11-11 Formulation and Recommendation of Countermeasures for Energy Conservation

IBF plans to construct a new dyeing factory next to the new IPM factory in a suburb of Izmir in the near future. According to this plan, natural gas will be used instead of coal. The open width bleaching range, the mercerizing unit and Max Goller washing range in the factory will be moved to the new factory and used. The existing utility supply facilities will be discarded. Against this background, recommendations for energy conservation measures are prepared for the new factory and the existing factory as below.

11-11-1 New Factory Case

(1) CHP System (Co-generation System)

The CHP is recommended. There are many types of CHP system; therefore, a case study based on the demand and supply condition of utilities for the new IBF factory is needed for optimizing the CHP system. An example of a CHP system using a gas engine as generator is shown in Figure 11-21. In this case, the generated utilities are electricity, steam and hot water.

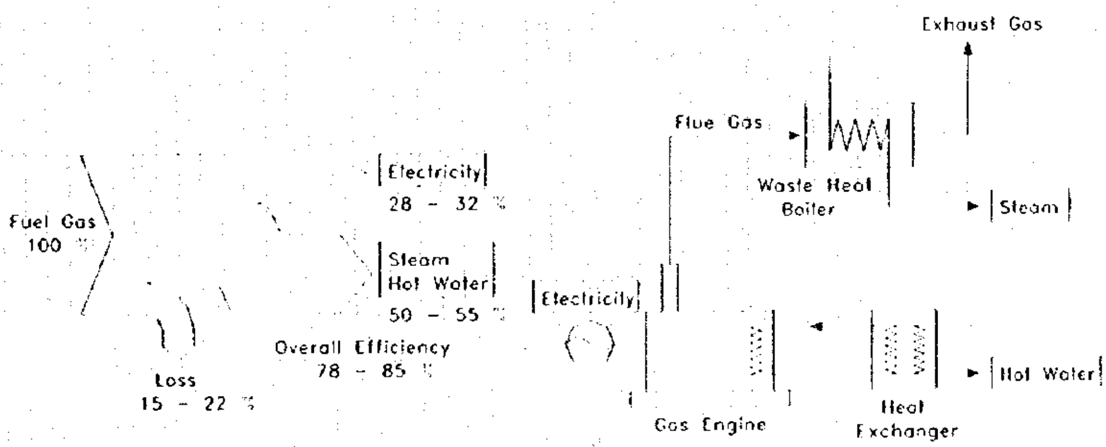


Figure 11-21 CHP System Using Gas Engine

(2) Package Boiler System

The package boiler system is recommended as an alternative steam supply system for the CHP system. The package boiler system consists of a few fully automated small-capacity boilers. Operation of each boiler is intermittent depending upon the demand for steam, which fluctuates as operation changes.

(3) Direct Heating System

The direct heating system is recommended as a local heating device in the finishing unit as an alternative for the hot oil system. Natural gas is a very useful fuel for this system. Figure 11-22 illustrates an example of a direct heating system burning LPG.

(4) Establishment of Good Energy Management System

A computer control system including measuring equipment for operation control and energy management is recommended. The system should incorporate a data logger capable of monitoring energy consumption. This system should be a good tool for energy management. Various pieces of information useful in energy management will be obtained from the analysis of energy consumption.

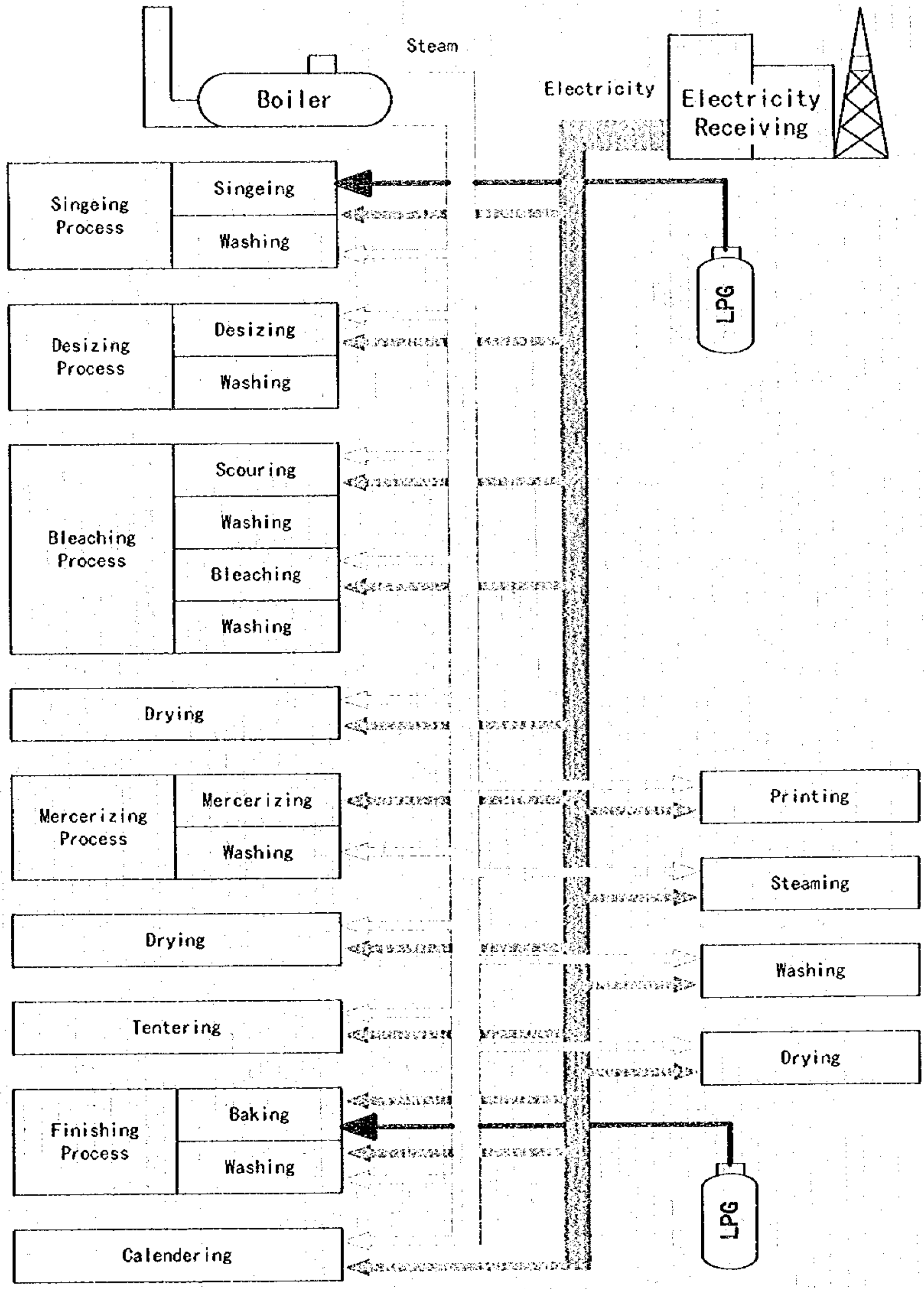


Figure 11-22 Direct Heating System Using LPG

11-11-2 Existing Factory Case

(1) Heat Recovery from Waste Water of Open Width Bleaching Range

As shown in Figure 11-17, an energy flowchart of the open width bleaching range, the heat loss associated with the waste water leaving the range at higher temperatures represents the largest portion, 77.2 percent, of the heat loss from the range. This includes the following.

1) Heat Loss with Waste Water Directly from the Machine (49.5 %)

The heat content of this effluent (based on 0℃) is large. This effluent is rather cool at 50℃. This means that the potential for recovering energy from it is low. Supposing that heat is recovered from this effluent and the temperature of the effluent is reduced to 40℃, the recovered heat is:

$$25{,}000 \text{ kg/h} \times (50 - 40)℃ \times 1 \text{ kcal/kg ℃} = 256 \times 10^3 \text{ kcal/h } (9.9\ \%).$$

The heat loss still remains at 39.6 %.

2) Heat Loss with Waste Water Overflowing before Recovery by the Heat Recovery Unit (27.7 %)

The temperature of this effluent is 99.6℃, or high temperature energy. When heat is recovered at 40℃, the recovered heat is:

$$7{,}200 \text{ kg/h} \times (99.6 - 40)℃ \times 1 \text{ kcal/kg ℃} = 429 \times 10^3 \text{ kcal/h } (16.6\ \%)$$

Based on the above calculation and observations made during the field survey, the following countermeasures for energy conservation from the waste water are recommended.

1. Fundamentally, reduction of water use and lowering the standard operation temperature should be tried, as far as product quality permits, in a careful and stepwise manner.

2. Improvement of the system for water supply including bath connections and operating conditions, and improvement of heat recovery system from hot waste water, such as installation of a high temperature waste water reservoir, automatic cold and hot water supply system, etc.

3. It is recommended to install a series waste heat recovery system in parallel to the existing waste heat recovery system in the open width bleaching unit. An outline of the system is shown in Figure 11-23.

The system consists of the following pieces of equipment.

1.	Pump	2 Kg/cm^2, 7.2 m^3/h, 0.75 kW
2.	Plate type heat exchanger	425,000 kcal/h, 8 m^2
3.	Hot water tank	1 m^3
4.	Instrument	LIC x 2
5.	Piping	1.5 B x 20 m, 2 B x 20 m

And also better maintenance of the rotary filter, heat exchanger, and related facilities of the recovery unit is important.

4. Although not quantified during the field survey, overheating of Baths 1, 2, 5, 6 and others was frequently observed. The operating temperatures of these baths were set very near to 100°C, the standard temperature, but the temperature was controlled by manual adjustment of steam valves and it was difficult. At times, the water was boiling in the baths and the steam generated lifted the top covers. As Figure 11-24 indicates, the heat dissipation from water surface becomes large when the temperature is high and vaporization takes place. The recommendations are:
   (1) The steam flow to higher temperature baths should be controlled automatically.
   (2) The standard operating temperature should be lowered as far as product quality permits. (Refer to Item 1.)

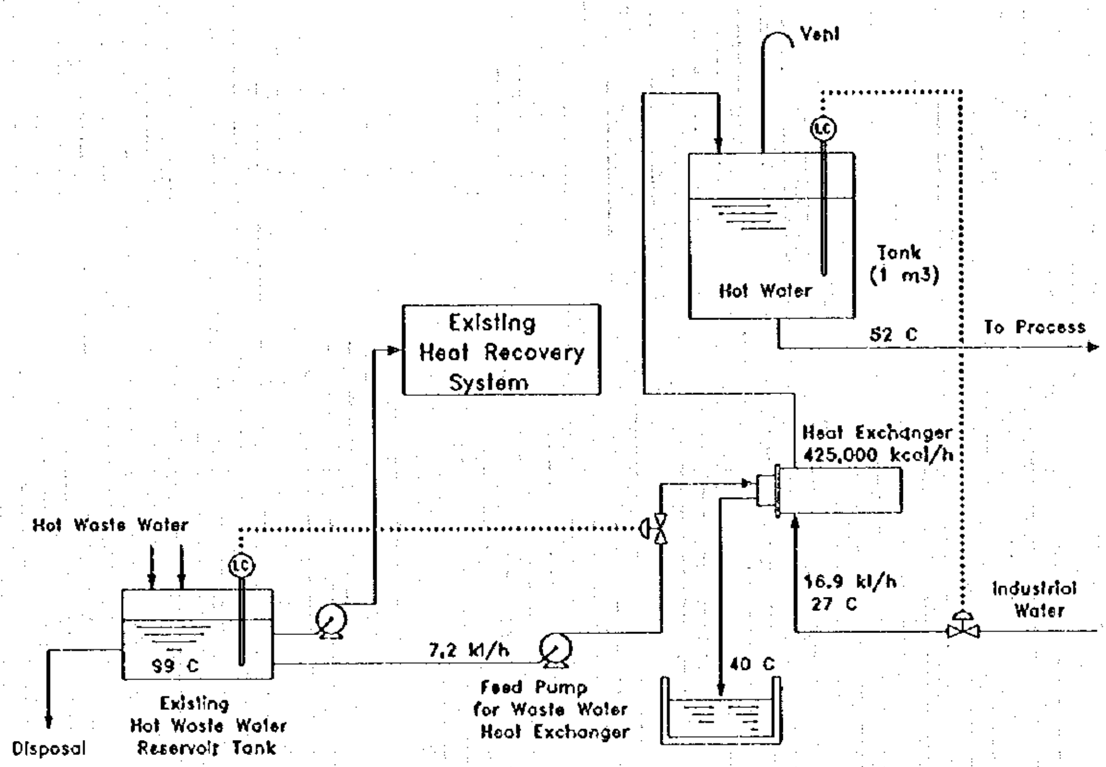
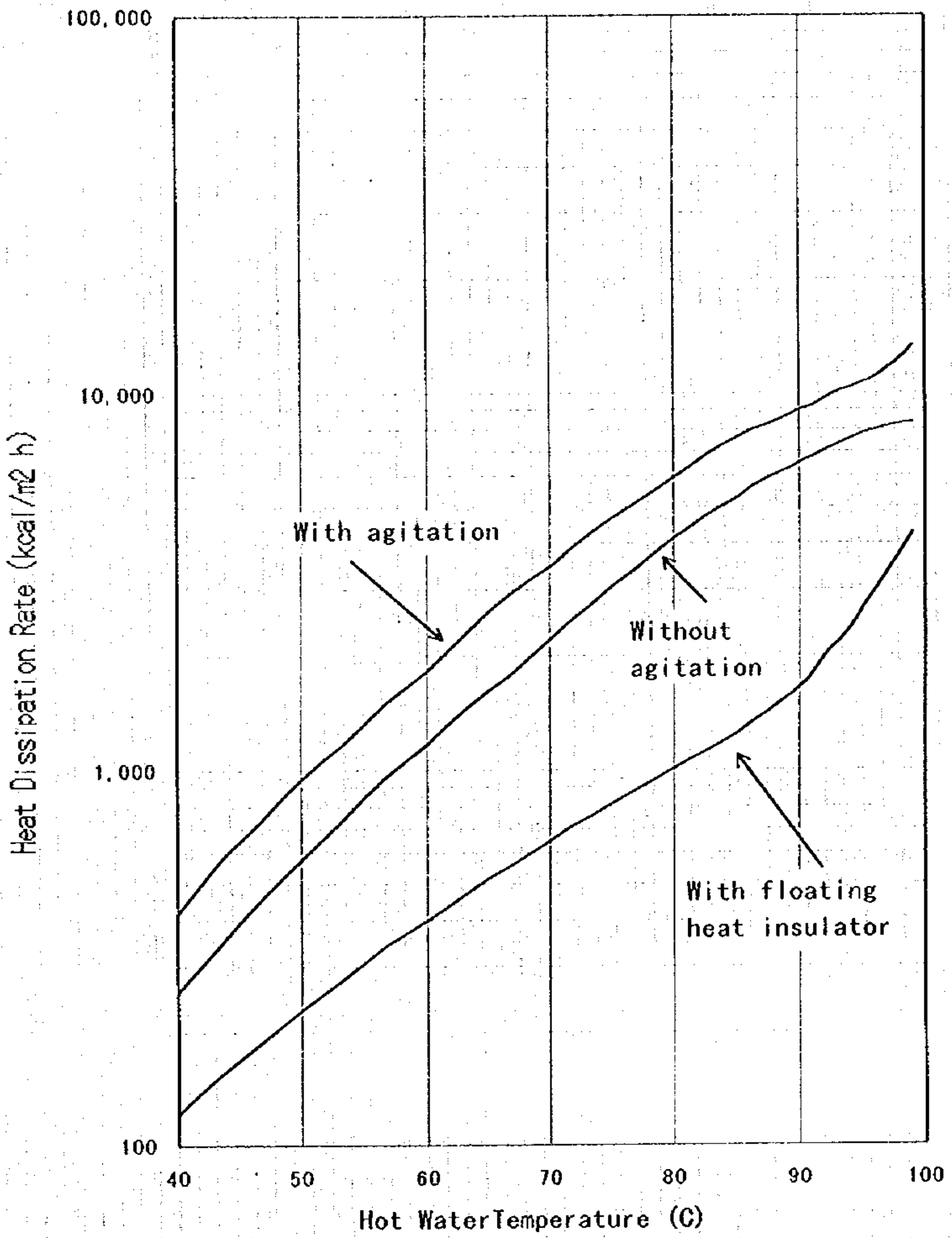


Figure 11-23 Waste Heat Recovery System



Source: Energy conservation technology in textile industry
by Tokyo Metropolitan textile research institute

Figure 11-24 Heat Dissipation from Hot Water Surface

(2) Recommendations for the Max Goller Washing Range

The Max Goller washing range of IBF is new, built in 1995, and fully automatically controlled. When the energy audit by the study team was executed, the range was operated more intermittently than the open width bleaching range was. From the technical point of view, including energy conservation, the Max Goller washing range is rationally designed. The steam consumption of the range was measured to be 370 kg/h at the flash ager plus 1,580 kg/h at the washer, with a total of 1,950 kg/h, by the method described in Section 11-9-2. The nominal value is 1,600 kg/h, and the measured value may include the excess as described in the same section. Assuming the measured results of the steam flow rate to the range to be correct, the following countermeasures for energy conservation are recommended.

1) Measurement of Steam Flow Rate to the Range

From the energy flowchart, steam is the major input of energy to the range, accounting for 68.2 %. As already described, direct and accurate measurement of steam flow to the range is essential. Installation of a flow meter on the steam line to the range is recommended.

2) Heat Recovery from Waste Water

The heat loss with the hot waste water was calculated to be 1,414 x 10^3 kcal/h, or 74.9 %. Presently, the range is not equipped with a unit for heat recovery from hot waste water. Max Goller's brochure says, "When washing continuously, still considerable quantities of waste water, having temperatures about 90°C, flow to the drainage. Because of increasing energy costs the waste water is more and more reused for preparation of fresh water. This is done by using heat exchangers with a capacity, calculated according to machine size and the required processes." When operation is stabilized, a heat recovery unit should be considered. If the heat recovery reduces the temperature from 70°C to 40°C,

$$20{,}200\ \text{kg/h} \times (70 - 40)^\circ\text{C} \times 1\ \text{kcal/kg}\ ^\circ\text{C} = 606 \times 10^3\ \text{kcal/h}\ (32.1\ \%)$$

will be recovered.

Although a heat recovery system should be designed as quoted above, the study team considered a system in a way similar to the open width bleaching range. The system consists of the following components.

1.	Pump	2 Kg/cm², 20 m³/h, 2.1 kW
2.	Filter	20 m³/h
3.	Plate type heat exchanger	300,000 kcal/h (To obtain 10 m³/h fresh water of 57°C), 8 m²

4.	Hot water tank	2 m^3
5.	Instrument	LIC x 2
6.	Piping	1.5 B x 20 m, 2 B x 20 m

(3) Condensate Recovery

To install a condensate recovery system is recommended in the drying unit and the open width bleaching range for effective use of steam traps. The number of steam traps is 13 in the drying unit and 9 in the open width bleaching range. Amount of condensate recovered is estimated to be 2,650 kg/h based on the system design. The condensate directly goes to the elevated hot water tank planned in the waste heat recovery system in the open width bleaching range through a newly installed 2 inch line. Length of the line is estimated at about 30 meters. Usable heat is estimated to be 193,000 kcal/h based on the following assumption.

1. Condensate temperature is 100°C.
2. Fresh water in the open width bleaching range is 27°C.
3. Specific heat of water is 1 kcal/kg °C.
4. Usable heat = 2,650 x 1 x (100 - 27) = approximately 193,000 kcal/h

(4) Insulation on Hot Valves and Flanges

To insulate the valves and flanges in the hot oil system and the steam supply system is recommended. Some valve portions and flange are not insulated to facilitate maintenance and inspection work, but they should be insulated. Figures 11-25, 11-26 and 11-27 (sources: JICA Report) show insulation on a valve, a flange, and a pipe hanger, respectively. The equivalent lengths of valves and the flanges in terms of bare pipe lengths of the same size are given in Table 11-33. These equivalent lengths are used for estimating heat losses from the insulated valves and flanges. The rate of heat release from pipe surface may be estimated by using Figures 11-28, 11-29 and 11-30.

Table 11-33 Equivalent Lengths of Valve and Flange in terms of Bare Pipe Length

Pipe	A mm	15	25	40	50	65	80	100
Size	B inch	1/2	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4
Glove valve with flange		1.15	1.22	1.11	1.11	1.23	1.25	1.27
Gate valve with flange		1.12	1.15	1.31	1.22	1.16	1.31	1.20
Valve for reducing pressure		1.96	1.67	1.49	1.55	1.60	1.66	1.58
Control valve		--	1.84	1.56	1.60	--	1.54	--
Flange		0.50	0.53	0.47	0.44	0.42	0.42	0.39

Source: "Energy Conservation Technology in Textile Industry" by Tokyo Metropolitan Textile Research Institute

Illustration: Heat release rate from 6 B valve in the hot oil line

1.	Surface temperature on valve, ℃	167
2.	Room temperature, ℃	37
3.	Heat release rate from 6 B bare pipe, kcal/m h	1,100
4.	Heat release rate from 6 B insulation pipe, kcal/m h (insulation thickness is 50 mm)	100
5.	Difference of heat release rate, kcal/m h	1,000
6.	Heat release rate from 6 B valve, kcal/h (equivalent length factor is 1.2)	1,200

(5) Necessity of Measuring Equipment for Monitoring Energy Consumption

It is recommended to install a steam flow meter at the outlet of generated steam line of each boiler and also a hot oil flow meter for each hot oil heater. Each machine should have water, electric and steam flow meters.

(6) Computerized Maintenance System

To improve the maintenance management by using a personal computer is recommended.

(7) Adjustment of the Load of Steam Boiler

It is recommended to operate two, instead of three, boilers in summer when the load is low.

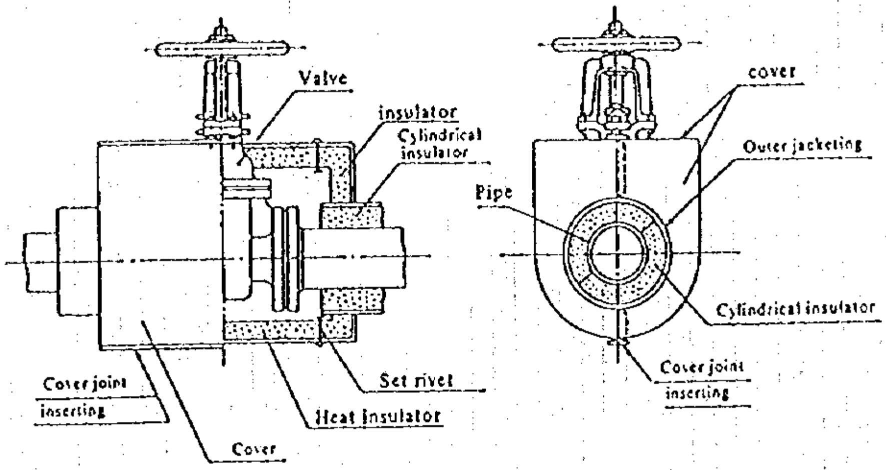


Figure 11-25 Insulation Work of Valve

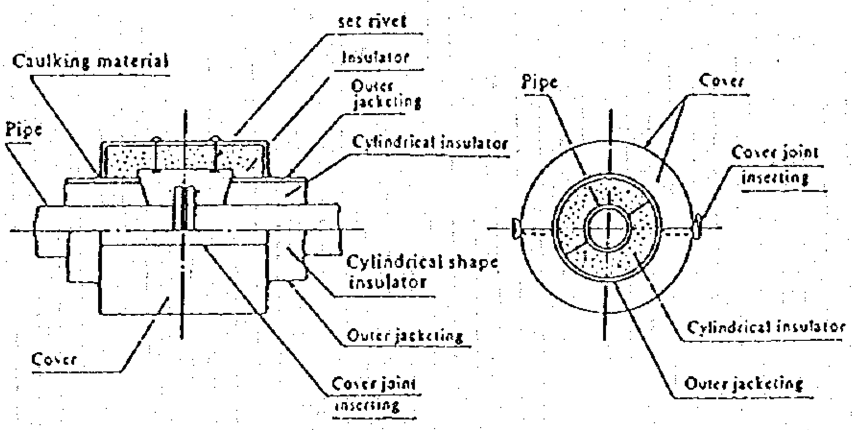


Figure 11-26 Insulation Work of Flange

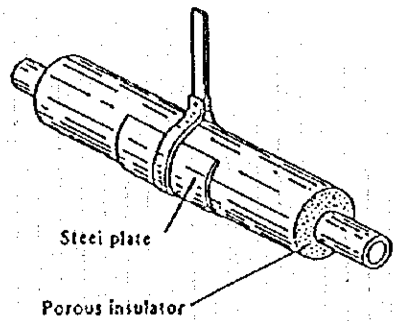
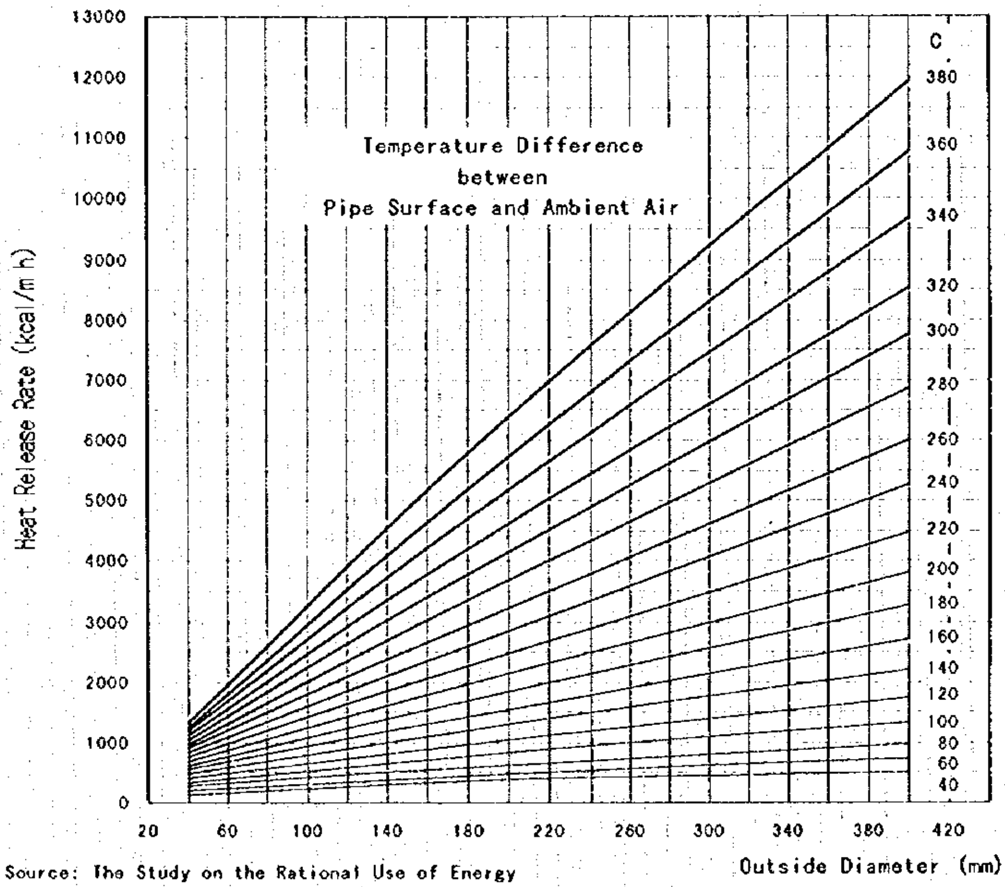
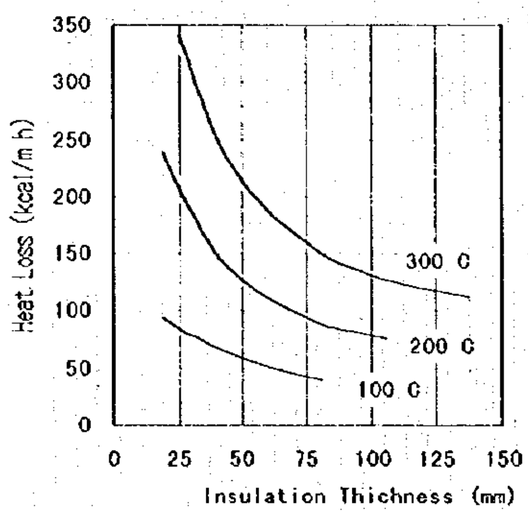


Figure 11-27 Insulation Work of Hanger



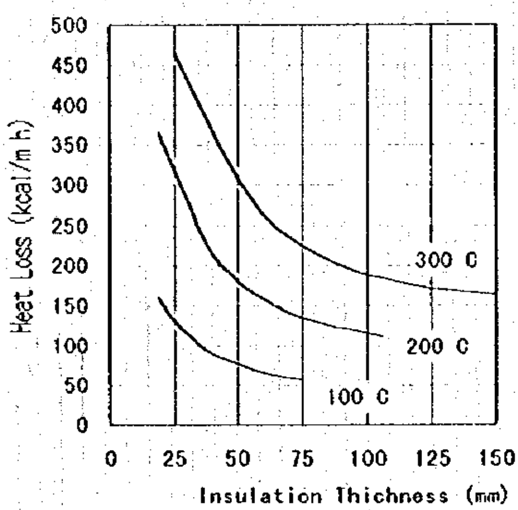
Source: The Study on the Rational Use of Energy in the Republic of Bulgaria by JICA

Figure 11-28 Heat Release Rate from Bare Pipe



Source: The Study on the Rational Use of Energy in the Republic of Bulgaria by JICA

Figure 11-29 Heat Release Rate from 6 B Pipe



Source: The Study on the Rational Use of Energy in the Republic of Bulgaria by JICA

Figure 11-30 Heat Release Rate from 10 B Pipe

11-12 Cost Estimation of Countermeasures for Energy Conservation

Budget-type costs as of August 1996 were estimated for four recommended modification works (1) heat recovery in the waste hot water of the open width bleaching, (2) Max Goller washing ranges, (3) condensate recovery, and (4) insulation on hot valves and flanges. The exchange rates used for estimation are 86,500 TL/US$, 109 Yen/US$, the rates prevailing in August 1996.

1. Heat recovery plan for the open width bleaching range

		Yen	Million TL
1.	Pump and Motor		35
2.	Heat exchanger		630
3.	Tank		150
4.	Filter		3
5.	Instrument		333
6.	Piping and Others		25
7.	Total		1,175

2. Heat recovery plan of the Max Goller washing range

		Yen	Million TL
1.	Pump and Motor	274,000	
2.	Filter	500,000	
3.	Heat exchanger	1,320,000	
4.	Tank	300,000	
5.	Instrument	420,000	
6.	Piping and Others	348,000	
7.	Total	3,162,000	2,509

3. Condensate recovery plan

		Yen	Million TL
1.	Piping	184,000	
2.	Insulation	115,000	
3.	Valve	317,000	
4.	Total	616,000	489

4. Insulation on valve

Cost of insulation on the 6 B valve is estimated 31,200 Yen, or 25 Million TL.

It should be noted that the Japanese costs were not merely converted into Turkish Lira; instead the general price difference between the two countries was taken into account.

11-13 Overall Evaluation of Countermeasures for Energy Conservation

11-13-1 Energy Cost

The unit cost of energy in the IBF factory is estimated as below.

1. Steam type energy

1.	Coal price, Million TL/ton 2.5 x 1.15	2.875
2.	Low heating value of coal, kcal/kg	4,385
3.	Energy conversion efficiency, %	85.4
4.	Steam delivery to user/generated steam *	0.907
5.	Usable heat of steam 540/640	0.84
6.	Unit cost of energy of steam type, TL/kcal	1

Note* (Boiler evaporation rate-Steam consumption rate of degasifier in boiler unit)/ Boiler evaporation rate

(9,680 - 900)/9,680 = 0.907

2. Hot oil type energy

1.	Special fuel oil/No. 6 fuel oil price, TL/kg	23,700 - 15,500
2.	Low heating value, kcal/h	9,600
3.	Energy conversion efficiency, %	73.8
4.	Unit price energy of hot oil type, TL/kcal	3.3 - 2.2

11-13-2 Overall Evaluation of Countermeasures

(1) Heat Recovery Plan of Open Width Bleaching Range

The amount of money saved by this plan is estimated as follows:

Money saving calculation

1.	Recovery heat rate, kcal/h	425,000
2.	Operation time a month (take), h	360
3.	Total recovery heat a month, Million kcal	153
4.	Unit cost of energy, TL/kcal	1
5.	Amount of money saved per month, Million TL	153

Investments are evaluated in terms of the repayment period, because the costs are low and the working times are short. Here, internal rate of return is not calculated.

Repayment period calculation

1.	Amount of saving money a month, Million TL	153
2.	Investment money, Million TL	1,175
3.	Pay back period, month	7.7

(2) Heat Recovery Plan of Max Goller Washing Range

The investment in modification of the Max Goller Washing Range is evaluated as follows

1.	Recovery heat rate, kcal/h	300,000
2.	Operation time a month (take), hour	360
3.	Total recovery heat a month, Million kcal	108
4.	Unit cost of energy, TL/kcal	1
5.	Amount of saving money a month, Million TL	108
6.	Investment money, Million TL	2,509
7.	Repayment period, months	23.2

(3) Condensate Recovery Plan

The plan is evaluated as follows:

1.	Usable heat rate, kcal/h	193,000
2.	Operation time per month (take), hour	360
3.	Total recovery heat per month, Million kcal	69
4.	Unit cost of energy, TL/kcal	1
5.	Amount of saving money per month, Million TL	69
6.	Investment money, Million TL	489
7.	Repayment period, month	7.1

(4) Insulation on 6 B Valve Plan

The plan is evaluated as follows.

1.	Heat saving rate, kcal/h	1,200
2.	Operation time per month , hour	720
3.	Total saving heat per month, Million kcal	0.864
4.	Unit cost of energy for hot oil, TL/kcal	2.8
5.	Amount of money saved, Million TL	2.4

6.	Investment money, Million TL	25
7.	Repayment period, month	10.4

(5) Overall evaluation

The results of evaluations of (1), (3) and (4) mean that execution of these plans are justifiable. Plan (2) should be examined as one of the candidates in the new factory. The study team recommend IBF to recheck the cost of the each plan in the Turkish background and to reevaluate the situation of IBF.

11-14 Technical Guidelines for Energy Conservation

11-14-1 Outline of Major Production Facilities

In general, typical production facilities in the factory of the textile industry are as follows.

1. Spinning
   - Blowing/Opening/Beating
   - Carding
   - Drawing
   - Roving
   - Spinning
   - Winding
2. Weaving
   - Warp winding
   - Warp beaming
   - Sizing
   - Drawing-in
   - Weft preparation (weft winder, loom winder, etc.)
   - Weaving
3. Knitting
4. Dyeing and finishing
   - Singeing
   - Desizing
   - Scouring
   - Bleaching
   - Mercerizing
   - Dip dyeing
   - Soaping
   - Printing
   - Steaming
   - Washing
   - Drying
   - Finishing
   - Raizing
   - Calendering

5. Garment Manufacturing
   - Cutting
   - Sewing
6. Packaging and Other facilities

Figures 11-31, 11-32, and 11-33 show a typical block flow diagram of production facilities in a textile factory.

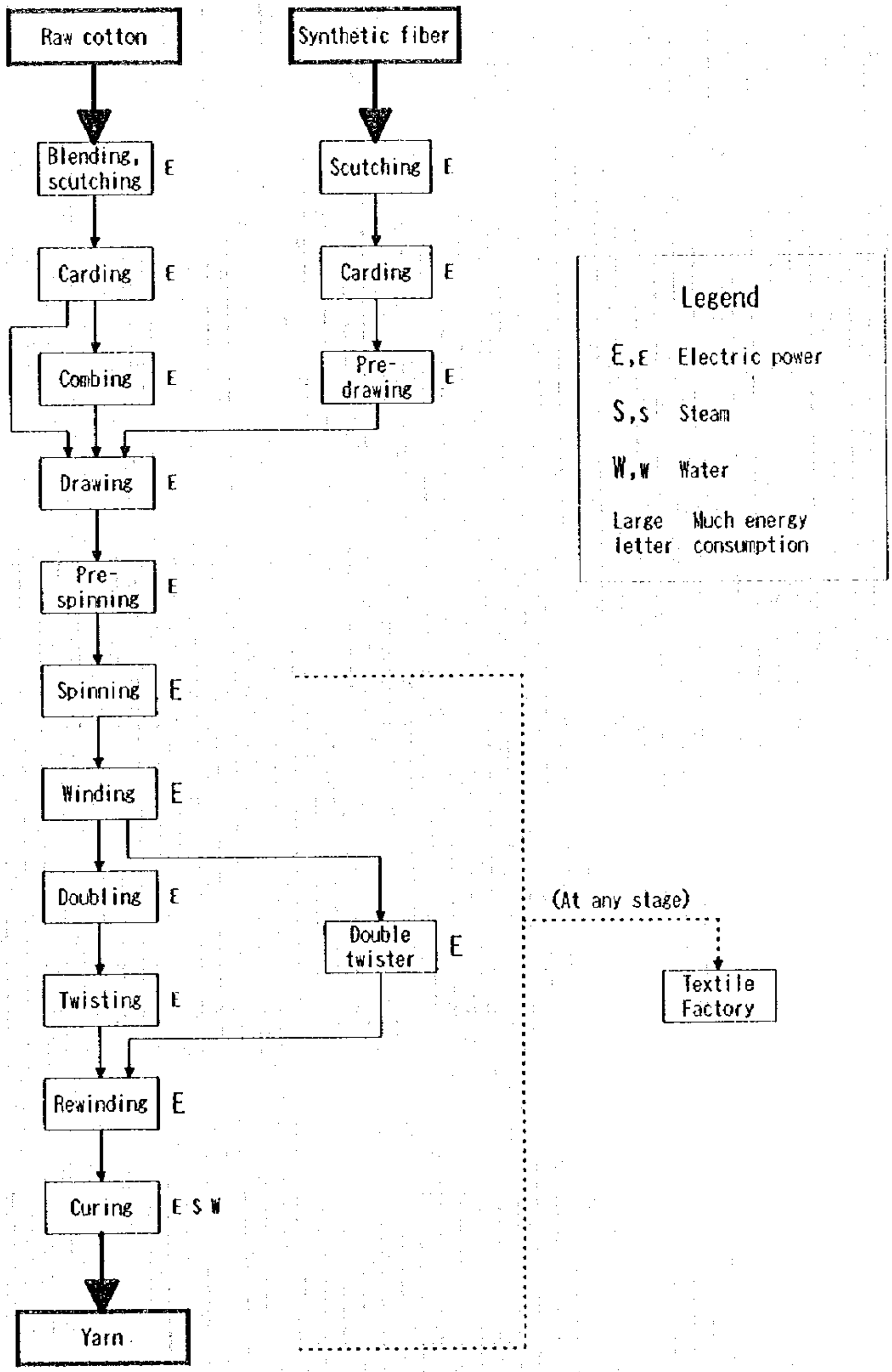


Figure 11-31 Cotton Spinning Block Flow Diagram

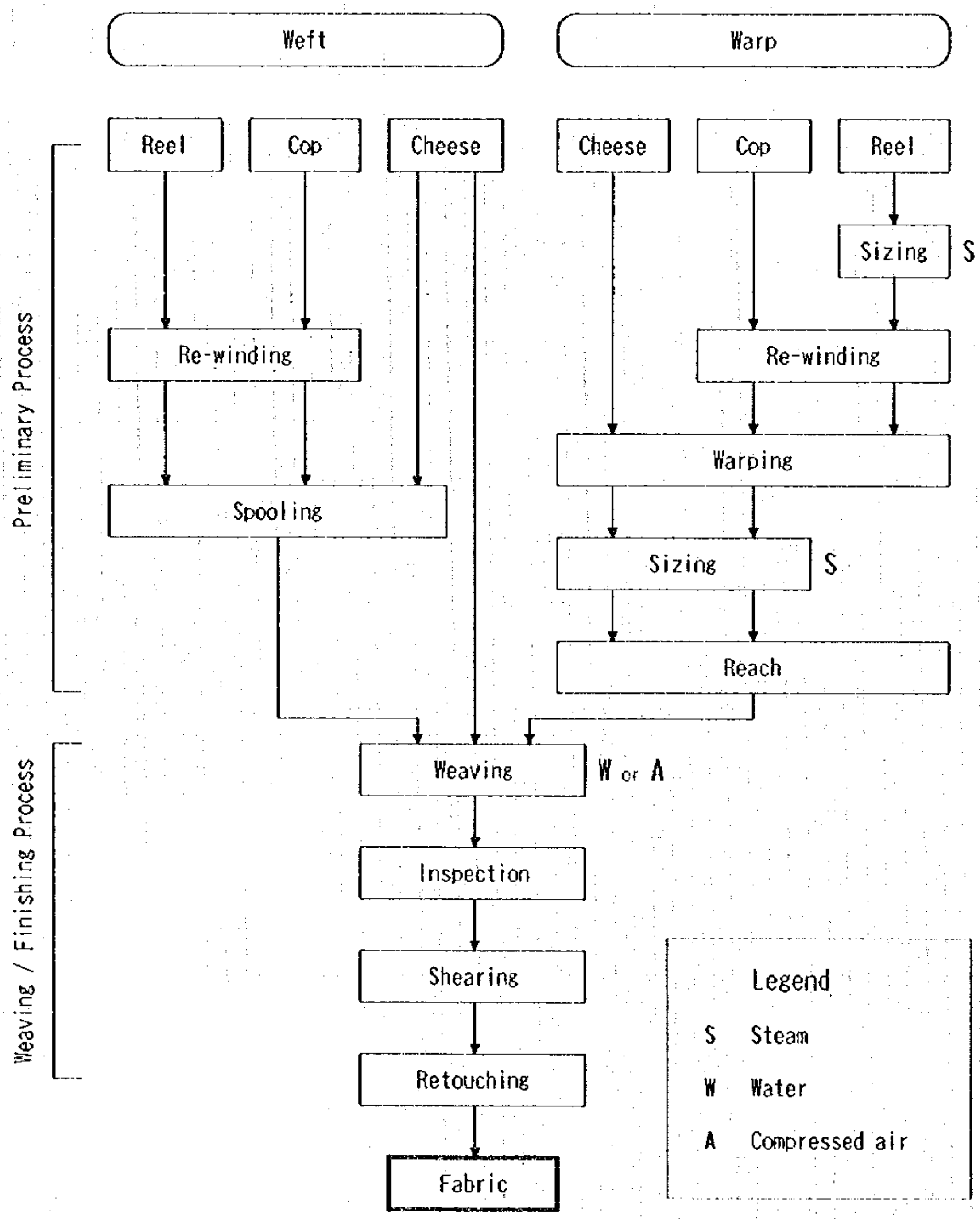


Figure 11-32 Weaving Block Flow Diagram

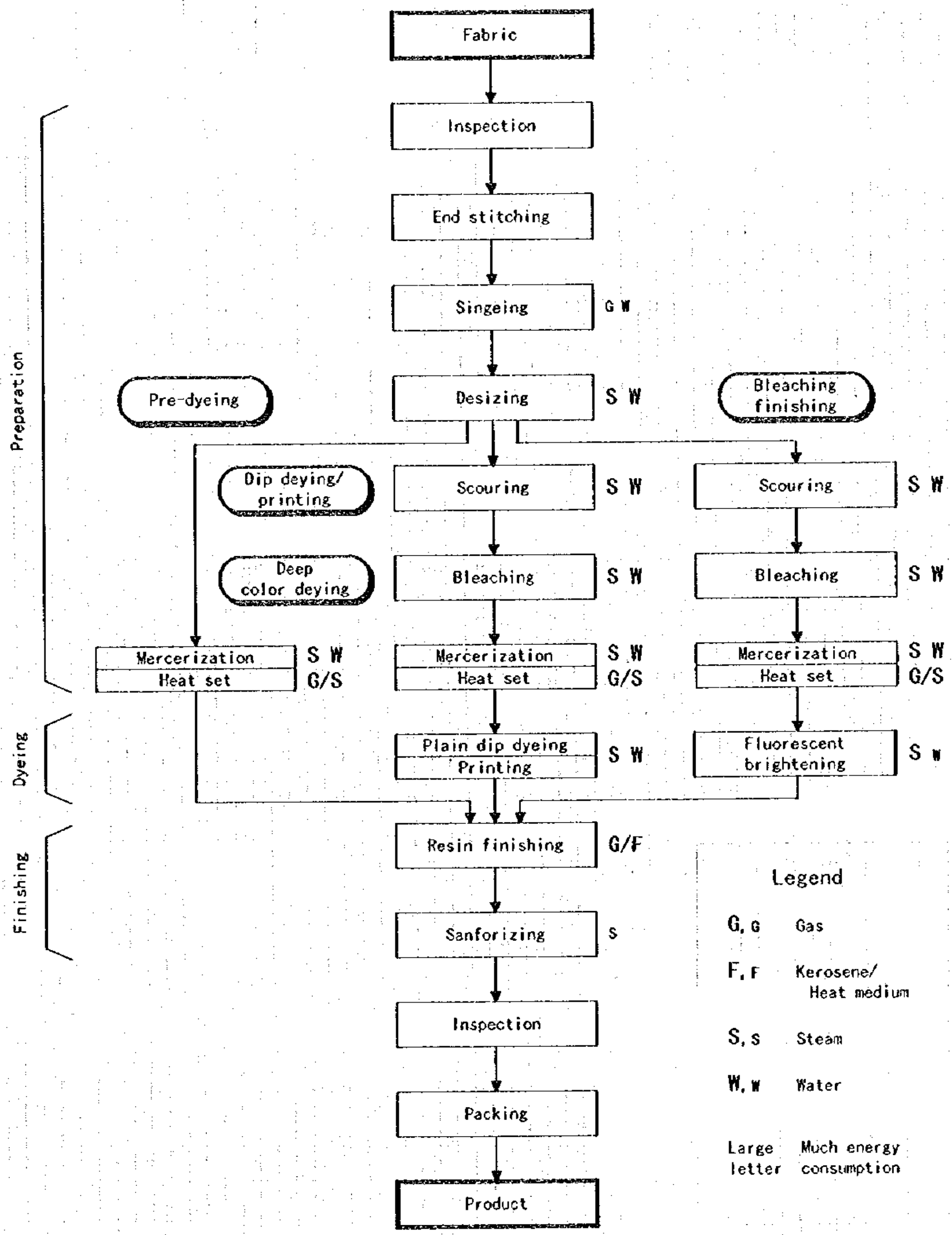


Figure 11-33 Dyeing and Finishing Block Flow Diagram
(Short-Fiber Textiles)

11-14-2 General Procedure for Energy Audit

The outline of the factory audit procedure is shown in Figure 11-34.

(1) Determination of Current Conditions

1. Factory outline (name of factory, type of business, capital, sales, number of employees, brief history, market share, and position in the industry)
2. Production of main products in the past 5 years
3. Energy consumption in the past 5 years
4. Production process of main products
5. Types, capacities, and operating conditions of main energy consuming facilities
6. Energy flowchart
7. Electrical single-line diagrams; condition of power receiving facilities
8. Equipment layout
9. Problems pointed out by the factory management and desired to be checked
10. Energy conservation measures taken in the past
11. Energy conservation measures planned for the future
12. Business condition of the industry and the factory, and factors negatively affecting the promotion of energy conservation measures

(2) Identification of Current Problems

1. Problems with major energy consuming facilities
2. Problems with energy consumption already recognized and items requested for energy audit
3. Major items and points of energy audit

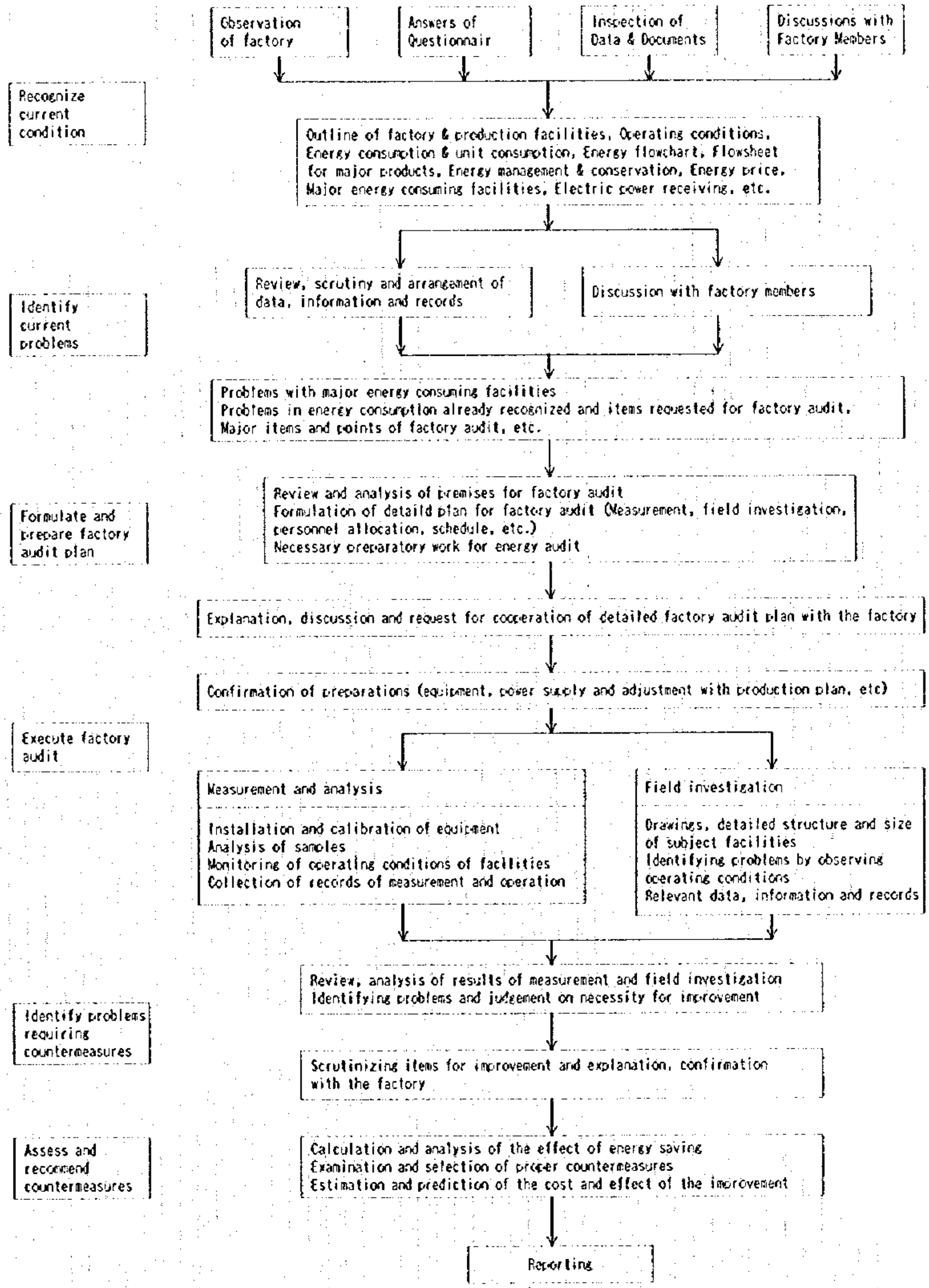


Figure 11-34 Outline of Factory Audit Procedure (Excel)

(3) Formulation of and Preparation for a Detailed Energy Audit Plan

1) Review and Analysis of Premises for Energy Audit

Following items were reviewed and analyzed as premises for energy audit.

1. Problems with facilities and operation
2. Major points and facilities of energy audit
3. Degrees of superannuation and maintenance of facilities
4. Fluctuation of operating load
5. Trends of unit energy consumption figures
6. Necessary precaution for implementation of energy audit
7. Measuring equipment possibly provided by EIE
8. Measuring equipment possibly owned by factory for energy audit
9. Installed instrument and equipment in the plant for energy audit

2) Formulation of Detailed Plan

The following items were formulated and prepared as a detailed plan for energy audit.

1. Details of subject facilities and objectives of energy audit
2. Methods of energy audit (measurement, utilization of operating data and calculation)
3. Points, methods, frequency and equipment of measurement
4. Points and methods of field investigation
5. Personnel allocation and schedule of energy audit

3) Preparation for Energy Audit

The following items were reviewed and prepared for energy audit.

1. Detailed plans for modifications for measurement
2. Items of preparation requested for energy audit
3. Specifications and number of additional pieces of measuring equipment

(4) Execution of Measuring and Surveying

1) Measurement and Analysis

1. Arrangement and installation of equipment
2. Adjustment and calibration of equipment
3. Measurement, analysis and confirmation of data obtained
4. Monitoring of operating conditions
5. Collection of relevant data and records of measurement

2) Field Investigation

1. Investigation of drawings, detailed structure and size of subject facilities
2. Identifying problems by observing operating conditions
3. Collection of relevant data, information and records

(5) Review, Analysis and Scrutinizing of the Results

1) Checking the Results of Measurement and Field Investigation

1. Review and analysis of the results of measurement and field investigation
2. Identifying problems in facilities

2) Analysis of Results

1. Detailed analysis of results of energy audit
2. Calculation and analysis of heat and energy balance
3. Judgment of necessity for improvement
4. Preparation of items for improvement

(6) Formulation and Recommendation of Countermeasures

1. Studying the improvement plan
2. Calculation and analysis of the effect of energy saving
3. Engineering calculation and cost estimation of countermeasures
4. Assess and evaluation of countermeasures for energy conservation
5. Recommendations

11-14-3 Questionnaire

The questionnaire on energy audit is needed for recognizing the outline of the current condition of the factory. The questionnaire including required items and the data sheet are shown below.

1. Outline of the factory		
(1)	Name of the factory	
(2)	Address	
(3)	President	
	Factory manager	
	Energy manager	
(4)	Type of industry	
(5)	Capital	
(6)	Organization chart	
(7)	Number of employees	
(8)	Number of engineers	
(9)	Number of energy related engineers	
(10)	Factory area	
(11)	Building area	
(12)	Factory layout	
(13)	Plant layout (Confidential)	
(14)	Major products	
(15)	Trend of annual sales amount (Confidential)	
	1) Total products	
	2) Each major products	data sheet F-1
(16)	History of the factory	
(17)	Share and position in its industrial sub-sector	
2. Production and energy consumption		
(1)	Production capacity and trends of production amount of major products	data sheet F-2
(2)	Plan for increasing production capacity (Confidential)	
(3)	Flow sheet of major products	
(4)	Trends of unit consumption figure of raw materials of major products (Confidential)	data sheet F-3
(5)	Material loss in the production process (Confidential)	
(6)	Details of major production facilities (without know-how)	

(7)	Annual operating hour and day	data sheet F-2
(8)	Type of operation (batch/semi-batch/continuous)	
(9)	Trends of annual utility consumption	data sheet F-4
(10)	Trends of unit consumption figure of energy	data sheet F-3
	1) Heat/Product	
	2) Electricity/Product	
(11)	Production costs of each major product (Confidential except for utility cost)	data sheet F-5
(12)	Trends of unit price of energy	data sheet F-4
(13)	Energy flow chart	
(14)	Details of major energy consuming facilities	
	1) Boilers	data sheet F-6
	2) Furnaces	data sheet F-7
	3) Other major facilities	data sheet F-8
(15)	Ratio of electric consumption of house generation to received power	
(16)	Electric power receiving	
	1) Received voltage	
	2) Maximum demand	
	3) Power factor	
	4) Flow sheet of single-line connection	
	5) Transformer capacity per unit and number of transformers	
	6) Capacity of reserving power generation for emergency	
3. Energy management/conservation and others		
(1)	Establishment of target for energy conservation	
(2)	Systematic energy management in the organization	
(3)	Energy management utilizing data and records	
(4)	Education, training of employees for energy management	
(5)	Maintenance management of facilities	
(6)	Schedule of annual maintenance	
(7)	Measures carried out for energy conservation and their effects	
(8)	Planning measure for energy conservation and their expected effects	
(9)	Economic condition of the factory and its industrial sub-sector (Confidential)	
(10)	Problems in promotion of energy conservation	
(11)	Environmental pollution management	
	1) Working condition	

	2) Waste gas 3) Waste water 4) Waste disposal
4. Remarks on energy audit	
(1)	Problems in major energy consuming facilities
(2)	Problems in energy consumption and requested items for energy audit
(3)	Schedule of energy audit
(4)	Implementation of energy audit
5. Preparation for energy audit	
(1)	Drawings of the facilities to be audited (Confidential)
(2)	Detailed structure and size of the facilities to be audited (Confidential)
(3)	Arrangement of equipment for energy audit
6. Confirmation of installation of equipment for energy audit	
(1)	Necessary approval procedure for installation of measuring equipment, such as flow meters and pressure gauges.
(2)	Possible measuring equipment owned by factory for energy audit
(3)	Instruments installed in the plant for energy audit

Data Sheet F-1 Trends of annual sales amounts (Confidential) (Unit: Million TL)

No.	Name of major products	1992	1993	1994	1995	1996
	Total products (including other products)					

Data Sheet F-2 Production capacity, production amount and annual operating hour, etc.

No.	Name of major products	Production capacity		1992		1993		1994		1995		1996	
		Unit		Production amount	Annual operating hour/day	Production amount	Annual operating hour/day	Production amount	Annual operating hour/day	Production amount	Annual operating hour/day	Production amount	Annual operating hour/day

Data Sheet F-3 Unit consumption figure of raw materials and energy of each major products

Name of major products	Unit consumption figure	Unit	1992	1993	1994	1995	1996
	1. Raw materials* (1) (2) (3)						
	2. Energy (1) Heat / Product	kcal/					
	(2) Electricity / Product	kWh/					

* Confidential

Data Sheet F-4 Annual consumption and unit price

No.	Name of utility	Unit	Lower heating value (kcal/kg)	1992		1993		1994		1995		1996	
				Consump-tion	Unit price	Consump-tion	Unit price	Consump-tion	Unit price	Consump-tion	Unit price	Consump-tion	Unit price
1.	Fuel oil	kiloliter											
2.	Diesel oil	kiloliter											
3.	Kerosene	kiloliter											
4.	Gasoline	kiloliter											
5.	LPG	ton											
6.	Natural gas	nor-m3											
7.	Lignite or Brown coal	ton											
8.	Other fuels												
9.	Steam/Hot water	ton											
10.	Electricity	kWh											
11.	Process water	m3											
12.	Cooling water	m3											
13.	Boiler feed water	m3											
14.	Well water	m3											
15.	City water	m3											

Data Sheet F-5 Production cost of each major product (Confidential except for utility cost)

Name of major products		Unit	1992	1993	1994	1995	1996
1. Variable cost		TL/					
(1) Raw materials							
(2) Utility							
1) Fuel							
2) Electricity							
3) Steam							
4) Others							
(Sub-total)							
2. Fixed cost							
(1) Labor							
(2) Maintenance							
(3) Depreciation							
(4) Tax / Insurance							
(5) Administration							
(6) Interest for loan							
(7) Sales, Research & Development							
(Sub-total)							
Total production cost							

Data Sheet F-6 Detail of Boilers

No.	Particulars of boiler	Specifications
1.	Manufacturer's name	
2.	Date of construction / Modification	
3.	Type of boiler	
4.	Max. continuous evaporation rate	
5.	Max. working pressure	
6.	Normal pressure	
7.	Normal temperature	
8.	Boiler heat transfer area	
9.	Superheater heat transfer area	
10.	Economizer heat transfer area	
11.	Air preheater heat transfer area	
12.	Combustion chamber volume	
13.	Calorific capacity of combustion chamber	
14.	Fuel	
15.	Burner type / Number	
16.	Drafting method	
17.	Smokestack (top bore x height)	
18.	Control system	

Data Sheet F-7 Detail of furnaces

No.	Particulars of furnaces		Specifications
1.	Manufacturer's name		
2.	Date of construction / Modification		
3.	Type of furnace		
4.	Heated material		
5.	nominal capacity		
6.	Effective length & width		
7.	Normal heating load		
8.	Kind of energy (Fuel or Electricity)		
9.	Burner type, capacity and numbers		
10.	Fan capacity		
11.	Recovery system for waste heat		
12.	Smokestack (top bore x height)		
13.	Combustion chamber volume		
14.	Calorific capacity of combustion chamber		
15.	Transformer capacity (Electric furnace)		
16.	Operating situation	(1) operating method	
		(2) operating time	
		(3) operating days	
17.	Control system		

Data Sheet F-8 Detail of other major facilities

No.	Name of Facility	Manufacturer's name	Date of Construction/ Modifications	Treated material	Kinds of energy	Nominal output	Nominal Consuming energy	Operating condition		
								shift/day	hour/shift	day/month day/year

11-14-4 Check Points of Energy Audit on Processes in the Textile Industry

(1) Spinning and Weaving Process

1) Production Technology and Management

1. Monitoring system	1. Introduce a production monitoring system, if possible with the aid of computers, for (1) Broken thread (2) Idle spindle (3) Idle running motor, etc.
2. Review of package size	1. Review the size and unit quantity of individual packages.

2) Conservation of Electricity (See also Items 3) and 4))

1. Checking motor performance	1. Measure the power of each motor, and re-adjust or replace depending on the fault. 2. Reduce the unevenness of performance of each machine.
2. Reducing the motor base load	1. Adjust correctly the means of power transmission, such as tension of belts, etc. 2. Selection and/or replacement of the correct size and materials of (1) Belt (2) Tape (3) Gear wheel (4) Metal/bearings, etc. 3. Thorough lubricating, cleaning and maintenance of machines.
3. Optimization of machine speed	1. Increase of machine speed causes an exponential energy consumption increase. Optimization of machine speed should be examined from an energy consumption point of view as well as an economic one.
4. Proper illumination in the factory	1. Unnecessary lighting should be avoided. 2. In Table 11-34 the recommended

	illumination in Japanese factories is shown for reference.

Table 11-34 Recommended Illumination in a Spinning and Weaving Factory (Japan)

Unit: lx

Working Place	Recommended Illumination
Blowing, Opening & Beating	80
Carding	100
Drawing	100
Roving	100
Spinning - Finishing	200
Preparation for Weaving	100
Weaving	200
Fabric Inspection	200
Passage	from 30 to 50

Source: Japan Spinners' Association, 1995

3) Conservation of Air

1. Reduction of air use	1. Air is used for many purposes, such as (1) Transport of material fibers (2) Handling of yarn (3) Collection of yarn waste and dust for cleaning, etc. For energy conservation, examine the following methods (1) Centralize the air supplying machines (2) Replace by smaller capacity fans, etc. (3) Reduce the fan rpm. (4) Reduce the diameter of the pneumatic fan impellers. (5) Intermittent operation of the dust and waste yarn collector.
2. Improvement of the air compressor operation	1 Integration of air compressors to reduce the number of operating units.

	2. Automatic start/stop system with pressure switch. 3. Reduction of discharge pressure, as far as possible. 4. Reduction of air nozzle diameter. 5. Periodic and thorough maintenance.

4) Air Conditioning

1. Review the air conditioning load	1. Air conditioning consumes about one-third of the energy for yarn production. In Table 11-35, the recommended conditions in the Japanese factories are shown for reference. 2. The temperature and humidity should be varied gradually, and check the quality of yarn. Then the new conditions can be determined.
2. Change the spray nozzles	1. When air is cooled directly by cold water, enlarging the spray nozzles and reducing the number of them will reduce the original pressure. This results in reduction of the power of pumps.
3. Control the number of units and rotations of refrigerating machine	1. When load is largely fluctuating, using turbo-compressors, the control of the number of units or rotations contributes to reduction of the power.

Table 11-35 Recommended Conditions of Air Temperature and Relative Humidity in a Spinning and Weaving Factory (Japan)

Process	Cotton 100%		Polyester/Cotton	
	℃	%RH	℃	%RH
Blowing, Opening & Beating	26±2	70±5	26±2	65±5
Carding	26±2	60±3	26±2	58±3
Drawing, Roving	26±2	60±3	26±2	58±3
Spinning	28±2	58±3	28±2	53±3
Winding	27±2	60±3	27±2	60±3
Preparation for Weaving	27±2	65±3	27±2	65±3
Weaving	28±2	78±3	28±2	68±3
Finishing	26±2	65±5	26±2	65±5

Source: Japan Spinners' Association, 1995

5) Sizing

1. Change the type of sizing agent	1. This makes it possible to obtain a thicker agent, and makes possible preparation and sizing at lower temperature.
2. Increase the number of yarn sized at a time	1. Increasing the number of yarns sized at one time reduces the speed and contributes to energy conservation.
3. Reduce the number of repetitions of dipping	1. Reduce the number of repetitions of dipping into the sizing bath as far as the results permit.
4. Squeeze at high pressure	1. After dipping, increase the squeezing pressure. For example, the pressure increase from 350 kg to 1,500 kg contributes to a 33 percent reduction of moisture.
5. Dryer	1. Provide proper thermal insulation. 2. Avoid overdrying. (Refer to (2) of this section.)

6) Unit Consumption of Energy

1. Compare the unit consumption of energy with that of a similar factories	1. Carefully examining the difference of the premises of two factories, compare the unit consumption. 2. Notes and examples in Japan (Tables 11-36 to 11-42) are given below.

Note: Difficulty of comparison of unit energy consumption

When unit consumption is compared between different factories, the following premises should be carefully examined.

1. The circumstances surrounding the factory, climate, site, cost compositions (personnel expense, etc.), for example
2. The difference of the quantity and quality of the product, process and operation of each factory

   In the case of a textile industry, for instance, a yarn count, fabric weight, fabric style, kind of color, finish, size of lot, the use of product, operation mode, etc., and naturally the difference of operating conditions according to those factors

Table 11-36 Example of Unit Raw Material Requirement at a Typical Spinning Factory in Japan (Case of Comber Ne 40)

Process	Cotton Waste (%) B that cannot be recycled	Cotton Waste (%) C that can be recycled	1/1-(B+C)
Raw Cotton	-	-	1.373
Blowing, Opening & Beating	1.9	4.0	1.292
Carding	3.6	0.8	1.235
Combing	15.0	1.3	1.034
Drawing	0.1	0.5	1.028
Roving	0.1	0.4	1.022
Spinning	0.2	1.4	1.006
Finishing	0.6	-	1.000

Source: Japan Spinners' Association, 1995

Table 11-37 Unit Requirement of Material by Processes in a Weaving Factory in Japan (Cotton and Polyester/Cotton)

Unit: ton/ton Fabric

	Type of Fabric		Warp	Weft	Total
	Ne	g/m^2			
Shuttle					
Light Weight	40 x 40	133	0.66	0.35	1.01
Heavy Weight	14 x 14	304	0.69	0.32	1.01
Air Jet					
Light Weight	40 x 40	133	0.68	0.35	1.03
Heavy Weight	14 x 14	304	0.71	0.32	1.03

Source : Japan Chemical Fibres Association, 1993

Table 11-38 Example of Waste Yarn Ratio at a typical Weaving Factory in Japan

Unit: percent

Yarn Count	Warp	Weft
Shuttle Loom		
less Ne 10	2	2.5
over Ne 10	1	1.5
Innovated Loom		0.2~0.5

Source: Japan Spinners' Association, 1995

Table 11-39 Unit Energy Consumption by Yarn Count at a Spinning Factory in Japan

	Yarn Count	Electricity		Fuel	Process Water	Total
		kWh/kg	kcal/kg	kcal/kg	kcal/kg	kcal/kg
Standard	10	1.485	1,277	248	50	1,575
Cotton	20	2.416	2,078	403	82	2,563
Yarn	30	3.405	2,928	569	116	3,613
	40	4.354	3,744	727	148	4,619
	50	5.547	4,770	926	189	5,885
	60	6.670	5,736	1,114	227	7,077
	20/2	2.933	2,522	489	100	3,111
Two Folded	30/2	4.134	3,555	691	141	4,387
Cotton	40/2	5.286	4,546	883	180	5,609
Yarn	50/2	6.734	5,791	1,124	229	7,144
	60/2	8.097	6,963	1,352	276	8,591

Source: Japan Chemical Fibres Association, 1993

Table 11-40 Unit Electricity Consumption in a Spinning Factory in Japan (Ne 40 Comber, 50,000 Spindle Capacity)

Unit : kWh/kg

Fiber Manufacturing Machines		
	Blowing, Opening & Beating	0.116
	Carding	0.198
	Combing	0.249
	Drawing	0.039
	Roving	0.138
	Spinning	1.702
	Winding	0.471
	Others	0.038
	Sub-Total	2.950
Air Conditioning		
	for Front Process (Blowing --> Roving)	0.220
	for Back Process (Spinning - Winding))	0.403
	Sub-Total	0.623
Refrigerating		
	for Front Processes	0.096
	for Back Processes	0.183
	Sub-Total	0.278
Lighting		
	Blowing, Opening & Beating	0.005
	Carding	0.017
	Combing → Roving	0.043
	Spinning	0.066
	Winding	0.033
	Sub-Total	0.164
Fiber Production - Total		4.015

Source: Japan Spinners' Association, 1995

Table 11-41 Estimated Mean Value of Unit Consumption of Electricity and Steam in Weaving Factories in Japan (Cotton and Polyester/Cotton)

	Type of Fabric		Electricity		Steam		Total
	Nc	g/m^2	kWh/ton	kcal/ton	ton/ton	kcal/ton	kcal/ton
Shuttle				x 10^6		x 10^6	x 10^6
Light	40 x 40	133	2,630	2.262	1.88	1.462	3.724
Heavy	14 x 14	304	893	0.768	1.14	0.887	1.665
Air Jet							
Light	40 x 40	133	2,460	2.116	1.90	1.478	3.594
Heavy	14 x 14	304	773	0.665	1.18	0.918	1.583

Source: Japan Chemical Fibres Association, 1993

Table 11-42 Unit Consumption of Electricity and Steam by Processes in a Weaving Factory (Cotton and Polyester/Cotton)

Unit: 10^6 kcal/ton-Fabric

Type of Fabric (as of Table 11-37)	Energy	Weft Preparation	Warp Beaming	Sizing	Drawing-in	Weaving	Finishing Inspection	Total	
Shuttle									
Light Weight	Electricity	0.110	0.019		0.003	2.049	0.007	2.188	3.845
	Steam			1.657				1.657	
Heavy Weight	Electricity	0.112	0.008		0.001	0.615	0.003	0.739	1.703
	Steam			0.964				0.964	
Air Jet									
Light Weight	Electricity	-	0.018		0.002	2.029	0.007	2.056	3.686
	Steam			1.63				1.63	
Heavy Weight	Electricity	-	0.008		0.001	0.622	0.003	0.634	1.632
	Steam			0.998				0.998	

Source: Japan Chemical Fibres Association, 1993

(2) Dyeing, Printing and Finishing Process

1) Production Technology and Management

1. Production schedule	1. Rational production schedule considering the rational use of energy.
2. Re-examination of the present operating conditions	1. Less water use results in reduction of steam consumption. 2. Lower temperature operating conditions result in reduction of both water and steam.

2) Reduction

1. Process step	1. Skip unnecessary process steps. (1) For some types of fabric, the drying process can be omitted. Some types of fabric can be forwarded to the next process. This is called the "Wet on wet method" (2) For dark color dyeing, the bleaching process may be eliminated.
2. Liquor ratio	1. Liquor ratio (the quantity (liter) of water used to dye 1 kg of fabric) is dependent on dyeing equipment and dyeing method. 2. Low liquor ratio contributes to productivity increase and hence energy conservation. 3. An excellent example of a low liquor ratio is 1:5 by jet dyeing.
3. Washing water	1. From experience, normally the amount of washing water required is 4 to 5 times the weight of fabric. 2. Efficient washing machines incorporate the following techniques. (1) Increase the frequency of contact between fabric and water. (2) Direction of water flow is counter to that of fabric. (3) Agitating fabric and water.

4. Steam	1. Provide both energy supply and consuming facilities with proper thermal insulation. 2. Prevent leakage of steam. 3. Good steam trap management and promote condensate recovery. 4. Improve drying efficiency (Refer to Item 3)
5. Time	1. Speed up the fabric treating by improved machine and/or operating conditions.
6. Treatment temperature	1. Reduce bleaching, dyeing and other treatment temperatures by changing chemicals used. 2. Washing water temperature should be lowered, as far as the quality of products permits.

3) Improvement of Dryer Efficiency

1. Thorough dewatering using mangle	1. Sufficient water should be removed before drying. For example, by using a non-woven fabric roller and vacuum, the water content of from 25 to 50 % is attained.
2. Increase of dryer efficiency	1. Select an efficient dryer, for instance a cylinder type, and maintain it well.
3. Moisture content in exhaust air and dried fabric	1. Measure the moisture content in exhaust air and adjust operation conditions. 2. Measure the moisture content of dried fabric, to avoid overdrying. The equivalent moisture content of cotton at room temperature is 8 %.

4) Recovery

1. Waste water	1. Separate higher temperature waste water (about 70 to 90℃) and lower temperature waste water (room temperature to 50℃). Keep the higher energy potential. 2. For higher temperature waste water, a

	liquid-liquid type heat exchanger, and for lower temperature waste water, the use of a heat pump should be investigated.
2. Hot exhaust gas from dryer	1. A rotary disk-type sensible heat exchanger should be examined.
3. Steam condensate	(as Item 2)-4)

5) Unit Consumption of Energy

1. Compare the unit consumption of energy with that of similar factories	1. Carefully examine the difference of the premises of two factories, and compare the unit consumption. 2. Notes are as in (1) of this section. Examples in Japan are given in Tables 11-43 to 11-47.

Table 11-43 Estimated Mean Unit Consumption of Utilities in Dyeing, Printing and Finishing Factories in Japan (Cotton)

Unit : 10^6 kcal/ton

Process	Products	Flow & Material Requirement	Energy Type	Unit Energy Consumption
Dyeing, Bleaching	Shirt (130g/m²)	Raw Fabric→Singeing→Scouring, Bleaching→Dip Dyeing→Resin Finish→ Sanforizing→Inspection→Shipment (Material Requirement: Raw Fabric/Product=1.087)	Electricity	1.260
			Steam	7.158
			Gas	4.510
			Water	0.002
			Total	12.930
Dyeing, Bleaching	Casual Pants (250g/m²)	Flow: as above Material Requirement: 1.064	Electricity	0.790
			Steam	6.071
			Gas	3.820
			Water	0.002
			Total	10.683
Printing	Lady's Dress Fabric (130g/m²)	Raw Fabric→Singeing→Scouring, Bleaching→Secondary Bleaching→ Printing→Steaming→Washing→ Drying→Resin Finish→Sanforizing→ Inspection→Shipment Material Requirement: 1.075	Electricity	2.264
			Steam	11.574
			Gas	3.730
			Water	0.003
			Total	17.571
Printing	Home Textiles (200g/m²)	Flow: as above Material Requirement: 1.075	Electricity	1.558
			Steam	12.147
			Gas	4.010
			Water	0.003
			Total	17.718

Source: Japan Chemical Fibres Association, 1993

Table 11-44 Estimation of Unit Heat Consumption for Dyeing, Printing and Finishing Processes

1. Material to be processed

   Cotton Fabric (150g/m^2) with 1500mm Width

2. Notation

   A: Estimated unit consumption of effective heat for processing

   B: Heat discharged with effluent (liquid and/or gas)

   C: Heat loss from apparatus (via surface, etc.)

   E_1: Heat input necessary for processing

   $E_1 = A + B + C$

   E_2: Heat loss during idling time

   E_3: Heat for warming up apparatus

   EP: Total unit heat consumption at present

   $EP = E_1 + E_2 + E_3$

   EN: Total unit heat consumption after heat conservation

   Heat recovery is done by

   (1) Waste water (higher temperature) --- Liquid/liquid heat exchanger.
       Waste water (lower temperature) --- Heat pump. Recovered hot water is used as boiler feed water.

   (2) High temperature exhaust gas ---- Gas/gas or gas/liquid heat exchanger.

3. Unit

   kcal/kg and (percent)

Source: Japan Textile Machinery Association, 1983

Table 11-45 Estimated Unit Heat Consumption for a Scouring - Bleaching - Mercerizing Process

Process	Apparatus	A	B	C	E_1	E_2	E_3	EP	EN
Singeing	Singeing	32	213	11	256	1	1	258	258
	Machine	(12.4)	(82.6)	(4.3)	(99.2)	(0.4)	(0.4)	(100)	
	Pad-Steamer	430	393	45	868	21	28	918	896
Scouring		(46.8)	(42.8)	(4.9)	(94.6)	(2.3)	(3.1)	(100)	
	Washer	30	764	53	847	21	27	895	210
		(3.4)	(85.4)	(5.9)	(94.6)	(2.3)	(3.1)	(100)	
	Pad-Steamer	430	393	45	868	21	28	918	895
		(46.8)	(42.8)	(4.9)	(94.6)	(2.3)	(3.1)	(100)	
Bleaching	Washer	21	544	38	603	15	19	637	210
		(3.3)	(85.4)	(6.0)	(94.6)	(2.3)	(3.1)	(100)	
	Cylinder	532	0	122	654	16	21	691	----
	Dryer	(77.0)	(0)	(17.7)	(94.6)	(2.3)	(3.1)	(100)	
Sub-total of Singeing-		1475	2308	314	4097	96	125	4318	2470
Scouring-Bleaching		(34.2)	(53.5)	(7.3)	(94.9)	(2.2)	(2.9)	(100)	
	Mercerizer	24	617	43	685	20	21	726	
		(3.3)	(85.0)	(5.9)	(94.4)	(2.7)	(2.8)	(100)	286
Merceri-	Washer	42	1084	75	1201	35	36	1271	
zation		(3.3)	(85.3)	(5.9)	(94.5)	(2.7)	(2.8)	(100)	
	Cylinder	529	0	121	650	19	20	689	322
	Dryer	(76.8)	(0)	(17.6)	(94.4)	(2.7)	(2.9)	(100)	
Sub-total of		595	1701	239	2536	73	77	2686	608
Mercerization		(22.2)	(63.3)	(8.9)	(94.5)	(2.7)	(2.8)	(100)	
Total		2070	4009	554	6633	169	202	7005	3078
		(29.6)	(57.2)	(7.9)	(94.7)	(2.4)	(2.9)	(100)	

Table 11-46 Estimated Unit Heat Consumption for a Dyeing - Finishing Process

Process	Apparatus	A	B	C	E_1	E_2	E_3	EP	EN
	Dyeing	178	231	250	659	11	40	710	391
	Machine	(25.0)	(32.5)	(35.2)	(92.8)	(1.5)	(5.6)	(100)	
	Roller	448	264	22	734	13	51	798	
	Dryer	(56.1)	(33.1)	(2.8)	(92.0)	(1.6)	(6.4)	(100)	
Continuous	Steamer	690	706	130	1526	72	32	1630	291
Dyeing		(42.3)	(43.3)	(8.0)	(93.6)	(4.4)	(2.0)	(100)	
	Washer	63	1407	94	1564	74	32	1670	951
		(3.8)	(84.3)	(5.6)	(93.7)	(4.4)	(1.9)	(100)	
	Cylinder	695	0	163	858	39	18	915	----
	Dryer	(76.0)	(0)	(17.8)	(93.8)	(4.3)	(2.0)	(100)	
Sub-total of		2074	2608	659	5341	209	173	5723	1633
Continuous Dyeing		(36.2)	(45.5)	(11.5)	(93.2)	(3.6)	(3.0)	(100)	
	Pad-Roller	394	234	14	643	19	22	684	583
	Dryer	(57.6)	(34.2)	(2.0)	(94.0)	(2.8)	(3.2)	(100)	
Finishing	Tenter	568	205	53	825	24	28	877	753
		(64.8)	(23.4)	(6.0)	(94.1)	(2.7)	(3.2)	(100)	
	Baking	153	384	86	623	18	21	662	662
	Machine	(23.1)	(58.0)	(13.0)	(94.1)	(2.7)	(3.2)	(100)	
Sub-total of		1115	823	153	2091	61	70	2223	1998
Finishing		(50.2)	(37.0)	(6.9)	(94.1)	(2.7)	(3.1)	(100)	
Total		3189	3431	812	7432	271	243	7946	3631
		(40.1)	(43.2)	(10.2)	(93.5)	(3.4)	(3.1)	(100)	

Table 11-47 Estimated Unit Heat Consumption for a Printing - Finishing Process

Process	Apparatus	A	B	C	E_1	E_2	E_3	EP	EN
Tentering	Tenter	350	245	71	665	27	38	730	730
		(47.9)	(33.6)	(9.7)	(91.1)	(3.7)	(5.2)	(100)	
Printing	Screen	1466	1860	217	3543	749	170	4461	4521 *
	Printing	(32.9)	(41.7)	(4.9)	(79.4)	(16.8)	(3.8)	(100)	
Steaming	Steamer	926	892	185	2003	38	129	2169	2169
		(42.7)	(41.1)	(8.5)	(92.3)	(1.8)	(5.9)	(100)	
Sub-total of Tentering-Printing-Steaming		2742	2997	472	6211	813	336	7360	7420
		(37.3)	(40.7)	(6.4)	(84.4)	(11.0)	(4.6)	(100)	
Washing	Washer	1184	666	311	2161	39	77	2276	453
		(52.0)	(29.3)	(13.7)	(94.9)	(1.7)	(3.4)	(100)	
	Cylinder	532	0	122	654	23	30	707	457
	Dryer	(75.2)	(0)	(17.3)	(92.5)	(3.3)	(4.2)	(100)	
Sub-total of Washing		1717	666	432	2815	62	107	2984	918
		(57.5)	(22.3)	(14.4)	(94.3)	(2.1)	(3.6)	(100)	
Finishing	Roller	392	233	14	639	20	2	662	322 (Roller Dryer and Tenter)
	Dryer	(59.2)	(35.2)	(2.1)	(96.5)	(3.0)	(0.3)	(100)	
	Tenter	565	203	53	821	26	29	876	
		(64.5)	(23.2)	(6.1)	(93.7)	(3.0)	(3.3)	(100)	
	Baking	153	384	86	623	18	21	662	222
	Machine	(23.1)	(58.0)	(13.0)	(94.1)	(2.7)	(3.2)	(100)	
Sub-total of Finishing		1110	821	152	2083	64	53	2199	544
		(50.5)	(37.3)	(6.9)	(94.7)	(2.9)	(2.4)	(100)	
Total		5568	4483	1057	11108	939	496	12543	8882
		(44.4)	(35.7)	(8.4)	(88.6)	(7.5)	(4.0)	(100)	

Note * Smaller lots are assumed.

11-14-5 Check Points for Energy Audit on Unit Operation

In Japan, the Ministry of International Trade and Industry sets forth the items to be observed by factory operators as criteria in achieving efficient use of energy within technically and economically possible limits, in the Energy Conservation Law.

The Ministry classifies energy conservation techniques into the following seven categories, which are not compulsory but serve as guidelines.

1. Improvement of fuel combustion in combustion equipment
2. Improvement of heating, cooling, heat transfer, etc. in heat using equipment
3. Prevention of heat loss due to radiation, conduction, etc. from heat using equipment
4. Recovery and utilization of waste heat
5. Improvement of conversion from heat to power in combined heat and power generation equipment
6. Prevention of electricity loss due to resistance, etc. in electrical equipment
7. Improved conversion from electricity to power, heat, etc. in electrical equipment

The Japanese standards, targets and examples of improvement measures as guidelines are useful for planning check points and judging the results of energy audit in the textile industry. These guidelines are shown for reference as follows.

(1) Improvement of Fuel Combustion

1) Standard Air Ratio

Standard air ratios in boilers and furnaces are given in Table 11-48 and Table 11-49 respectively.

Table 11-48 Standard Air Ratio of Boiler

Amount of Evaporation	Solid Fuel	Liquid Fuel	Gaseous fuel
Large Boiler for Electric Company	1.2 -- 1.3	1.05 -- 1.1	1.05 -- 1.1
30 tons/h or more	1.2 -- 1.3	1.1 -- 1.2	1.1 -- 1.2
10 to 30 tons/h	--	1.2 -- 1.3	1.2 -- 1.3
Smaller than 10 tons/h	--	1.3	1.3

Remark Load factor: 75 to 100 %

Table 11-49 Standard Air Ratio of Furnace

Purpose	Liquid Fuel	Gaseous Fuel
Oil Heating Furnace	1.4	1.4
Gas Generating Furnaces	1.4	1.4

2) Check points

Check points are as follows.

1. Burner selection	Type, Size, Turn down ratio, Maintenance, Cleaning tip
2. Better atomization	Fuel temperature, Viscosity, Proportion of atomizing air or steam to fuel, Fuel pressure, Dispersion reagent, Emulsified fuel
3. Prevention of air intrusion	Furnace pressure control, Reduction of opening, Double door, Sealing, Shortening door open time
4. Advanced automatic control	Fuel air ratio control by oxygen content in exhaust gas, Fuel air ratio control by carbon oxide content in exhaust gas, Fuel air ratio cascade control Fuel air ratio cross limit control
5. Load leveling	Optimum load sharing, Operation unit number control, Steam accumulator
6. Flame temperature raise	Combustion with enriched oxygen, Gas atomized fuel oil combustion, Fluid bed combustion

(2) Improvement of Heating, Cooling and Heat Transfer

Check points are as follows.

1. Heating in industrial furnaces	
(1) Optimum heating temperature	Setting work standard
(2) Search for best heat pattern	Temperature distribution, heating velocity, Improvement flow of gas in furnace
(3) Optimum load	Optimum load on furnace bed, Load sharing to multiple facilities, Load leveling
(4) Improve furnace shape	
(5) Decrease heat content of furnace body	Lighten the weight
(6) Increase of flame emissivity	
(7) Direct heating	Modify to direct firing
2. Heating by steam	
(1) Adjusting steam pressure to proper level	
(2) Perfect air purge	
(3) Improvement of direct steam injection	
3. Heat transfer	
(1) Decrease of heat transfer resistance	Prevention of scaling, Sludge deposit, Frost, Boiler feed water quality control, Chemicals injection, Optimum blow off of boiler water, Tearing off condensate film, Defrosting, Cleaning of heat transfer surface, Soot blowing, Filter cleaning
(2) Improvement of heat transfer coefficient	High-speed gas flow, Jet heating, High-speed burner, Fluid bed heat transfer Mist cooling
(3) Heat exchange system	Addition of heat exchanger, Minimization of energy loss
(4) Advanced heat exchanger	High heat conductivity material, Shape of heat transfer tube, Heat exchanger tube arrangement Enlarging heating surface, fin plate,

	Buffer plate, turbulence accelerator
4. Operation	
(1) Start/stop time optimization	Adjusting operation plan
(2) Decrease of load	Air conditioning (temperature, rate of air circulation), Utilization of holding heat of material from previous process, Shortening of waiting time between processes, Shortening of furnace idling time, Lot concentration, Distillation (optimum reflux ratio, selection of feed or extraction tray)
5. Process	
(1) Controlling method improvement	Decrease of margin
(2) Automation	
(3) Heat utilization as cascade	Multiple effect evaporator, vapor recompression, Increasing distillation tray, plant integration, Inter-factory energy pooling
(4) Separation process	Mechanical separator instead of heating process, Separation through membrane, Adsorption, Extraction, Supercritical separation
(5) Improvement of layout	Shortening of transport distance, Prevention of complicated transport, Decrease of idling time through shortening of transport pass
(6) Operating reactor under less extreme conditions	Improvement of catalyzer, Improvement of reagent, bio reactor
(7) Change of product specification	Avoidance of providing quality that surpasses the market requirement., Material not requiring heat treatment in next process
(8) Change of raw material	Recycle
(9) Scale up	Shortening operating time by increasing electric power
(10) Modification of continuous process	

(11) Modification to high speed process	
(12) Simplified process	Hot charge
(13) Use of high-efficiency devices	

(3) Prevention of Heat Loss Due to Radiation, Conduction, etc.

1) Standard for Surface Temperature

The standards for surface temperature for furnaces are given in Table 11-50.

Table 11-50 Standard for Surface Temperature on Furnace

(Unit: ℃)

Internal Temperature	Outer Ceiling Surface	Outer Wall Surface
1,300	140	120
1,100	125	110
900	110	95
700	90	80

2) Check Points

1. Prevention of leakage	Inspection and repair, Selection and maintenance of steam trap, Reinforcing seals of rotary parts and joints
2. Narrowing heat radiation surface area	Improvement of steam piping route, Removing unnecessary pipe, Shutting main valve of unused pipe, or inserting blind plate
3. Insulation	Enforcement of insulation at flange and valve, Use of heat insulating material of low heat conductivity, Lowering emissively of insulator cover, Setting cover, lid, Maintenance of insulator, Use of lightweight heat insulation material for batch furnace (bulk specific gravity < 1.3)
4. Preventing heat loss by exhaust of internal	Reducing size of openings, closing openings, or

gas	mounting doors on openings, Shortening door open time
5. Optimum boiler water blow	

(4) Recovery and Utilization of Waste Energy

1) Standard Temperature of Exhaust Flue Gas

The standard temperature of exhaust flue gas of boiler and industrial furnace is shown in Table 11-51 and Table 11-52.

Table 11-51 Standard Temperature of Exhaust Flue Gas of Boiler

(Unit: ℃)

Amount of Evaporation	Solid Fuel	Liquid Fuel	Gaseous Fuel
Large Boiler for Electric Companies	145	145	110
30 tons/h or more	200	200	170
10 -- 30 tons/h	--	200	170
Smaller than 10 tons/h	--	320	300

Remark Load ratio 100 %

Table 11-52 Standard Temperature of Exhaust Flue Gas of Industrial Furnace

Furnace Outlet Exhaust Gas Temperature	Exhaust Gas Temperature after Waste Heat Recovery (℃); Waste Heat Recovery Ratio (%)					
	Larger than 19 10^6 kcal/h		4.8 - 19 10^6 kcal/h		1 - 4.8 10^6 kcal/h	
500 ℃	200 ℃	(20) %	200 ℃	(20) %		
600	290	(20)	290	(20)		
700	300	(30)	330	(25)	370 ℃	(20) %
800	370	(30)	410	(25)	450	(20)
900	400	(35)	490	(25)	530	(20)
1,000	420	(40)	520	(30)	570	(25)
Higher than 1,000		(40)		(30)		(25)

Remark Liquid fuel, Air ratio 1.2

2) Check Points

1. Source of waste energy	Exhaust gas, air, Exhaust water, liquid, condensate, Hot solid, product, ash, Mechanical energy (water head), Unused pressure, combustible gas, Natural energy (solar energy)
2. Use	Heating material, Heating air for combustion or process, Preheating boiler feed water, Preheating fuel (oil, gas), steam generation, Power generation, electricity generation, Air conditioning
3. Measures	Heat exchanger, heat pipe, Fluid bed (suspension preheater), Heat pump, heat transport medium, Waste heat boiler, Vacuum evaporation type water heater, Turbine (steam, organic reagent)

(5) Improvement of Conversion from Heat to Power

Check points are as follows.

1. Increase of energy efficiency	Steam condition upgrade, Combined system, cogeneration, Recovery of drive power at depressurization of steam
2. Operation improvement in power plant	Improvement of turbine, nozzle shape, Vacuum maintenance of condenser of turbine (cleaning, water temperature), Optimization of power plant use, Variable pressure operation according to load, Auxiliary equipment load control, revolution, Optimizing back and extraction pressure,

	Peak shift (use of electricity during midnight hours and holidays, heat storage as ice)
3. Improvement of engine efficiency	
4. Rational operation of steam ejector	Optimization of number of stages, Steam pressure, substitution to vacuum pump

(6) **Prevention of Electricity Loss by Resistance**

Check points are as follows.

1. Power transportation	Higher voltage
2. Wiring	
(1) Minimization of length	Arrangement of receiving facility and load, Improvement of wiring route
(2) Improvement of wiring way	
(3) Optimization of wire size	
(4) Balancing loads between 3-phase	
3. Transformer	
(1) Optimum capacity	
(2) Load allotment, Adjusting the number of operating units	
(3) Connection way	
(4) Cutting off in unused time	
4. Facilities using electricity	Minimization of resistance at contact point
5. Improvement of power factor	Installing condenser (Capacitor), Power factor control by synchronous generator, Avoidance of low load running of motor
6. Operation	Suppression of peak demand (Low leveling, Demand control)

(7) Improvement of Conversion from Electricity to Power, Heat, etc.

Check points are as follows.

1. Motor	High efficiency type, optimum capacity
2. Power transmission	Improvement of transmission, Transmission belt (material, relaxation degree), Lubrication control
3. Operation	Keeping rated voltage, Preventing idling, intermittent running
4. Fluid transportation	
(1) Reduction of load	Decrease of flow (preventing leakage), Reducing pipe resistance (streamlining of pipe route, cleaning pipes), Lowering suction temperature, Selection of transport measures, High-efficiency devices, impellers, Movable blades
(2) Optimizing equipment capacity	Modifying shape of impeller
(3) Control	Rotation speed control, unit number control
5. Electric heating	Hot charge, Comparative study between electric and other heating methods
6. Air conditioning	Reduction of load, Shape, structure, direction, surroundings of building, Induction of outdoor air, Total enthalpy heat exchange, Prevention of outdoor air invasion (automatic doors, curtains) Optimum rate of air circulation, insulation, Isolation of heat generating body, Lighting facilities, localized air conditioning, Zoning (setting different condition by zone) Far infrared ray heating

(1) Ventilation	Lowering flow resistance in duct, Filter cleaning, fan rpm control, Optimum size of humidifier nozzle
(2) Operation	Cooling water temperature control, Water quality control in cooling tower line, Cleaning of heat exchanger
7. Lighting	
(1) Optimum illuminance	
(2) Better interior finishing of room	Wall color
(3) Improving lighting fixture arrangements	
(4) Utilization of daylight	
(5) Enforcement of turn-off of unnecessary lamps	
(6) Illumination control	
(7) Cleaning fixtures	
(8) Replacing bulbs at proper intervals	
(9) High efficiency facilities	Lamp

11-14-6 Evaluation Method of the Result of Energy Audit

(1) Evaluation of Main Operating Condition

There are some standard guidelines for evaluating the operation condition of energy consuming facilities. The main items are as follows.

1. Temperature of exhaust flue gas in the boiler and the furnace
2. Air ratio on combustion in the boiler and the furnace
3. Surface temperature on the equipment
4. Power factor of electricity
5. Temperature of waste water

Rough evaluation of energy management will be done by comparing the audit result with standard for related items.

(2) Evaluation of Energy Unit Consumption

Unit consumption is the most important factor for evaluating the energy management. There are two methods for the evaluation. One is checking the level of unit consumption in comparison with that of similar factories and facilities in Turkey and foreign countries, and the other is checking the trend of unit consumption, whether it is improving or becoming worse. The factors for evaluation of unit consumption of energy are total energy, fuel (coal, liquid fuel, gas), electricity, steam, and water.

(3) Evaluation of Investment for Energy Saving

A recommendation to expand a factory is sometimes made for energy saving. In this case, two evaluation methods for investment may be used. One is rate of return on investment. The other is repayment period for investment.

(4) Evaluation of Awareness of Factory Employees

The most important thing is awareness of those who work for the factory, managers in particular, for energy saving, improving energy unit consumption. In the energy audit, this item must be evaluated in comparison with their awareness after promotion activity by the audit team.

11-14-7 Reporting

The report consists of the following items.

1. Preface
2. Introduction
3. Background of the study
4. Achievement of the study
5. Summary of the result of the study
6. Characteristics of each industrial sub-sector
7. Outlines of factory, facilities and flow sheet for major products
8. Outline of operating conditions
9. Trends of consumption and unit consumption of energy
10. Current condition and problems with major energy consuming and supply facilities
11. Method and procedure of energy audit
12. Execution procedure of measurement
13. Results of measurement and analysis
14. Energy flow chart of factory and major energy consuming facilities
15. Formulation and recommendation of countermeasures for energy conservation
16. Cost estimation of countermeasures

17. Overall evaluation of countermeasures for energy conservation

18. Conclusions and recommendations

Chapter 12 Technical Study for IDC

Chapter 12 Technical Study for IDC

12-1 Characteristics of Minimill Subsector

Minimill is one steel production process. The main products made by this process are rebar and section, which are long products. Production of long products was 9.3 million tons in 1995 in Turkey, 78 percent of the total steel production of 12.0 million tons in Turkey. Minimill consists of production plants including a steelmaking plant (Electric Arc Furnace, Ladle Furnace and Continuous Casting Machine) and rolling mill plant (Bar Rolling Mill and/or Rod Rolling Mill) with auxiliary facilities such as oxygen plant, compressed air plant, water treatment station, main receiving sub-station, analysis and inspection laboratory, maintenance shop, etc.

Total energy consumption of minimill is generally 65 percent in the steelmaking plant (SMP); and 85 percent of electricity is consumed in the SMP. For energy conservation, electric arc furnace (EAF) measurements are essential considering that the EAF is the greatest energy consuming facility in the minimill.

Energy saving in the electric arc furnace has been achieved together with efforts to increase the productivity. Energy saving in an electric arc furnace includes (1) utilizing oxygen gas by means of oxy-lancing and oxy-fuel burners, (2) adoption of a large-scale furnace and a large-capacity transformer, (3) introduction of new technologies, EBT (eccentric bottom tapping system), ladle furnace operation, scrap preheating, DC (direct current) arc furnace system, and twin furnaces to use most efficiently the exhaust gas heat, for example, and (4) improvement of operational technique such as long arc operation and foamy slag operation. Nowadays the DC twin furnace operation is considered the most advanced furnace. In the rolling mill plant, energy use is reduced in the reheating furnace, by adoption of hot charge operation together with improvement of the refractory, heat exchangers, combustion burners and combustion control. The slit rolling practice has also contributed to increased productivity.

12-2 Outlines of Factory, Facilities and Flowsheet of Major Products

12-2-1 Outline of Factory

(1) General

Izmir Demir Celik Sanayi A. S. (IDC) is one of the five minimills located in the Foca Area:

Cukrova, Habas, Cbitas, Ege Metal and IDC. IDC was established in 1975 as a rolling mill. After a series of expansions IDC now has production capacities of 550,000 tons per year of rebar and 700,000 tons per year of billet. The production in 1994 of rebar and billet was 506,000 tons and 621,000 tons, respectively. The company's paid capital was 3,684 billion TL in December 1995. IS Bank holds 60 percent of the shares and general investors hold the rest.

(2) Organization

Mr. Dogan Arikan is president of the factory. The number of employees is about 600 at present. The organization chart of IDC is shown in Figure 12-1. The organization comprises three divisions, seven departments and 21 sections.

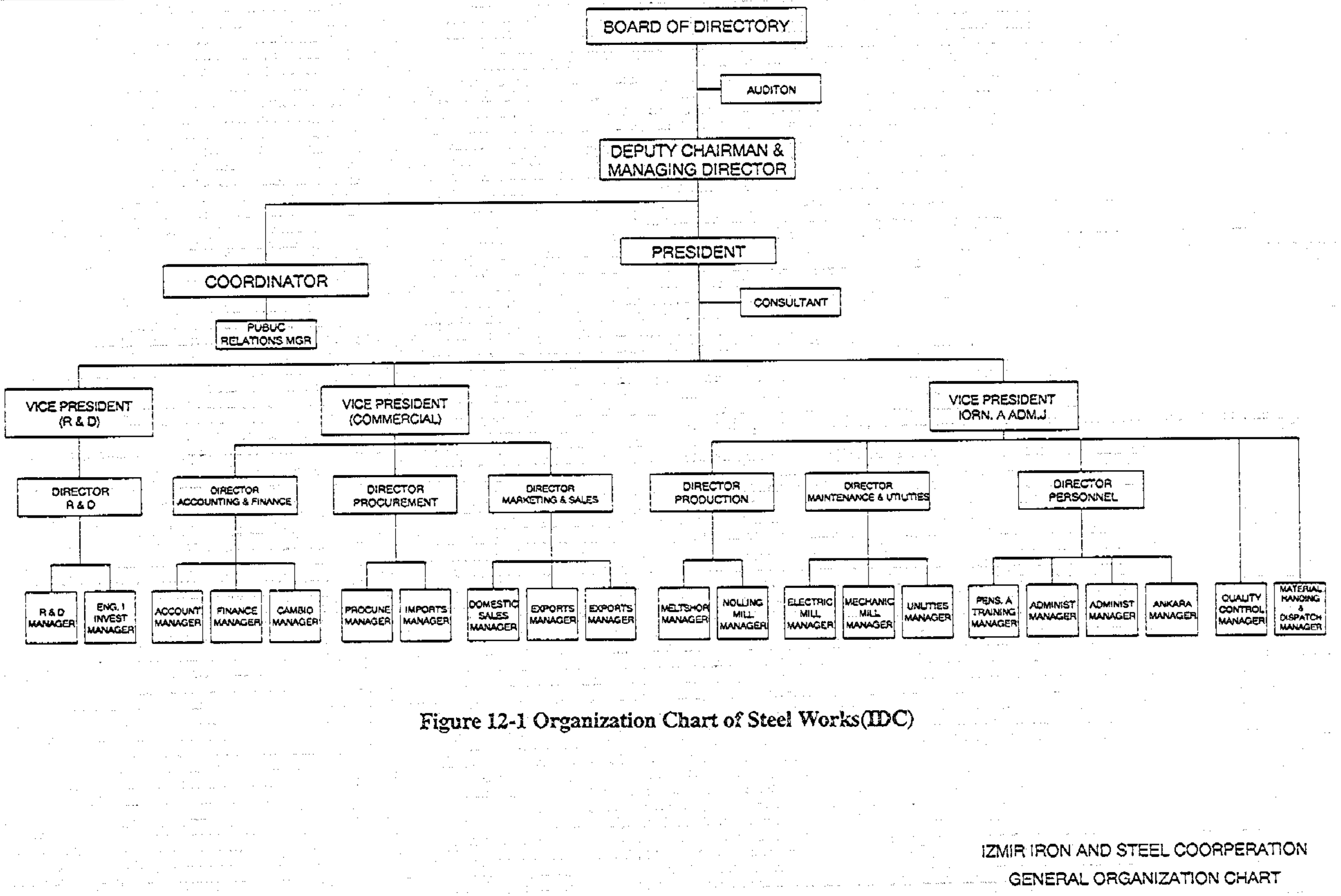


Figure 12-1 Organization Chart of Steel Works(IDC)

(3) Employment and Training

1) Employment

The school education system of Turkey is basically the so-called 5-3-3-4 system. In Turkey 100 percent school enrollment has almost been attained at the elementary education level. Though it is relatively easy to employ competent workers, IDC does not need to employ new workers at this moment, because their workers do not leave the company. When additional personnel are required, IDC can obtain them from its subsidiaries. When recruiting employees, the company interviews the applicants after examination of written applications.

2) Education and Training

Education and training may be classified into three categories: Basic Education, Training Abroad and Management Education.

(a) Basic Education

New employees are given room lectures for about one week on the outlines of the works, plants, equipment and facilities, operation process, quality and cost controls and safety measures. Workers are given on-the job training (OJT) for a week. Newly recruited engineers spend one month visiting all the plants and facilities and they are also given room lectures for one month. From time to time, all employees are given brush-up training and education in the works and outside.

(b) Training Abroad

Selected people are given OJT at similar mills abroad and have opportunities to attend seminars, symposiums, conferences, etc. held overseas.

(c) Management Education

This course is to provide the department manager or section manager classes with management education, human relations for example, in Turkey and abroad.

(4) Area

IDC occupies an area of 550,000 square meters. IDC has its own mineral jetty capable of berthing two 50,000 dwt vessels two kilometers from the works.

(5) Grade of Steel

The steel produced by IDC is mainly of rebar quality.

(6) Main Products and Production

The products are as follows:

1. 100 to 140 square millimeter billets from 5.5 to 6 meters long, and
2. 8 to 50 millimeter diameter plain and deformed bars from 6 to 18 meters long.

Production in 1994 is shown in Table 12-1, Production in Recent 5 Years. Products are mostly exported to Europe, the Middle East and the Far East. Export reached 90 percent in 1994 because of the supply and demand situation then prevailing in Turkey.

Table 12-1 Production for Recent Five Years

(Unit: tons per year)

	Molten steel	Billet	Rebar
1990	498,790,799	494,598,000	339,642,000
1991	508,775,250	500,202,000	304,959,000
1992	558,264,500	542,069,000	340,123,000
1993	490,604,929	485,712,000	432,262,000
1994	626,325,569	620,841,000	506,062,000
1995 (First 11 Months)	563,992,037	561,394,000	407,619,000

Source: IDC

As the production capacity of the steelmaking plant (SMP) exceeds that of the rolling mill plant (RMP), the surplus billets are sold to the local market.

(7) Main materials

The main raw materials to be charged to the electric arc furnace (EAF) are scrap and pig iron, both almost entirely imported from Europe and USA, though domestically available in small amounts. Ferro-alloys, about 70 percent of refractories, and electrodes are also imported.

12-2-2 Outline of Production Facilities

(1) Layout of the Steel Works

The layout of the steel works is shown in Figure 12-2.

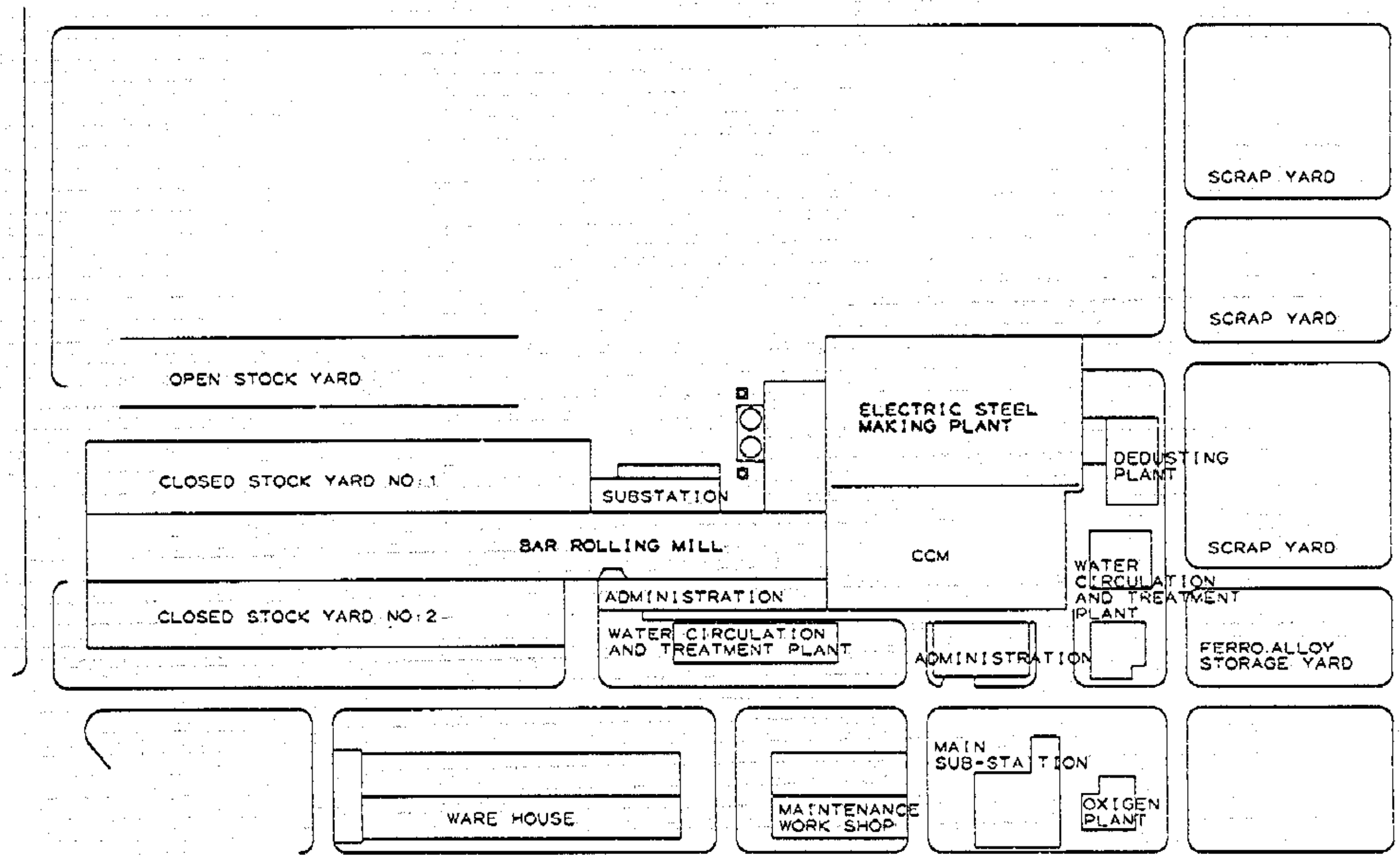


Figure 12-2 Layout of Steel Works

(2) Steelmaking Plant (SMP)

1) Outline of SMP

The main facilities of the SMP are as follows:

1. Electric Arc Furnace (EAF)
   One unit x 70 tons/heat (hereinafter the unit "heat" is used to mean one melt.) with eccentric bottom tapping system (EBT), a transformer of 72 MVA (Mega volt ampere), 5 oxy-fuel burners
2. Ladle Furnace (LF)
   One unit x 70 tons/heat with a transformer of 10 MVA
3. Continuous Casting Machine (CCM)
   One unit x 6 strands for billets 100 to 140 mm square and 5.5 to 6 meters long

The SMP was originally designed to produce 400,000 tons per year of billets with one 60 ton EAF using scrap, one 60 ton LF and one CCM of 4 strands. It has been expanded to produce 700,000 tons per year of billets with 70 tons/heat of EAF, 70 tons/heat of LF and 6 strands of CCM.

The plant began operation in May 1987. The plant has been satisfactorily operated since startup except when the supply of scrap was insufficient. As shown in Table 12-1, the production of molten steel in 1994 reached 626,300 tons and that of billets 620,800 tons. Billets produced in the SMP are mainly of rebar quality, from low carbon steel of between 0.15 and 0.20 percent carbon to high carbon steel of 0.45 percent carbon.

2) Layout

The layout of the plant is shown in Figure 12-3.

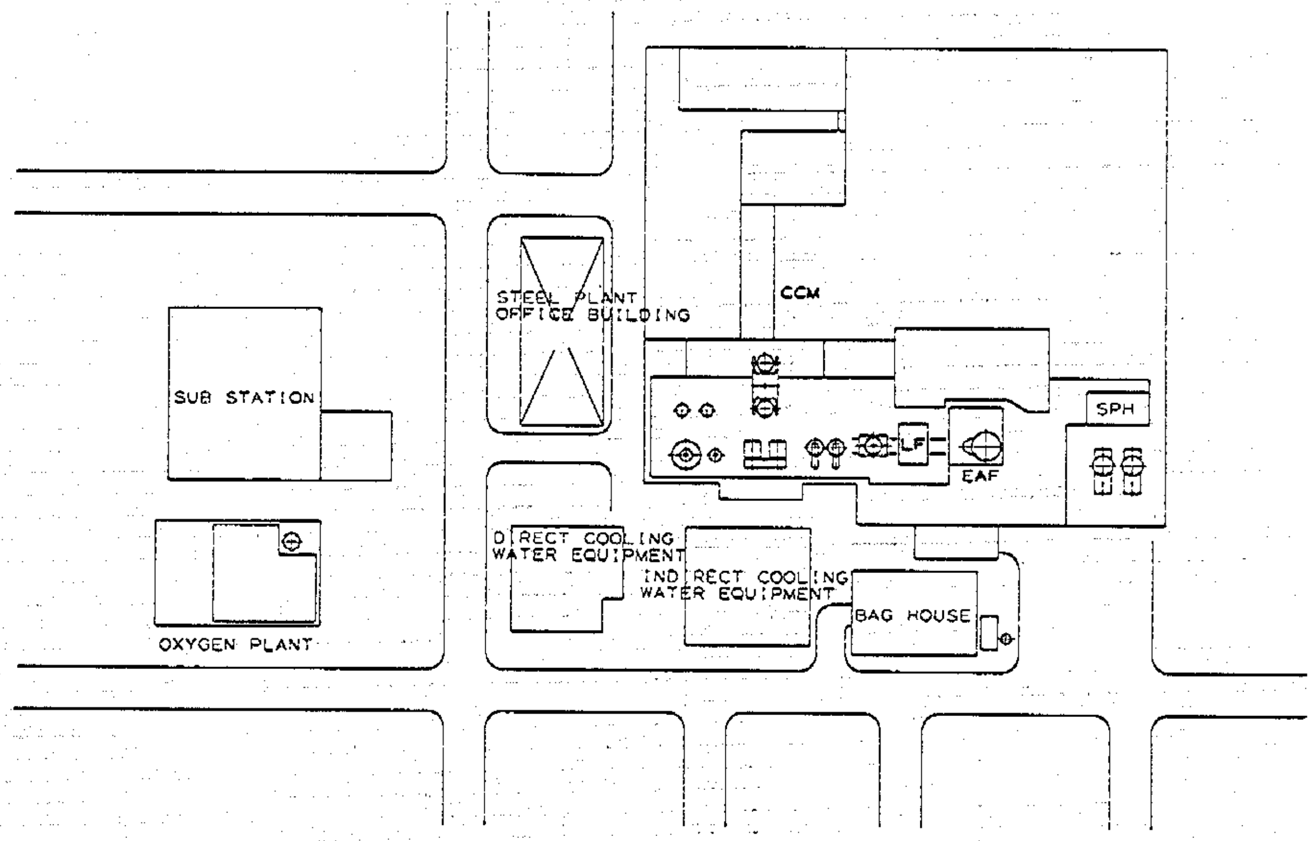


Figure 12-3 Layout of Steelmaking Plant

3) Main Equipment

The steelmaking plant (SMP) facilities, except for the continuous casting machine (CCM), were supplied by NKK, Japan. The electric arc furnace (EAF) was originally of NKK/5300 MH type, with a shell diameter of 5.3 meters, capacity of 60 tons/heat and transformer capacity of 45 MVA, capable of being overloaded to 120 percent. It has been expanded to a shell diameter of 5.5 meters, a capacity of 70 tons/heat and a transformer capacity of 72 MVA. Moreover, IDC has a plan to expand the heat capacity of 80 tons/heat together with an increase of the ladle crane capacity to 140 tons.

The CCM was supplied by CONCAST of Switzerland, with four strands which were also expanded to six strands.

The dust removal system was originally installed to treat the exhaust gas from the EAF only. Now another unit has been added as a secondary dust removal system from the viewpoint of environmental conservation.

The equipment specifications are shown in Table 12-2.

Table 12-2 Equipment List - Steelmaking Plant (SMP)

No.	Equipment	Q'ty	Main Specification	Remarks
1	Scrap Preheater (SPH)	2	Scrap heating by exhaust gas from EAF 1st and 2nd of three buckets heated by 35,000 Nm^3/hr hot gas. Heating scrap upto 200 - 250°C, upto 20 kWh/ton-MS of energy saving.	
2	Electric Arc Furnace (EAF)	1	70 tons/heat, 72 MVA transformer, 900 V max. tap voltage, 5.5 meter shell, 1.3 meter pitch circle diameter, water cooled shell and roof, EBT type, four furnace oxy-fuel burners and one door oxy-fuel burner, two oxygen/one carbon manipulator, 20 inches electrode with water spray cooling, automatic alloy charging system, 50 minutes of tap-to-tap for	

No.	Equipment	Q'ty	Main Specification	Remarks
			three bucket practice	
3	Ladle Furnace (LF)	1	10 MVA transformer, 240 V max. tap voltage, water cooled roof, 12 inches electrode with water spray cooling, automatic charging system	
4	Continuous Casting Machine (CCM)	1	Six strands, 100 - 140 mm square diameter billet, turret type, two tundish cars, mechanical shear cutting, pusher type cooling bed, mold level equipment	
5	Cranes	1	Ladle crane Main hoist: 100 tons Auxiliary hoist: 30 tons	
		1	Charging crane Main hoist: 60 tons Auxiliary hoist: 15 tons	
		1	Casting hoist crane Hoist: 25 tons	
6	Scrap Stock Yard and Facilities		Open scrap yard, concrete foundation, four Sumitomo crab equipped scrap loaders, bulldozers, magnets, etc., two Hino scrap bucket transport cars	
7	Slag Transport	1	Slag pot transport car	
8	Additive Charging Facilities		Automatic charging system for lime, limestone and ferro-alloys, serving EAF, LF and ladle during tapping	

Source: IDC

(3) Rolling Mill Plant (RMP)

1) Outline of RMP

Main facilities of the RMP are as follows:

1. Reheating furnace
   One unit x 85 tons per hour for cold charge and 100 tons per hour for hot charge with walking beams, oil fired burners

2. Rolling stands

One unit x continuous rolling with 8 roughing stands, 4 intermediate stands, 4 finishing stands, shears, finishing facilities

The RMP was designed to produce 350,000 tons per year of rebar with one 60 tons per hour reheating furnace and 16 rolling strands. Now production capacity has been expanded to 550,000 tons per year, associated with an increase in capacity of the reheating furnace of 85 tons per hour for cold charge and 100 tons per hour for hot charge. The plant started in 1983; since then the plant has been satisfactorily operated. As shown in Table 12-1, production of final products reached 506,000 tons in 1994.

2) Layout

The layout of the plant is shown in Figure 12-4.

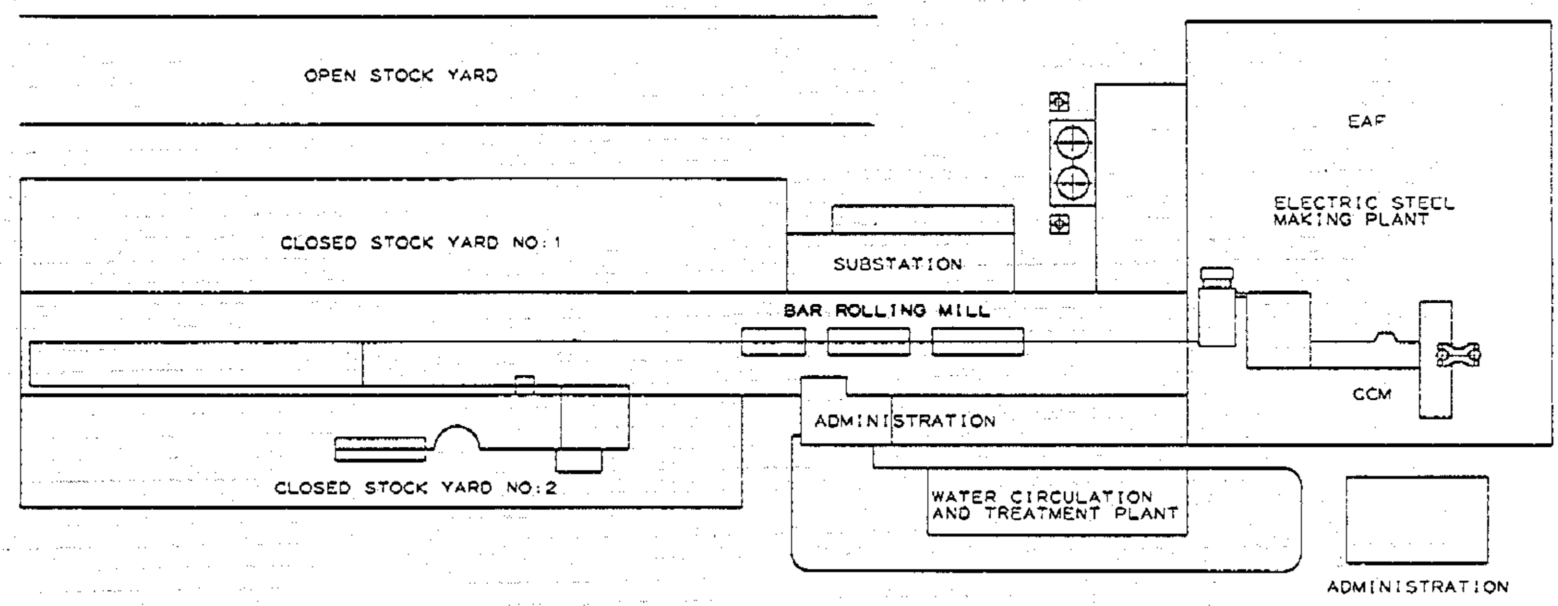


Figure 12-4 Layout of Rolling Mill Plant

3) Main Equipment

The facilities belonging to the rolling mill plant (RMP) were designed by IDC and supplied by ASMAS (a sister company of IDC). The reheating furnace was supplied by OFU of Germany.

The specifications of the equipment are shown in Table 12-3.

Table 12-3 Equipment List - Rolling Mill Plant (RMP)

No.	Equipment	Q'ty	Main Specification	Remarks
1	Reheating Furnace		Design capacity: 60 tons/hour + 20 %	
			6 m x 120 m x 120 mm	
			Walking beam type	
			Top and bottom firing	
2	Rolling Mills			
	Nos. 1 and 2 stands		300 mm length x 460 mm diameter	
	Nos. 3,4,5, & 6 stands		800 mm length x 540 mm diameter	
	Nos. 7 & 8 stands		800 mm length x 400 mm diameter	
	Shear 1		Max. 50 mm diameter	
	Nos. 9,10,11 &12 stands		700 mm length x 360 mm diameter	
	Shear 2		Max. 40 mm diameter	
	Nos. 13, 14, 15 & 16 stands		600 mm length x 340 mm diameter	
3	Cooling Bed		7.5 m width x 80 m length	
4	Cold Shear		400 tons cutting force	

Source: IDC

(4) Auxiliary Facilities

In addition to the above major facilities, the steel works has the following auxiliary facilities:

1. Open scrap yard,
2. Oxygen plant (air separation),
3. Compressed air plant,
4. Water treatment station,
5. Main receiving sub-station (MRSS),
6. Analysis and inspection laboratory,
7. Maintenance shop, etc.

12-2-3 Flow Sheet for Major Production

(1) SMP

In the open scrap yard, scrap is loaded by mobile hydraulic loaders into the scrap bucket placed on the bucket carrier that is equipped with an automatic weighing device, and then transported to the EAF yard. The EAF is normally charged with three buckets of scrap by a charging crane. Before charging, two bucket scrap (1st and 2nd charges) is preheated in the scrap preheater (SPH), utilizing the heat of the exhaust gas generated from the EAF to save electric power for melting.

In the EAF scrap is melted by electric power with the help of five oxy-fuel burners and oxy-lancing as well as carbon injection to achieve rapid melting and generation of foamy slag. After melting at the target temperature and achieving the desired composition of molten steel, the heat is tapped through the EBT (eccentric bottom tapping system) into the ladle lying on the ladle transfer car, leaving 15 tons hot heel in the furnace. After tapping is completed, the heat is transferred to the LF station adjacent to the EAF by the ladle transfer car. The burnt lime and de-oxidants are fed into the ladle during tapping by means of an automatic alloy feeding system. Before receiving steel from the EAF, ladles are heated by oil fired burner. As of this writing preheating of the combustion air by own exhaust gas is being tested as a means to improve thermal efficiency.

At the LF station, molten steel is finally subjected to metallurgical treatment for adjustment of composition, and temperature is also adjusted by electric means, alloy addition and inert gas bubbling. Then the heat is transferred by the ladle crane to the CCM turret and cast into billets. Those billets are directly charged to the reheating furnace of the rolling mill by a chain conveyer.

(2) RMP

Billets transferred from the CCM cooling bed are generally charged hot into the walking-beam-type reheating furnace equipped with oil burners. To save fuel oil, hot charge and preheating of combustion air by the exhaust gas from the reheating furnace are adopted. Some 60 to 70 percent of the billets are subjected to hot charge of from 300 to 600 °C. Billets heated to from 1,100 to 1,150 °C are rolled into 8 to 50 millimeter plain and deformed bars in eight stands of the roughing mill, four stands of the intermediate mill and four stands of the finishing mill. The products are cut into 6 to 18 meter lengths after being cooled on the 80 meter cooling bed. Slit rolling is applied to manufacturing small-size products to increase the productivity. After being bundled, the products are shipped.

12-3 Outline of Operating Conditions

Annual production of molten steel, billet and rebar for recent 5 years is shown in Table 12-1. The material balance sheet in 1994 in SMP is shown in Figure 12-5.

Unit: ton/year

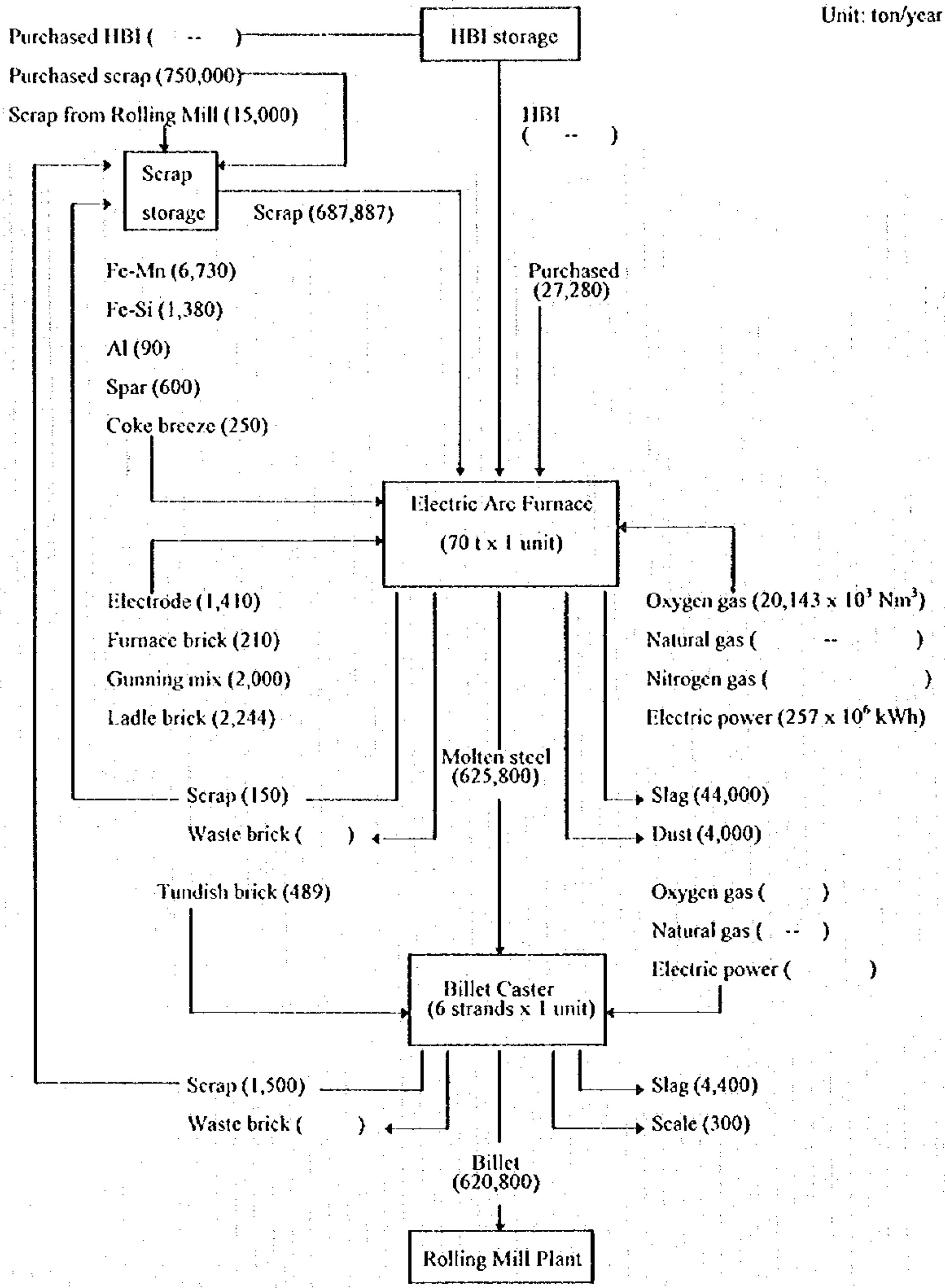


Figure 12-5 Material Balance Sheet for Steelmaking Plant, 1994

12-4 Trends of Energy Consumption and Unit Consumption

Monthly operation parameters in SMP including the unit consumption are shown in Tables 12-4, 12-5 and 12-6. These tables indicate superb operation results of tap-to-tap time of 53 minutes, electric power consumption of from 400 to 420 kWh/ton-MS (Molten steel), at the oxygen consumption of 30 Nm^3/ton-MS in EAF, and electrode consumption of less than 2.0 kilograms/ton-MS.

Monthly operation parameters in RMP including the unit consumption and productivity for the last five years are shown in Tables 12-7 and 12-8, respectively. These tables show superb productivity of 70 - 90 tons per hour, with oil consumption of 25 kilogram per ton.

Table 12-4 Monthly Operating Parameters for EAF - Steelmaking Plant (SMP)

	'95/JAN	'95/FEB	'95/MAR	'95/APR	'95/MAY	'95/JUN	'95/JUL	'95/AUG	'95/SEP	'95/OCT	'95/NOV	'95/DEC
A EAF												
1. Nominal capacity (tons/heat)	70	70	70	70	70	70	70	70	70	70	70	70
2. Transformer Capacity (MVA)	72	72	72	72	72	72	72	72	72	72	72	72
B Main raw materials												
3. Scrap (tons/heat)	80.49	80.20	79.96	80.25	79.60	79.53	77.90	77.74	78.58	78.26	80.16	
4. Total (tons/month)	61,330	55,097	44,378	60,669	56,038	56,069	65,202	58,694	53,749	54,938	60,680	
C Products												
5. Molten steel (tons/heat)	71.25	71.67	72.10	71.69	71.63	71.18	70.79	71.21	73.29	70.70	69.55	
6. Molten steel (tons/month)	54,292	49,237	40,016	54,196	50,428	50,180	59,251	53,766	50,128	49,640	52,645	
D Production parameter												
7. Operating hours (hours/month)	645.8	590	465	645.7	587	607	661	596.5	562	563.5		
8. Total heats (heats/month)	762	687	555	756	704	705	837	755	664	702		
9. Average heats (heats/day)	28.32	27.94	28.63	28.13	28.78	27.86	30.38	30.26	29.21	28.87		
10. Charging time (minutes/heat)	5.88	5.44	4.94	5.84	5.92	5.92	4.52	4.76	5.88	5.94		
11. Melting time (minutes/heat)	32.12	33.56	33.06	32.16	30.08	33.08	33.08	32.48	32.24	30.1		
12. Refining time (minutes/heat)	10	9	8	10	10	10	8	8	10	10		
13. Fettling time (minutes/heat)	8	9	13	7	8	9	8	9	7	7		
14. Tap-to-tap time (minutes/heat)	56	57	59	55	54	58	53	54	53	54		
15. Steel yield (%)=6/4	88.53	89.37	91.39	89.34	89.97	85.50	90.86	91.61	90.47	90.35		

E Auxiliary raw materials											
16. Burnt lime (kg/ton-MS)	42.0	39.4	37.6	42.7	36.0	42.0	36.0	37.5	34.6		
17. Limestone (kg/ton-MS)	0.73	0.52	0.72	1.06	-	1.20	-	0.07	-		
18. Coke breeze (kg/ton-MS)	8.1	8.2	7.5	5.8	5.70	4.8	5.1	4.6	4.9	5.63	6.56
F Utilities											
19. Electric power (kWh/ton-MS)	414	430	416	417	408	423	406	405	423	425	
20. Oxygen gas (Nm^3/ton-MS)	35.0	33.7	32.7	33.2	29.9	30.1	30.4	31.2	32.5	31.8	
21. Fuel oil (kg/ton-MS)	5.13	5.20	4.24	5.3	4.10	5.00	5.40	4.35	5.10	5.1	5.40
G Electrode and refractories											
22. Electrode (kg/ton-MS)	2.48	2.63	2.27	2.08	2.00	1.88	1.77	1.57	1.92	1.83	1.82
23. Furnace brick (kg/ton-MS)	0.29	0.34	0.62	0.50	0.32	0.81	0.07	0.56	0.34	0.54	0.27
24. Gunning materials (kg/ton-MS)	3.93	3.92	3.10	3.64	3.15	3.84	3.89	3.61	3.53	3.60	4.41
25. Ladle brick (kg/ton-MS)	2.56	2.79	3.64	2.55	2.94	2.75	2.88	3.01	2.60	2.71	2.64
H Operation hour (hour/month)											
26. Scheduled repair (Refractory repair)	26.33	16.25		27.3	-	42.65	7.4	26.1	16.9	26.8	
27. Scheduled repair (General repair)	-	-	24.1	-	-	-	-	-	-	40.6	
28. Scheduled repair (Electricity)	-	-	-	-	-	3.4	1.5	4.4	101.6	3.9	
29. Scheduled repair (Public holidays)	4	-	-	-	114	-	-	26	-	44.6	
30. Total of scheduled repair=26+27+28+29	30.33	16.25	24.1	27.3	114	46.05	8.9	56.5	118.5	115.9	
31. Down-time	67.90	65.8	38.2	47.7	43	67	74.1	89	39.4	44.6	
32. Operation hours = calendar hours-30-31	645.77	590	681.7	645.0	587	607	661	574.5	562	583.5	

Source: IDC

Table 12-5 Monthly Operating Parameters for LF - Steelmaking Plant (SMP)

	'95/JAN	'95/FEB	'95/MAR	'95/APR	'95/MAY	'95/JUN	'95/JUL	'95/AUG	'95/SEP	'95/OCT	'95/NOV	'95/DEC
A LF												
1. Nominal capacity (tons/heat)	70	70	70	70	70	70	70	70	70	70	70	70
2. Transformer Capacity (MVA)	10	10	10	10	10	10	10	10	10	10	10	10
B Production parameter												
3. Operating hours (hours/month)	406.4	366.4	286.7	415.8	375.5	399.5	446.4	402.7	376.2	397.8		
4. Total heats (heats/month)	762	687	555	756	704	705	837	755	684	702		
5. LF operation time (minutes/heat)	32	32	31	33	32	34	32	32	33	34		
C Auxiliary raw materials (kg/ton-MS)												
6. Burnt lime	8.1	7.9	7.8	8.2	8.0	8.1	7.9	8.1	8.2	7.9	8.0	
7. Fluorspar	1.2	1.4	1.2	1.2	1.0	1.2	1.1	1.6	1.7	1.76	1.1	
8. Dolomite	2.5	2.2	1.8	2.3	2.3	3.2	2.6	2.6	3.4	3.1	2.9	
9. Fe-Mn	0.43	0.54	0.28	0.74	0.80	0.55	0.37	0.86	0.89	1.7	0.94	
10. Si-Mn	11.7	11.7	10.9	10.4	9.2	9.2	9.6	9.7	8.1	10.6	11.7	
11. Fe-Si	2.7	2.0	2.7	2.6	2.3	2.5	2.5	2.5	2.9	2.0	2.2	
12. Al	0.11	0.12	0.10	0.10	0.10	0.02	0.01	-	0.07	0.04	0.06	
D Utilities												
13. Electric power (kWh/ton-MS)	35	37	33	31	32	35	35	34	36	35		
E Electrode												
14. Electrode (kg/ton-MS)	0.38	0.38	0.43	0.37	0.39	0.40	0.39	0.38	0.41	0.40	0.43	

F Working time (hours/month)										
15. LF operation time	406.4	366.4	286.8	415.8	375.5	399.5	446.4	402.6	376.2	397.8
16. Accident	0.33	0.63	1.15	0.71	0.17	1.03	1.25	3.65	1.63	2.55
17. Waiting time	314.4	282.2	433.2	280.7	345.5	296.7	273.6	315	319.4	320.9
18. Scheduled repair time	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8

Source: IDC

Table 12-6 Monthly Operating Parameters for CCM - Steelmaking Plant (SMP)

	'95/JAN	'95/FEB	'95/MAR	'95/APR	'95/MAY	'95/JUN	'95/JUL	'95/AUG	'95/SEP	'95/OCT	'95/NOV	'95/DEC
A CCM												
1. Billet size												
2. Number of strands												
B Products												
3. Sound billets (tons/heat)	70.9	71.4	72.0	71.9	71.7	71.1	71.0	70.9	70.9	70.5		
4. Sound billets (tons/month)	54,032	49,038	39,940	54,369	50,466	50,115	59,390	53,557	48,503	49,496		
C Production parameter												
5. Operating hour (hour/month)	647.7	595.4	462.5	642.6	575	611	655.6	604	570	585		
6. Casting heats (heats/month)	762	687	555	756	704	705	837	755	684	702		
7. Average casting heats (heats/day)	28.2	27.7	28.8	28.2	29.4	27.7	30.6	30	28.8	28.8		
8. Avarage CCC heats (heats/tundish)	17.72	19.63	25.23	29.08	23.47	16.79	19.02	20.4	20.92	20.65		
9. Avarage casting time (minutes/heat)	51	52	50	51	49	52	47	48	50	50		
D Yield (%)												
10. Sound billets	99.5	99.6	99.8	99.9	99.9	99.9	99.9	99.6	99.7	99.7		
11. Scale and cutter loss	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
12. Skull in tundish	0.095	0.085	0.066	0.06	0.07	0.10	0.089	0.083	0.084	0.082		
13. Top and bottom crop	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
14. Accident loss												
15. Rejected billets												

E Refractories										
16. Refractories for tundish (kg/ton-MS)	0.54	0.44	0.45	0.40	0.47	0.70	0.52	0.52	0.54	0.55
F Working time (hour/month)										
17. Casting time	647.7	595.4	462.5	642.6	575	611	655.6	604	570	585
18. Preparation time	8.6	7	4.4	5.2	6	8.4	8.8	7.4	6.8	6.8
19. Accidents	1.25	-	0.4	1.3	3.8	0.3	0.6	9.9	5.25	3.5
20. Waiting time	63.65	46.8	253.9	48.7	136.4	77.5	56.2	99.9	115.15	145.9
21. Scheduled shutdown	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8
G By-products (kg/ton-MS)										
22. Slag										
32. Scale	0.5									
33. Scrap										
34. Waste brick										

Source: IDC

Table 12-7 Monthly Operating Parameters - Rolling Mill Plant (RMP)

	'94/DEC	'95/JAN	'95/FEB	'95/MAR	'95/APR	'95/MAY	'95/JUN	'95/JUL	'95/AUG	'95/SEP	'95/OCT	'95/NOV
A Production (tons/month)												
1. Products	44,398	31,538	36,921	44,233	40,922	38,282	43,053	46,329	42,864	19,424	27,472	36,582
2. By-products=3~4	1,535	1,182	1,795	1,952	2,157	1,894	1,876	1,884	1,813	669	1,540	1,909
3. Scrap and Cobble	1,059	845	1,400	1,504	1,607	1,505	1,393	1,142	1,267	463	1,303	1,307
4. Scale	476	337	395	448	550	389	483	742	546	206	237	602
B Utilities												
5. Fuel oil (kg/ton-product)	26	26	22	25	26	25	26	24	26	22	33	
6. Electric power (kg/ton-billet)	68	84	84	70	83	73	71	77	75	82	89	
7. Make-up water for direct cooling (m^3/ton-billet)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
8. Make-up water for in-direct cooling (m^3/ton-billet)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
9. Compressed air (Nm^3/ton-billet)	30-40	30-40	30-40	30-40	30-40	30-40	30-40	30-40	30-40	30-40	30-40	

C Working ratio (%)												
10. Effective rolling ratio=100-18	69.82	52.11	68.43	68.92	71.82	60.59	69.12	69.72	71.29	29.29	57.91	
11. Operational shutdown=12+13	21.99	17.83	26.90	21.37	24.04	17.58	22.09	21.89	21.21	9.78	25.31	
12. Roll, groove change and adjustment of roll, guide	4.97	5.07	4.46	5.41	4.88	3.92	7.76	5.48	4.62	3.07	9.25	
13. Mis-roll	17.02	12.76	22.44	15.96	19.16	13.66	14.33	16.41	16.59	6.71	16.06	
14. Equipment shutdown=15+16	3.62	3.01	2.45	2.71	3.24	1.62	6.35	6.16	2.90	1.43	4.34	
15. Mechanical equipment	2.56	2.21	1.73	1.33	2.44	1.35	5.1	2.35	2.09	1.20	3.22	
16. Electrical equipment	1.06	0.80	0.72	1.38	0.80	0.27	1.25	3.81	0.81	0.23	1.12	
17. Others	4.57	27.05	2.22	7.00	0.90	20.21	2.44	2.23	4.60	59.50	12.44	
18. Shutdown total=11+14+17	30.18	47.89	31.57	31.08	28.18	39.41	30.88	30.28	28.71	70.71	42.09	
D Repair (hour/month)												
19. Major repair (more than 3 hours shutdown in a day)	5	6	11	-	-	-	-	24	-	-	-	-
20. Minor repair	172	312	171	191	168	264	166	160	180	487	244	172
21. Periodical repair	11	-	-	-	-	-	-	-	-	-	-	-
22. Total=19+20+21	188	318	182	191	168	264	166	184	180	487	244	172

E Yield (%)												
8 mm diameter	-	-	-	-	-	-	-	-	-	-	87.5	90.0
10	89.8	93.9	94.2	-	94.0	-	94.0	94.8	94.0	-	-	92.8
12	-	-	93.8	93.5	94.4	94.6	94.9	94.0	94.4	94.3	93.5	95.3
13	91.8	94.5	94.8	93.4	-	94.2	-	94.9	-	-	-	94.3
14	-	-	94.3	-	94.5	-	93.4	95.5	95.7	93.8	-	94.4
16	-	94.8	-	94.9	95.1	95.3	95.5	95.7	95.6	95.3	93.5	93.0
18	-	94.2	-	93.8	-	-	91.0	94.5	93.5	95.3	94.0	95.1
19.2	-	-	-	-	-	94.7	-	-	-	-	-	-
19.5	-	-	-	-	-	-	-	-	94.3	-	-	94.2
20	94.7	94.2	95.9	95.8	95.4	95.2	95.3	96.1	95.5	95.1	94.3	94.9
22	-	94.2	-	92.5	-	-	91.1	94.3	-	95.4	-	95.3
24	-	-	-	-	-	-	95.1	-	-	-	-	-
25	94.4	94.6	-	95.1	95.0	95.2	95.0	95.3	95.4	95.7	93.2	93.9
26	-	93.8	-	-	95.1	95.0	95.0	95.9	95.5	93.4	93.4	-
28	94.6	93.9	92.3	94.5	95.2	92.7	93.8	94.2	-	-	-	-
32	94.1	94.7	95.1	92.4	94.2	94.1	94.4	95.0	95.6	-	-	-
36	-	-	-	-	-	-	95.3	-	-	-	-	-
40	94.0	-	95.0	94.7	94.3	95.0	91.8	93.2	95.0	-	94.0	-
50	-	88.9	-	-	-	-	-	-	-	-	86.4	-

No.3 (BS standad, 1/8")	-	-	93.2	-	-	-	-	92.5	-	-	93.3
No.4	-	-	94.5	-	-	-	-	90.3	-	91.9	-
No.5	-	-	95.4	-	-	-	95.0	91.6	-	94.2	-
No.6	-	-	95.0	-	-	-	-	93.5	-	-	-

Source: IDC

Table 12-8 Productivity for Recent Five Years - Rolling Mill Plant (RMP)

(Unit: tons/hr)

Size of products (millimeter)	1990	1991	1992	1993	1994
10	-	38.5	47.0	64.3	72.9
12	54.0	55.4	51.0	77.0	75.9
13	58.0	55.5	58.8	73.6	81.9
14	61.4	71.3	76.4	74.5	80.6
16	65.0	76.5	77.3	81.0	90.1
18	57.5	54.3	69.8	77.3	82.5
20	62.0	80.0	74.0	79.2	90.0
22	62.3	71.8	74.0	76.7	74.8
24	66.4	63.9	66.1	67.4	-
25	66.0	66.4	74.4	83.7	89.7
26	64.2	64.6	83.6	77.7	80.2
28	52.3	65.2	72.3	76.2	81.3
30	-	-	-	77.0	-
32	63.9	42.2	73.5	77.9	86.2
36	-	49.3	66.4	72.4	71.7
40	62.2	53.5	58.7	82.3	86.0
50	-	-	-	56.3	59.0
No.3	-	33.0	33.3	51.6	59.5
No.4	50.4	55.8	54.2	64.8	70.5
No.5	60.0	62.2	71.2	65.1	74.0
No.6	62.9	63.0	94.2	82.1	72.1
No.7	70.0	62.3	81.2	-	-
No.8	60.4	71.1	-	88.5	-
No.10	-	-	-	84.0	-

Source: IDC