• Power company	:	MEA
• Peak demand	:	10,980 kW
• Power consumption	:	81,684,000 kWh/year
• Load factor	:	88.6%
• Penalty	:	No penalty
• Power factor	:	90%
• Transformers	:	12,000 kVA
• Power consumption rate	:	yarn 2.333 kWh/lb
		cloth 0.502 kWh/yard

7.2. Load composition

• Motor	:	49.9%
• Air conditioning	:	45.8%
• Lighting	:	3.1%
• Compressor	:	1.2%
Total		100 %

7.3. One Line Diagram



8. Problems in Electric Power Control and Potential Solutions

8.1. Significant Achievements

The following achievements are found in the plant.

8.1.1. Motors in Fine Spinning Process

The factory accepted advice given by consultants to use energy conservation type motor belts and roller bearings in all rotating sections to reduce transmission losses. The factory's efforts have been successful.

The motor speed is changed by changing pulleys in accordance with the yarn counts to accomplish two purposes — energy conservation and prevention of end breakages.

8.1.2. Improved Power Factor

The power factor has been increased to 90% by installing condensers having appropriate capacities for effective use of power.

8.1.3. Energy Conservation in Air Conditioning

Each production process has a setting for the temperature and humidity needed for industrial air conditioning. The quality of products is assured by controlling chillers dampers, etc. linking with 26 sensors to maintain temperature and humidity.

8.2. Problems and Solutions

8.2.1. Optimization of Motor Capacity

The load factors of large-capacity motors in main processes, namely, (Actual load/Rated capacity) were measured. Almost all motors were operated in the high efficiency range of 80 to 100% load factor.

The load factors of eight 26 kW motors in the twisting process were 22.2%, and a total of 34 motors were found to be in the low load factor range.

It is possible that the loads were low only when the measurement was made. Data should be gathered continuously. If the load factors are always low, motors with appropriate capacities should replace those currently in operation at appropriate times.

Process	capacity	Units	Load Factor
• Ring-twisting	11kW	22	58.6%
• Twister	26	8	22.2
• Water-pump	22	4	53.6

The energy conservation effect of this plan can be calculated as shown in the following.

Motor Capacity	Efficiency	Loss	No. of Units	Reduced loss
kW	%	kW		kWh/year
11 → 7.5	89.5 → 87.5	1.16 → 0.94	22	39.160
26 → 7.5	83.0 → 87.5	4.42 → 0.94	8	228.106
22 → 15	90.0 → 91.0	2.20 → 1.35	4	27.826
Total				294.990

Electric power savings 294,990 kWh/year

Savings ratio 294,990 kWh/year ÷ 81,684,000 kWh/year = 0.4%

Note: Due to a time consideration, measurements could be made of the A2 factory only. It is assumed that the A1 factory would show a similar trend.

8.2.2. Lower Fabric Fraction Defective

(1) At present, approximately 10% of the fabrics are defected. This means that 10% of the energy input to manufacture fabrics is wasted, and this is a large energy loss.

(2) Fabric defection can be attributed to the following reasons:

a. There is quite a large amount of floating cotton which attaches to the yarn during the fabric weaving process, causing "nodes" on the fabric.

b. The weaving machines vibrate considerably, causing substantial fabric "twisting" and end breakage.

c. The weaving machine motor belts are excessively loose, and many of them had fewer belts than required. This caused insufficient transmission of energy to the weaving machines and "loose" fabrics.

(3) The following countermeasures can lower the fabric fraction defective.

a. Elimination of Floating Cotton

A cleaner for this purpose is assigned to thoroughly eliminate floating cotton on the floor and on ventilator duct.

After humidifying the air to the extent that it does not affect quality, fine floating cotton drifting in the air drops onto the floor and is cleaned up.

b. Prevention of Vibration

Antivibration rubber or antivibration springs are fitted underneath the feet of the weaving machines to prevent vibration of the weaving machines.

c. Increased Illumination

The average illumination was 135 lux and was not enough for precision work such as ending. After thoroughly removing floating cotton, the illumination should be increased to approximately 200 lux to increase the work efficiency and lower the rejection rate.

The average illumination for the warping process was 120 lux and was not sufficient for precision work. The illumination should be increased to about 200 lux in terms of quality control.

d. Optimal Motor Belt Tension

Approximately 10% of the motor belts were excessivley loose. The optimal motor belt tension is when the belt lowers by its thickness when the belt is pushed down by a thumb applying normal force.

8.2.3. Lower Yarn Fraction Defective

(1) At present, about 2% of the yarn is defected. and the bulk of this defection can be attributed to floating cotton.

(2) A large number of cleaners are used in the fine spinning process to clean the principal parts of the fine spinning machines and floors. However, a considerable quantity of floating cotton can still be found, and floating cotton should be thoroughly cleaned up and removed by the method described in Paragraph 8.2.2. — Lower Fabric Fraction defective.

(3) The spinning process had the following average illumination, which is generally the appropriate level:

Scutching	97 lux	Carding	75 lux
Spinning	114 〃	Winding	152 〃
Inspection	239 〃		

8.2.4. Reduced Air Conditioning Power Consumption

(1) The present air conditioning provides temperatures of 28 to 30°C and humidity of 42 to 55%, controlling the temperature and humidity within ±1°C and ±2%, respectively.

(2) Measurements in the A2 factory and weaving factory showed the following results.

Process	Temperature	Humidity
Scutching	27.1°C	58.6%
Spinning	28.3	46.1
Winding	28.1	48.2
Inspection	26.0	75.4
Weaving	28.5	74.0

(3) The temperature and humidity are currently set for two seasons, summer and winter, and the number of chiller in operation is controlled. However, control of the number of chiller in operation by setting the temperature and humidity according to the temperature differences in the morning, afternoon and evening is not conducted.

(4) Large energy conservation can be accomplished by setting the temperature and humidity precisely in accordance with variations in the season and time of day and by means of automatic control using a microcomputer, if necessary. This should be accomplished after sorting out the air conditioning in individual production processes and after making minute adjustments such as duct blow out wind quantities.

(5) It is also important to clean the nozzles of the atomizer equipment used to adjust humidity and ventilation filters which may be clogged with floating cotton. Ducts should also be cleaned thoroughly.

Assuming that the obstruction to the air conditioners could be reduced 5% after taking the foregoing steps, the following energy conservation effect can be considered.

Electric power savings	4,857 kW x 0.05 x 24 h x 341 day
	≑ 1.987,480 kWh/year
Saving ratio	1.987,480 kWh/year − 81,684,000 kWh/year
	≑ 2.4%

9. Summary

The abovementioned remedial measures, if actually taken, will bring about energy-saving effects as shown.

	kl/year	%
Insulation	143.9	10.9

	10^3 kWh/year	%
Motor capacity changes:	295.0	0.4
Reduced electric power for air conditioner	1,987.5	2.4
Total	2,282.5	2.8

Report No. 2: Textile

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

— Union Thread Co., Ltd. —

June, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

— Union Thread Co., Ltd. —

1. Outline of the Factory

Address	32/3 Ladpraw Rd. Twangthongrang A. Bangkapi Bk.		
Capital	200 million Bt		
Type of industry	Textile		
Major products	Synthetic fiber, Cotton fiber, Dyeing fiber		
Annual product	2,300,000 lb/year		
No. of employees	1,600	1 Shift	Spinning 250 Dyeing 150
Annual energy consumption	Electric Power		11,988,000 kWh/year
	Fuel		Bunker C 597,990 ℓ/year Diesel Oil 15 kℓ/year
Interviewees	Mr. Surachai, Mr. Anon Mr. Supason and 4 person		
Date of diagnosis	Jan. 24 ~ 25, 1983		
Diagnosers	K. Nakao, Y. Ohno and M. Matsuo		

Combing yarn made of cotton and mixed carding yarn with synthetic fiber (polyester, polynosic and rayon) are produced in 50% shares.

The number of spindles is 12,000 and the current maximum production capacity is 2.3 x 10^6 lbs/year. Full operation at present. Eighty percent of the product is dyed for sale and the remaining 20% is sold as raw yarn.

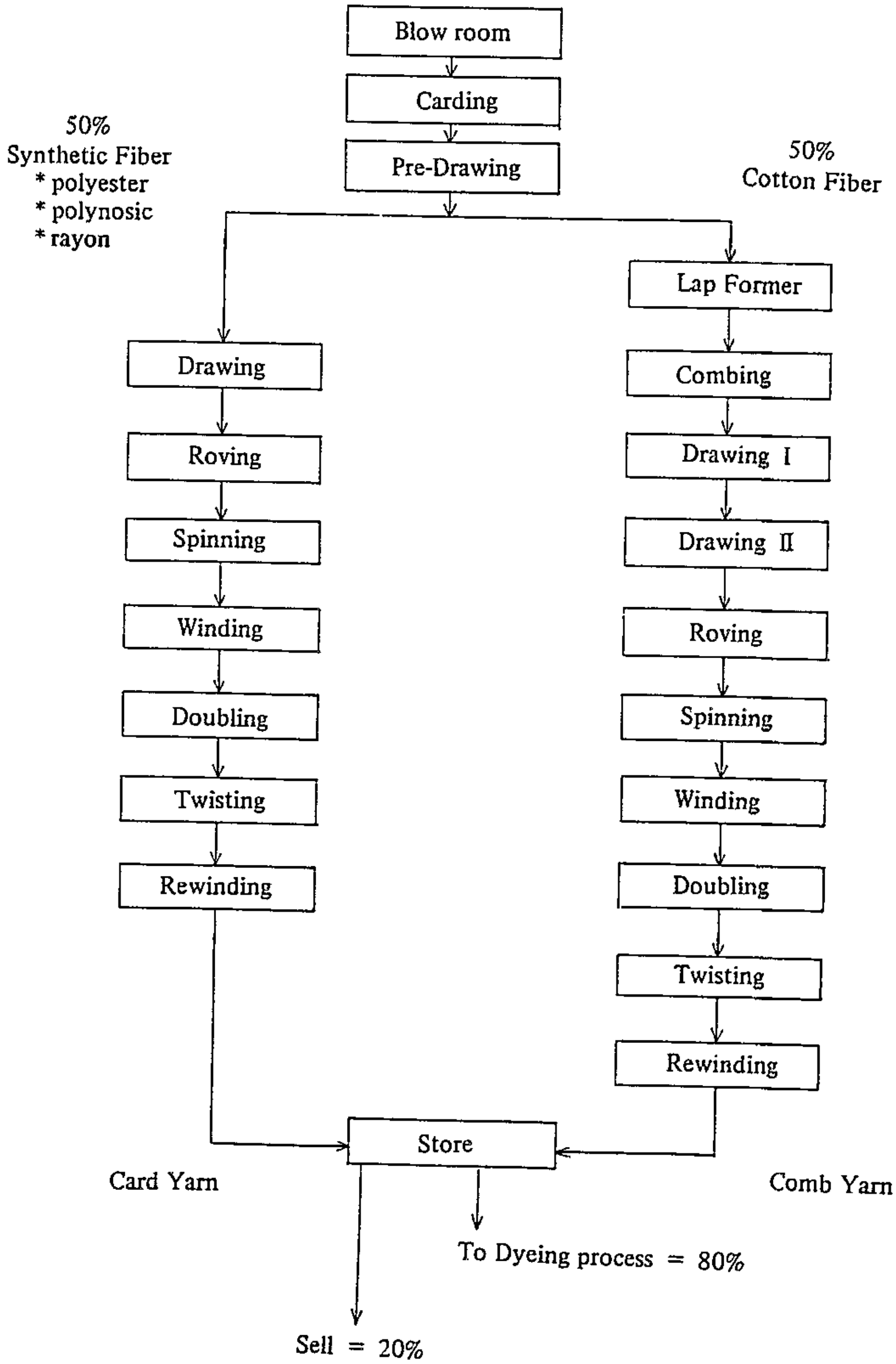
Cotton materials originating in Thailand and Egypt are used and synthetic fiber is supplied from Thailand Teijin Polyester, with the exception of occasional imports from Taiwan.

This factory belongs to the Union Group and was constructed in 1972. Although the factory received technical assistance during a business relationship with Kanebo, Ltd. in the initial six-year period, capital was thereafter supplied in Thailand. Currently, an engineer retired from Unitika, Ltd. is employed at the factory.

It should be noted that as many as 12 electrical engineers and 7 heat management engineers are employed and are receiving practical training. The factory is well maintained. A safety route is laid out and all employees wear uniform and cap, giving a neat appearance.

It was very impressive that a list of ten items to achieve employee, as well as management, teamwork was displayed at the plant office as a slogan.

2. Manufacturing Process

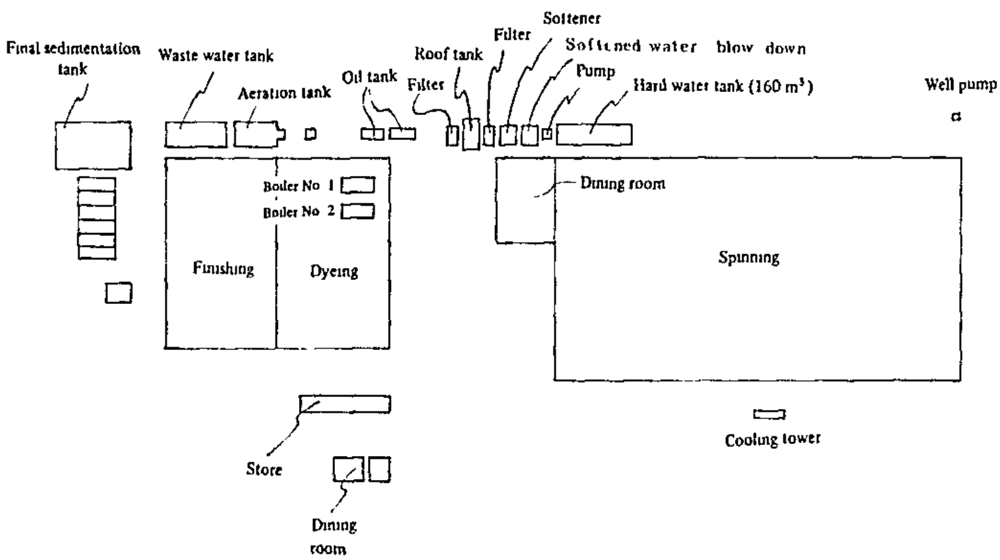


3. Major Equipment

3.1. Major Equipment

Name	No. of units installed	Type, etc.
Dyeing machine		
Hank dyeing machine	3	Normal pressure type 25 kg/cycle
	3	Increased pressure type 25 kg/cycle
Cheese dyeing machine		Increased pressure type
	1	300 kg/cycle
	2	〃 100 kg/cycle
	3	〃 75 kg/cycle
	3	〃 50 kg/cycle
Dryer	2	Cone dryer
	1	Hank yarn dryer
Boiler	2 One is stand by	IHI–KMH4 Evaporating volume 2 t/h Operating pressure 7 kg/cm^2

3.2. Layout



4. State of Energy Management

Efforts are being made to promote energy saving but concrete targets have not been set.

Though special investment for equipment to conserve energy has not been made to date, it was reported that the number of fluorescent lamps was reduced and a part of the condensate was recovered.

They intend to actively carry out measures hereafter if a two-year recovery period of investment is possible.

4.1. Grasp of Energy Consumption

Concerning the amount of energy consumed, electricity is recorded once every two hours, fuel is recorded every hour and a watt hour meter is installed for each major process to calculate consumption rate. A monthly control report for the boiler is prepared and data are well maintained. Various instruments are under an excellent control system.

Though a control chart was not prepared and an analysis of factors was not executed, it was reported that an analysis of factors was executed as a penalty was added to the energy charges for the first time last month.

We recommend further upgrading. By pinpointing problems in the collected data and improving with consistent efforts.

4.2. Energy Conservation Committee and Suggestion System

Judging from the fact that the energy conservation committee was established and then was abolished after three months of inactivity, it is believed that its method and procedures were incorrect.

It is desirable that the energy conservation committee be expanded to an organization which includes shop foremen, because employees working in the shop are best acquainted with the nature of the problems and the actual conditions in the shop.

It is essential to set a policy and a goal, inform the employees and to propose a problem area.

It is at times effective to perform an activity using a project team.

All parties concerned must not be satisfied with the current state of energy use and operating procedures, but it is important for them to improve efficiency based upon their wisdom.

We hear that there is a suggestion system and we expect its utilization in the field of energy conservation and the promotion of suggestion by means such as award systems.

4.3. Employee Training

Staff members are dispatched to a TPA seminar. We consider it important and beneficial to upgrade all employees.

A seminar within the company is necessary so that this intention extends to employees within the substructure.

In addition, it is also valuable that the promotion of energy conservation is encouraged by such means as posters. It is an important factor in promoting energy conservation that all employees are aware and have a sense of participation.

4.4. Others

The plant is geneerally in good order and safety routes are well maintained.

All employees wear a uniform and cap and are neat.

5. State of Fuel Consumption

5.1.

598 kl/year of the bunker C fuel oil is used to generate steam for a boiler. Almost all of the generated steam becomes a heating source for a dyeing mahcine and dryer.

A part of the condensate from the dyeing machine and dryer is recovered but the current recovery rate is 50 to 60%.

5.2. Boiler Control Monthly Report Prepared by the Factory

Boiler No. 2 date 11 – 1982 Bunker C price 4,504 Bt/ℓ

Description	Unit	Amount	Remarks
Oil consumption	ℓ	53,575	241,301.8 Bt
Balance (last month)	ℓ	19,915	
Receive	ℓ	48,000	
Balance	ℓ	14,340	
Feed water	ℓ	767,423	
Blow water	ℓ	97,300	
Conversion	Kg	52,235.6	SG = 0.975
Heat value of oil	Kcal/Kg	10,000	
Steam enthalpy	Kcal/Kg	659.6	
Feed water enthalpy	Kcal/Kg	51	
Boiler water enthalpy	Kcal/Kg	165	
Average steam pressure	Kg/cm^2	6	
Efficiency	%	80.2	
Evaporation multiple		12.8	
Steam unit price		360.08	

5.3. Boiler Heat Balance

Heat balance was conducted as a result of the daily report on the No. 1 boiler dated December 17, 1982.

Input			Output		
Item	10^3 Kcal/h	%	Item	10^3 Kcal/h	%
Heat of fuel combustion	785.9	99.7	Heat of steam	669.6	84.9
Sensible heat of fuel	2.6	0.3	Heat loss in exhaust gas	68.5	8.7
			Heat loss in blow water	19.8	2.5
			Heat release from boiler body, Others	30.6	3.9
Total	788.5	100.0	Total	788.5	100.0

Note 1) Specifications for calculating boiler efficiency and heat balance

Type of fuel		C fuel oil
Fuel consumption	(F)	81.8 kg/h
Heat content of fuel (low)	(Hl)	9,608 kcal/kg
Specific gravity of fuel	(S_G)	0.975
Specific heat of fuel	(C_P)	0.45 kcal/kg
Temperature of fuel	(T_F)	101°C
Reference temperature	(T_o)	30°C
Oxygen content in exhaust gas	(O_2)	4.8%
Temperature of Exhaust gas	(T_G)	215°C
Quantity of blow water	(B)	4,200 kg/day = 175 kg/h
Temperature of blow water	(T_B)	165°C
Quantity of feed water	(W)	30,644 kg/day = 1,277 kg/h
Temperature of feed water	(T_w)	52°C
Steam pressure	(P)	6.1 kg/cm²G

Note 2) Quantity of Evaporation (S)

S = W − B = 1,102 kg/h

Enthalpy of steam	(E_S)	659.6 kcal/kg
Enthalpy of feed water	(E_F)	52 kcal/kg

Note 3) Heat balance calculation

Input

Heat of Fuel Combustion (Q_C)

$Q_C = F \times Hl = 785.9 \times 10^3$ kcal/h

Sensible heat of fuel (Q_S)

$Q_S = F \times C_P (T_F - T_O) = 2.6 \times 10^3$ kcal/h

Output

Heat of steam

$Q_V = (W - B)(E_S - E_F) = 669.6 \times 10^3$ kcal/h

Heat loss in exhaust gas (Q_E)

Theoretical amount of air (A_O)

$A_O = 0.85\ Hl/1{,}000 + 2.0 = 10.17\ Nm^3/kg$

Theoretical amount of exhaust gas (G_O)

$G_O = 1.11\ Hl/1{,}000 = 10.67\ Nm^3/kg$

Air ratio (m)

$m = 21/(21 - O_2) = 1.3$

Actual amount of exhaust gas (G)

$G = G_O + A_O(m - 1) = 13.72\ Nm^3/h$

$Q_E = F \times G \times 0.33\,(T_G - T_O) = 68.5 \times 10^3$ kcal/h

Heat loss in blow water (Q_B)

$Q_B = B \times (T_B - T_W) = 19.8 \times 10^3$ kcal/h

Heat releas from boiler body and others (Q_R)

Surface temperature	Surface area	Radiation Heat release	
180°C	4 m^2	2,504 kcal/m^2h	10.0×10^3 kcal/h
90	4	790	3.2 〃
50	30	295	8.8 〃
Total			22.0

Heat loss of auxiliary equipment and others 8.6

6. Problems in Heat Control and Potential Solutions

6.1. Boiler

(1) Boiler Control

Hourly recording and daily and monthly totals of the boiler log are well maintained. Monthly averages of boiler efficiency, evaporation and unit cost of steam are calculated.

Therefore, it is evident that the person responsible for the boiler is highly motivated for heat control.

The air ratio also shows an acceptable value.

(2) Control of Boiler Water

Values of analysis are as follows (as of July 30, 1982):

		Softened water	Condensate	Blow down
PH		7.75	7.9	11.8
Conductivity	μS/cm	665	600	6,900
Chloride	ppm	8	8	94
Total Hardness	mg $CaCO_3$/l	20	26	nil

According to the table of analysis, the results for softened water and condensate do not differ very much, however we would like to recommend that the analysis be repeated since the quality of condensate should be excellent.

In addition, it is neccesary to maintain electric conductivity in an order of 4,500 $\mu s/cm$ and the current value is rather high.

Because heat loss also increases further when the current blow down rate is increased, we would like to recommend that a change in raw water or the introduciton of a pure water device be investigated.

When the blow down rate is reduced to 8%, saving in fuel oil is as follows:

$$\frac{(B - B') \times (T_B - T_W) \times 24 \text{ h/day} \times 352 \text{ day/year}}{\eta \times Hl \times S_G} = 8.8 \text{ kl/year}$$

Note) Specifications for calculation

B : 175 kg/h

B' : W x 0.08 = 102 kg/h

T_B: 165°C T_W: 52°C

η : 84.9% Hl: 9608 kcal/kg

S_G: 0.975

(3) Insulation of Steam Piping

The insulation of steam piping is seemed to be almost proper, but the insulation of valves, flanges, strainers, pressure-reducing valves, etc. on the boiler should be improved. Heat release for these parts is as follows:

Three 4" valves (primary side)	2,941 kcal/h
Three 4" valves (secondary side)	2,819 kcal/h
One 4" pressure-reducing valve	1,220 kcal/h
One 4" strainer	1,081 kcal/h
Two sets 4" flange (primary side)	602 kcal/h
4" valve (main steam valve of stopped boiler)	980 kcal/h
Total	9,643 kcal/h

Accordingly, when reduction of heat release by means of insulation is converted into saving of fuel oil, the result is as follows:

$$\frac{9{,}643 \text{ kcal/h} \times 24 \text{ h/day} \times 352 \text{ day/year} \times 0.75}{9{,}608 \text{ kcal/kg} \times 0.849 \times 0.975} = 7.7 \text{ kl/year}$$

Insulation efficiency: 75%

6.2. Insulation of the Dyeing Machine

The insulation of main units in the dyeing machine and dryer and auxiliary piping and valves is required.

Surface temperature and reduced heat release due to insulation of each dyeing machine are shown in the following table:

No.	Name	Set(s)	Surface temperature °C	Processing time mm	Decrease heat loss Kcal/day,set	Remarks
1 A	Injection type skein dyeing machine	1	85 70	60 30	Set(s) 31,700 x 1	8 times/day
2A, 3A	Injection type skein dyeing machine	2	85 70	60 30	51,600 x 2	"
4A,5A,6A	High temperature, high pressure	3	114 70	60 75	138,300 x 3	"
1, 2, 3	Obermeyer type cheese dyeing machine	3	105 70	60 75	50,900 x 3	"
4, 5, 6	"	3	"	60 75	73,500 x 3	"
7, 8	"	2	"	60 75	94,700 x 2	"
9	"	1	"	–	–	1 times/day
D-1, D-2	Drying machine	2	83 70	60	162,600 x 2	20 times/day
D-3	Drying machine 650 lbs/h	1	(drying temperature 90°C)	–	–	8 h/day
T	Hot water tank	1	85		48,200 x 1	16 k/day
	Total decrease heat loss in case of full capacity operation	Q = 1,485,800 Kcal/ day				

Insulation Material

Glass wool 25 mm thickness

When an improved effect in the case of fullcapacity operation is calculated on a trial basis, fuel saving is as follows,

$$\frac{1{,}485.8 \times 10^3 \text{ kcal/month} \times 26 \text{ day/month} \times 12 \text{ month/year}}{9{,}608 \text{ kcal/kg} \times 0.849 \times 0.975} = 58.3 \text{ kl/year}$$

and the amount of fuel saving is; 264,000 Bt/year, while expenses for insulation are roughly estimated as 200,000 Bt.

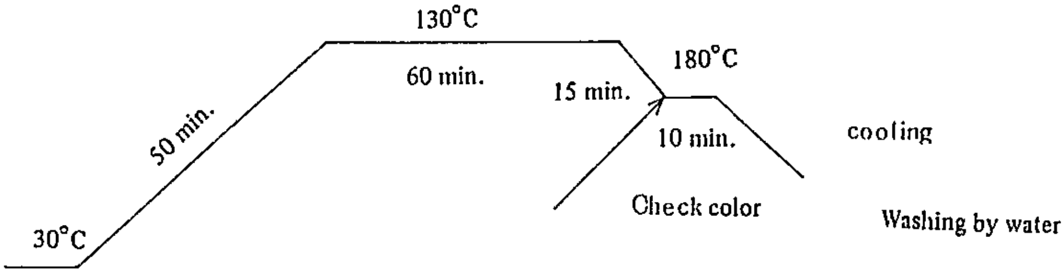
When the dyeing bath and circulating piping of each dyeing machine are subjected to insulation, the saving effect will increase further by 3%.

(Example of Calculation)

1A Injection type skein dyeing machine

Surface area: 5.26 m^2

Dyeing temperature and processing time (Synthetic fiber)



Deying temperature and processing time of fiber (synthetic fiber)

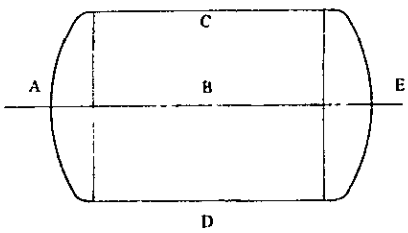
	Current states	After improvement	Difference
Surface temperature			
60 minutes	85°C	42°C	
30 minutes	70°C	40°C	
Heat release			
60 minutes	680 kcal/m^2h	111 kcal/m^2h	569 kcal/m^2h
30 minutes	460	90	370

Reduction of heat release

$(569 \times 1 + 370 \times 0.5)\ 5.26\ m^2 = 3{,}966$ kcal/batch

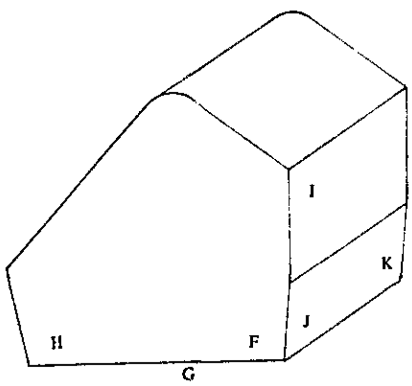
3966 kcal/batch x 8 times/batch = 31,700 kcal/day

High-pressure, high-tmperature injection type skein dyeing machine



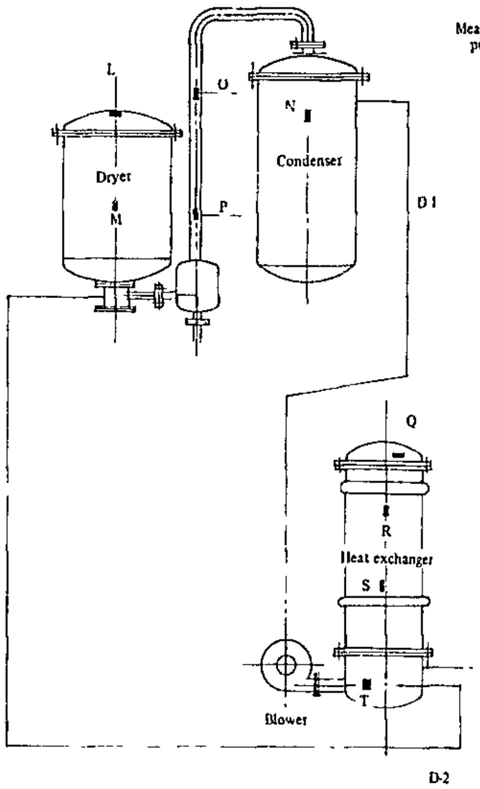
Machine No		Heat loss Kcal/m²h	Surface temperature °C
No 4	A	640	77
	B	550	68
	C	750	80
	D	660	76
	E	686	78
No 6	A	1175	120
	B	1375	104
	D	1105	121
	E	1350	110

噴射式かせ染色機



	Heat loss Kcal/m²h	Surface temperature °C
F	493	76
G	443	76
H	576	75
I	500	71
J	520	67
K	555	75

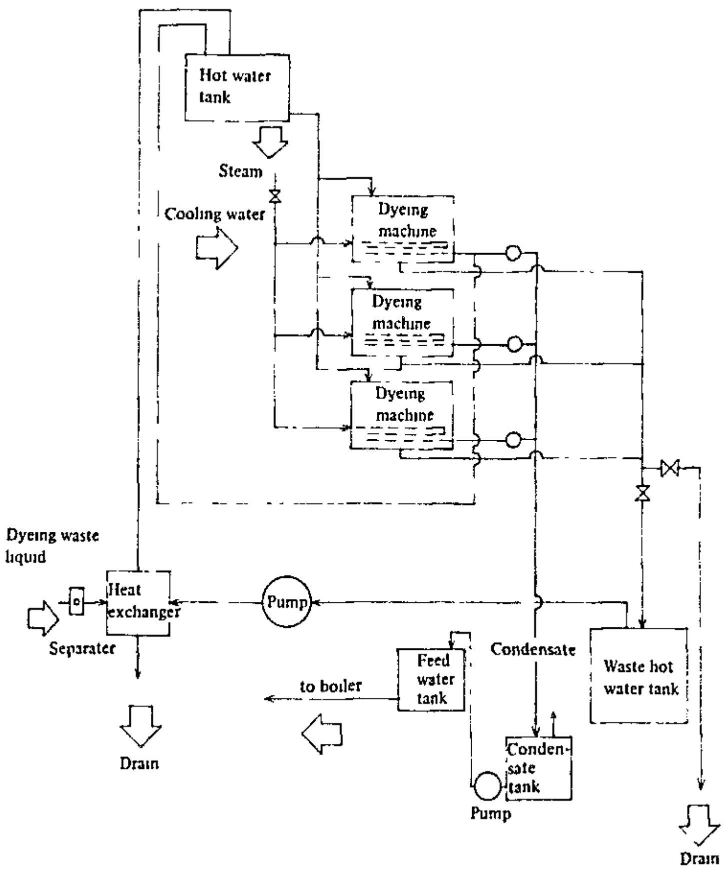
Measurement results of heat release of cheese drying machine



Measuring point	Heat loss Kcal/m²h	Surface temperature °C
L	517	71
M	620	74
N		48
O	650	76
P	538	74

	kcal/h	℃
Q	470	75
R	1000	96
S	900	93
T	160	54

Heat recovery flowsheet of dyeing waste liquid



6.3. Utilization of Cooling Heat of Water and Wate Liquid for Dyeing

Since the temperature of cooling water from dyeing machine has been raised, it can be utilized as hot water for the next dyeing process if it is stored in an insulated tank.

Although much energy is consumed by the dyeing solution due to heating, it is discharged each time as one process is completed.

If heat in the high temperature portion of the dyeing waste liquid is recovered by installing a heat exchanger, hot water with a higher temperature can be obtained.

If the water temperature is raised from 30° C to 60° C by means of heat recovery, fuel saving becomes as follows:

Water used = Dye goods x Wet ratio

= 2,300,000 lbs x 0.8 x 5 l/lbs = 9,200 kl/year

Fuel saving

$$= \frac{9{,}200 \times 10^3 \text{ l/year} \times (60 - 30)}{9{,}608 \times 0.849 \times 0.975} = 34.7 \text{ kl/year}$$

The amount of saving due to this becomes about 160,000 Bt.

If the temperature difference of both liquid is 20° C and the overall heat transfer coefficient is 500 kcal/m^{2}h, the heat transfer area of the heat exchanger becomes as follows:

$$\frac{9{,}200{,}000 \text{ l} \times 30°\text{C}}{312 \text{ days} \times 12 \text{ h} \times 500 \text{ kcal/m}^2\text{h} \times 20°\text{C}} \doteqdot 8 \text{ m}^2$$

Since the cost of installation is estimated to be about 500,000 Bt including a tank and accessory piping, an investment can be recovered in a short period.

In one case in Japan, dyeing waste liquid with a temperature of more than 60° C was discharged after heat recovery to obtain hot water with an average temperature of 60° C. The saving of fuel was 20%.

6.4. Recovery of Condensate

Though about 60% of condensate is recovered, the recovery of all generated condensate is desired since the installation using steam is conveniently located in the same room as the boiler.

When the recovery rate of condensate is raised and, in addition, the temperature of the feed water is raised from the current 52° C to 85° C by insulating the recovery tank and feed water pipe, the fuel oil savings are as follows:

$$\frac{(W - B)(E_S - D_F)}{F\{Hl + Cp(T_F - T_O)\}} = \frac{(W - B)(E_S - E_F^+)}{x\{Hl + Cp(T_F - T_O)\}}$$

$$\therefore \frac{x}{F} = \frac{E_S - E_P}{E_S - E_F}$$

Note 4) Calculation specifications

- Enthalpy of feed water at 85°C:

E_F : 85 kcal/kg

- Fuel oil consumption with feed water at 85°C: x (kg/h)

$$x = 81.8 \frac{659.6 - 85}{659.6 - 52} = 77.3 \text{ kg/h}$$

$$\frac{(81.8 \text{ kg/h} - 77.3 \text{ kg/h}) \times 24 \text{ h/day} \times 352 \text{ day/year}}{0.975} = 39.0 \text{ kl/year}$$

Besides the 39.0 kl/year of fuel oil that can be saved annually, a decrease in blow by improving the water quality can be expected.

6.5. Steam Trap

As a result of inspecting a part of the steam traps, some defective operations were found.

It is necessary to place a plate which indicates its number on the steam trap and to inspect and repair the steam traps periodically.

6.6. Upgrading of Production Control

In order to effectively execute energy conservation under conditions where production involves small lots of various products and an order is received for a short-term delivery, total improvement in the combining of hardware with software is necessary:

- Work must be concentrated so that the processing capability of the dyeing machine which corresponds to the production capacity may be fully utilized.
- Setting must be improved and waiting time must be shortened.
- Technical improvement of dyeing such as a decrease in the wet ratio must be attained.

Since production amount fluctuates to a great extent in the dyeing factory rational control can be achieved by setting a target based on heat consumption rate such as fuel consumption (l/kg) per unit of production rather than on only aiming at a certain percent reduction comparing it with a previous year for setting a target for energy conservation.

7. State of Electric Power consumption

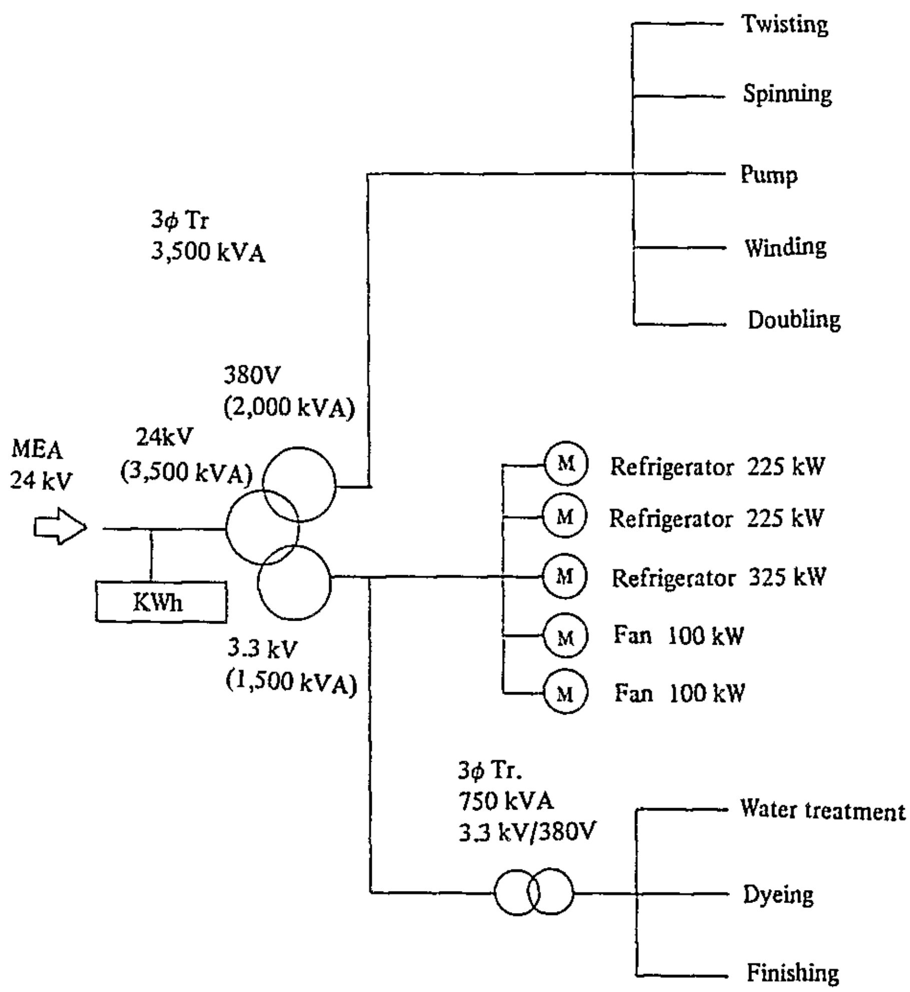
7.1. The Principal Data Relating Power Consumption

- Power company : MEA
- Peak demand : 1,840 kW
- Power consumption : 999,000 kWh/m
- Load factor : 75.4%
- Penalty : No penalty
- Power factor : 98%
- Power conumption rate : 5,212 kWh/lbs

7.2. Load Composition

• Motor	:	54.1%
• Air conditioning	:	26.3%
• Lighting	:	3.9%
• Pump	:	15.7%
Total		100 %

7.3. One Line Diagram



8. Problems of Power Control and Potential Solutions

8.1. Current Advantages

This plant has the following advantages:

8.1.1. Motor of Fine Spinning Process

It is intended to reduce power loss by utilizing an energy conservation type of belt for the motor.

8.1.2. Improvement of Power Factor

The power factor has been improved up to 98% by installing a condenser with appropriate capacity and the effective use of power has been actively sought.

8.2. Problems and Potential Solutions

8.2.1. Power Control

Although a power receiving log book is updated every two hours, the electric power used has better be recorded every hour to the extent possible which may be used for power control.

Although the load factor is currently rated considerably high, it is desirable to normalize the load and to further improve the load factor by recording the electric power used, preparing a daily load curve and analyzing the load.

8.2.2. Facility Control

(1) Motor

a. Two fans (100 kW each) control an outlet damper corresponding to the variations in air flow but the energy conservation effect is less due to an increase in the duct line resistance.

Therefore, after arranging data related to air conditioning for each production process and making minute adjustments such as the amount of air flow discharged from a duct, large savings in electric power can be attained by utilizing a microcomputer and controlling the fan speed with minute temperature and humidity settings corresponding to seasonal changes and changes due to the time frame.

For instance, if the speed control rate of a fan is assumed to be 10% by change of pulley ,the following energy conservation effect can be expected because the shaft output is proportional to the three power's of velocity:

Electric power saving : $100\ kW \times 2\ units \times \{(1 - 0.9^3) - 0.03^3\}$
$\times\ 24\ h \times 350\ day = 404,880\ kWh/year$

Rate of saving : $404,880\ kWh/year \div 11,988,000\ kWh/year$
$\fallingdotseq 3.4\%$

b. 48 large capacity motors in the cotton and polyester processes are selected and when the load factor, namely, $\frac{\text{actual load}}{\text{rated capacity}}$ is actually measured, many of them fall into the high-efficiency range between 80 and 100% but there are some with a low load factor as shown below.

However, since this motor may be lightly loaded at the time of actual measurement, additional data should be taken.

If the load factor is always low, it had better be replaced by a motor with the appropriate capacity from time to time.

Process	Application	Capacity	Number of units	Load factor
Spinning	Spinning	15 kW	28	36%
Dyeing	Air compressor	22	2	37
Dyeing	Pump	22	2	49.6

Energy-saving effect due to this is calculated on a trial basis as follows:

Motor capacity	Efficiency	Loss	Number of units	Reduction of loss
kW	%	kW		kWh/year
15→5.5	87.0→86.0	1.95→0.77	28	277,536
22→11	87.5→90.0	2.75→1.10	2	27,720
22→11	89.5→91.0	2.31→0.99	2	22,176
			Total	327,430

Rate of saving : 327,430kWh/year ÷ 11,988,000kWh/year
≒2.7%

c. Motors which suffered from power loss due to defective transmission caused by excessively loose motor belts are as follows:

Process	Capacity	Number of units	Total
Scutching	0.75 kW	3 units	2.25kW
Lap	3.7	1	3.7
Combing	1.5	1	1.5
Winding	1.5	2	3
Winding	2.2	1	2.2
Blower	100.0	2	200.0
Total			212.65kW

By properly tension of the belt so that the abovementioned motor belt deflects by its thickness when a normal force is applied to it with a thumb, the following energy conservation effect can be expected:

Electric power saving : 212.65kW x 0.03 x 24h x 350day
≒ 53,600kWh/year

Rate of saving : 53,600kWh/year ÷ 11,988,000kWh/year
≒ 0.4%

(2) Lighting

a. 2,500 general type 40 W fluorescent lamps are used for lighting.

When these are replaced by an energy conservation type fluorescent lamp, power consumption is reduced by about 10% under the same intensity of illumination.

Electric power saving : 40W x 2,500lamps x 0.1 x 24h x 350day
≑ 8,400kWh/year

Rate of saving : 84,000kWh/year ÷ 11,988,000kWh/year
≑ 0.7%

b. Illumination for major processes was measured, the following results were obtained.

These are considered almost appropriate.

Process	Intensity of illumination	Process	Intensity of illumination
Scutching	29 Lux	Spinning	107 Lux
Carding	67	Rewinding	128
Drawing	85	Doubling	134
Roving	101	Twisting	145

c. Many fluorescent lamps currently used are in their last stage of life.

If a fluorescent lamp is replaced by a new one after 6,000 hours of use, its illumination will not be degraded and it will be more economical.

(3) Air Conditioning

a. A water washer device for cooling and humidifying the circulated air currently has 88 nozzles with diameters of 4 mm.

b. It is encouraging to see that saving of power related to the cooling tower, etc. is being planned by reducing the water used to a maximum of 20% while checking the quality of the product during major processes.

8.2.3 Production Process Control

(1) Actual States of Proportion of Defective Yarn

Currently, the proportion of defective cotton yarn and polyester yarn are as high as 25% and 5% respectively at this factory. Such a large proportion of defects not only causes degradation of the power consumption rate but also results in the loss of considerable energy consumed up to the completion of the product and therefore, it is essential to positively reduce the defective yarn by utilizing the QC method.

(2) Reason for Large Proportion of Defects and Potential Solutions

The following matters are the reasons for the large proportion of defects.

a. A lot of floating filament is generated.

Currently, a lot of floating filament is generated in each process in the factory.

Although there are many patrol air-cleaners for the fine spinning machine, a lot of floating filament exists and causes a large proportion of defects by sticking to the yarn during the manufacturing process.

To reduce this floating filament, drastic countermeasures described below must be taken:

- Thoroughly clean off the floating filament on the floor which cannot be removed by an air-cleaner as well as all that is sticking to the filter.
- An appropriate humidifier is provided to keep the humidity constant during major processes and floating filament in the upper spaces absorb moisture and drop to the floor.

b. Removal of impurities in raw cotton is not complete.

Raw cotton originating in Thailand and Egypt is used. Currently, lower priced raw cotton originating in Thailand occupies a larger share.

Since the cotton originating in Thailand includes many impurities, the proportion of defects does not decrease much with increased efforts being exercised in subsequent processes if the impurities are not completely removed.

Although a scuchting machine is used to remove impurities in raw cotton, an investigation is required to determine whether using the scutching machine is suitable for the current situation where raw cotton originating in Thailand occupies a larger share.

Depending on the case, it may be that large impurities can be removed in the process prior to the scutching machine to allow the present scutching machine to exert its maximum efficiency.

c. There is room for investigation of the air-conditioning.

Specific air conditioning factors such as temperature, humidity, air stream, cleanliness, etc. are required for each yarn manufacturing process.

In particular, in the case of this factory, where the composition between production volume between cotton and polyester changes to a great extent, it is essential that air-conditioning factors for each process change minutely corre-spoinding to this situation.

However, there is not much difference in air-conditioning factors as described below.

Process	Temperature	Humidity
Scutching	28°C	65 ~ 70%
Carding, etc.	26°C	60 ~ 65%

It is believed that this situation becomes one of the causes for the large proportion of defective yarn.

Therefore, it is essential to finely control temperature, humidity, etc. by setting an ideal air-conditioning factor for each process and by always placing each process in an ideally set air-conditioning factor immediately corresponding to changes in various conditions such as the current production volume and composition ratio of cotton and polyester, the composition of raw materials, atmospheric temperature, and humidity.

Incidentally, since the manual method of measurement currently used for indoor and atmospheric temperature and humidity is not adequate, it is necessary to use an electronic sensor.

Additionally, because the present entrance and exit doors are not double doors, much outside air infiltrates the inside. Therefore, it is necessary to provide double doors at entrances and exits to completely seal the air-conditioning.

Further, there is no ceiling and this causes a larger space requiring air-conditioning and also requires increased power.

Since this situation may cause dust particle to drop from up above and adhere to the yarn during major production processes resulting in a higher defective proportion, it is desirable to provide a ceiling as soon as possible, at least for the major processes.

9. Summary

The abovementioned remedial measures, if actually taken, will bring about energy-saving effects as shown:

	kl/year	%
Improvement in quality of feed water (converted into fuel oil)	8.8	1.5
Insulation of steam piping	7.7	1.3
Insulation of dyeing machine	58.3	9.7
Heat recovery from cooling water and from dyeing exhaust	34.7	5.8
Increased condensate recovery	39.0	6.5
Subtotal	148.5	24.8

	10^3 kcal/year	%
Speed control for fan	404.9	3.4
Capacity change of motor	327.4	2.7
Correction of motor belt tension	53.6	0.4
High efficiency of light source	84.0	0.7
Subtotal	869.9	7.2

Report No. 3: Textile

REPORT ON THE DIAGNOSIS
FOR
ENERGY CONSERVATION

— The Thai Textile Co., Ltd. —

June, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation
— Thai Textile Co., Ltd.—

1. Outline of the Factory

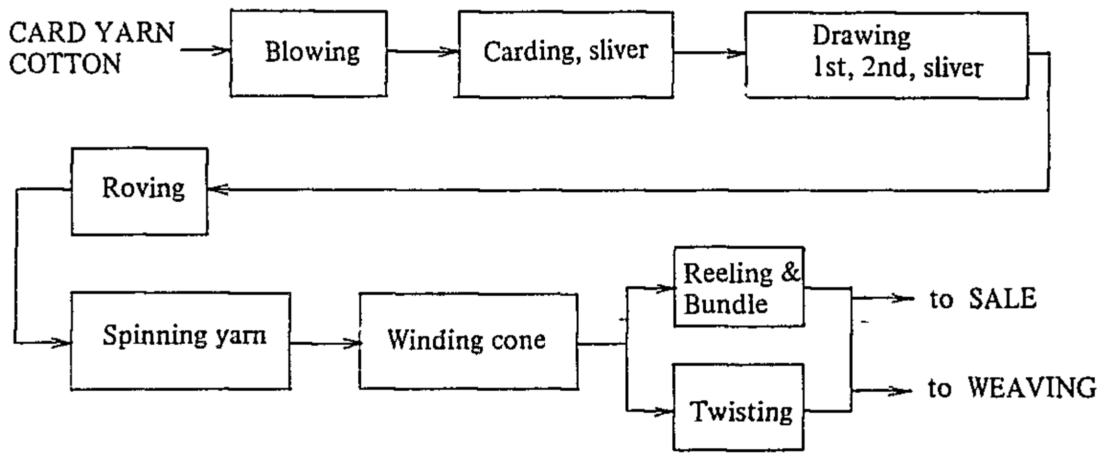
Address	175 Phaholyothin Rd., Donmuang Bangkok	
Capital	55 million Bt	
Type of industry	Textile	
Major products	Cotton Yarn, Cotton Textile (100% Cotton yarn and mixed yarn with polyester)	
Annual product	Yarn 6,000 t/year Textile 24 Billion yard/year	
No. of employees	1,350	
Annual energy consumption	Electric Power	34,938,000 kWh
	Fuel	Bunker C oil 240 kℓ Diesel oil 46.8 kℓ
Interviewees	Managing Director, H. Takizawa	
Date of diagnosis	Jan. 27 ~ 28, 1983	
Diagnosers	M. Matsuo, K. Nakao, Y. Ohno	

Thai Textile Co., Ltd. started operations in 1960 as a joint venture between Thailand and Japan. Major products include cotton yarn, cotton, polyester-mixed yarn and cloth. The company has 47,000 spindles and 600 weaving machines which are now in full operation.

Sixty percent of the yarns produced are sold in the domestic market, and 40% of them are processed into clothes, 70% of which are exported. The ratio of defective products is about 2%.

As the factory is located in the neighborhood of Bangkok airport, regulations are imposed on the voltage of power distribution within the factory.

2. Manufacturing Process

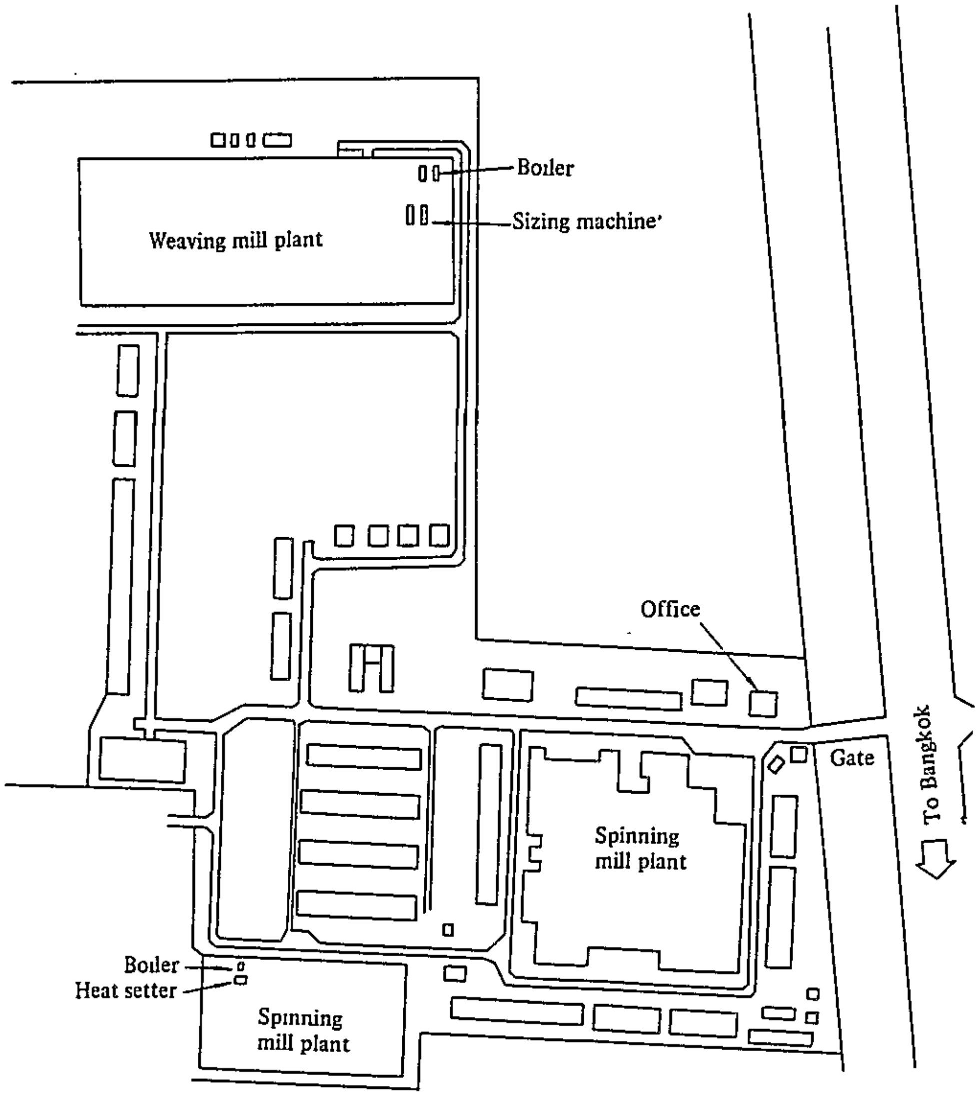


3. Major Equipment

3.1 Major Equipment

Plant or facility	Unit	Specification
Heat setter	1	Steaming by hot water-saturated steam
Sizing machine	2	Equipped with cylinder type dryer
Boiler	1	Fuel and smoke tube boiler, 1.5 t/h, 7 kg/cm^2
Boiler	1	Fuel and smoke tube boiler, 2.5 t/h, 7 kg/cm^2
Boiler	1	Fuel and smoke tube boiler, 0.5 t/h
Refrigerating machine	5	500 USRTx2, 350 RTx1, 330 RTx1, 250 RTx1

3.2 Layout



4. State of Energy Management

Although the price of products has remained more or less the same, the unit price of electric power has soared to the extent that the cost of electric power represents 45% of the total cost of yarn production. The company intends to promote energy-conservation programs, particularly for power savings, though with no definite target figures indicated.

The energy-conservation measures implemented by the company so far include:

(1) Overhaul of the refrigerating equipment; 1,600 thousand Bt.

(2) Purchase of a demand controller; 430 thousand Br.

(3) Recovery of condensate in sizing machines.

(4) Survey of electricity change by the rotations of each fine spinning machine. Study on the most economical points relating the rotations and radius of spindles.

(5) Adoption of energy-saving type driving belts.

(6) Replacement with high efficiency motors.

An enlightenment policy on energy-conservation activities started two years ago. With no suitable stickers available, the company decided to produce them by themselves and held a prize contest for designs by and among employees.

The Energy-Conservation Committee was initiated last year and meetings are held once a month. The committee consists of Deputy Factory Manager as the chairman and 14 to 15 persons who are supervisors or foremen.

The suggestion system is not working due to considerations for labor relations, but small group activities are actively carried out.

Supervisors and managers are given the chance for training at a seminar held outside the company or for an inspection tour. Training is also provided on the prevention of idle operation or the control of demand at the start of operation after a holiday.

The data on energy consumption in each process and in each major equipment is collected every month. The consumption rates are regularly calculated, and the causes for major fluctuations, if any, are identified. There is no control chart available at present, but graphs will be compiled by the recorder of the demand controller after it is installed.

As described above, the level of energy management for this factory is very high.

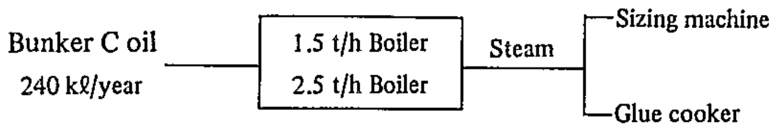
The company has requested the government to take the following actions:

(1) To distribute stickers, posters and other materials related to the promotion of energy conservation,

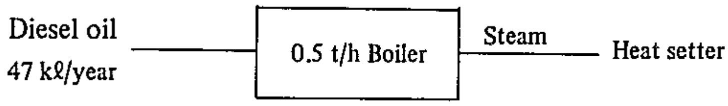
(2) To reduce the tariff on the import of energysaving equipment, particularly microcomputer-incorporated equipment.

(3) To establish an electricity charge system with incentives on energy conservation.

5. State of Fuel Consumption



One or two boilers are used depending on the operation of the sizing machine.



A boiler operates 16 to 18 hours a day.

Heat Balance in a Boiler (1.5 t/h)

Heat input			Heat output		
Item	10^3 Kcal/h	%	Item	10^3 Kcal/h	%
Heat of fuel combustion	502.0	99.62	Enthalpy of steam	415.8	82.52
Sensible heat of fuel	1.9	0.38	Sensible heat of waste gas	57.6	11.43
			Sensible heat of blow down	7.8	1.55
			Heat loss from furnace body plus miscellaneous	22.7	4.50
Total	503.9	100.00	Total	503.9	100.00

As the feedwater meter was out of order, the calculation of the heat balance in a boiler was based partly on assumption.

Note 1: Data Given for Calculation of the Heat Balance

type of fuel		Bunker C
Fuel consumption (measured on the day)	(F)	52 kg/h
Heat content of fuel (low level)	(Hl)	9654 kcal/kg
Specific grabity of fuel	(S_G)	0.945
Specific heat of fuel	(C_P)	0.45 kcal/kg°C
Temperature of fuel	(T_F)	110°C
Reference Temperature	(T_O)	30°C
Oxygen content in exhaust gas	(O_2)	5.4%
Temperature of exhaust gas	(T_G)	265°C
Specific heat of exhaust gas	(C_G)	0.33 kcal/Nm^2°C
Amount of blow water	(B)	80 kg/h
Temperature of blow water	(T_B)	160°C

Temperature of feedwater	(T_W)	62°C
Steam pressure	(P)	5.3 kg/cm^2
Enthalpy of Steam	(E_S)	658.4 kcal/kg
Enthalpy of Feedwater	(E_F)	62 kcal/kg

Note 2: Equations for Calculating the Heat Balance

Input

Heat of fuel combustion (Q_C)

$\dot{Q}_C = F \times Hl = 502.0 \times 10^3$ kcal/kg

Sensible heat of fuel

$Q_S = F \times C_P (T_F - T_O) = 1.9 \times 10^3$ kcal/kg

Output

Heat loss in exhaust gas (Q_E)

Theoretical amount of air (A_O)

$A_O = 0.85\ Hl/1000 + 2.0 = 10.21$ Nm^3/kg

Theoretical amount of exhaust gas (G_O)

$G_O = 1.11\ Hl/1000 = 10.72$ Nm^3/kg

Air ratio (m)

$m = 21\ (21 - O_2) = 1.35$

Actual amount of exhaust gas (G)

$G = G_O + A_O (m - 1) = 14.29$ Nm^3/kg

$Q_E = F \times G \times C_G (T_G - T_O) = 57.6 \times 10^3$ kcal/h

Heat loss in blow water

$Q_B = B \times (T_B - T_W) = 7.8 \times 10^3$ kcal/h

Heat release from boiler body and other heat loss (Q_R)

Heat release from boiler body (Q_r)

Side:	60°C	330 kcal/m^{2}h	26.3 m^2	8700 kcal/h
Rear:	120°C	1250	3.4	4300
Front:	80°C	630	3.4	2100

$Q_r = 15.1 \times 10^3$ kcal/h

Other heat loss (Q_O) (1.5% of input heat)

$Q_O = 7.6 \times 10^3$ kcal/h

$Q_R = Q_r + Q_O = 22.7 \times 10^3$ kcal/h

Heat content of steam (Q_V)

$Q_V = Q_C + Q_S - Q_E - Q_B - Q_R = 415.8 \times 10^3$ kcal/h

Amount of steam evaporation (S)

$S = Q_V \div (E_S - E_F) = 697$ kg/h

6. Problems in Heat Control and Potential Solutions

6.1 Boiler Control

(1) Improvement of Combustion

The oxygen content in the exhaust gas is too high. It should be reduced to less than 4% by adjusting the air damper.

If the oxygen content is reduced to 4%, the exhaust gas amount will decrease by about 8% and the required fuel amount will decrease by 1%.

Temperature of exhaust gas is also high. It is necessary to clean up the inside and outside of the boiler tubes as well as to reduce the exhaust gas by adjusting the air ratio. If the oxygen content is reduced to 4% and the temperature of the exhaust gas is dropped to 210°C, the boiler efficiency would improve to 85.6%, thus reducing fuel consumption by 4% or 9.6 kl/year.

$m' = 1.24$

$G' = 13.17\ Nm^3/kg$

By taking the heat balance of the boiler putting the fuel amount after improvement in X:

$$\frac{503.9}{52} X = (415.8 + 7.8 + 22.7) + \frac{13.17 \times 0.33 \times (210 - 30)}{1{,}000} X$$

$$\therefore X = 50.1\ kg/h, \quad \frac{F - x}{F} = 0.04$$

240 kl/year x 0.04 = 9.6 kl/year

(2) Installation of Feedwater Meter

There is a flowmeter for the replenished softened water in the factory, but there is no flowmeter for the feed water entering into the boiler. The value obtained from dividing the feedwater by fuel i.e. a simplified evaporation factor should be calculated every day for the evaluation of the boiler efficiency. It would be possible to obtain the condensate recovery by the difference between the flowmeter for the water entering into the boiler and the flowmeter for the softened water.

(3) Control of Boiler Water

The analytical values for the boiler water and softened water was as follow:

	Softened water	Boiler water
pH	8.5	11.0
electric conductivity μS/cm	830	7,040

The standard values for the boiler water are 11.0—11.8 for pH, 80—600 as $CaCo_3$ mg/l for the ratio of M alkali, less than 3,000 mg/l for total residue of vaporization, less than 4,500 μS/cm for the electric conductivity, less than 500 mg/l for Cl^- and 20—40 mg/l for PO_4^{-3}. The analytical values showed that the electric conductivity was a little high. The blow down ratio should be determined by periodical analysis of the boiler feedwater and boiler water as well as feedwater amount. The increase of condensate recovery will improve the quality of the feedwater and reduce the blow down, which will lead to higher boiler efficiency and less use of boiler compound.

(4) Small boiler

A small boiler of 0.5 t/h is used for generating steam for heat setters. Its working conditions could not be surveyed during the period of diagnosis, but it is recommended that the evaporation ratio controlled by installing the flowmeters for fuel and feedwater and that the temperature controll of the exhaust gas be implemented by installing a thermometer for the exhaust gas. The water level indicator should be replaced because it is not working well. Insulation is required for the 2"— main valve, etc. As the type of burners are same as those of other boilers, bunker C can be used as fuel.

(5) Others

Insulation should be enhanced at the rear wall of the boilers, auxiliaries, piping and valves.

6.2 Recovery of Condensates and Utilization of Flash Steam

Condensates are recovered from the sizing machines. The condensates of the glue cooker, which is close to the boiler, should also be recovered.

Insulation is required for two condensate tanks, the feedwater tank and the piping for the condensates (see the List of Insulation Effects).

Part of Condensates coming out of the steam traps at atmospheric pressure evaporates again, but the steam generated at that time is not utilized. If the condensates from the cylinder (2.0 kg/cm^2) of the sizing machine are guided to the newly installed flash tank to decompressed to 0.5 kg/cm^2, energy of about 20% can be recovered as the steam of 0.5kg/cm^2 which can be used to warm the glue tank.

Further, effective utilization of heat energy can be ensured by feeding the condensates left in the flash tank to the boiler for feedwater.

Enthalpy of saturated water;	2.0 kg/cm^{2}g	133 kcal/kg
	0.5 kg/cm^{2}g	111 kcal/kg
Evaporated latent heat at 0.5 kg/cm^2;		532 kcal/kg
Enthalpy of steam at 0.5 kg/cm^2;		643 kcal/kg

Ratio of generated flash steam; $\frac{133 - 111}{532} = 4.1\%$

Ratio of heat turned into flash steam; $\frac{643 \times 0.041}{133} = 20\%$

6.3 Prevention of Heat Loss by Improvement of Insulation

Insulation of the steam utilizing equipment in the factory is generally insufficient at present. Significant improvements could be brought about by the implementation of proper insulation measures. Though thicker insulation material provides a greater insulation effect, insulation costs increase accordingly. So, it is necessary to determine the most economical thickness by taking into account of fuel saving effects.

The possible effects and costs of major improvments on insulation are indicated in the following table. Apparently the costs required for insulation can be recovered within a year.

Effects of Insulation

Facility	Specification of equipment	Skin temp. °C		Heat loss Kcal/m²h		Recovered heat by insulation		Fuel cost to be saved	Insulation cost
		actual	insu	actual	insu	actual	insu	Bt/year	Bt
Condensate recovery	Pipe 2" x 42 mL	90	42	(76)	(11)	(65)	Kcal/h 5,898	38,800	20,100
	1½" x 32 mL			(116)	(17)	(99)	1,775		
	Drain tank, surface area 2.73 m²						7,673		
Sizing machine	Steam valve 2" x 3 pcs	123	48	1,345	177	Kcal/m²h 1,168	Kcal/h 739	3,700	700
	Dryer cylinder shell plate 6.7 m²	110	46	1,100	155	945 "	6,332 "	32,000	6,000
	O d ϕ750 mm x I d ϕ300 mm x 9								
	Glue tank, surface area 5 9 m²	82 ~ 96	40	693	93	600 "	3,540 "	17,900	3,900
	Steam pipe / drain pipe						2,730 "	13,800	6,000
	Steam pipe 3/4" x 9 mL	122	48	(100)	(15)	(85)			
	Steam pipe 2" x 7 mL			(200)	(34)	(186)			
	Condensate pipe 1½" X 5 mL	95	42	(128)	(17)	(111)			
Coocker	Cooker								
	ϕ1,100x1,400mH, surface and 7 2m²	90	43	760	122	638 "	4,950 "	25,000	6,600
	Steam pipe 1" x 11 mL	130	50	(161)	(22)	(139)	1,529 "	7,700	3,100
Glue supply pipe	2" x 36 mL, from coocker to glue storage tank	90	42	(145)	(21)		4,464 "	22,600	12,600
Glue storage tank	ϕ1,082mm x 1,400mH surface area 6 6 m² with cover and stirrer	79	42	(707)	(111)		3,943 "	19,900	5,000
Total							Kcal/h 30,422	153,800	54,000

Notes 1. The thickness of insulation material of 25 mm is availed to pipings and equipments

2 The figures within parenthesises are signified in Kcal/m h

3 The item of "Fuel cost to be saved" is calculated by following equation

$$\text{Bt/year} = \frac{(\text{recovered heat}) \times 4.5\ \text{Bt/l} \times 24\ \text{h} \times 350\ \text{days}}{9{,}650\ \text{kcal/kg} \times 0.82 \times 0.945}$$

7. State of Electric Power Consumption

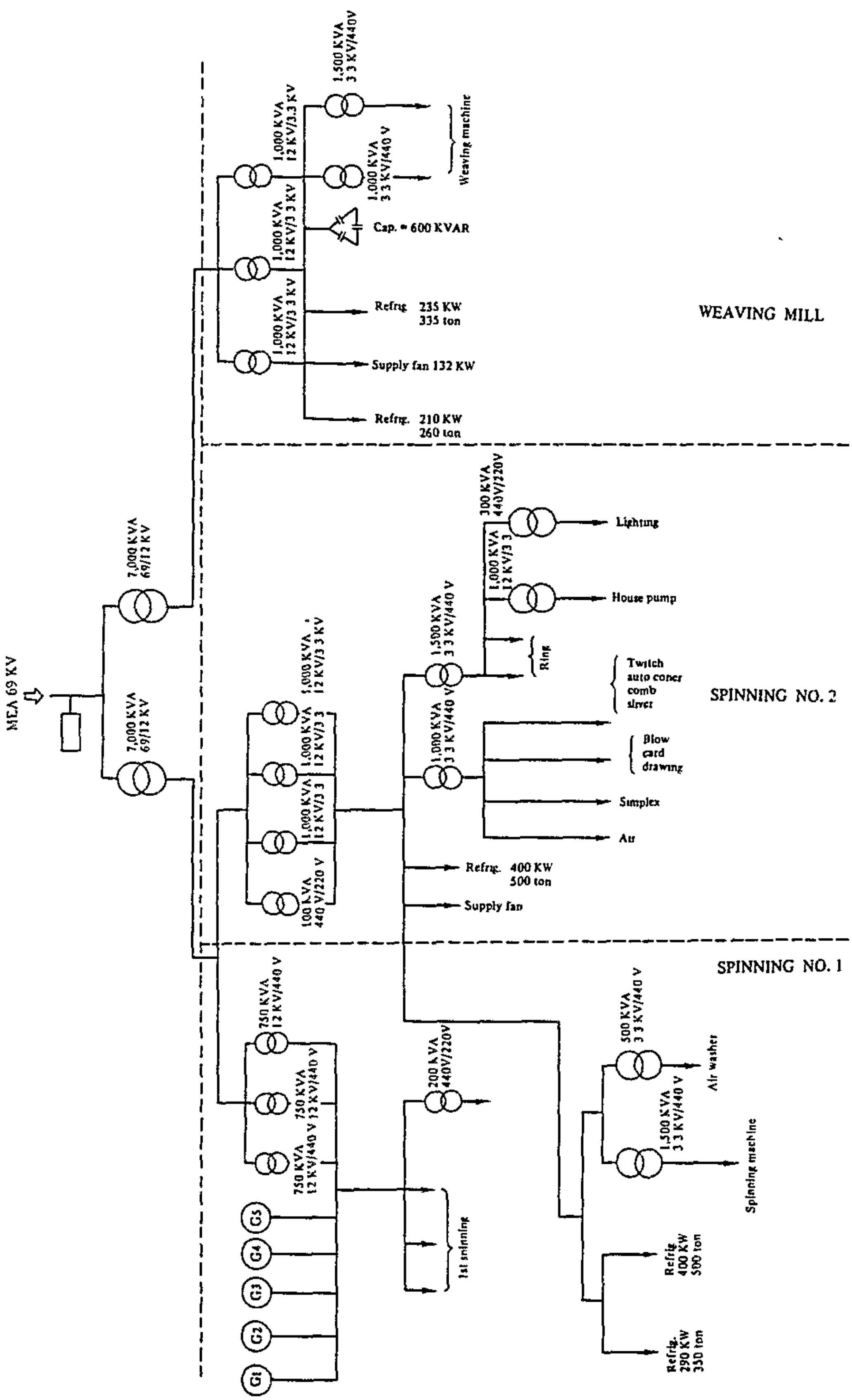
7.1 Principal Data Relating to Power Consumption

- Power company : MEA
- Peak demand : 4,860 kW
- Power consumption : 34,938,000 kWh/year
- Load factor : 83%
- Penalty : nil
- Power factor : 93%
- Transformers : 7,000 KVA (one set)
  (another set of 7,000 KVA as a spare)
- Power consumption rate : Yarn, 2,338 kWh/lb
  Fablic, 0.41 kWh/yard

7.2 Load Composition

Motor	: 56.0%
Air conditioning	: 40.0%
Lighting	: 4.0%
Total	: 100 %

7.3 One line diagram



8. Problems in Electric Power Control and Potential Solutions

8.1 Significant Achievement

The factory achieved the following.

8.1.1 Reduction of Iron Loss in Transformerr

Of the two transformers of 7,000 KVA, one is regularly used and the other is held as a stand by to ensure the reduction of iron loss.

The iron loss for one transformer of 7,000 KVA is approximately 0.3% of its capacity, so reduction of electric power is significant as indicated below:

(7,000 x 0.003) kW x 24 hrs x 350 days = 176,400 kWh/year

The load being 4,860 kW and the power factor 93%, the load factor is calculated at about 75%, showing the transformer is operating at high efficiency.

8.1.2 Fine Spinning Process

(1) Energy-saving type belts installed on the axle of the spinning motor to drive of the spindles are effective in reducing the loss of electric power to poor conduction.

(2) Rapid-start type white fluorescent lamps are used as the lighting source in the second spinning and weaving factory (in contrast to ordinary type daylight fluorescent lamps in the first spinning factory).

The utilization of white fluorescent lamps serves an energy-saving purpose because it requires less electric power by about 10% keeping at the same illuminance as daylight lamps.

The illuminance was kept at about 200 lux a sufficient level.

8.1.3 Reduction of Driving Loss in the Weaving Machine

Driving loss of electric power on the shuttle type weaving machines is reduced by adopting direct drive coupling at the weaving plant.

8.1.4 Proper Air Conditioning

Air conditioning in each process are kept in proper levels of temperature and humidity for the production of quality yarns and fablics.

8.2 Problems and Possible Solutions

8.2.1 Effective Utilization of a Computer

If a computer is installed in the factory in the near future, it will prove helpful for energy-conservation as well as for production control, process control and quality control as described below.

(1) Demand Control

The following will be implemented by linking the computer with the demand controller in order to reduce peak demand substantially:

a) Automatic recording of load

b) Automatic illustration of a daily load curve

c) Load analysis (analysis and check of processes which caused peak demand)

d) Leveling of loads

e) Improvement of load factor

f) Demand control

(2) Speed control of motors

If each large-capacity motor in the blowers, pumps, etc., whose load is likely to fluctuate, is equipped with an inverter to change the revolution continuously, a substantial reduction of electric power will be achieved.

If speed control using an inverter is adopted for blowers with the total capacity of 450 kW to substitute for damper control of 10%, the following energy savings can be obtained.

Saved electricity	: $450\ kW \times \{(1 - 0.9^3) - 0.03\}$
	$= 108.45\ kW$
Annual savings	: 108.45 kW x 24h x 350 days
	= 910,980 kWh/year
Saving rate	: 910,980 kWh/year ÷ 34,938,000 kWh/year
	= 2.6%

The estimated charges for saved electric power are about 1,330,000 Bahts. As the price of an inverter is about 2,000,000 Bahts, it would be possible to amortize it during a relatively short time.

Further, if changes in the flow rate of air or water are detected and the data are fed back to the computer to determine optimum conditions which are input into a revolution controller of each motor, the revolution control would be more effectively to conform to the conditions of the entire factory. The energy saving would be much greater in this case.

(3) Automatic Control of Air Conditioning

a) As temperature and humidity in Bangkok changes greatly depending upon seasons and time of day, it is prefereable to use sensors in order to control air conditioning closely. In addition, by using a computor to be introduced in near future, if one of control methods described below is adopted to the flow rate of air and water, as well as to the load of chiller motors, additional energy savings would be obtained.

* Sequence control

The patterns of air conditioning load changing with season and time of day are identified to prepare schedules, start or stop air conditioning equipment via a computer and maintain the standards of temperature, humidity, etc.

* Consecutive control

The temperature and humidity inside and outside a room are detected for feedback to a computer and are then input into each air conditioning unit and related equipment.

Then, the following controls are implemented to maintain the standards of temperature and humidity;

- Control of air intake from outside.
- Optimum allocation of air flow from a duct
- Control of starting and stopping time of air conditioning equipment based on the calculation of minimum start-up time.
- Control of optimum flow rate of cold water, cooling water and air.

b) The standards for air conditioning in the weaving factory are 30°C in temperature and 65% in humidity. However, if the quality of products is not likely to be affected, the standards might be changed to 32°C in temperature and 70% in humidity from the viewpoint of industrial air conditioning.

In this case, energy saving by about 8% would be achieved by reducing air-conditioning load.

Saved electricity	: 445 kW x 0.08 = 35.6 kW
Annual savings	: 35.6 kW x 24h x 350 days = 299,040 kWh/year
Saving rate	: 299,040 kWh/year ÷ 34,938,000 kWh/year = 0.8%

From the viewpoint of hygienic air-conditioning, it is preferable to raise ventilation flow rate upto proper level to improve sensible temperature for employees.

8.2.2 Improvement of Power Control

(1) It is recommended to install watt-hour meters on switchboard in substation, and to record power consumption by factory, process and major equipment (such as chillers). The recorded data can be utilized for demand control, load analysis, operations analysis, etc. in general energy-conservation programs.

(2) The one-line diagram currently used by the electrical staff of the factory is rather roughly hand-written and does not clearly show equipment wire connections. As a one-line diagram is essential for electric power control, a proper one with clear, simple indication of the arrangement and wiring of major equipment should be prepared and conspicuously displayed in offices and the central areas in a substation.

Wirings in each processes and major equipments seems to be rather redundant. It is preferable to shorten them to reduce distribution loses.

8.2.3 Adoption of High Efficiency Equipment

(1) The adoption of a high efficiency motor for a fine spinning machine, which is driven at a constant speed, will improve efficiency by about 3 to 5%. It must be noted, however, that this type of motor is more expensive by 20~30% than the

convertional, and it needs long time to recover investment.

Estimeted power savings

No. 1 fine spinning process	: 15 kW x 34 = 510 kW
No. 2 fine spinning process	: 15 kW x 54 = 810 kW
Total	1,320 kW
Annual savings	: 1,320 kW x 0.04 x 24h x 350 days = 443,520 kWh/year
Saving ratio	: 443,520 kWh/year ÷ 34,938,000 kWh/year = 1.3%

(2) A white fluorescent lamp used as the light source will require 10% less electric power than ordinary lamp at the same illuminance.

At present, fluorescent lamps of a daylight color are used in the No. 1 fine spinning factory. They should be replaced with white fluorescent lamps of rapid-start type at an early opportunity.

(Note) It was told that, because of the short life of a glow-starter type lamp due to large voltage fluctuation in this factory and the risk of fire caused by stabilizer overheating originating in defective contact of glow starter, the factory was adopting the quick-start type lamps only.

(3) Reduction of Electric Power Loss

a) It was learned that 30%~50% of motors had loose driving belts, indicating a substantial loss of electric power caused by poor driving.

If the looseness is corrected to have tension that the belt may be displaced only by its thickness when it is pushed down under normal thumb pressure, electric power loss would be reduced by about 3%.

Motors with large belt looseness on driving belts

Process	Capacity	Number of units	Total capacity
No. 1 spinning factory			
Reaching	0,375 kW	2	0.75 kW
Winding	1.5 kW	11	16.5 kW
Spinning	9 kW	9	81 kW
Simplex	9 kW	6	54 kW
No. 2 spinning factory			
Drawing	3.7 kW	4	14.8 kW
Simplex	7.5 kW	2	15 kW
Winding	1.5 kW	3	4.5 kW
Total			186.55 kW

Annual saving : 186,55 kW x 0.03 x 24h x 350 days

= 47,010 kWh/year

Saving ratio

: 47,010 kWh/year ÷ 34,938,000 kWh/year

≒ 0.1%

b) There are many shag cottons floating throughout each process, in particular, the filters of the air intake under the fine spinning machine are clogged with them. If they are not removed, the required air flow will not be able to take in, making it difficult to maintain the requirments of air conditioning. It is necessary to regularly clean floors and filters.

9. Summary

The abovementioned remedial measures, if actually taken, will bring about energy-conservation effects as shown below.

	kl/year (equivalent to oil)	%
Improvement of combustion in boiler	9.6	4.0
Improvement of insulation	34.2	14.2
Subtotal	43.8	18.2

	10^3 kWh/year	%
Speed control of motors	911.0	2.6
Reduction of air conditioning load	299.0	0.8
Adoption of high efficiency motors	443.5	1.3
Adjustment of belt tension	47.0	0.1
Subtotal	1,700.5	4.8

Report No. 4: Textile

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

— The Phiphatanakit Textile Co., Ltd. —

June, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation
— Phiphatanakit Textile Co., Ltd. —

1. Outline of the Factory

Address	222 Putaraksa Rd. A. Muang Samutprakarn	
Capital	2,000 million Bt	
Type of industry	Textile	
Major products	Fiber, Cloth (cotton, polyester)	
Annual product	Fiber 5,600 t/year Cloth 1,243 million yard/year	
No. of employees	1,380	
Annual energy consumption	Electric Power	20,752,000 kWh
	Fuel	Bunker A oil 300 kℓ
Interviewees	Factory Manager Somvang Pinyavat Energy Manager Sompong Panjai	
Date of diagnosis	Jan. 31 ~ Feb. 1, 1983	
Diagnosers	Y. Ohno, K. Nakao, M. Matsuo	

This factory started operation in 1971 and produces cotton yarn, mixed yarn of polyester cotton, and cloth. It has 45,000 spindles and 500 weaving machines.

Forty percent of the yarn produced is used in its own weaving factory and the remaining sixty percent is sold.

It entered into a technical licensing agreement with Fuji Spinning Co., Ltd. of Japan and a specialist is dispatched every two years.

Currently, the factory is operated 22 days per month and the operating capacity is rather low, compared with a normal operating month of 26 days.

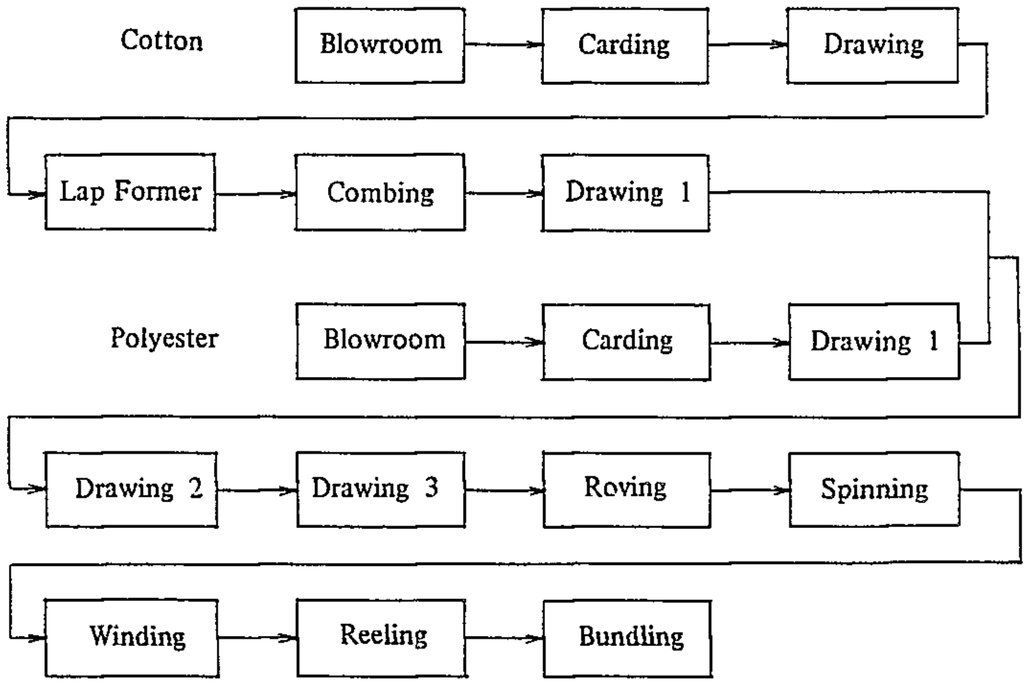
Proportion of defects is a considerably large 10% for yarn and 3% for cloth.

An important problem for the factory at present is the sinking of the land, and repairs are being made to the foundations of weaving machines.

Many failures of burnt motors occur and the persons concerned at the factory think this land sinking to be one of the major reasons.

2. Manufacturing Process

Combed Yarn

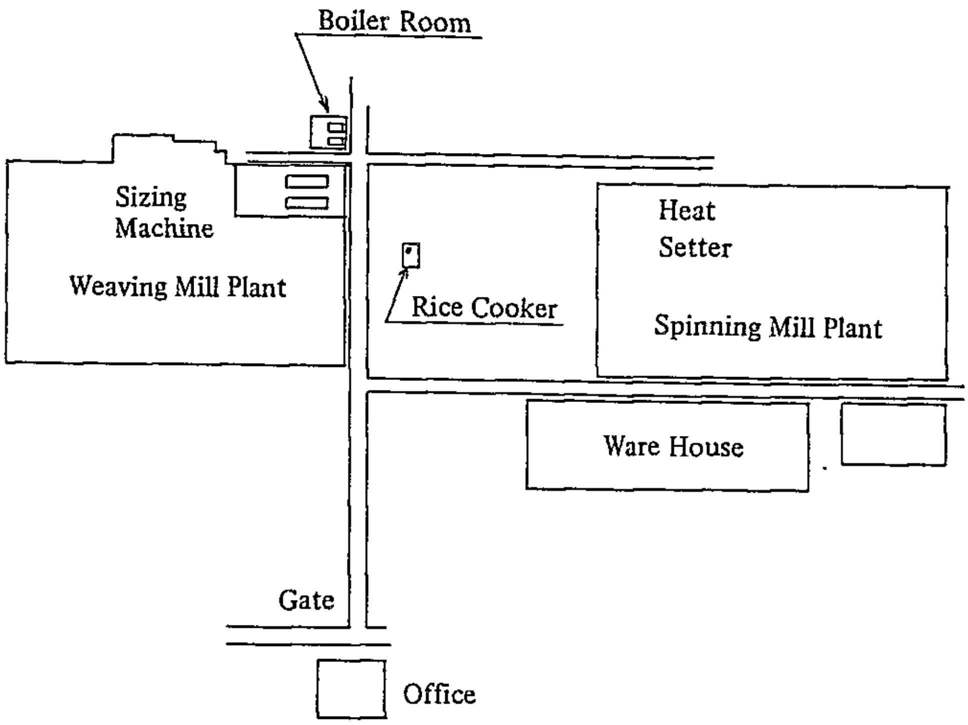


3. Major Equipment

3.1. Major Equipment

Name	No. of units installed	Type, etc.
Heat setter	1	Hot water – saturated steam injection type
Sizing machine	2	Cylindrical drying type
Boiler	2	Flue and smoke tube type 1.25 t/h operating pressure 8.1 Kg/cm^2 G
Refrigerating machine	4	460 kW x 3, 250 kW x 1

3.2. Layout



4. State of Energy Management

An energy conservation of about 10% is desired as an objective. The factory manager hopes to implement the results of diagnosis since energy conservation are directly linked to cost reductions.

4.1. Investment in Energy Conservation and Cases of Improvement

To date, the following improvements have been made:

(1) The rotation of the spinning machines has been decreased to the minimum required to maintain quality.

(2) Unnecessary lighting is turned off.

(3) Since air-conditioning requires a large amount of energy, temperature is readjusted from 28 ~ 29° C to 30 ~ 32° C to decrease the load.

The following are considered in a plan for future energy conservation:

(1) Strengthening of daily maintainance such as insulation of steam piping and repair of valves;

(2) Implementation of a part of recovered condensate;

(3) Heat recovery of chiller drainage;

(4) Recovery of cooling tower overflow cold water.

Although the factory has made visible improvmeent, there is an intention to collect and use measured data to promote the improvement of equipment. Portable electric measuring instruments have been ordered for this purpose.

4.2. Grasp of Energy Consumption

Power consumption is recorded for the entire factory and for each major process. Fuel consumption is recorded every day.

However, analysis of data and calculation of the power consumption rate are not made. It is necessary to calculate the power consumption rate and to compare and study it by arranging daily data and by totalling monthly and yearly data.

4.3. Energy-Conservation Committee and Suggestion System

It was reported that the managers had a conference last December

The energy-conservation committee should be chaired by the factory manager. It is important to install a sense of participation in all members by enlarging the organization to include committee members consisting of employees foremen, and responsible persons, who are familiar with the manufacturing process and equipment. It is necessary to promote energy conservation by setting an objective and proposing various problems. For this purpose, the QC circle activities which have been conducted are effective.

A suggestion system is not concretely formed but it is reported 30% of employee suggestions are implemented. It is hoped that effective suggestions are awareded.

4.4. Employee Training

Training concerning maintenance and control of machines, such as boilers, is carried out. The importance of the role of each machine operated by a worker is understood.

It was reported that overseas training of staff and authorized plant tours are also carried out.

Hereafter, it is important to upgrade the level of management by holding discussions in in-house seminars, and also by dispatching responsible at work-site to TPA-seminars, etc.

In addition, in communicating with employees, it is necessary for management personnel to clearly indicate their policy and objectives.

5. State of Fuel Consumption

Annual consumption of fuel oil is 300 kl and is entirely used by boilers.

Steam generated by the boilers is used as a heat source for finishing work of sizing and heat set and cooking.

The number of boilers operated was changed to correspond to the number of sizing machines.

Although the proportion of fuel cost in sales price is only about 0.5%, energy conservation is not an insignificant problem because fuel cost reaches 1,350,000 Bt annually.

Input			Output		
Item	10^3 Kcal/h	%	Item	10^3 Kcal/h	%
Heat of fuel combustion	437.0	99.8	Heat of steam	371.9	84.9
Sensible heat of fuel	1.1	0.2	Heat loss in exhaust gas	47.4	10.8
			Heat release from boiler body, Others	18.8	4.3
Total	438.1	100.0	Total	438.1	100.0

The feed water meter is out of order and accurate heat balance can not be made but it was roughly estimated by assuming a partial supposition.

5.1. Data Given for Calculation of the Heat Balance

Type of fuel		Fuel Oil
Fuel Consumption	(F)	46kg/h
Heat content of fuel (low level)	(Hl)	9,500kcal/kg
Specific heat of fuel	(C_P)	0.45kcal/kg°C
Temperature of Fuel	(T_F)	83°C
Reference temperature	(T_O)	30°C
Oxygen content in exhaust gas	(O_2)	6.6%
Temperature of exhaust gas	(T_G)	230°C
Temperature of feed water	(T_W)	33°C
at inlet of deaerator		65°C at boiler inlet
Amount of blow water		
		no blow during the test
Steam pressure	(P)	8.1kg/cm^2
Test time		3.7h
Heat loss through the outer walls of boilers		
Longitudinal direction	(Q_{L}')	190kcla/m^{2}h

Font of tank (burner side)	(Q_F')	$150 kcal/m^2h$
Rear side wall	(Q_B')	$900 kcal/m^2h$
Boiler dimensions (outer dimensions)		$\phi 1,500 \times 4,450$ mm

5.2. Equations for Calculating the Heat Balance

Input

Heat of fuel combustion (Q_C)

$Q_C = F \times Hl = 437 \times 10^3$ kcal/h

Sensible heat of fuel (Q_S)

$Q_S = F \times C_P (T_F - T_O) = 1.1 \times 10^3$ kcal/h

Output

Heat loss in exhaust gas (Q_E)

Theoretical amount of air (A_O) $= (0.85\ Hl/1,000) + 2.0 = 10.1\ Nm^3/kg$

Theoretical amount of exhaust gas (G_O) $= 1.11\ Hl/1,000 = 10.5\ Nm^3/kg$

Air ratio (m) $= 21/(21 - O_2) = 1.5$

Actual amount of exhaust gas (G) $= G_O + (m - 1)A_O = 15.6\ Nm^3/kg$

$Q_E = F \times G \times 0.33 (T_G - T_O) = 47.4 \times 10^3$ kcal/h

Heat release from boiler body (Q_R)

$Q_R = (190 \times 20.97) + (150 \times 1.77) + (900 \times 1.77) = 5.8 \times 10^3$ kcal/h

Other heat loss (Q_O): given as 3% of input

$Q_O = 0.03 (Q_C + Q_S) = 13.0 \times 10^3$ kcal/h

Heat of steam (Q_V)

$Q_V = Q_C + W_S - Q_E - Q_x - Q_O = 371.9 \times 10^3$ kcal/h

Amount of steam evaporation (S)

Enthalpy of steam (E_S) = 662.0 kcal/kg

Enthalpy of feedwater (E_f) = 33.0 kcal/kg

$S = Q_V \div (E_S - E_f) = 591.3$ kg/h

6. Problems in Heat Control and Potential Solutions

6.1. Boiler

(1) Feedwater meter

The feedwater meter was out of order for one year but it is desired that

$$\text{Simple evaporation ratio} = \frac{\text{Quantity of feedwater} - \text{Qty of Blow Water}}{\text{Fuel consumption}}$$

be calculated and changes in boiler efficiency be monitored everyday.

(2) Improvement of air ratio

Oxygen content in exhaust gas was measured and rather high value of 6.6% was obtained (during low combustion).

The ratio of the actual amount of input air to the amount of air theoretically required for combustion e.g. air ratio (m),

$$m = \frac{21}{21 - O_2} = 1.46$$

Since the proper value for m is less than 1.3, it is expected that the amount of air will be reduced to the point where no black smoke is discharged from the chimney to reduce exhaust gas losses.

According to the heat balance table, the fuel conservation when the air ratio is improved to 1.3 is 1.6%.

Assuming half of the time is at low combustion, annual fuel savings are as follows:

300 x 0.5 x 0.016 = 2.4 kl/y

(3) Boiler Water Control

The quality of feedwater and boiler water is as follows:

	Feedwater	Boiler water
pH	7.1	10.9
conductivity	848 μS/cm	9,700 μS/cm

It is necessary to keep conductivity of boiler water less than 6,000 μS/cm.

By appropriately controlling the concentration of boiler water, degradation of boiler efficiency and corrosion of the boiler body can be prevented.

In this case, it is necessary to improve the control of softener operation because the conductivity of feedwater is high.

(4) Leakage of steam

Leakage of steam from a valve gland on a steam header was found. In case of steam with pressure of 6 kg/cm^2G, about 3 kg/h escapes from a hole with a diameter of 1mm.

This should be repaired because the quantiyt of leakage will increase if left as it is.

6.2. Improvement of insulation

Poor insulation was found at several places. Locations and improvements in insulation are shown in the following table.

Since cost of improvement for insulation can be recovered in a short period, immediate steps should be taken.

Steam piping of the sizing machine and glue cooker room and glue piping should be rearranged and the pipe lengths shortened as much as possible.

Outdoor piping from the boiler room to sizing machines and heat setters is not completely insulated.

It is necessary that insulation on outdoor piping be adequate and rain-proof.

Expectation effect of energy conservation by insulation for equipment

Name of equipment	Part of insulation and specification	Surface temperature °C		Heat loss Kcal/m²h		Decrease heat loss by insulation		Fuel conservation amount (Kℓ/year)	Cost Saving Bt/y	Cost to insulating (Bt)
		Existing state	After improvement	Existing state	After improvement	Per hour (Kcal/h)	Per year (x10³Kcal/year)			
Sizing machine	Steam piping 2" x 3.5 mℓ (inlet header) ¾" x 0.8 mℓ x 4 (from inlet header to steam drum) (Steam pressure 1.8kg/cm²)			Kcal/mh 271 122	75% decrease	1,339	9,600	1.2	5,600	1,600
Glue cooker	Surface area of glue tank 3.6 m²	120		1,240	75% decrease	3,348	16,070	2.0	9,400	2,400
	No. 2 Bottom area of storage tank 1.13 m² No. 3 " 1.04 m² Total 2.17 m²	72		427	75% decrease	695	5,000	0.6	2,800	1,400
Heat setter	Steam piping 2" x 11 mℓ Valve 2" x 1 pce. (equivalent length 1.1 mℓ) (Steam pressure 7.5kg/cm²)			Kcal/mh 430	75% decrease	3,580	25,800	3.3	15,500	4,400
Boiler	Feed water piping between deaerator and boiler 3" x 20mL			Kcal/mh 150	Kcal/mh 20	2,600	18,700	2.4	11,300	7,600
	Fuel service tank 580D x 2,100H, surface area 5.54 m²	80		605	90	2,853	20,500	2.6	12,200	3,600
	Accessories valves of steam header 2" x 3 p'cs 2½" x 3 p'cs					1,132 1,956	22,200	2.8	13,200	7,800
Total									14.9	28,800

Notes:
1. Insulation material is glass wool and it's thickness is 25 mm
2. Annual operating hours is 24 h x 300 day (16 h/day for glue cooker)
3. Fuel conservation amount $= \dfrac{\text{decrease heat loss per year by insulation}}{9{,}500 \times 0.85 \times 0.975} \times 10^{-3}$ kℓ/year

6.3. Recovery of Condensate

Since the distance to the boiler room is short, it is expected that condensate of the sizing machine and heat setter jacket can be recovered and utilized as feedwater to the boiler. Then the temperature of feedwater raises, its quality is improved.

Assuming that temperature of feedwater entering deaerator is raised from 30° C to 60° C as a result of the recovery of condensate, fuel consumption can be saved as follows:

$$\text{Rate of saving} = \frac{591.3\,(60 - 30)}{(438.1 - 47.4) \times 10^3} = 0.045$$

Quantity of fuel saving = 300 x 0.045 = 13.5 kl/year

Insulation of the condensate return pipe must not be neglected.

It is acceptable that condensate from the mixing tank of the glue cooker has been already being recovered in the hot water tank.

6.4. Inspection and Maintenance of Steam Traps and Meters

One steam trap in the sizing machine of the No. 1 dryer and five in the No. 2 and No. 3 dryers were defective.

Condensate discharge pipes form four traps in No. 1 dryer are inclined upwards and these must be inclined downwards.

One pressure gauge on No. 1 dryer was defective.

It is necessary to prepare a list of all pressure and temperature gauges and steam traps and inspect and maintain them periodically.

6.5. Change of Steam Pressure

It is acceptable that the steam pressure is reduced to 2.2 kg/cm^2 G at the heat setter and 1.8 kg/cm^2 G at the sizing machine.

Though steam pressure is not reduced, but used as is for the glue cooker and rice cooker, it is advantageous to effectively utilize retained heat by reducing the steam pressure.

Fuel oil conservation are as follows when pressure-reducing valves are mounted on the glue cooker and rice cooker. They are used at a pressure of 3 kg/cm^{2}G:

- 8.1 kg/cm^{2}G (9.1 kg/cm^2 abs) Latent heat of steam: 485.2 kcal/kg
- 3.0 kg/cm^{2}G (4.0 kg/cm^2 abs) Latent heat of steam: 510.0 kcal/kg

The rate of steam conservation is $1 - \frac{485.2}{510.0} = 0.049$

Assuming 20% of the generated steam is used for the glue cooker and rice cooker, the savings are as follows:

300 kl/year x 0.2 x 0.049 = 2.9 kl/year

7. State of Electric Power Consumption

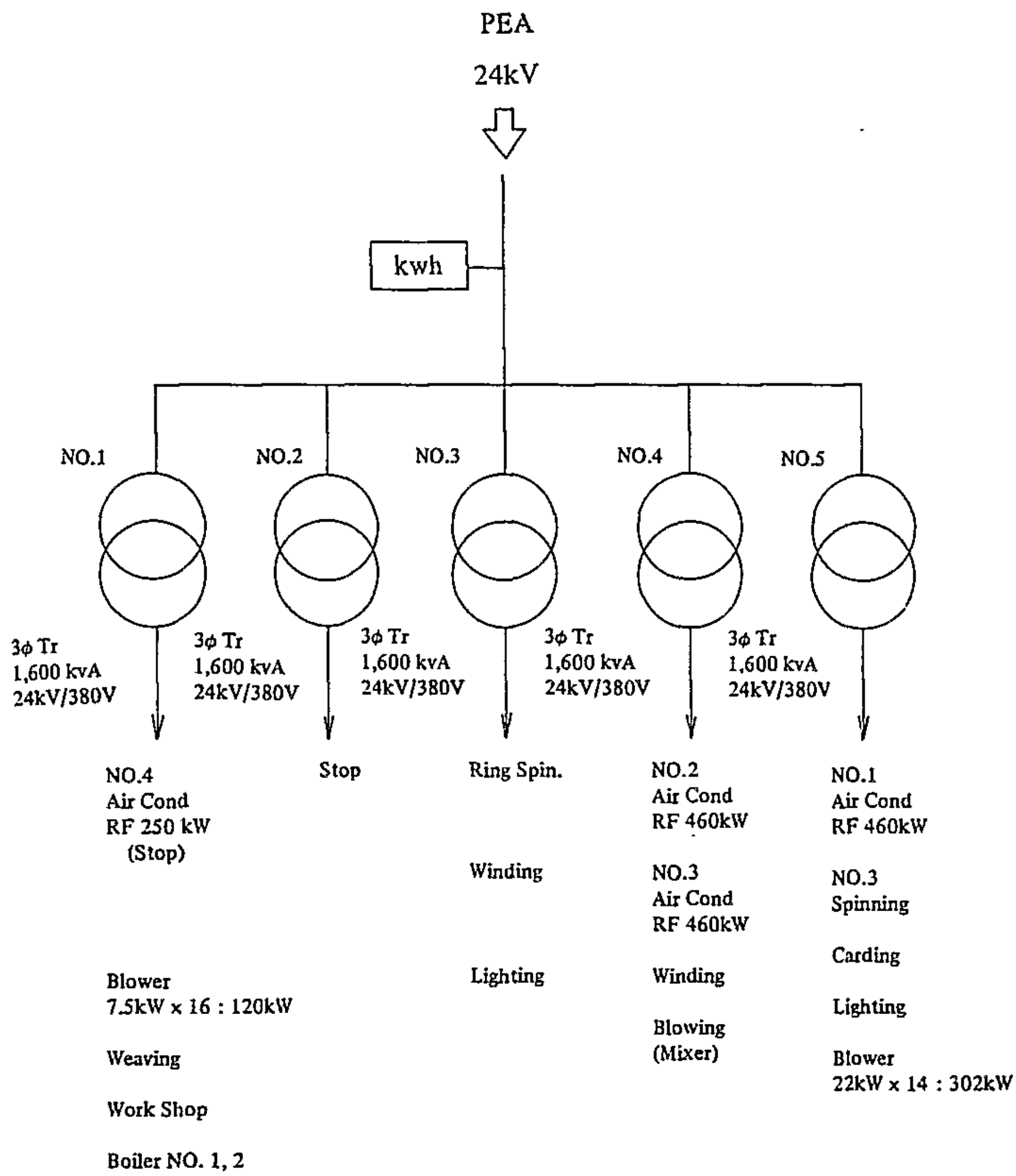
7.1. The Principle Data Relating to Power Consumption

- Power company : PEA
- Peak demand : 4,160 kW
- Power consumption : 20,752,000 kWh/year
- Load factor : 57.7%
- Penalty : None
- Power factor : 85%
- Transformers : 6,400 kVA (1,600 kVA x 4 units)
- Power Consumption rate: Yarn 3.319 kWh/kg; Cloth 0.463 kWh/yard

7.2. Load Composition

• Motor	:	65.0%
• Air conditioning	:	30.0%
• Lighting	:	5.0%
Total		100 %

7.3. One line diagram



8. Problems in Electric Power Control and Potential Solutions

8.1. Significant Achievements

This factory has achieved the following:

(1) Reduction of loss in electric power distribution.

Since the load center is about 700 m from the location of power reception, power is distributed at 24 kV to reduce loss.

In addition, a transformer is installed at each spinning and weaving factory which form a load center to reduce loss due to wiring.

(2) High efficiency operation of transformer

While the capacity of the transformer is 6,400 kVA, peak demand is 4,160 kW and the power factor is 85%. Therefore, the load factor of the transformer becomes about 76% and it is operated within a high efficiency range.

8.2. Problems and Potential Solutions

8.2.1. Maintenance and Utilization of Data of Electric Power

(1) An integrating wattmeter should be installed for each process and major equipment (example: refrigerator).

(2) Currently, the integrating wattmeter for received electric power is read every day but electric power consumed is not calculated by multiplying this reading by a factor. Therefore, statistical data on the electric power for basis of energy conservation is not maintained.

Therefore, electric power consumption every hour should be recorded in a logbook.

In this factory, it is considered pratical to automatically record at a substation of the factory because the position of the integrating wattmeter for received power is too far from the factory.

(3) By utilizing this record, a daily load curve is prepared and the electric power consumption rate is confirmed to contribute to the rationalization of the management of the factory.

In particular, since the load factor is low, irrespective of a three-shift system, peak demand is controlled and the load factor is improved about of 87% by utilizing daily load curves and finely adjusting so that production equipment of the spinning and weaving departments are not started at the same time.

Since the load of the transformer is small, it is very important to make an effort to be able to stop one transformer by controlling the peak demand as well as maintaining the power distribution sytem.

In this case, energy conservation can be calculated as follows. Here, electric power loss of the 1,600 kVA transformer is estimated at 24,100 W according to the manufacturer's data.

Electric power savings: 24,100 W x 24 h x 312 days
≑ 180,460 kWh/year

Saving rate: 180,460 kWh/year ÷ 20,752,000 kWh/year
≑ 0.9%

8.2.2. Improvement of Equipment Control

(1) Motor

a. It was reported that there are many troubles such as burned motors during opening and scutching processes and these may be attributed to the following reasons:

- Because a great amount of Thailand cotton is used as raw cotton and impurities in this cotton are not completely removed, a large force is applied to a part of the cotton opener and scutcher, thereby causing motor failures.
- Due to clogging of the filters in motors of cotton opener and scutcher caused by floating cotton, heat radiation becomes inadequate, causing motor failure.
- Since belt tension is too tight, an excessive load is applied to the bearing causing motor failure.

b. The following countermeasures are considered:

- When Thailand cotton is used, impurities should be completely removed. A potential solution might be the selection and removal of impurities carried out during a process prior to existing cotton opener and scutcher.
- Clean completely to eliminate filter clogging due to floating cotton.
- Belt tension is corrected and the bearing is periodically inspected. The bearing is well-maintained and the looseness of the bearing retainer is remedied.

c. It was learned that during the spinning process there were many motor failures due to sinking of land in the past, but improvement of motor foundations was made then and failures were reduced.

As a result of measurement of the load factor of large capacity motors, mainly in the spinning process, the maximum value was 86.7% and motors with extremely excessive loads were not found.

In addition, temperature of the motor surfaces fell into an allowable range and no abnormality was found.

This may be a result of the execution of the previously mentioned improvements to motor foundations. Anti-vibration rubber and springs should be applied to motors to prevent failures, such as defective bearings due to vibration.

It is important to reduce electric power loss caused by friciton due to detective bearings by periodical inspection.

d. Belt tension on motors in each process is generally proper, although there are some exceptions as shown below. When normal force is applied under thumb pressure, proper tension of the belt is when the amount of deflection equals the thickness of the belt. It is very important to reduce electric power loss due to defective transmission.

The motor in the following has unsuitable belt tension.

Process	Capacity	No. of units	Total capacity
Carding	2.2 kW	3 units	6.6 kW
Drawing (I)	2.2	2	4.4
Drawing (II)	2.2	3	6.6
Roving	3	3	9
	7.5	1	7.5
Spinning	4.8	14	67.2
	10	9	90
Winding	1.5	1	1.5
	3.5	3	10.5
	5.5	1	5.5
Total			208.8 kW

By optimizing the belt tension on motors, energy conservation are calculated as follows, when the electric power loss is reduce by 3%:

Electric power conservation

208.8 kW x 0.03 x 24 h x 312 days ≒ 46,900 kWh/year

Saving rate

46,900 kWh/year ÷ 20,752,000 kWh/year ≒ 0.2%

e. When the load factors of large capacity motrs in each process were measured, the following motors experience light load, but others were operated within a high efficiency range from 80 to 100%.

Process	Application	Capacity	No. of units	Load factor
Spinning	Main motor	15 kW	23	19.1%
Spinning	Blower	15	4	53.7
Finishing	Press	22	1	58.2
Weaving	Sizing	11	2	51.4

By optimizing the capacity of these motors and operating them at high efficiency, the resulting energy saving are calculated as follows:

Motor capacity	Efficiency	Loss	No. of units	Reduction of loss
kW	%	kW		kWh/year
15 → 3.7	79.5 → 86.5	3.08 → 0.50	23	443,559
15 → 11	89.5 → 00.0	1.58 → 1.10	4	14,227
22 → 15	90.5 → 91.0	2.09 → 1.35	1	5,541
11 → 7.5	89.0 → 87.5	1.21 → 0.94	2	4,080
			Total	467,410

Electric power savings   467,410 kWh/year

Saving rate

$$467{,}410 \text{ kWh/year} \div 20{,}752{,}000 \text{ kWh/year} \doteqdot 2.3\%$$

(2) Air Conditioning

a. The capacity of blowers is 422 kW in total and the following energy conservation are calculated by controlling speed by means of changing pulley diameters or by frequency conversion utilizing a semi-conductor: Currently at this factory, since 10% of dampers are controlled, the speed control of motors is replaced by this means.

Electric power savings

$$422 \text{ kW} \times \{(1 - 0.9^3) \times 24 \text{ h}\} \times 312 \text{ days} = 761{,}540 \text{ kWh/year}$$

Saving rate

$$761{,}540 \text{ kWh/year} \div 20{,}752{,}000 \text{ kWh/year} \doteqdot 3.7\%$$

b. A person concerned in the factory reported that temperture and humidity of each process are set at 30° C and 65% equally.

The results of the measurement are as follows. They are almost equivalent to the value set by the factory.

Hereafter, it is necessary to set the temperature and humidity for each process by providing a different value.

	Section-I		Section-II	
• Spinning factory				
Spinning	32° C	60%	30° C	64%
Simplex	32	55	31	60
Drawing	32	51	31	56
Carding	32	54	29	64
Twisting	34	51	31	59
• Weaving factory				
Weaving	27	72		
Sizing	33	54		

c. Realization of a plan in which cold water from a cooling tower is subjected to over-flow and is then stored in a separate tank to reutilize energy is recommended.

d. Since a ventilation fan installed in a wall rotates irregularly, the bearing of the motor is periodically inspected and electric power loss due to friction must be reduced.

e. There are 1,740 (29 each/unit x 20 unit/room x 3rooms = 1,740) nozzles of air-washers with a diameter of 4 mm.

Since there is no data concerning the amount of water used, details must be obtained. Based on adjustment, such as enlarging nozzle diameters and reducing the number of nozzles, the reduction of water, namely a reduction in electric power used, is recommended.

f. It is necessary to completely remove floating cotton by cleaning more frequently since there is much floating cotton in each process. If required, a humidifier should be used to allow floating cotton to fall onto the floor where it can be later cleaned and removed.

Since raw cotton, dropping into a suction hole of a blower on a floor during the cotton opening process, adverse affects the blower capacity, it is very important to change the area where raw cotton is dropped or place a cover on the suction hole.

(3) Illumination

a. Although ordinary fluorescent lmaps (total capacity: 200 kW) are used for the lighting source in the factory, about 10% of electric power consumption can be saved with the same intensity of illumination by replacing these lamps with energy conservation type.

Energy conservation can be calculated as follows:

Electric power conservation

$$200 \text{ kW} \times 0.1 \times 24 \text{ h} \times 300 \text{ days} \doteqdot 144{,}000 \text{ kWh/year}$$

Saving rate $144{,}000 \text{ kWh/year} \div 20{,}752{,}000 \text{ kWh/year} \doteqdot 0.7\ \%$

b. Most of the fluorescent lamps are nearing the end of their rated life and replacement after 6,000 hours will result in less deterioration of the light beam and will also be economical.

c. Irrespective of the ceiling height of the nearly 6 meters, the cotton opening and scutching processes experience low illumination level because the fluorescent fixtures are directly mounted to the ceiling.

When the fixtures are lowered to about 3 meters from the floor, without interfering with the work, the intensity of illumination will be improved about four times.

d. During the inspection process, flickering of illumination on the cloth surface occurs due to lack of illumination over the inspection table. Also, the rotation of a fan on the ceiling casts shadows. The results in the worsening of efficiency and fatigue of the worker.

It is necessary to prevent flickering by replacing or increasing the number of fluorescent lamps over the inspection table and by utilizing a floor fan instead of a ceiling fan.

e. Intensity of illumination for other processes was measured and it showed almost satisfactory values.

8.2.3. Improvement of Production Process

(1) Improvement of quality

Currently, the rate of defects is 10% for yarn and 3% for cloth, and because 75% of the total electric power used is required for the production of yarn, it is an immediate problem and requires reduciton.

(2) Countermeasures for improvement of quality

The following countermeasures are required to decrease the rate of defective yarn.

a. Impurities in raw cotton must be completely removed to decrease the defective portion before the cotton opening and scutching processes. A key point in improving quality is the strict selection of raw material.

b. Floating cotton in each process must be completely removed by cleaning. Worsening of the defective portion in the spinning process due to the mixing of floating cotton must be prevented.

c. Suitable temperature and humidity for each process are set, and yarn is produced under the most suitable air conditions with improved quality.

9. Summary

The abovementioned remedial measures, if actually taken, will bring about energy-conservation effects as shown below:

	(equivalent oil) kl/year	%
Improvement of air ratio	2.4	0.8
Improvement of insulation	14.9	5.0
Recovery of condensate	13.5	4.5
Change of steam pressure	2.9	1.0
Subtotal	33.7	11.2
	10^3 kWh/year	%
Stoppage of transformer	180.5	0.9
Adjustment of motor belt tension	46.9	0.2
Optimization of motor capacity	467.4	2.3
Contorl of motor speed	761.5	3.7
High efficiency of light source	144.0	0.7
Subtotal	1600.3	7.8

Report No. 5: Textile

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

— Siam Synthetic Weaving Co., Ltd. —

June, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation
— Siam Synthetic Weaving Co., Ltd. —

1. Outline of the Factory

Address	Chuchat Road, Tambol Prachatipat Ampur Thanyaburi Pratumthani	
Capital	18 million Bt	
Type of industry	Textile	
Major products	Yarn, Dyeing yarn, Cloth	
Annual product	Cloth 1,200,000 yards Yarn 700,000 Kg	
No. of employees	400	
Annual energy consumption	Electric Power	6,362,400 kWh
	Fuel	Oil 890 kℓ
Interviewees	Factory director, Mr. Yamawaki and another	
Date of diagnosis	Feb. 3 ~ 4, 1983	
Diagnosers	K. Nakao, Y. Ohno, M. Matsuo	

In 1971, the factory was founded as a joint venture with a Japanese enterprise. For the first five years, the plant maintained a technical assistance relationship with the Japanese enterprise. The technical assistance agreement has since been terminated.

The factory is a leading manufacturer producing woven fabrics and spun yarn after receiving orders. The factory holds the top position in terms of yarn dyeing. Its characteristic is yarn with a silky treatment, and the factory is enjoying an exclusive position in the market.

It produces woven fabrics that have a depth of texture weaving polyester fibers from Thai Teijin as warps after treating them and Thai silk as wefts.

Fabric and yarn production facilities are new and are well maintained. Six of the latest shuttleless weaving machine are used. The factory plans to use more of them.

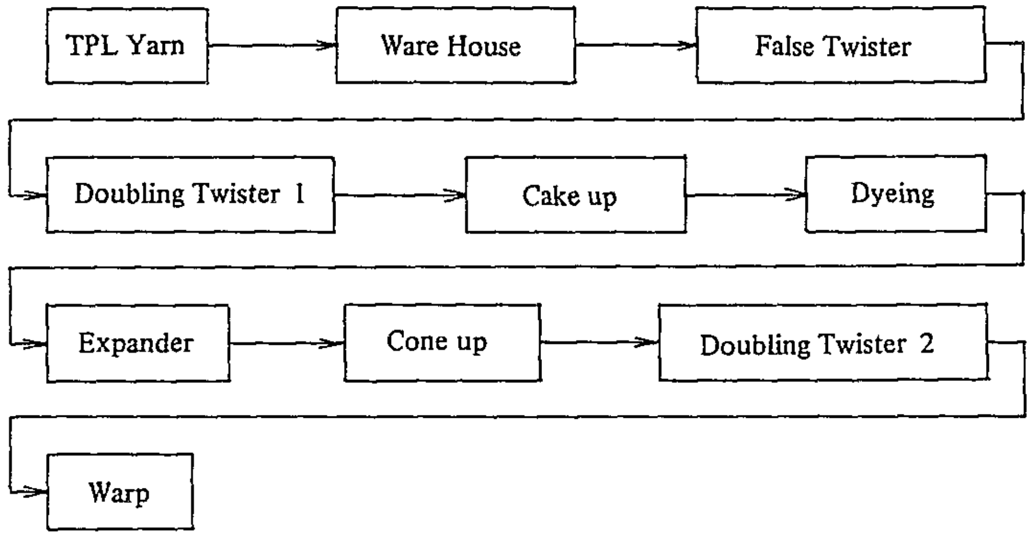
The company sells 40% of its yarn, using the rest to weave fabrics. In sales value, fabrics account for 70%.

The rejection rates for fabrics and yarn are 1 and 2%, respectively, which are very low.

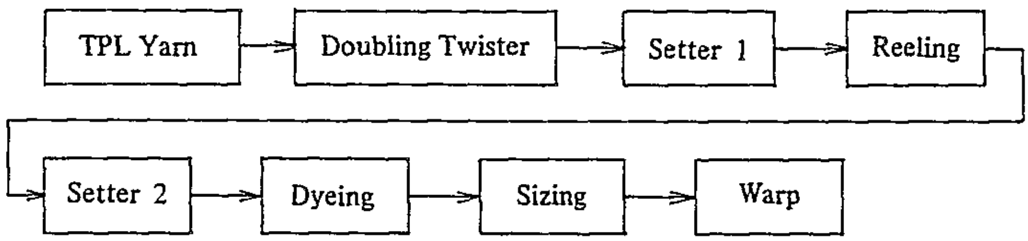
The selling price has remained the same since its founding, while costs, particularly power charges, have increased significantly. The proportion of power charges in the production cost of its products has increased form 0.75% in 1971 to 4.5% (6 times) in 1983, deteriorating its position. The company is seriously copeing with the problem of energy conservation and was looking forward to receiving advice.

2. Manufacturing Process

2.1 WOOLY



2.2 SILKY

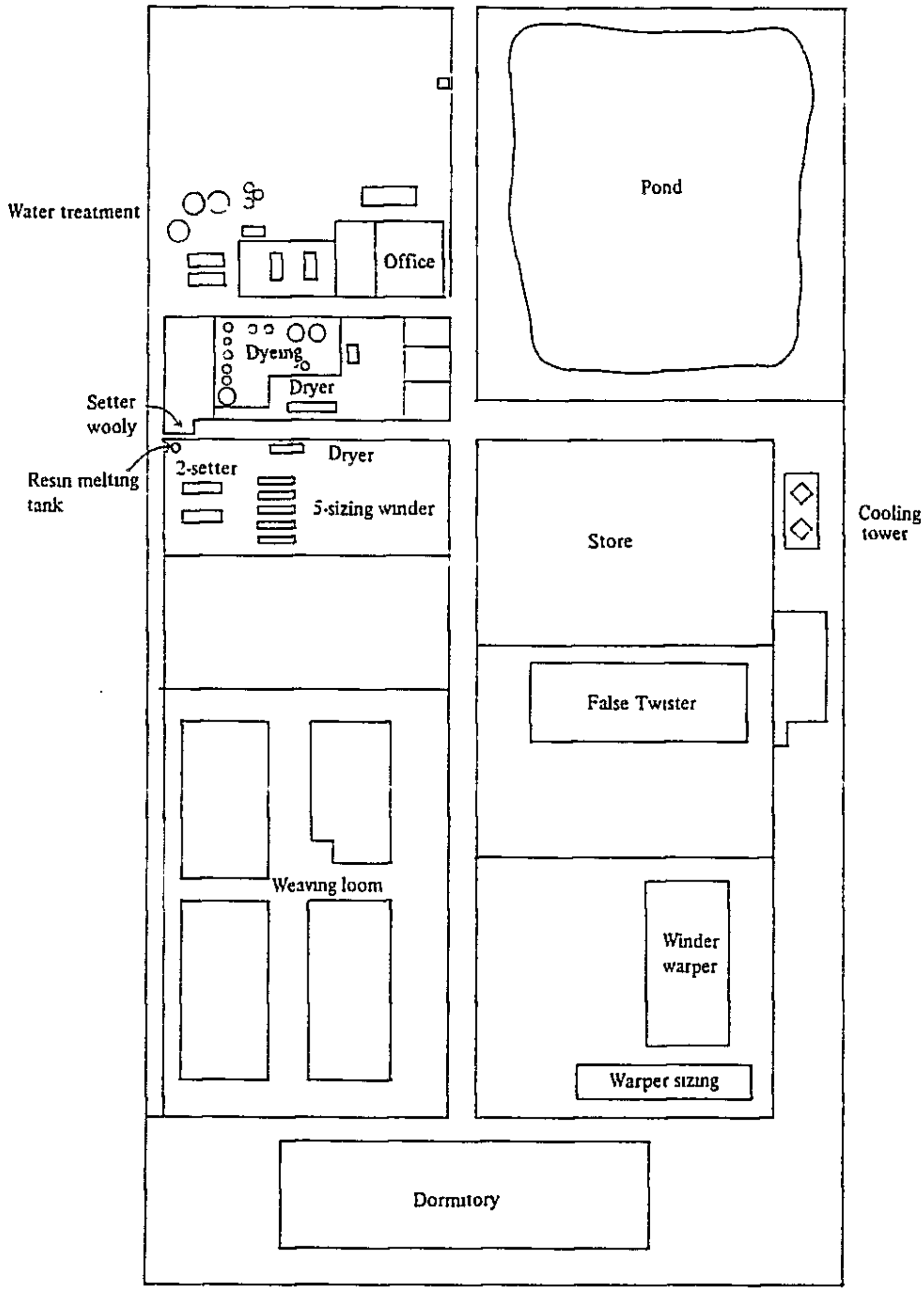


3. Major Equipment

3.1. Major Equipment

Name	No. of units installed	Type, etc.
Boiler	2	3 t/h, 8.5 kg/cm^2 TAKUMA
Heat setter	3	Vacuum, steam injection type (2 sets) Normal pressure " (1.set)
Sizing machine	5	To use together steam heater and infrared lamp
Dyeing machine	14	Operating 30 kg x 2, 50 kg x 2 100 kg x 2, 200 kg x 2 Stand by 0.5 kg x 1, 1 kg x 1 5 kg x 1, 400 kg x 1 10 kg x 2
Dryer	1	Another one is stopping
Weaving machine	106	

3.2. Layout



Water treatment
Office
Pond
Dyeing
Dryer
Setter
wooly
Resin melting
tank
2-setter
Dryer
5-sizing winder
Store
Cooling
tower
False Twister
Weaving loom
Winder
warper
Warper sizing
Dormitory

4. State of Energy Management

The company's policy is to save energy centering on lowering the power cost. However, no goals·have yet been set. Greater participation by the employees and numerical control based on measured values are important in implementing energy conservation measures.

4.1. Investment in Energy Conservation and Cases of Improvement

The company invested 80,000 Bt in 1979 in condensate recovery facilities. Since then, no investments in energy conservation facilities have been made. The company's investment criterion is to recover the initial cost within two years.

4.2. Grasp of Energy consumption

Fuel and power consumtpion for the entire factory is grasped every month. However, it is important to grasp consumption of such principal equipment as boilers everyday to calculate their consumption rates and to check variations in order to implement countermeasures without delay. Statistics should be compiled broken down by process and facility and should be shown to the employees to increase their interest.

Variation factor analysis is not always performed. However, the factory has experience of conducting it. It is recommended that this practice be utilized.

4.3. Energy Conservation Committee and Suggestion System

The factory has no organizations such as an energy conservation committee. It is recommended that some organizaitons be created.

The actual work procedures, equipment characteristics, etc. are known best to veteran employees and foremen in the factory. The organization should be xpanded to include them and should be headed by the factory manager as the committee chairman, to set goals and to solve problems. Suggestions by employees should be promoted and the committee should decide which ones should be accepted. Employees should be organized into groups and should be given individual goals. Awarding of prizes to those participants in outstanding groups is also a good practice.

The company has contracts with consultants, and their knowledge and wisdom should be fully utilized.

4.4. Employee Education and Training

An elevation of the employee education level is important. Therefore, employees should be encouraged to attend seminars sponsored by TPA and other organizations, and the results of such meetings should be conveyed to company employees for education and training purposes.

The company was calling upon its employees to conserve energy and was showing posters, etc. These efforts should be continued adding a freshness from time to time so that the employees will not get tired of seeing the same material.

5. State of Fuel Consumption

Bunker A is used entirely to generate steam in the boiler, and approximately 890 kl/year is consumed.

The steam produced is primarily consumed for dyeing, as well as for heating in the drying, heat setting, and sizing processes.

5.1. Boiler Operations

The boiler is operated at an evaporation rate of 3 t/h and 5 to 6.5 kg/cm^2G normal operating pressure. Reflecting the market trend, the boiler is operated 16 hr/day at present. Two boilers are operated alternately every 6 months. They are operated 300 days a year. The boiler load is estimated at about 90%.

5.2. Boiler Heat Balance

The heat balance was prepared using some assumptions, as the feedwater meter was out of order.

Input			Output		
Item	10^3 Kcal/h	%	Item	10^3 Kcal/h	%
Heat of fuel combustion	1,757.5	99.8	Heat of steam	1,525.4	86.6
Sensible heat of fuel	4.2	0.2	Heat loss in exhaust gas	169.7	9.6
			Heat loss in blow water	4.2	0.2
			Heat release from boiler body others	62.4	3.5
Total	1,761.7	100.0	Total	1,761.7	100.0

5.3. Data Given for Calculations of the Heat Balance

Type of fuel		A heavy oil
Fuel consumption	(F)	185 kg/h
Heat content of fuel (low)	(Hl)	9,500 kcal/kg
Specific heat of fuel	(C_p)	0.45 kcal/kg°C
Specific gravity of fuel		0.975
Temperature of fuel	(T_F)	80°C
Reference temperature	(T_o)	30°C
Oxygen content in exhaust gas	(O_2)	5.3%
Temperature of exhaust gas	(T_g)	230°C

Temperature of feedwater	(T_w)	75°C
Quantity of blow water	(B)	50 kg/h
Blow water temperature	(T_B)	159°C
Steam pressure	(P)	5.2 kg/cm₂g
Heat release from boiler body		
Longitudinal side walls of boiler	(Q_L')	187 kcal/m^2/h
Front of boiler (side of burner)	(Q_F')	150 kcal/m^2/h
Back of boiler	(Q_B')	917 kcal/m^2/h
Boiler dimensions (outer dimensions)		φ2,160 x 4,440L

5.4. Equations for Calculatiang the Heat Balance

Input

Heat of Fuel Combustion (Q_C)

$Q_C = F \times Hl = 1{,}755.5 \times 10^3$ kcal/h

Sensible Heat of Fuel (Q_S)

$Q_S = F \times C_P (T_F - T_o) = 4.2. \times 10^3$ kcal/h

Output

Heat Loss in Exhaust Gas (Q_E)

Theoretical amount of air

$(A_O) = (0.85\ Hl/1{,}000) + 2.0 = 10.1\ Nm^3/kg$

Theoretical amount of exhaust gas

$(G_O) = 1.11\ Hl/1{,}000 = 10.5\ Nm^3/kg$

Air ratio $m = 21/(21 - O_2) = 1.34$

Actual amount of exhaust gas

$(G) = G_O + (m - 1)A_O = 13.9\ Nm^3/kg$

$Q_E = F \times G \times 0.33(T_g - T_o) = 169.7 \times 10^3$ kcal/h

Heat Loss in Blow Water (Q_B)

$Q_B = B \times (T_B - T_W) = 4.2 \times 10^3$ kcal/h

Heat Release from boiler body (Q_R)

$Q_R = (\pi \times 2.16 \times 4.44 \times 187) + \{(2.16/2)^2\pi \times 150\} + \{(2.16.2)^2\pi \times 917\}$

$= 9.5 \times 10^3$ kcal/h

Other Heat Losses (Q_O) 3% of input

$Q_O = 0.03(Q_C + Q_S) = 2.9 \times 10^3$ kcal/h

Heat of Steam (Q_V)

$Q_V = Q_C + Q_S - Q_E - Q_B - Q_R - Q_O = 1{,}525.4 \times 10^3$ kcal/h

Quantity of Steam Evaporation (S)

Enthalpy of steam (E_S) = 658.3 kcal/kg

Enthalpy of feedwater (E_f) = 75 kcal/kg

$S = Q_V \div (E_S - E_f) = 2{,}615$ kg/h

6. Problems in Heat Control and Potential Solutions

6.1. Checking of Steam Piping etc.

Generally, insulation was good. However, unnecessry pipe portions should be eliminated, piping distances should be shortened, secure insulation work to minimize condensate generation should be undertaken, maintenance and repairs of steam traps to facilitate condensate separation should be carried out, and complete elimination of steam leakage is necessary.

Steam traps, valves, pressure gauges, etc. should preferably be checked after preparing an annual checking schedule.

6.2. Normal Pressure Heat Set Chamber

The door packing was defective, and steam was leaking. For this reason, the door surface temperature was high, 73 to 81°C. Complete door sealing is recommended. Insulation of the 1" steam piping for heating was not sufficient.

The sensors for the internal thermometers were set in the jacket, failing to indicate the temperature in the chamber. The temperature does not return to the normal temperature level even when the chamber is opened, and no decision as to the appropriateness of thermometer indication is possible. The sensor positions should be restudied.

6.3. Sizing Machines

Asbestos tape, or other material, should be taped on 1/4" branch pipes, etc. connected to the sizing machines for insulation. Nos. 1, 2, and 5 steam traps counting from the right could not be operated smoothly and required overhauling. Steam was leaking from the Nos. 2 and 3 1/4" unions, which should be repaired.

6.4 Idling Dryer

The steam pipe for the idling dryer should be disconnected by inserting a blind plate at the junction from the main pipe to prevent inflow of steam into idling and unnecessary pipes.

6.5. Glue Cooker

Insulation is needed for part of the 1" entrance pipe for the coiled pipe for heating the glue cooker, for valves, and for other items. Condensate has to be discharged using steam traps. Discharge by valves causes large steam losses.

The tank should be insulated, and insulating covers should be installed.

The following conversion can be derived when heat losses reduction from the tank are converted into fuel oil consumption.

- Tank surface area 3.2 m^2
- Surface temperature 78°C
- Amount of heat loss 617 kcal/m^2h

- Insulation efficiency 75%
- Fuel oil low heating value 9,500 kcal/kg
- Fuel oil specific gravity 0.975
- Boiler efficiency 85%
- Heating time 16 h/day

$$\frac{617\ \text{kcal/m}^2\text{h} \times 3.2\ \text{m}^2 \times 16\ \text{h/day} \times 300\ \text{day/year} \times 0.75}{9{,}500\ \text{kcal/kg} \times 0.85 \times 0.975} = 0.9\ \text{kl/year}$$

6.6. Dryer

Approximately 20 m of the 2" main steam pipe for the dryer was bare. Insulation is rquired for the 2" header pipes to various zones of the dryer, inlets, outlets, branch pipes, valves, joints, couplings, condensate headers, etc.

Some of the valves, steam traps, and pressure gauges did not operate smoothly. Please check all of them and repair when necesary.

The following calculations can be made when heat losses reduction of the 2" main steam pipes are converted into fuel oil consumption.

- Bare pipe length 20 m
- Steam pressure 5 kg/cm^2
- Amount of heat loss 387 kcal/mh

$$\frac{387\ \text{kcal/mh} \times 20\ \text{m} \times 16\ \text{h/day} \times 300\ \text{day/year} \times 0.75}{9{,}500\ \text{kcal/kg} \times 0.85 \times 0.975} = 3.5\ \text{kl/year}$$

Insulation cost is estimates at approx. 5,800 Bt.

6.7. Pressure Type Heat Setters

Insulation and steam trap operations were satisfactory. Plan to recover condensate in the future as is the case with the sizing machines.

6.8. Pressure Dyeing Machines

All the by-pass pipes of the pressure reducing valves at entrances to the dyeing machines were bare.

- 100 kg/cycle type x 2 1 1/2" by-pass pipe
- 200 kg/cycle type x 2 2" by-pass pipe
- 50 kg/cycle type x 2 1 1/2" by-pass pipe
- 30 kg/cycle type x 2 1" by-pass pipe
- 10 kg/cycle type x 2 3/4" by-pass pipe
- 5 kg/cycle type x 1 3/4" by-pass pipe

Water was leaking prominently from the flange of the lower main pipe to the 400 kg/cycle type dyeing machine. The flange should be repaired.

Steam was leaking from the 3/4" inlet steam by-pass pipe of the 10-kg/cycle type dyeing tank and from the 1" inlet steam by-pass pipe of the 30-kg/cycle type dyeing tank.

These pipes should be repaired.

Steam was leaking from the 100-kg/cycle type dyeing tank because of a defective packing. This should be repaired immediately.

The following calculations can be made as an example, when heat losses reduction by insulation of a 2" inlet steam by-pass pipe of a 200-kg/cycle type dyeing tank are converted into fuel oil consumption.

• 2" pipe section	approx. 7 m
• 2" pressure reducing valve x 1	equivalent to 1.55 m pipe length
• 2" flange x 3	equivalent to 1.3 m pipe length
• 2" valve x 4	equivalent to 2.7 m pipe length
• 2" strainer x 1	equivalent to 1.2 m pipe length
• Total pipe length converted to 2" pipes	12.75 m
• Steam pressure	3 kg/cm²G
• Time in service	16 h/day
• Amount of heat loss	308 kcal/mh

$$\frac{308 \text{ kcal/mh} \times 12.75 \text{ m} \times 16 \text{ h/day} \times 300 \text{ day} \times 0.75}{9{,}500 \text{ kcal/kg} \times 0.85 \times 0.975} = 1.8 \text{ kl/year}$$

The foregoing loss calculations are for one dyeing machine. As there are many units installed, a large saving in fuel oil will be made possible by insulating the systems. It is also important to close steam traps by-pass valves securely while heating the dyeing tanks. The heating speed does not accelerate even when live steam is discharged.

The surface temperature of a dyeing machine is high, resulting in large heat losses. Insulation of the tank should be studied.

The following calculations can be made when heat losses reduction of a 100-kg/cycle type dyeing tank are converted into fuel oil consumption.

• Tank and cover surface areas	8.5 m²
• Average surface temperature	115°C
• Average amount of heat loss	1,265 kcal/m²h
• Heating time	3 h/cycle x 3 cycle/day = 9 h/day

$$\frac{1{,}265 \text{ kcal/m}^2\text{h} \times 8.5 \text{ m}^2 \times 9 \text{ h/day} \times 300 \text{ day/year} \times 0.75}{9{,}500 \times \text{kcal/kg} \times 0.85 \times 0.975} = 2.8 \text{ kl/year}$$

Insulation cost is estimated at approx. 5,500 Bt.

The foregoing loss calculations are for one dyeing machine, and a large saving in fuel oil will be made possible by insulating the others.

6.9. Condensate Recovery

Condensate and cooling hot water (softened water) of the dyeing machines are recovered together and are returned to the boiler feedwater tank. There is a large amount of water, and water was overflowing from the feedwater tank.

The temperature of the dyeing tank cooling waste water is high, and the water itself is softened water. As mentioned in Section 6.10, it would be reused for dyeing.

Aside from condensate from the dyeing tanks, condensate from the sizing machines, glue cooker, heat setters, dryers, etc. should also be recovered for recovery in the boiler feedwater tank. The condensate recovery pipes are not insulated at present, and water was leaking from some flanges. The feedwater tank was not insulated, either. These should be insulated, and the tanks should have covers on them so that water can be fed to the boiler at as high a temperature as possible.

By raising the feedwater temperature 15°C, approximately 2.4% of the fuel oil can be saved.

890 kl/year x 2.4% = 21 kl/year

6.10. Utilization of Heat Recovered from Dyeing Cooling Water and Dyeing Waste Liquid Steam can be saved by installing an insulated storage tank to store dyeing cooling waste hot water and by heat-exchanging with dyeing waste hot liquids in a heat exchanger to be newly installed to further raise the temperature of the cooling hot water for the next cycle.

a) Data prepared by a manufacturer of 100-kg/cycle type dyeing tanks

Dye raw material weight	100 kg
Amount of dyeing liquid	1500 l
Cooling water quantity	140 l/min

b) Measured results in the field

Dyeing liquids are cooled from 130 to 90°C and is discharged.

Cooling water temperature is raised from 31 to 56°C.

Cooling time	17 min
Cooling water quantity	140 l/min x 17 min = 2380 l

c) Capacity of the required heat exchanger

Dyeing waste liquid is cooled from 90 to 75°C. Cooling hot water temperature is raised from 56 to 64°C.

Assuming the heat exchanging time to be 17 min.

Heat exchanging area 4.6 m^2 (equivalent to approx. 24 m in 2" pipes)

Considering fouling during operation, approximately 6 m^2 is needed.

A plate-type heat exchanger is recommended, as it can be cleaned easily.

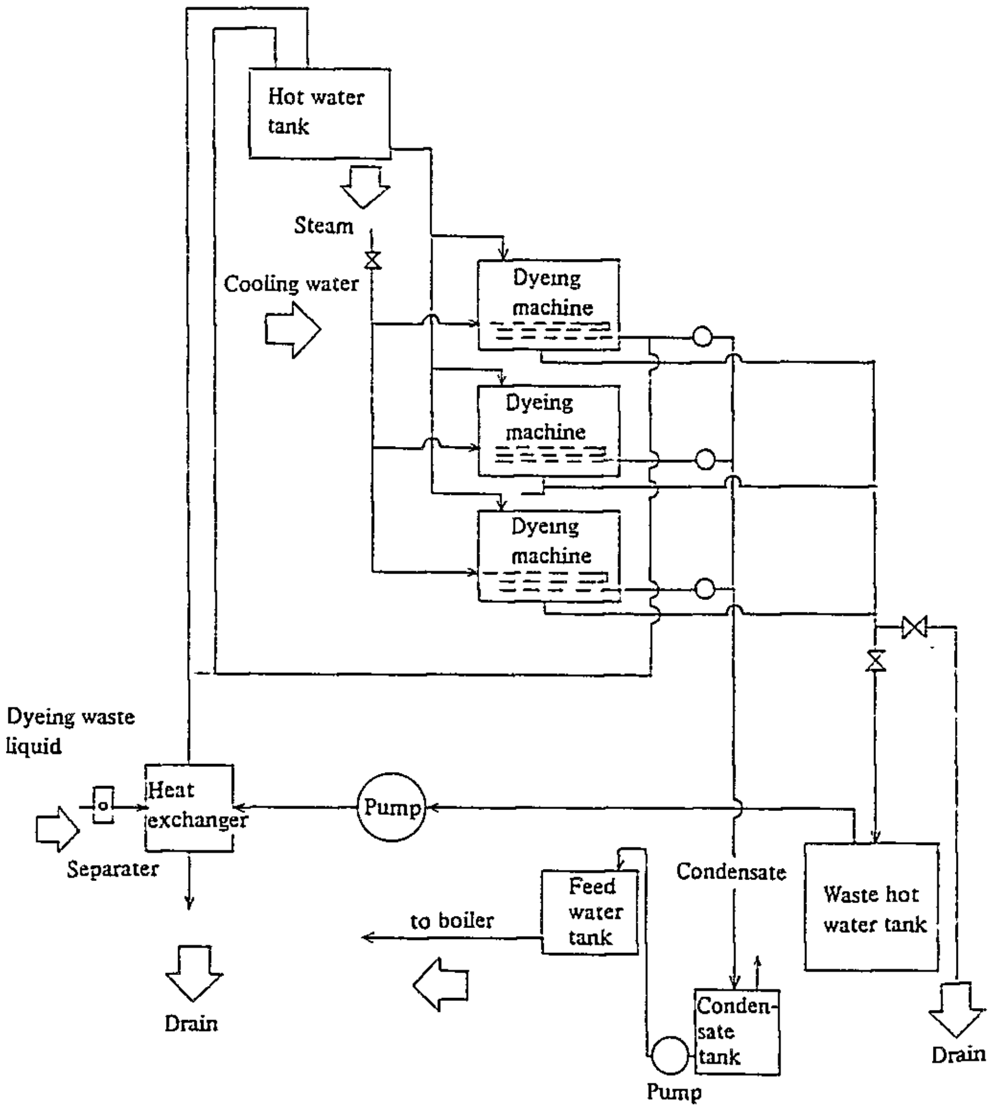
Assuming a day's treatment quantity to be 4,000 kg/3 cycles and an average wet ratio to be 1:15, dyeing waste liquid of 3,000 kg/day x 15 = 45,000 l/day is discharged. By heat-exchanging them,

$$45{,}000 \text{ l/day} \times \frac{2{,}380 \text{ l}}{1{,}500 \text{ l}} = 71{,}400 \text{ l/day}$$

71,400 l/day of hot water at 64°C is produced. Therefore, heat-recovered hot water can be used in the dyeing process and the rest of it can also be used for reduction, oiling, and scouring, permitting a saving of fuel oils as shown in the following. (Temperature drop by heat loss is estimated at 10%)

$$\frac{\{(71{,}400\ l/day \times (64°C - 31°C) \times (1 - 0.1)\} \times 300\ day/year}{9{,}500\ kcal/kg \times 0.85 \times 0.975} = 80.8\ kl/year$$

In a case in Japan, cost for the improvement was recoverd in 3 years.
The flow sheet is shown in the following.



6.11. Boiler Control

Measurement records of boiler feedwater quantities are basic data which is indispensable in determining the boiler efficiency. The feedwater flowmeter should be repaired immediately, adjusted, and used.

The fuel oil flowmeter includes the returned oil quantity in its indication value because of its installation position. Correct consumption cannot be determined as it is. Another flowmeter must be installed before the return pipe to the oil service tank.

6.12. Reinforced Boiler Insulation

The measured surface temperature of the steel plate covering the check opening in the rear of the boiler was considerably high.

Surface tmperature 127°C

Amount of heat loss 1,300 kcal/m^2h

Insulation of this section needs to be reinforced while the boiler is not in operation. The steam main valves, headers and valves should preferably be insulated further also. The steam headers are well insulated. However, in some locations, two valves are installed in series for one system. Steam piping should be simplified whenever possible to avoid unnecessary heat loss.

6.13. Use of Bunker C Oil

The boiler oil burner in the factory is of a rotary type. Utilizing the existing facilities, the fuel can be changed from bunker A to bunker C oil.

The price difference between the two oils is estimated to be approximately 0.2 Bt/l, and the following amount of fuel cost can be saved annually.

0.2 Bt/l x 890 kl/year = 178 x 10^3 Bt/year

But,

(1) The oil preheating temperature should be raised

Specific Gravity of Heavy Oil and Suitable Heating up Temperature

Specific gravity	Heating up temperature °C	Specific gravity	Heating up temperature °C
0.9402	74	0.9792	124
0.9465	82	0.9861	132
0.9529	88	0.9930	140
0.9593	99	1.0000	150
0.9659	107		
0.9725	116		

The heating value per liter of bunker C oil is slightly higher than that of bunker A oil. Study the exact value based on the fuel analysis.

(2) Frequency of checking and cleaning oil filters and burner nozzles should be increased.

(3) To check fuel oil standards, oil should be analyzed once every 2 or 3 months. This is also necessary for boiler calculating efficiency and evaporation ratio.

The following items should be analyzed.

- Higher heating value
- Specific gravity
- Viscosity
- Moisture
- Ash
- Sulfur
- Flash point

6.14. Heat Recovery from Exhaust Gases

The temperature of boiler exhaust gases measured was slightly high, as shown in the following.

At high combustion	250°C
At low combustion	230°C

A large energy conservation effect can be expected by preheating air for oil burner by recovered heat.

In implementing this plan, corrosion of the heat exchanger will have to be contended with when the sulfur content in the fuel is high. Assuming sulfur in the fuel to be 3 wt% and the oxygen content in exhaust gases, 5%, there will be a 0.17 vol% of SO_2 in the gases. Approximatley 2% of it is converted into SO_3, and the quantity of SO_3 will be approximately 30 ppm. The acid dew point at that time will be 120 to 140°C, and care should be taken not to lower the temperature on heat exchanger surfaces below this temperature.

Calculations of the effect accomplished by recovering exhaust gas heat to preheat air and by lowering the exhaust gas temprature from 230 to 160°C are shown in the following.

Heat recovered from exhaust gases (Q_g)

$$Q_g = F \times G \times 0.33 \times (T_{g1} - T_{g2}) = 59.4 \times 10^3 \text{ kcal/h}$$

provided: $F = 185$ kg/h

$G = 13.9$ Nm^3/kg

$T_{g1} = 230$°C

$T_{g2} = 160$°C

Heat transferred to preheated air (P)

Assuming 85% of Q_q is transferred to preheated air.

$$P = Q_q \times 0.85 = 50.5 \times 10^3 \text{ kcal/h}$$

Assuming the heat loss other than the heat loss in exhaust gas (Q_E) in the heat balance table to be an effective heat (H),

Effective heat (H) when air is not preheated:

$$H = \text{Heat input} - Q_E = 1{,}592.0 \times 10^3 \text{ kcal/h}$$

The effective heat does not change even when the air is preheated. However, exhaust gas losses vary proportionate to the fuel quantity, and putting the fuel quantity when prehating the air to be F':

$$F' \frac{\text{Heat input}}{F} + F' \frac{P}{F} = H + F' \frac{Q_E}{F}$$

Rearranging the foregoing equation, the equation shown in the following can be derived:

$$\frac{F'}{F} = \frac{H}{H + P} = \frac{1592.0}{1{,}592.0 + 50.5} = 0.969$$

This means that a 3.1% fuel savings can be achieved. Estimating the fuel consumption after implementing the foregoing insulation, waste liquid heat recovery and other energy conservation measures to be 700 kl/year,

700 x 0.031 = 21.7 kl/year

can be saved. An estimated investment in equipment to achieve this saving will be 100,000 Bt. The investment can be recovered in about a year.

7. State of Electric Power Consumption

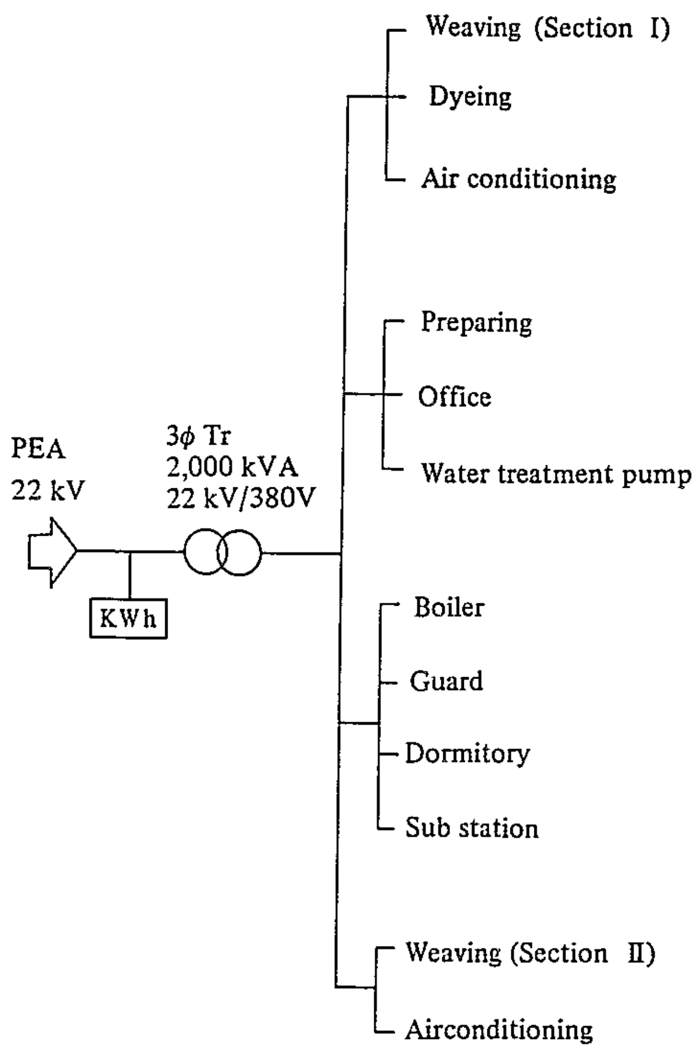
7.1. The Principal Data Relating to Power Consumption

- Power company : PEA
- Peak demand : 968 kW
- power consumption : 530,200 kWh/month
- Load factor : 75%
- Penalty : None
- Power factor : 95%
- Transformers : 2,000 k VA (1 unit)
- Power consumption rate : Yarn 2,727 kWh/kg
  Cloth 3,711 kWh/yard

7.2. Load Composition

Motor	:	62.5%
Air conditioning	:	22.2%
Lighting	:	3.1%
Electric heating	:	12.2%
Total		100 %

7.3. One Line Diagram



8. Problems in Eletric Power Control and Potential Solutions

8.1. Significant Achievements

Very few problems could be found in this factory. The factory has, for exmaple, achieved the following.

8.1.1. Improvement of Power Factor

The power factor was 95%, indicating that the factory was aggressive in its efforts to utilize power effectively. The power factor is automatically adjusted to prevent a leading power factor under low load.

8.1.2. Maintenance of Facility Ledger

A facility ledger is well kept and is utilized for maintenance.

8.2. Problems and Potential Solutions

8.2.1. Maintenance of Receiving Station and Substation

(1) The receiving station and substation are generally well managed. Watt-hour meters are used for receiving only and should be installed also for individual processes.

(2) The substation is not divided into processes. There are only four switchboards for feeders and two switchboards for preparation processes installed in the substation. These switchboards have only ammeters and voltmeters.

Individual switchboards for different processes need to be installed, and wattmeters and power factor meters should also be installed, in addition to ammeters and voltmeters, for energy conservation management.

(3) A daily report for the power consumption is maintained and recorded eveyr hour. However, only watt-hour meter readings are recorded, and the electric energy used is not calculated by multiplying the multiplication factor. It is recommended that the hourly electrical energy used be recorded to prepare daily load curves and to analyze the load broken down into individual processes in order to equalize the load and to increase the load factor.

After determining the trends of electric power consumption, the rate of power consumption is calculated based on the electric energy consumed for each process and product and on production quantities to improve produciton processes.

(4) The capacity of the receiving transformer is 2,000 kVA at present. The load at peak demand is approximatley 1,000 kW, and the power factor, 95%. the transformer load factor will be approximately 53%, indicating that the transformer is operated nearly within a high-efficiency range.

However, all production lines will stop if the transformer fails when there is only one transformer. Considering that the load will increase to approximately 1,700 kW in the future when expansion plans are implemented, the installation of one

2,000-kVA transformer as a stand-by unit is desired.

(5) Without prior warning, the factory is faced with 3 to 4 power failures a month, each one for 10 to 20 minutes.

The twisting machines are affected most in the factory by these power failures. Once yarn is cut, 3 to 4 hours are needed to restore operations. Delay relays should be installed to prevent end breakage caused by sudden power failures.

· The following items need be studied to cope with power failures of long duration such as 10 to 20 minutes each.

a. Delay relays are operated on twisting machines to make the machines stop slowly without breaking the yarn.

b. A diesel generator is started simultaneously with a power failure to start the twisting machines within the time range of delay relays.

The twisting machines are separated from the system, so that the generator will receive the load for the twisting machines only, in order to lower its capacity to a minimum.

c. Once a power failure is recovered, the power supply for the twisting machines is switched from diesel generation back to the utility power.

8.2.2. Equipment Control

(1) Motors

a. Load variations of the motors for the following equipment are great, and speed control should be exercised by changing pulley diameters to save energy.

Blowers	Total	44 kW
Cooling towers	Total	29.5 kW
Total	Grand total	73.5 kW

Assuming the speed control factor of each motor to be 10%, the necessary power varies proportionately to a third power of the speed, and the following energy can be conserved.

- Power savings $73.5\ kW \times \{(1 - 0.9^3) - 0.03\} = 17.71\ kW$
- electric power savings $17.71\ kW \times 24\ h \times 350\ day \fallingdotseq 148{,}760\ kWh/year$
- Saving ratio $148{,}760\ kWh/year \div 6{,}362{,}400\ kWh/year \fallingdotseq 2.3\%$

c. The motor belt tension in the following processes is great. Power losses are minimized when the motor belt tension is adjusted so as to loosen only by its thickness when it is pressed down by normal thumb pressure.

Process	Capacity	No. of Units with Large Deflection	Total Capacity
• Sizing	0.75 kW	2	1.5 kW
• Bobbin-Winder	0.75	3	2.25
• Inspection	0.75	4	3
• SP. Winding	1.5	7	10.5
• Reeling	0.2	3	0.6
Total			17.35 kW

Assuming that power losses can be saved by 3% by optimizing the motor belt tension, the energy conserved will be as shown in the following.

Power savings 17.35 kW x 0.03 = 0.5205 kW

Electric power savings 0.5205 kW x 24 h x 350 days = 4,370 kWh/year

Saving ratio 4,370 kWh/year ÷ 6,362,400 kWh/year ≑ 0.1%

d. The motor load factor, namely, $\frac{\text{actual load}}{\text{rated capacity}}$, in dyeing, twisting, and other processs was measured. Most of them were operated at low loads. Of 13 machines, 11 were operated at low loads. Of 13 machines, 11 were operaitng at load factors less than 80%.

Motors demonstrate a high efficiency when they are operated at a load factor between 80 and 100%. Motor capacities should be optimized to meet the actual load at appropriate opportunities. the energy savings that can be achieved by this plan will be as shown in the following.

Motor capacity (kW → kW)	Efficiency (% → %)	Loss (kW → kW)	Number of units	Power saving (kWh/year)
55 → 37	92.5 → 92.0	4.12 → 2.96	1	9,786
18.5 → 11	91.0 → 91.0	1.66 → 0.99	2	11,340
30 → 15	90.0 → 91.5	3.00 → 1.28	1	14,490
30 → 22	92.5 → 92.0	2.25 → 1.76	1	4,116
15 → 5.5	86.5 → 86.0	2.02 → 0.77	6	63,252
7.5 → 3.7	85.0 → 86.0	1.12 → 0.52	10	50,988
7.5 → 5.5	85.0 → 86.0	1.12 → 0.77	11	32,802
11 → 5.5	87.5 → 91.0	1.38 → 0.50	6	44,352
7.5 → 5.5	87.0 → 86.0	0.98 → 0.77	2	3,444
2.2 → 1.5	81.0 → 79.5	0.41 → 0.31	25	23,205
22 → 18.5	91.5 → 91.5	1.87 → 1.57	2	4,998
				262,773

Electric power savings 262,770 kWh/year

Saving ratio 262,770 kWh/year ÷ 6,362,400 kWh/year = 4.1%

(2) Air Conditioning

a. Conditions of air (temperature and humidity) for major processs were set, and appropriate air conditioning was in operation. Measurements showed that both tmperature and humidity were generally close to the set values.

Fine adjustments will be required to check whether quality may be affected when the temperature is raise further.

Process	Setting		Measurements	
	Temperature	Humidity	Temperature	Humidity
• Weaving	25 ~ 28°C	65%	27°C	76
• False-Twisting	28	70	30	76
• Bobbin-Winder	28	75	30	76
• SP. Winder	28 ~ 30	75	29	67
• CR. Winder	28	70	30	66
• Cake-Rocket	28	70	31	64
• Doubling Twister	28	70	29	76
• Warper	28 ~ 30	75	28	78

b. The following steps should be taken to lower the air conditioning load.

- Install double doors at building entrances to prevent cool air in the factory from escaping outdoors.
- Some machines are being moved in the factory. Thick vinyl curtains should be hung in places where no machines are installed at present to seal out the flow of air to and from other air-conditioned areas.

Assuming that the air conditioning load is lowered by 5% with this plan, the energy savings will be as follows

Ratio of power consumption of air conditioning 22.2%

Saving ratio 22.2% x 5% = 1.1%

Electric power saving 6,362,400 kWh/year x 1.1%
= 69.986 kWh/year

(3) Infrared heaters were used in combination with steam to dry yarn in the sizing process.

The heaters were emitting visible red rays and were assumed to be near infrared heaters (wavelength 0.75 to 4 μ).

Glue is composed of high polymers and has good absorptance for far infrared rays. By changing to far infrared beam heaters, the power consumption can be reduced 1/3 to 1/2, and the time required for processing will be shortened to about 1/10.

This will result in energy savings as shown in the following.

Power savings 32.5 kW x 0.3 = 9.75 kW

Electric power savings 9.75 kW x 24 h x 350 day = 81,900 kWh/year

Saving ratio 81,900 kWh/year ÷ 6,362,400 kWh/year ≒ 1.3%

(4) Illumination

a. Ordinary fluorescent lamps are used as lighting sources. Replacing these lamps with those of an energy conservation type, electric power can be saved by approximately 10% under the same level of illumination.

There were about 150 lamps that were lighted where there were not machiens installed, or not goods stored, in factory areas not requiring lighting. These lights should be turned off.

The following energy savings will be possible by this plan.

Power savings	(77 kW x 0.1) + (40 W x 150) = 13.7 kW
Electric power savings	13.7 kW x 24 h x 350 day = 115,080 kWh/year
Saving ratio	115,080 kWh/year ÷ 6,362,400 kWh/year ≒ 1.8%

b. The fluorescent lighting fixtures installed on walls of the dyeing lines were installed parallel to the walls. Only areas in front of the lights were illuminated, leaving the areas under them dark.

These fluorescent lights should be reinstalled angled to the walls after identifying what requires illumination.

c. Daylight was utilized in part of the plant. Daylight should also be utilized positively in other areas of the factory.

Translucent materials are made of vinyl chloride and are downgraded by ultraviolet solar rays. As a result, the materials have surface cracking, greatly lowering the transmission.

Polycarbonate, acrylic resins, or other resins which resist surface degradation by the ultraviolet solar rays are preferred as translucent materials.

d. The illumination in the processes measured 100 to 200 lux, which were generally satisfactory values.

The inspeciton process in particular had high illumination, 480 lux, greatly contributing to inspection accuracy and preventing workers' fatigue.

The products are silk. To check uneven surface texture, nodes, and other defects in addition to precisely inspecting feeling, color scheme, etc., incandescent floodlights should be used together with high-rendition fluorescent lamps.

9. Summary

	(equivarent oil) kl/year	%
Insulation	9.0	1.0
Recovery of drainage	21.4	2.4
Heat recovery of dyeing waste	80.8	9.1
Heat recovery of exhaust gas	21.7	2.5
Subtotal	132.9	14.9

	10^3 kWh/year	%
Motor speed control	148.8	2.3
Motor belt tension adjustment	4.4	0.1
Optimization of motor capacity	262.8	4.1
Lower air conditioning load	70.0	1.1
Use of far infrared heaters	81.9	1.3
High efficiency of light sources	115.1	1.8
Subtotal	683.0	10.7

Report No. 6: Textile

REPORT ON THE DIAGNOSIS
FOR
ENERGY CONSERVATION

— Thai Warp Knitting Co., Ltd. —

June, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation
— Thai Warp Knitting Co., Ltd. —

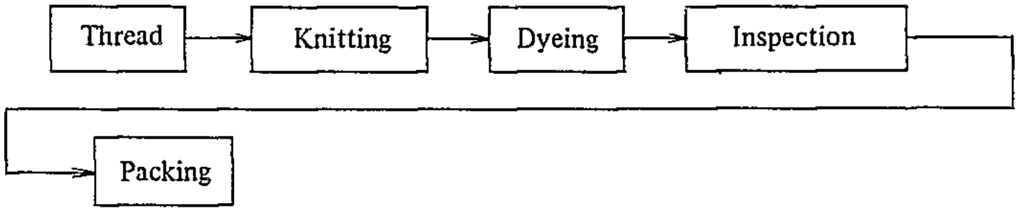
1. Outline of the Factory

Address	33/3 Tivanond Road Soi Wadsalaknur Pràkret Nonthaburi	
Capital	40 million Bt	
Type of industry	Textile	
Major products	Knit cloth (lace materials) Textile cloth (nylon clothing materials)	
Annual product	Knit cloth 240 t Textile cloth 1,260,000 yard	
No. of employees	302	
Annual energy consumption	Electric power	3,783,000 kWh
	Fuel	Heavy C Oil 924 kℓ Heavy A Oil 282 kℓ
Interviewees	Factory Manager, Mr. Sittichai Satitsatianchai Ass. Factory Manager, Mr. Suton Sansukol	
Date of diagnosis Diagnosers	Feb. 7, 1983 K. Nakao, Y. Ohno, M. Matsuo	

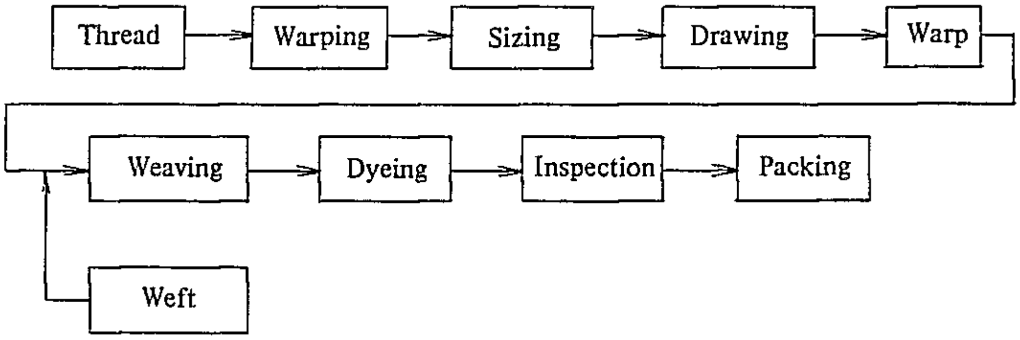
Thai Warp Knitting is a manufacturer of knit cloth and textiles with 17 knitting machines and 60 weaving machines. The company is ranked among the second largest group of manufacturers in the field. All the knitting machines are new models. Both wide and medium-width models are designed to produce patterned quality goods mainly used as materials for "futon" mats. Dyeing machines and knitting machines are made in Taiwan. Taiwanese engineers give technical guidance in the factory. The proportion of defective products is about 3% to 5%.

2. Manufacturing Process

Knitting Process



Weaving Process

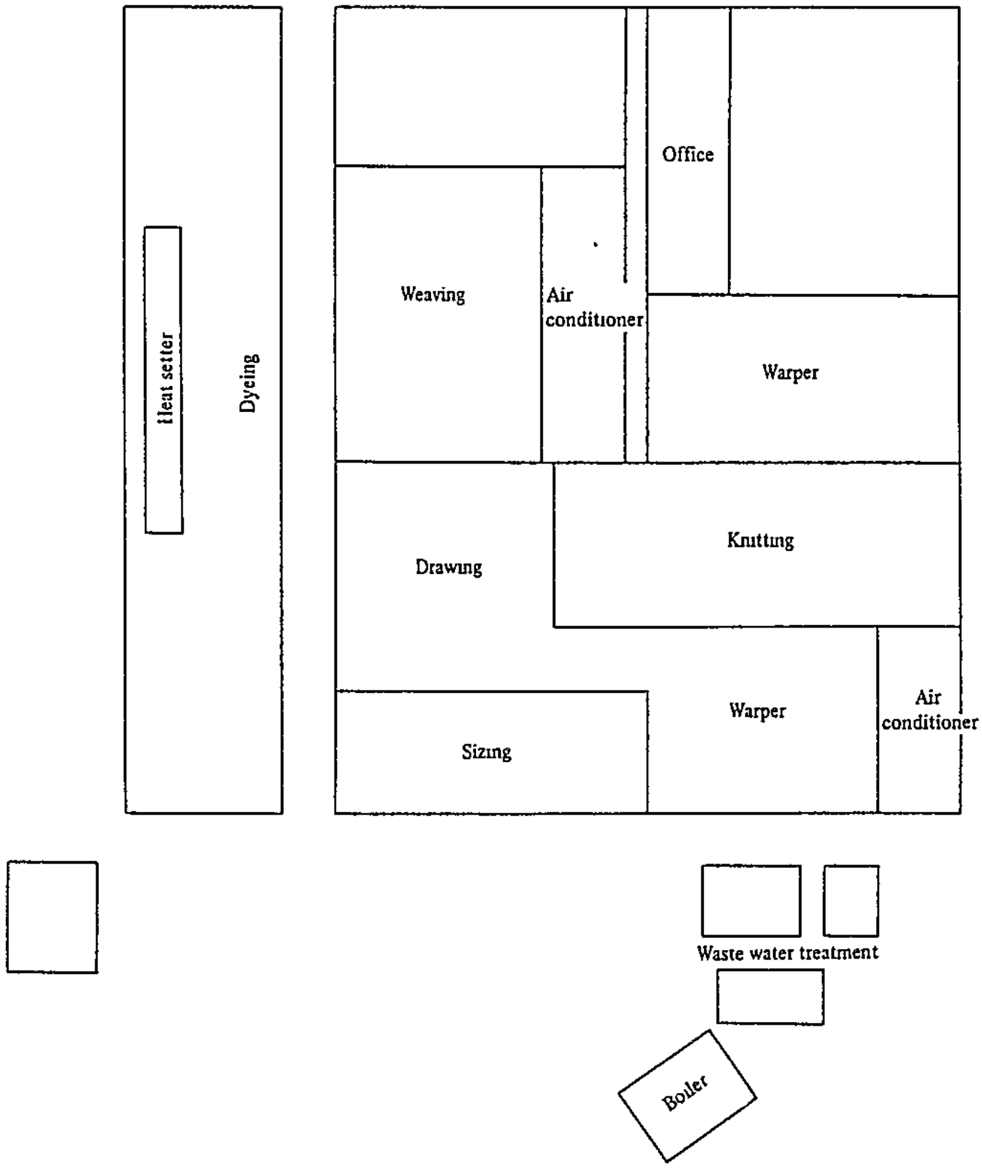


3. Major Equipment

3.1 Major Equipment

Name	No. of units installed	Type, etc.
Boiler	2	4.7 t/h (10.5 kg/cm^2) York Shipley
Dyeing machine	4	High pressure type
	12	Normal pressure type
Sizing machine	1	
Tendering machine	2	Dowtherm heating type
Knitting machine	17	168 inch 62 inch x 2 line
Weaving machine	60	

3.2 Layout


Heat setter
Dyeing
Office
Weaving
Air conditioner
Warper
Knitting
Drawing
Warper
Air conditioner
Sizing
Waste water treatment
Boiler

4. State of Energy Management

The company intends to take positive action for energy conservation and aims to achieve an energy conservation of 20% by the end of this year.

4.1 Investment in Energy Conservation and Improvement of Facilities

The focus of the current investment plans for energy conservation is on recovery of condensate and installation of condensers to improve power factor. The company is going to invest in facilities in case that the investment funds can be recovered within three years. The positive management stance is laudable.

4.2 Grasp of Energy Consumption

Daily fuel consumption is recorded from the scale of float indicators of the service tank. Consumption of electric power is also recorded on a daily basis. The factory has installed watt-hour meters for each of the major processes for the purpose of electricity management. It is one of the best factories covered by this study as far as energy conservation efforts are concerned. However, the logbook of electric power receipts contains the "reading" of meters only. Calculation of electricity usage by multiplying the differences in "reading" data for every hour by a given factor or the use of a graphic representation of fluctuations in "reading" data have not been attempted. It is recommended that the valuable data be used as follows:

- To prepare daily load curve for the purpose of improving the load factor and reducing the peak demand.
- To calculate power comsumption rates and plot them on the control chart for the purpose of recognizing the change.
- To grosp monthly Electricity consumption for the purpose to improve operations and processess which results in promotion of energy conservation programs.

Energy costs are allocated to each process for the purpose of cost accounting. This is helpful to increase interest in energy conservation in the persons responsible for each process.

4.3 Energy Conservation Committee and Suggestion System

There is no Energy Conservation Committee in the company, but the Factory Manager and the managers of each department meet once or twice a month to discuss various general problems. The company has technical consultant agreement with regard to electric power and drainage treatment.

There is no Suggestopm System in the company. Whenever an issue is taken up by the meeting of managers, workers are requested to submit suggestions. If such suggestions are found to be feasible, they are implemented.

The promotion of energy conservation requires awareness and positive action by all employees toward common goals. A committee chaired by the factory manager, and consisting of chiefs of each section and experienced workers should confirm the necessity of energy conservation, set targets for energy conservation and discuss potential solutions.

Encouragement and solicitation of proposal and the utilization of QC circles may be helpful to deal with special issues.

4.4 Employee Training

Several employees were trained in West Germany and other foreign countries prior to the installment of new equipment or at other opportunities. The results of this training are conveyed to the related manager or other responsible persons and other employees. The training of engineers and workers is a subject of fundamental importance to enterprises. the training of foremen and other responsible persons in the fields is particularly important. It is recommended that they participate in TPA and other seminars.

The company is discussing the recovery of condensate and other problems with members of the regional industrial circle and the other companies of the same and other trades. These discussions are mutually beneficial and should be held on a regular basis.

5 State of Fuel Consumption

The annual consumption of Bunker C, used to generate steam in boilers, is 924 kl and its price is 4.47 Bt/l. The generated steam is used as a heating source for dyeing, sizing and glue cooking.

The annual consumption of Bunker A, used in Dowtherm boilers, is 282 kl and its price is 4.7 Bt/l. Dowtherms are used as a heat source for drying intendering machines after dyeing process.

Heat Balance in the Boiler

Input			Output		
Item	10^3 Kcal/h	%	Item	10^3 Kcal/h	%
Heat of fuel combustion	1,401.6	99.8	Heat of steam	1,245.2	88.6
Sensible heat of fuel	3.3	0.2	Heat loss in exhaust gas	102.1	7.3
			Heat loss in blow water	7.2	0.5
			Heat release from furnace body and others	50.4	3.6
Total	1,404.9	100.0	Total	1,404.9	100.0

The heat balance is based partly on estimates because there is no flowmeter for feedwater in the boiler.

5.1 Data Given for Calculation of the Heat Balance (York-Shipley boiler) r)

Type of Fuel		Heavy Oil
fuel consumption (average)	(F)	146 kg/h *
Heat content of fuel (low level)	(Hl)	9,600 kcal/kg
Specific heat of fuel	(Cp)	0.45 kcal/kg
Specific gravity of fuel		0.975
Temperature of fuel	(T_F)	80°C
Reference temperature	(To)	30°C
Oxygen content in exhaust gas	(O_2)	7.7%
Temperature of exhaust gas	(Tg)	158°C
Temperature of feedwater	(Tw)	33°C
Quantity of blow water	(B)	50 kg/h
Temperature of blow water	(T_B)	176°C
Steam pressure	(P)	8.0 kg/cm^2g

*Based on actual fuel consumption of 86.5 kl in January, 1983

Loss of heat from walls of boiler		
Longitudinal side wall of a boiler	(Q_L)	160 $kcal/m^2h$
Front of boiler (on the side of the burner)	(Q_F)	160 $kcal/m^2h$
Rear side wall	(Q_B)	925 $kcal/m^2h$
Dimensions of boiler (outer dimensions)		Ø2,100 x 4,300 mm

5.2 Equations for Calculating the Heat Balance

Input

Heat of Fuel Combustion (Q_c)

$$Q_c = F \times Hl = 1{,}401.6 \times 10^3 \text{ kcal/h}$$

Sensible Heat of Fuel (Q_s)

$$Q_s = F \times C_p (T_F - T_o) = 3.3 \times 10^3 \text{ kcal/h}$$

Output

Heat Loss in Exhaust gas (Q_E)

Theoretical amount of air

$$A_o = (0.85\ Hl/1{,}000) + 2.0 = 10.16 \text{ Nm}^3\text{/kg}$$

Theoretical amount of exhaust gas

$$G_o = 1.11\ Hl/1{,}000 = 10.66 \text{ Nm}^3\text{/kg}$$

Air ratio

$$m = 21/(21 - O_2) = 1.58$$

Actual amount of exhaust gas

$G = G_o + (m - 1) A_o = 16.55\ Nm^3/kg$

$Q_E = F \times G \times 0.33 (T_g - T_o) = 102.1 \times 10^3\ kcal/h$

Heat Loss in Blow Water (Q_B)

$Q_B = B \times (T_B - T_w) = 7.2 \times 10^3\ kcal/h$

Heat release from boiler body (Q_R)

$Q_R = \{(2.1/2)^2\pi \times 160\} + \{(2.1/2)^2\pi \times 925\} + (2.1\pi \times 4.3 \times 160)$

$= 8.3 \times 10^3\ kcal/h$

Other Heat Loss (Q_o) (3% of input)

$Q_o = 0.03 (Q_c + Q_s) = 42.1 \times 10^3\ kcal/h$

Heat of Steam (Q_v)

$Q_v = Q_c + Q_s - Q_E - Q_B - Q_R - Q_o = 1,245.2 \times 10^3\ kcal/h$

Quantity of Evaporation (S)

Enthalpy of steam (E_s) = 662 kcal/kg

Enthalpy of feedwater (E_f) = 33 kcal/kg

$S = Q_v \div (E_s - E_f) = 1,980\ kg/h$

6. Problems in Heat Control and Potential Solutions

6.1 Installation of Feedwater Flowmeter

A flowmeter for fuel is installed only on a boiler (York-Shipley boiler); none for feedwater.

In order to recognize the changing trends of heat consumption rate of the boiler by measuring the quantity of feedwater and fuel consumption for the day and by calculating the evaporation ratio (quantity of feedwater/fuel consumption), and then to take appropriate action, it is essential to keep measurement records well-orgonized.

6.2 Insulation of Steam Valve

Although the steam header in the boiler room is insulated up to the flange area the surface temperature of it is 70°C a somewhat high level. 6B pipe between the boiler and the steam header has good heat insulation. Insulation of four valves on the steam header and two in the boiler valve is insufficient.

The calculation of heat loss from these valves is as follows:

Insulation effect

Valve name	No. of units	Heat release	
		No insulation	Insulated *
6"	5	9,500 Kcal/h	650 Kcal/h
4"	1	1,100 Kcal/h	100 Kcal/h
	Total	10,600 Kcal/h	750 Kcal/h

* Insulating material glass wool 30 mm

$$\frac{(10{,}600 - 750)\ \text{kcal/h} \times 24\ \text{hr} \times 300\ \text{days}}{9{,}600\ \text{kcal/kg} \times 0.88 \times 0.975} = 8.6\ \text{kl/year}$$

Fuel cost saving 38,000 Bt/year

6.3 Insulation of Flue and Smoketube Boiler (made by RAY)

There are a number of cracks in the back of the cleaning door and in the refractory insulation materials and the surface temperature is as high as 100°C. It is necessary to reinforce insulation in these areas through repair.

6.4 Inprovement of combustion control

The amount of combustion air led to burner is more than the optimal value.

Presently the percentage of O_2 in the combustion exhaust gas is 7.7% and the air ratio is 1.58.

$$m = \frac{\text{Actual amount of air required for fuel combustion}}{\text{Theoretical amount of air required for fuel combustion}}$$

$$= 21/(21 - O_2) = 1.58$$

The optimal air ratio for an oil burner is about 1.3. The damper at the air inlet should be adjusted to the point just before black smoke comes out of the chimney. If the air ratio is reduced to 1.3, fuel consumption would be reduced by 1.5%.

924 kl/y x 0.015 = 13.9 kl/year

6.5 Sizing Machine

Steam leakage is found at the drum inlet rotary value of the dryer. Insulation measures should be taken at the steam inlet header of the dryer, the 2" pipe with a length of about 3m, main steam pipe the reducing valve and other valves.

The amount of fuel saved by insulating the 2" pipe is calculated as follow:

- Steam pressure: 1.2 kg/cm^2G,
- Insulation efficiency: 75%

Thus,

$$\frac{237\ \text{kcal/mh} \times 3\text{m} \times \times 24\ \text{h/day} \times 300\ \text{day/year} \times 0.75}{9{,}600\text{kcal/kg} \times 0.88 \times 0.975} = 0.5\ \text{kl/year}$$

6.6 Dyeing Machine

(1) Rotary-type HT dyeing Machine

The surface temperature of the dyeing machine is rather high with 122°C in the shell and 123°C in the end plate. Heat loss by radiation is at a high level. The fuel saving by insulation is calculated as follows:

- Average surface temperature; 122°C
- Released heat; 1278 $kcal/m^2h$
- Surface area of the boiler; $13m^2$
- Heating time; 18 h/day

Thus,

$$\frac{1278\ kcal/m^2h \times 13m^2 \times 18\ h/day \times 300\ day/year \times 0.75}{9{,}600kcal/kg \times 0.88 \times 0.975} = 8.2\ kl/year$$

Insulating cost is estimated to be about 8,500 Bt.

As the other dyeing machine is larger, the heat loss of it is higher, equivalent to 14.6 kl/year. Insulation for the body would be very effective for energy conservation.

Insulating cost for this measure is estimated to be about 15,000 Bt.

(2) Z-type Pressure Dyeing Machine

The surface temprature of the Z-type pressure dyeing machine is as high as 110°C, indicating that the heat loss is great. Fuel saving by heat insulation is calculated as:

$$\frac{1{,}075\ kcal/m^2h \times 6.5\ m^2 \times 18\ h/day \times 300\ day/year \times 0.75}{9{,}600 \times 0.88 \times 0.975} = 3.4\ kl/year$$

Insulating cost is estimated to be about 4,300 Bt.

Considering that there is other Z-type pressure dyeing machine, the furl saving would be greater.

(3) Normal Pressure Type Dyeing Machine

There are 12 normal pressure type dyeing machines. Their surface temperatures are generally high. Particularly, the temperature of the dyeing bath area is as high as 90°C to 95°C. Insulation in these areas would result in fuel saving of about 35 kl per year.

6.7 Dowtherm Heating Tendering Machine

The piping and valves around the Dowtherm pump are not insulated for about 5m. Consideration should be given to their insulation.

6.8 Glue Cooker

In this cooker, glue is heated up to around 90°C . It is necessary to insulate the tang. Also, careful concern should be given to insulate valves and couplings even if they are of smell size.

6.9 Recovery of Condensate

Raising the temperature of the feedwater by recovering condensate in the sizing machine and the dyeing machine would substantially increase fuel saving. If the temperature of the feedwater is raised from 33°C to 60°C, fuel saving would amount to about 4.1%.

924 kl/year x 0.041 = 37.9 kl/year

6.10 Recovery and Utilization of Waste heat of Dyeing Cooling Water and Dyeing Solution

Waste heat is used cooling water can be reutilized for dyeing if kept in a insulated tank. If heat exchange with the dyeing solution is performed through heat exchanger the temperature would be raised to around 65° C, thus saving fuel by about 1%.

924 kl/year x 0.01 = 9.2 kl/year

It was reported that investment for such improvement could be recovered within about three years in Japanese experience.

7. State of Electric Power Consumption

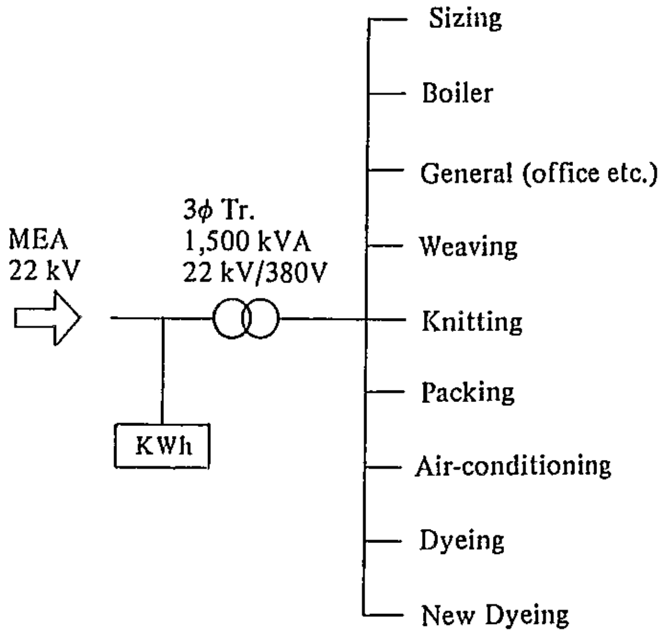
7.1 The Principal Data Relating to Power Consumption

• Power company	:	MEA
• Peak demand	:	730 KW
• Electric power used	:	315,250 kwh/month
• Load factor	:	61.7%
• Penalty	:	3,307 Bahts/month
• Power factor	:	69%
• Transformer	:	1,500 KVA (1 set)
• Power consumption rate	:	knitting cloth, 1,892 kwh/kg
		weaving cloth, 2,642 kwh/yard

7.2 Load Composition

• Motor	:	55.0%
• Air conditioning	:	31.9%
• Lighting	:	5.4%
• Electric heating	:	7.7%
Total	:	100%

7.3 One-line Diagram



8. Problems in Electric Power Control and Potential Solutions

8.1 Maintenance of Power Receiving Station

The wattmeter and power factor meter are out of order. They should be repaired immediately.

8.2 Improvement of Power Factor

(1) As the power factor is as low as 69%, it should be improved by installing condenser for effective utilization of the electric power.

(2) Assuming that power factor be improved from 69% to 85%, the capacity of condenser to be installed will be abour 300 kVar.

(3) At present, about 3,300 Bt. per month are paid as penalty, so the expenses for installing condenser (approximately 65,000 Bt) could be recovered during a short period of time.

Moreover, the loss of a transformer may be reduced by the improvement of power factor as follows:

If the power factor is improved from 69% to 85% by installing condenser the electric power savings is calculated as follows.

kVA at a power factor of 69% (K)

$$K = \frac{730\,(KW)}{0.69} \fallingdotseq 1{,}060\ kVA$$

Transformer loss (L) estimated by manufacturers' data

$$L = 17{,}400\ W$$

Power saving at a power factor of 85% (S)

$$S = L \times (1 - \frac{0.69^2}{0.85^2}) \fallingdotseq 5{,}900 \text{ W}$$

Thus, annual power saving will be $S \times 24 \text{ h} \times 360 \text{ days} \fallingdotseq 51{,}000$ kWh/year

8.3 Transformer

(1) As peak demand is presently 730 kW and the power factor is 69% for a transformer with 1,500 KVA, the load factor is about 70%, ensuring highly efficient operations.

(2) It is recommended that a diesel generator capable of supplying minimum power demand necessary to hold operation be installed in preparation for power failure which affects the dyeing process most heavily.
(Power failures occur three or four times per month during the rainy season, and twice per month during other seasons.)

(3) It is hoped that a 1500KVA back-up transformer is installed to avoid the entire stoppage of production due to transformer breakdowns.

8.4 Motor

(1) The following results were obtained by measuring the load factor for motors with capacities of over 15 kW in major processes.

In this case the load factor means actual load divided by rated capacity.

Load factor	Number of units	Composing ratio
80—100%	68 sets	63.6
Below 80%	35	32.7
Over 100%	4	3.7
Total	107	100

Motors with Light Loads

Process	Use	Capacity	Number of units	Load factor
Utility	Water Pump	18.5 kW	1	68.6%
Utility	Water Pump	30	1	67.3
Utility	Boiler Pump	15	2	64.7
Water Treatment	Beaming	7.5	1	29.3
Air conditioning	Compressor	55	3	69.1
Dyeing	Dryer	7.5	10	61.3
Dyeing	Dryer	7.5	10	69.3
Dyeing	Dyeing	22	3	52.7
Dyeing	Twisting	15	2	69.3
Dyeing	Pump	15	2	38.7
			35	

It is excellent that about 64% of the motors are driven at a high load factor of 80 to 100%.

(2) Motors with load factors below 80% is shown below and they are hoped to be replaced with power capacity ones. The anticipated power savings are calculated as follows:

Motor capacity kW	Efficiency %	Loss kW	Number of units	Power saving kWh/year
18.5 → 15	91.5 → 91.0	1.57 → 1.35	1	1,602
30 → 22	92.5 → 92.0	2.25 → 1.76	1	3,528
15 → 11	90.5 → 90.5	1.42 → 1.04	2	5,472
7.5 → 2.2	80.0 → 82.0	1.50 → 0.40	1	7,949
55 → 45	93.0 → 93.0	3.85 → 3.15	3	15,120
7.5 → 5.5	82.0 → 86.5	1.35 → 0.74	10	43,740
7.5 → 5.5	87.0 → 86.0	0.98 → 0.77	10	14,760
22 → 15	90.0 → 91.0	2.20 → 1.35	3	18,360
15 → 11	90.5 → 91.0	1.42 → 0.99	2	6,264
15 → 7.5	87.5 → 87.5	1.88 → 0.94	2	13,500
		Total	35	130,300

Electric power savings: 130,300 kWh/year

Saving ratio: 130,300 kWh/year ÷ 3,783,000 kWh/year

≑ 3.4%

(3) There are four 5.6 kW motors with load factors of about 120% in the dyeing process. They should be replaced with high capacity units for safety.

(4) Measuring of motor belt tightness in major processes indicated that most were satisfactory; only slowing that about half of sixteen 2.2 kW motors in the dyeing process had their belt slightly loosen.

8.5 Air Conditioning

Measuring of air conditioning in major processes (in terms of temperature and humidity) indicated that necessary condition for quality control was kept as indicated in the following:

Process	Temperature	Humidity
Weaving	34°C	58%
Warping	31	62
Knitting	33	56
Sizing	35	55
Winding	34	58
Dyeing	33	60
Finishing	34	55

8.6 Lighting

(1) Measuring of illuminance for major processes showed that the range was between 100 lux and 230 lux, a suitable working level.

(2) Ordinary fluorescent lamps are used as the light sources. As most are too old, they should be replaced with fluorescent lamps of the energy-conservation type. This would result in electric power savings of about 10% with the same level of illuminance.

Electric power savings	35.7kw x 0.1 = 3.57kw
Annual saving	3.57kw x 24h x 300day ≒ 25,700kwh/year
Energy saving ratio	25,700kwh/year ÷ 3,783,000kwh/year ≒ 0.7%

(3) Daylight is used for the dyeing process. But vinyl chloride transmission materials have deteriorated by exposure to ultraviolet rays, reducing the intensity of illumination to half. They should be replaced immediately.

It is recommended that polycarbonate, acrylite etc. be used as transmission materials because they are less vulnerable to ultraviolet rays.

9. Summary

The abovementioned remedial measures, if actually taken, will bring about energy-conservation effects as shown

	kl/year (equivalent to heave oil)	%
Insulation of steam valve	8.6	0.9
Improvement of combustion control	13.9	1.5
Insulation of sizing machine	0.5	—
Insulation of dyeing machine	61.2	6.6
Recovery of condensate	37.9	4.1
Waste heat recovery of dyeing cooling water and dyeing solution	9.2	1.0
Subtotal	131.3	14.2
	10^3kWh/year	%
Improvement of power factor	51.0	1.3
Replacement of motors	130.3	3.4
Replacement of lamps	25.7	0.7
Subtotal	207.0	5.4