Chapter 8 Brick Factory

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This chapter contains various kinds of information confidentially disclosed to EIE and JICA only and is not eligible to disclosure to the general public.

Chapter 9 Textile Factory

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9-1 Characteristics of the Textile Industry

This chapter concerns the energy audit of Izmir Basma Fabrikasi A.S. (IBF). IBF is a printing, dyeing, and finishing factory, processing gray cloth from Izmir Pamuk Mensucati T.A.S. (IPM), its sister spinning and weaving company, and other sources for commission printing. The main products are fabrics for dress, nightwear, sheeting for bedsets, curtains and others. Both factories are old and plan to move outside of Izmir in two to five years. From the energy audit point of view, spinning and weaving mills and dyeing, printing, and finishing factories are fairly different.

It may be noted from comparison between the spinning and weaving mills on one hand, and the dyeing, printing and finishing factories on the other, that:

1. The former is an industry of mass production and continuous operations are the rules. The latter produces many kinds of goods in small quantities in a number of steps, the combination of which varies depending upon the required qualities of the products. Operations of the processes are intermittent and batchwise.
2. The former consumes more electricity while the latter consumes more fuel. The total energy consumption is larger in the latter.

From these differences, the need for rationalizing energy use is more urgent in the latter than in the former.

9-2 Outlines of Factory, Facilities and Flowsheet of Major Products

9-2-1 Factory

(1) General

Outline of IBF is as follows:

1. Name of the factory:	Izmir Basma Fabrikasi A.S.
2. President:	Mr. Frederick Giraud
3. Capital, billion TL:	119.5
4. Number of employees:	406
5. Number of energy related engineers:	3 (Electrical 1, Mechanical 2)

The information given here is withheld from public disclosure because of its confidential nature.

(2) Outline of Major Products

The outline of manufactured goods is as follows:

The information given here is withheld from public disclosure because of its confidential nature.

9-2-2 Production Facilities and Flow Sheet

Figure 9-1 shows the production flow diagram of IBF.

(1) Singeing

The factory uses LPG. The cloth speed is 80 meters per minute.

(2) Bleaching

The factory has two types of bleaching machines, rope bleaching and open width bleaching. The washing temperature is from 30 to 95℃ and the bleaching temperature is from 30 to 100℃.

(3) Mercerizing

(4) Printing

Five printing machines of rotary type are installed. These are the main facilities in the factory. The factory considers themselves very skilled in preparation for printing rollers and pattern design.

The factory simultaneously prints a maximum of 15 colors.

(5) Dip dyeing

The factory has five jiggers. They are used for plain dyeing, bleaching, washing and other purposes. The plain dyeing temperature is from 60 to 90℃.

(6) Fixing

(7) Finishing

The number of finishing machines is four. Their finishes are water repellent, soil repellent, flame retarding, crease free, soft finishing, etc. The applied temperature is from 100 to 180℃.

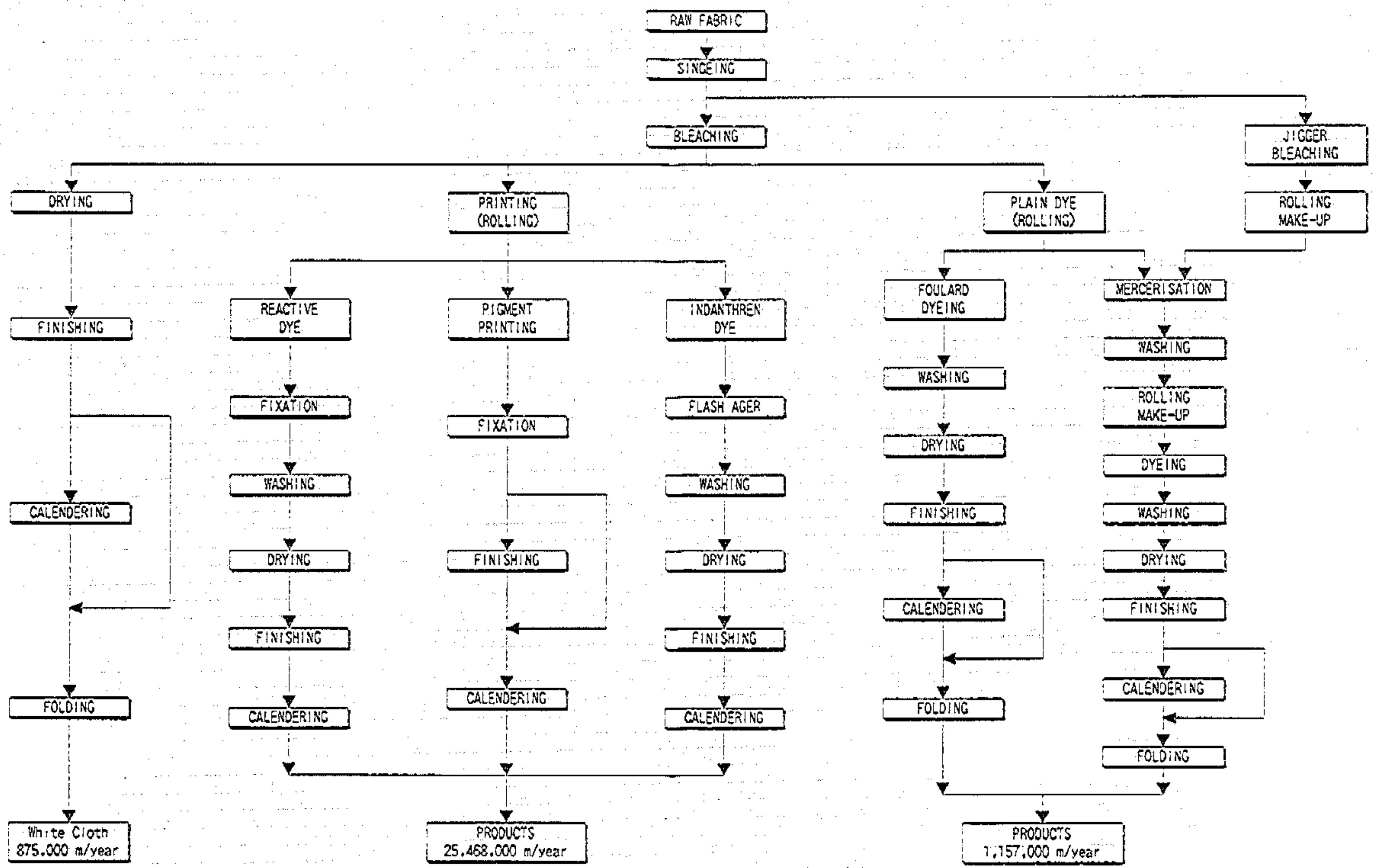

Figure-9-1 IBF Production Flow Diagram

9-2-3 Energy Supply Facilities

(1) Steam Boiler

IBF has four horizontally-fired type boilers, burning 35 tons a day of lignite from Soma. The steam is supplied to the processes of bleaching, mercerization, washing, drying, etc.

The features of the boilers may be summarized as follows:

1. Horizontal smoked tube type
2. Economizer installed
3. Small capacity at five tons per hour
4. IDF and FDF installed
5. Air preheat (Ash - Supply air heat exchange) installed.

(2) Hot Oil Heater

IBF has nine hot oil heaters for heating the printing, finishing and calendering machines, because IBF's steam boilers cannot easily generate the high temperature necessary for the processes. The factory burns fuel oil and diesel oil. Normally the temperature of outgoing and returning oil at the heaters is 240℃ and 220℃, respectively. The factory constructed a new large capacity heater, which is connected to the printing machines.

The features of the hot oil heater systems are as follows:

1. All the furnaces are of radiation type.
2. Each heater supplies heat by circulating hot oil to the given grouped machines.
3. The heat in each hot oil system is consumed by machines freely according to their operation. Naturally, the operation of the hot oil system fluctuates as demand for heat fluctuates.
4. The control of the hot oil system is as follows:
   (1) Hot oil is fed to the heaters without flow control; flows are determined by the capacities of the pumps.
   (2) Each machine receives hot oil via a temperature-indicating controller, TIC, equipped with a three-way valve. The temperature of the hot oil returning to the heaters fluctuates widely depending upon the load of the users.
   (3) Fuel oil is fed to the heaters, in such a way that the outlet temperature of the hot oil remains constant, by manual operation.
   (4) The flue gas temperature is watched but the oxygen content of the flue gas is not.
5. A waste heat recovery system is installed in the new hot oil heater.

(3) Electricity

Electric power is received from the City Electricity Network. IBF receives 3-phase and 10.5 kV electricity. The price of electricity is divided into three classes according to duration of consumption. The four transformers reduce the received voltage to 400 Volts. Nos. 2 and 3 transformers are connected in parallel, and electricity is distributed via three feed lines in the factory. Each feed branch has a condenser to improve power factor.

9-3 Outline of Operating Conditions

Operating conditions of the major production facilities and those of the energy supply facilities are described in Section 9-2. The operation mode is continuous, working 20 to 24 hours a day and 330 days a year. The factory has an annual maintenance schedule, and normally shuts down for maintenance for 2 weeks in August.

9-4 Trends of Consumption and Unit Consumption of Energy

Table 9-1 shows the trends in energy consumption and the unit consumption. The unit consumption of energy is calculated as follows.

(1) Annual Production

IBF's record shows production of fabric in meters. The width and weight of fabrics vary from one lot to another; the following numbers are assumed.

Fabric weight, gram/m^2:	140
Width of fabric, cm:	160

(2) Annual Energy Consumption

To facilitate comparison with other factories and with the data of Japanese counterparts, consumption of various energy types is converted into kilocalorie. The following conversion factors are used.

Lignite for steam boiler, kcal/kg-wet base	4,385
Fuel oil for hot oil heater, kcal/kg	10,000
Diesel oil for hot oil heater, kcal/kg	9,500
LPG for singeing, kcal/kg	11,000
Electricity, kcal/kWh	860

Table 9-1 Trends of Consumption and Unit Consumption of Energy in IBF

	1992	1993	1994	1995	1996 (Aug.)
Production, 10^3 m	33,047	32,013	26,979	27,215	16,885
tons	7,402	7,171	6,043	6,096	3,782
Energy Consumption					
Lignite, tons	7,299	15,918	16,306	13,428	8,063
10^6 kcal	32,006	69,800	71,502	58,882	35,356
Fuel Oil, tons	3,598	3,430	3,267	3,486	2,607
10^6 kcal	35,980	34,300	32,670	34,860	26,070
Diesel Oil, tons			70	86	77
10^6 kcal			665	817	732
LPG, tons	59	95	100	105	71
10^6 kcal	649	1,045	1,100	1,155	781
Electricity, 10^3 kWh	11,752	12,219	12,433	11,403	7,553
10^6 kcal	10,107	10,508	10,692	9,807	6,496
Total					
10^6 kcal	78,742	115,653	116,629	105,521	69,435
Unit Consumption of Energy					
10^6 kcal/ton-Fabric	10.64	16.13	19.30	17.31	18.36

The unit consumption of energy from 1994 to 1996 remained almost constant. The consumption increased from 1992 to 1993.

9-5 Current Condition and Problems with Energy Management and Conservation

The current practice of energy management may be expressed as follows against the generally accepted recommended practices.

1. Target for energy conservation: The factory does not have a target.
2. Systematic activities for energy management in the organization: Every Wednesday, an outside consultant comes. The factory has no such organization as an energy saving committee with participation by production managers.
3. Utilization of data and records for effective energy management: The factory records the consumption of electricity and coal every month, but the records are used only for

accounting.

4. Education, training of employees for energy management: Education in energy management has not been given to the workers.
5. Schedule of annual maintenance: The factory shuts down once a year and has an annual maintenance schedule.
6. Measures carried out for energy conservation and their effects: Energy conservation is achieved mostly by replacement of old machines by newer ones. The factory is moving to a new site in 2 to 5 years. Natural gas is intended for the main fuel for the new factory, because the factory considers LNG more economical. The factory also considers reducing hot oil use and introducing a co-generation system.

9-6 Current Condition and Problems with Facilities

(1) Common Items

The following items commonly apply to major energy consuming and supply facilities.

1. Lack of measuring meters for energy supply and consumption
2. Insufficient thermal insulation
3. Excessive electricity consumption

(2) Items for Production Facilities

1. Intermittent operation of the facilities
2. Heat loss from the bleaching range
3. Heat loss in the washing range

(3) Items for Energy Supply Facilities

1. Low efficiency operation of the boilers and hot oil heaters
2. Lower steam condensate recovery
3. Steam loss from the steam lines
4. Steam boilers
   (a) Insufficient installation of measuring equipment and manual control
   (b) Operation with the measuring equipment which does not work properly

9-7 Method and Procedure of Energy Audit

An energy audit has to examine the energy supplying side and the energy consuming side. In the case of IBF, the following items were selected as important and were audited.

(1) Energy Supply Side

1) Steam Boiler

Three of the four boilers under operation were audited.

2) Hot Oil Heater

All hot oil heaters and circulation systems were audited.

3) Steam Distribution System and Condensate Recovery System

IBF made by-passes on the steam lines to temporarily install eddy current flow meters for flow measurement. One such by-pass was made on the main steam delivery pipe, and the other on the distribution pipe to the bleaching machine. Along with this, the condensate recovery system was audited.

4) Water Supply and Drainage System

The amounts of water supply to the production facilities and the drainage were measured.

5) Electricity System

The electricity consumption in the whole factory and those of the main facilities were investigated.

(2) Energy Consumer Side

1) Bleaching Machines

The open width bleaching machine was audited, because this bleaching machine is operated continuously and IBF plans to bring this to the new site.

2) Washing Machines

The new one, built in 1996 by Max Goller, was selected for the same reasons as that for the open width bleaching machine.

9-8 Measurement Procedure

(1) Major Measuring Items

1. Flow rate: fuel, water, steam, steam condensate, hot oil, flue gas, cloth and others.
2. Temperature: fuel, water, steam, steam condensate, hot oil, flue gas, cloth, utility lines,

machine surface and others.

3. Pressure: steam, hot oil and others.
4. Chemical analysis: fuel, ash, flue gas, hot oil, boiler feed water, steam condensate and others.
5. Working condition of steam traps.
6. Electricity: current, voltage, power and power factor
7. Humidity and temperature in the factory

(2) Personnel Allocation

The measurement and analysis were done in cooperation of the members of EIE, IBF and the study team.

9-9 Results of Measurement and Analysis

9-9-1 Open Width Bleaching Range

The open width bleaching range may be divided into two parts, namely, (1) chemical treatment and washing baths and a steamer, and (2) heat recovery unit for recovering heat from hot waste water. Measurements were done on the two parts, and the following results were obtained.

(1) Fresh Water and Fabric Speed

The open width bleaching range has 9 baths, and the operators manually open or close the water and steam valves. The average total water consumption rate of the range was 38 m^3/h and the inlet temperature was 27.5°C. The fresh water flow is separated into two flows; one goes directly to the baths, the other to the heat recovery unit. The average fabric speed was 43 m/min.

(2) Waste Water

This range has a heat recovery unit that recovers heat from hot water discharges of Baths 1, 2, 3 and 5. The waste water in excess of the heat exchanger capacity overflows directly to the canal. Hot water temperatures of overflows were measured at 99.6°C and the amounts of overflows were 7.2 m^3/hour. The amount of waste water which exchanged heat was estimated as 5.2 m^3/h, with the temperature of 40°C. Another portion of water is considered to be dumped directly from the machines as waste water without heat exchange or to be evaporated to the atmosphere. An average temperature of 50°C was estimated.

(3) Steam

The total steam flow rate to the range is 2,200 kg/h. Steam is supplied directly to the baths, the steamer and the steam heater.

(4) Steam Condensate

Steam traps are provided; however, the condensate is not recovered.

(5) Cloth (in and out)

The fabric width was 100 to 220 cm (average 160 cm).

The fabric weight calculated by the measured weight by a balance and measured area, g/m^2

Average 140

The moisture of the fabric obtained by weighing the dry and wet samples, percent

Inlet: 79 to 80 Outlet: 80 to 81

The temperature of the fabric, ℃

Inlet: 31 Outlet: 31

(6) Temperature of Machine Surface and Heat Loss

The surface temperatures and sizes of the baths and steamer were measured. The heat loss from the machine surfaces by radiation and convection was calculated.

(7) Temperature of Machine Inside

The inside temperatures of the baths and steamer were measured.

(8) Analysis

Using the results of measurement and calculation, a heat balance (0℃ basis) was determined. The energy flowchart developed based on the heat balance is shown in Figure 9-2 in Section 9-10.

9-9-2 Max Goller Washing Range

The Max Goller washing range was quite recently acquired by IBF, and operation started in December 1995. The range comprises a foulard (padding)/flash ager and nine washing baths. All temperatures, water and steam flows are controlled by a computerized control system. The results of the measurements are as follows.

(1) Steam

The steam flow rate to the flash ager was 370 kg/h, and that to the washing part was 1,580 kg/h on an average. The steam consumption of the range was measured by the total flow rate to the factory, while all other machines were stopped intentionally for this measurement. The measured results are probably larger than the actual consumption, because some leakage to other facilities through apparently closed valves may be included.

(2) Fresh Water and Fabric Speed

The average fresh water consumption was 20.2 m^3/h, and the average fabric speed was 19.8 m/min.

(3) Cloth Flow Rate and Moisture Content (in and out)

The methods for measurement of the fabric width and fabric weight were the same as those for the open width bleaching range. The temperature and moisture content were measured to be 31℃ and 80 percent both at the inlet and outlet.

(4) Electricity

The flash ager has an electric superheater for steam to raise the inside temperature to 130℃. This is controlled automatically. The design capacity is 60 kW.

(5) Steam Condensate

All steam condensate is recovered.

(6) Waste Water

This Max Goller washing range has no heat recovery system to recover heat from the waste water. Two types of washing are done in this machine, cold washing and hot washing. The temperature of the discharge water from cold washing is about 30℃ and that from hot washing is about 70℃. Because a heat recovery system is not provided, all discharges are sent directly to the canal.

(7) Temperature of Machine Surface and Heat Loss

The surface temperatures and dimensions of each unit of the range were measured.

(8) Temperature of Machine Inside

The temperatures of water in the baths were also measured and are shown in Table 11-17.

(9) Analysis

The heat balance of the Max Goller washing range including the flash ager was calculated, and the energy flowchart is shown in Figure 9-3 in Section 9-10.

9-9-3 Energy Supply Side

The measurement items are as follows:

1. Hot oil flue gas.
2. Steam boiler flue gas.
3. Analysis of coal, ash, No. 6 fuel oil, DGO, special fuel oil and the hot oil.
4. Flow rate of water from the well.
5. Flow rates of boiler feed water and coal consumption in boilers.
6. Properties of boiler feed water and blowing drain.
7. Flow rates of water to each machine.
8. Operating temperature of the hot oil heaters.
9. Steam flow rates of each machine.
10. Surface temperatures of the steam line, hot oil line, boiler and hot oil heater.
11. Temperature and humidity in the factory.

9-9-4 Measurement and Analysis of Steam Boiler

(1) Measurement of Operating Condition

1. Flue gas temperature, °C: between 173 and 245, a large fluctuation
2. O_2 in flue gas, percent: 8.6 to 18.1, a large fluctuation
   The content of O_2 in the flue gas is very high. This means that the amount of air supply was too much and air might be leaking into the boiler combustion chambers.
3. Low heating value of coal and ash, kcal/kg:
   Coal 4,385
   Ash 488
   These values were obtained from the equations and the analytical values.
4. Draft at IDF inlet, mbar: 9.5

(2) Approximate Heat Balance and Efficiency of Steam Boiler

The approximate heat balance was calculated, and the energy flowchart is shown as Figure 9-4 in Section 9-10. The boiler efficiency was calculated to be 71.3 %.

9-9-5 Steam Balance

(1) Outline

There is no steam flow meter on the supply side (boiler outlet) or user side (each machine inlet) except for the flash ager. For this audit, two steam flow measuring instruments were installed, one on the main steam line and the other at the inlet of the open width bleaching machine. Steam flows were measured for groups of machines.

(2) Steam Balance, tons/hour

The steam balance of boilers was calculated as below.

1. Generation, tons/hour	
Boiler feed water	8.38
Blowdown	1.58
Steam evaporated	6.80
2. Consumption, tons/hour	
Degasifier	1.70
Soot blower	0.08
Fuel oil heater	0.40
Open width bleaching range	2.20
Flash ager	0.37
Max Goller washing range	1.58
Other machines	0
(Valves were closed at branch line from main line.)	
Others (end users, heat losses, unaccounted-for losses)	0.47
Total	6.80

9-9-6 Measurement and Analysis of Hot Oil Heater

(1) Main Operation Condition of the New Hot Oil Heater

The main operation condition of the new hot oil heater is given below.

	Item	Value	Unit
(1)	Flow rate of hot oil	300	kl/h
(2)	Temperature of hot oil		
	Inlet	240	℃
	Outlet	250	℃
	Temperature difference	10	℃
(3)	Properties of hot oil heater		
	Specific gravity	0.8783	
	Specific heat	0.45	kcal/kg ℃
(4)	No. 6 fuel oil combustion rate	4	tons/d
(5)	Properties of No. 6 fuel oil		
	Low heating value	9,600	kcal/kg
	Specific heat	0.48	kcal/kg ℃
(6)	Inlet temperature of No. 6 fuel oil at the burner	100	℃
(7)	Flue gas temperature		
	Outlet of combustion chamber	300	℃
	Outlet of flue gas-air exchanger	--	
(8)	Flue gas specific heat	0.34	$kcal/Nm^3$ ℃
(9)	O_2 % in flue gas	11	%
(10)	Temperature of air		
	Inlet of flue gas-air exchanger	35	℃
	Inlet of combustion chamber	90	℃
(11)	Specific heat of air	0.32	$kcal/Nm^3$ ℃

(2) Approximate Heat Balance and Efficiency of the New Hot Oil Heater

The result is shown as an energy flow chart (Figure 9-5). The calculated efficiency of the new hot oil heater is 68.9 %.

9-9-7 Audit of Steam Line, Hot Oil Line and Condensate Recovery Line

The result of the audit on the above subjects may be summarized as follows:

1. The main lines of steam, hot oil lines and condensate lines are insulated.
2. Small steam pipe lines to the end steam users are sporadically not insulated.
3. The insulation is of either glass wool or rock wool, from 50 to 90 millimeters thick covered by thin steel plate.
4. Measured surface temperatures of the steam line, hot oil lines and condensate lines at typical points are as follows. (Unit: ℃)

Steam line:	Uninsulated pipe	155
	Insulated pipe	52
Hot oil line:	Uninsulated pipe	167
	Insulated pipe	53
Condensate line:	Uninsulated pipe	91
	Insulated pipe	50

5. Measures to prevent heat losses from lines are to determine the effect of insulation on the valves and flanges in the main lines, to watch and prevent leaks of hot oil and steam using an appropriate device, and to conduct good maintenance and adequate repairing of the insulation on the small-sized steam lines.

9-9-8 Audit of Steam Traps

(1) Drain Pit

Steam traps are immersed in hot water in pits. The pits should not hold hot water. Devices to remove hot water are needed.

(2) Drying and Flash Ager

The steam line in the drying machine leaks at flanges and bonnets. There is some steam leakage from the flange of the piping at the upper section of the Flash Ager. These leaks should be stopped.

(3) Steam Trap System

Steam traps are needed at several points in and around the rope bleaching, mercerizing machines and Jigger.

(4) Check Valves before Rising Lines

It is necessary to install a check valve downstream of the steam trap in case the condensate recovery line rises to a higher position.

(5) Outline of the Steam Trap Audit

Only a small number of steam traps operated under the design conditions when the measurement was done. Most steam traps operated under conditions which deviated from the designs, notably to lower temperatures, because the production plan required many machines to be operated at lower temperatures which was maintained by throttling the steam valves. The equipment for diagnosis of steam traps the study team brought along showed:

1. A few steam traps: Good operation
2. One steam trap: Blowing
3. Many steam traps: Low temperature
4. Many steam traps: Blocked out

9-9-9 Electricity

Electricity measurements were done at each transformer and the points of main electricity consuming facilities by the energy analyzer. The power meter was read continuously at the factory entrance. During the last several years, distribution of electrical loads has been changed and some saving of energy and money realized. Peak power load has been reduced. Consequently, the demand agreement with the City Electric Company has been reduced from 2,500 kW to 2,100 kW. The measurement results show that the peak demand is below 1,900 kW.

9-10 Energy Flow Chart of Factory and Major Energy Consuming and Supply Facilities

9-10-1 Energy Flow Chart of Factory

Total energy consisting of fuel and electricity was used in each of the facilities in the factory from January to August in 1996 as in Table 9-2. The heat consumption in IBF is compared with that in a Japanese factory. Data on unit heat consumption in a Japanese factory are entered in the same table. Granting that the conditions of IBF and the Japanese factory would be different, the IBF's present unit heat consumption is fairly good, but, at the same time, as shown in the results of the present energy audit and the values of EN in Table 9-2, IBF has much potential to reduce energy consumption.

9-10-2 Energy Flowchart of Major Energy Consumption and Supply Facilities

The energy flowcharts of the open width bleaching range, Max Goller washing range, steam boiler and hot oil heater are shown in Figures 9-2, 9-3, 9-4 and 9-5.

Table 9-2 Energy Flowsheet of Factory

(1996 Jan. -- Aug.)

Input	Fuel: Coal		Fuel: No.6 Fuel Oil	Fuel: Special Fuel Oil	Fuel: Diesel Gas Oil	Fuel: LPG	Fuel: Sub Total	Electricity	Energy Total	Unit Heat Consumption 10^6 kcal/ton-product: IBF	Japanese Factory: EP	Japanese Factory: EN
ton or 10^3 kWh	8,063		586	2,021	77	70	----	7,533				
10^6 kcal	35,350		5,630	19,400	750	770	61,900	6,480				
Energy Conversion Efficiency (%)	4.49/5.26 85.4		1186/1608 73.8		(73.8)	100						
Energy Consuming Facility	Steam kg/h (%)	Steam 10^6 kcal	Hot Oil 10^6 kcal (%)			LPG 10^6 kcal	10^6 kcal (%)	10^6 kcal (%)	10^6 kcal (%)			
Singeing	----	----	----	----	----	770	770 (1.5)	40 (0.6)	810 (1.4)	0.23	0.26	0.26
Open Width Bleaching Rope Bleaching Jigger, Mercerization	4,200 (43.5)	13,130	----	----	----	----	13,130 (26.3)	370 (5.7)	13,500 (23.9)	3.86	6.75 (Open Width Bleaching to Drying)	2.82 (Open Width Bleaching to Drying)
Drying	900 (9.3)	2,810	----	----	----	----	2,810 (5.6)	30 (0.5)	2,840 (5.0)	0.83		
Printing Fixation	450 (4.6)	1,390	4,150 (21.8)	----	----	----	5,540 (11.1)	1,830 (28.2)	7,370 (13.1)	1.63	7.36	7.42
Max Goller Drying Washing	3,100 (32.0)	9,660	----	----	----	----	9,660 (19.3)	190 (2.9)	9,850 (17.5)	2.84	2.98	0.92
Finishing	----	----	----	14,320 (75.3)	----	----	14,320 (28.7)	1,250 (19.3)	15,570 (27.6)	4.21	2.20	0.54
Calendering Raising	130 (1.3)	390	----	----	550 (1.5)	----	940 (1.9)	320 (5.0)	1,260 (2.2)	13.60	19.55 (Sub-Total)	11.96
Utilities Facilities Others	900 (9.3)	2,810	----	----	----	----	2,810 (5.6)	2,450 (37.8)	5,260 (9.3)	1.11	---	---
Total 10^6 kcal		30,190 (60.4)		19,020 (38.1)		770 (1.5)	49,980 (%)	6,480	56,460	---	---	---
Energy Consumption Rate 10^6 kcal/ton-product (16,885 x 10^3 m, 1.6 m-width, 140 g/m²)							14.70	1.90	16.6	14.70	---	---

Note: EP: Unit heat consumption in a Japanese factory estimated in 1983.
EN: Unit heat consumption in a Japanese factory after possible heat recovery is performed.
The value of EN of printing is calculated by assuming the smaller lot than that in 1983.

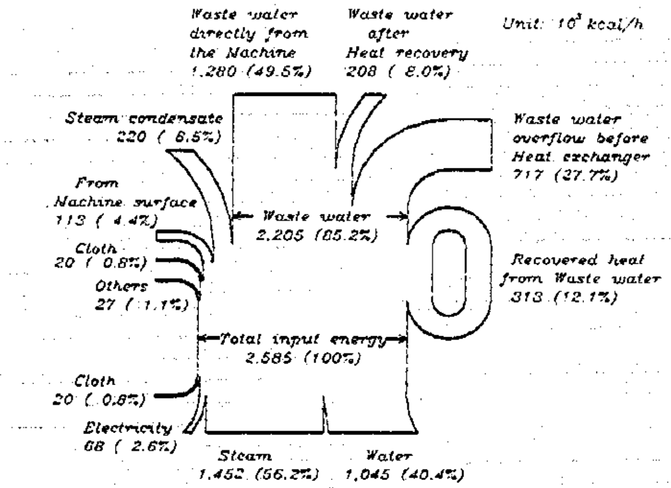

Figure 9-2 Energy Flow Chart of the Open Width Bleaching Range

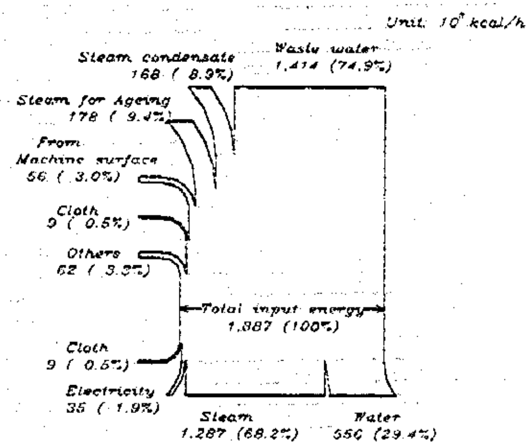

Figure 9-3 Energy Flow Chart of Max Goller Washing Range

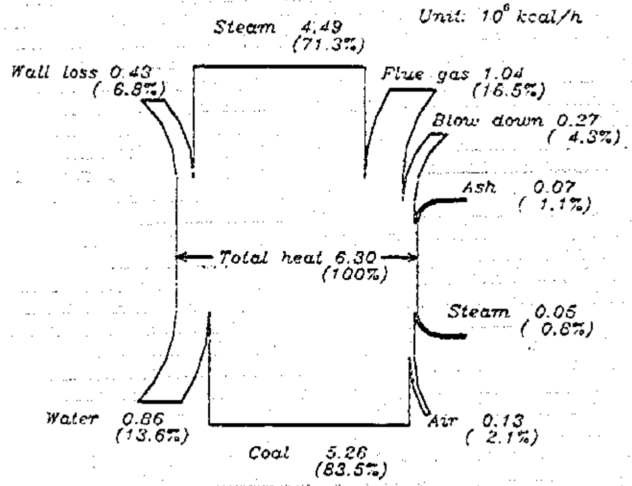

Figure 9-4 Energy Flow Chart of Steam Boiler

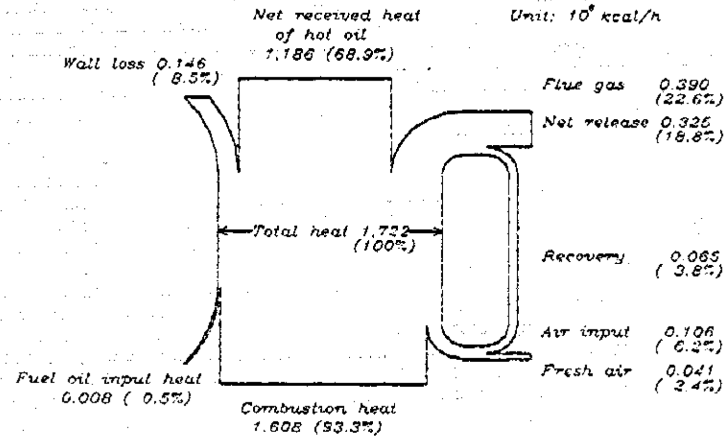

Figure 9-5 Energy Flow Chart of Hot Oil Heater

9-11 Formulation and Recommendation of Countermeasures for Energy Conservation

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

9-11-1 New Factory

(1) CHP system

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.

(2) Package Boiler System

This 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 for an alternative case for the hot oil system. Natural gas is very useful as fuel for this system.

(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. Many kinds of reports will be made based on the analysis of energy consumption to assist energy management in the factory.

9-11-2 Existing Factory

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

Heat loss associated with waste water at higher temperatures represents the largest portion, 77.2 percent, and the following countermeasures are recommended.

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

2. Improvement of the system for water, such as installation of a high temperature waste water reservoir, automatic cold and hot water supply system, etc.

3. As a concrete countermeasure, installing a series waste heat recovery system in parallel to the existing waste heat recovery system is recommended.

   The system consists of the following pieces of equipment.

(1)	Pump	2 Kg/cm², 7.2 m³/h, 0.75 kW
(2)	Plate type heat exchanger	425,000 kcal/h, 8 m²
(3)	Hot water tank	1 m³
(4)	Instrument	LIC x 2
(5)	Piping	1.5 B x 20 m, 2 B x 20 m

4. The steam flow to higher temperature baths should be controlled automatically.

(2) Recommendations for the Max Goller Washing Range

The Max Goller washing range of IBF is new, fully automatically controlled, and rationally designed. Nevertheless the following additional measures for energy conservation are recommended.

1) Measurement of Steam Flow Rate to the Range

Steam is the major energy input to the range, accounting for 68.2 %; hence, direct and accurate measurement of steam flow to the range is essential.

2) Heat Recovery from Waste Water

The heat loss with the hot waste water was calculated to be 74.9 %. Presently, the range is not equipped with a unit for heat recovery from hot waste water. The study team recommends a system similar to that used for the open width bleaching range.

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 m^2
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 realizing effective use of steam traps. The amount of condensate recovered is estimated to be 2,650 kg/h. The condensate goes directly 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 30 meters.

1. Condensate temperature is 100°C.
2. Fresh water in the open width bleaching range is 27°C.
3. Usable heat = 2,650 x 1x (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 of the valve portions and flange parts are not insulated to facilitate maintenance and inspection work, but they should be insulated. The equivalent lengths are used for estimating heat losses from the uninsulated valves and flanges.

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

1. Surface temperature on valve, °C	167
2. Room temperature, °C	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 Steam Boiler Load

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

9-12 Cost Estimation of Countermeasures for Energy Conservation

Budget-type cost as of August 1996 was estimated for four recommended modification works. The total cost estimated is as bellows. The exchange rate is 86,500 TL/US$, 109 Yen/US$. It should be noted that the Japanese costs are not merely converted into Turkish Lira; instead the general price difference between the two countries is taken into account.

	Recommended Modification Work	Yen	Million TL
a.	Heat recovery plan for open width bleaching range	2,535,000	2,012
b.	Heat recovery plan of Max Goller washing range	3,162,000	2,509
c.	Condensate recovery plan	616,000	489
d.	Insulation on 6B valve plan	31,200	25

9-13 Overall Evaluation of Countermeasures for Energy Conservation

(1) Energy Cost

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

1. Unit cost of energy of steam type, TL/kcal 1
2. Unit price energy of hot oil type, TL/kcal 3.3 - 2.2

(2) Evaluation of Recommended Modification Works

Investments are evaluated in terms of repayment period, because the costs are low and the working time is short. The results of evaluation of the four plans are shown in Table 9-3.

a. Heat recovery plan for open width bleaching range
b. Heat recovery plan of Max Goller washing range
c. Condensate recovery plan
d. Insulation on 6B valve plan

Table 9-3 Evaluation of Recommended Modification Works

Plan	a	b	c	d
1. Heat saving rate, kcal/h	425,000	300,000	193,000	1,200
2. Operation time a month (take), h	360	360	360	720
3. Total recovery heat a month, Million kcal	153	108	69	0.864
4. Unit cost of energy, TL/kcal	1	1	1	2.8
5. Amount of money saved per month, Million TL	153	108	69	2.4
6. Investment money, Million TL	2,012	2,509	489	25
7. Repayment period, month	13.2	23.2	7.1	10.4

(3) Overall evaluation

The results of evaluations of Items 1,3 and 4 imply that execution of these plans is justifiable. Item 2 should be examined as one of the candidates in the new factory. The study team recommends rechecking the cost of each plan in the Turkish business environment and reevaluation of the situation of IBF.

Chapter 10 Steel Mill

Chapter 10 Steel Mill

10-1 Characteristics of Each Industrial Sub-sector

Minimill is one of the steel production processes; main products are rebar and section, which are long products. Production of long products was 9.3 million tons in 1995 in Turkey, 78 % of the total production of 12.0 million tons in Turkey. A minimill plant consists of two production plants: steelmaking plant (Electric Arc Furnace, Ladle Furnace and Continuous Casting Machine) and of 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 % in the steelmaking plant (SMP); 85 percent of electricity is consumed in the SMP. For energy conservation, electric arc furnace (EAF) measurements are essential considering that the EAF is greatest energy consuming facility in minimill.

Energy saving in the electric arc furnace has been achieved together with efforts to increase productivity. Energy saving in the 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, for example, 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 and (4) improvement of operational technique like long arc operation and foamy slag operation. Nowadays the DC twin furnace operation is considered the most advanced furnace. In a rolling mill plant, energy saving practices are applied in the reheating furnace: hot charge operation is adopted, and improvements are made in the refractory, heat exchangers, combustion burners and combustion control. The slit rolling practice has also contributed to increasing productivity.

10-2 Outlines of Factory

10-2-1 Outlines 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 is 3,684 billion TL in December 1995. IS Bank holds 60 percent of the shares and general investors hold the rest. 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.

(2) 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 1990 through most of 1995 is shown in Table 10-1. Products are mostly exported to Europe, the Middle East and the Far East. The export reached 90 percent in 1994 because of the supply and demand situation then prevailing in Turkey. 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.

Table 10-1 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

10-2-2 Outlines of Production Facilities

(1) Steelmaking Plant (SMP)

Main facilities of the SMP are as follows:

1. Electric Arc Furnace (EAF)
   One unit x 70 tons/heat (hereinafter the word "heat" in unit 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 of 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 a 70 tons/heat of EAF, a 70 tons/heat of LF and 6 strands of CCM.

The plant began operation in May 1987. 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) Rolling Mill Plant (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 burner
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 stands. 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.

(3) Auxiliary Facilities

In addition to the above major facilities, the steel works has 1) An 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.

10-3 Trends of Energy Consumption and Unit Consumption

Monthly operation parameters in SMP including unit consumption are shown in Tables 10-2, 10-3 and 10-4. These tables indicate superb operation results including tap-to-tap time of 53 minutes, electric power consumption of from 400 to 420 kWh/ton-MS (Molten steel), at 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 10-5 and 10-6, respectively. These tables show superb productivity of 70 - 90 tons per hour, with oil consumption of 25 kilogram per ton.

10-4 Current Situation and Problems with Energy

10-4-1 Energy Management and Conservation

Consumption of electric power, oxygen gas and fuel oil -- all representing different types of energy -- is measured by the instruments installed at the control pulpit; and daily, weekly, monthly and annual reports are prepared for management review together with other operation parameters by computer treatment. Daily operation results are reported and discussed in the morning meeting every day, represented by section managers including the Personnel Affairs Section, chaired by Mr. Eldem, Maintenance and Utilities Director. IDC has organized, since the beginning of 1994, the Energy Saving Committee (headed by Mr. Eldem) consisting of experts of the production and the maintenance sections. Concerning energy saving, this committee examines and evaluates proposals by the workers, and reports the results of such evaluations to top management.

Table 10-2 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
1. 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	
2. 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	
3. Total heats (heats/month)	762	687	555	756	704	705	837	755	664	702		
4. Average heats (heats/day)	28.32	27.94	28.63	28.13	28.78	27.86	30.38	30.26	29.21	28.87		
5. Charging time (minutes/heat)	5.88	5.44	4.94	5.84	5.92	5.92	4.52	4.76	5.88	5.94		
6. Melting time (minutes/heat)	32.12	33.56	33.06	32.16	30.08	33.08	33.08	32.48	32.24	30.1		
7. Refining time (minutes/heat)	10	9	8	10	10	10	8	8	10	10		
8. Fettling time (minutes/heat)	8	9	13	7	8	9	8	9	7	7		
9. Tap-to-tap time (minutes/heat)	56	57	59	55	54	58	53	54	53	54		
10. Steel yield (%)	88.53	89.37	91.39	89.34	89.97	85.50	90.86	91.61	90.47	90.35		
11. Burnt lime (kg/ton-MS)	42.0	39.4	37.6	42.7	36.0	42.0	36.0	37.5	34.6			
12. Limestone (kg/ton-MS)	0.73	0.52	0.72	1.06	-	1.20	-	0.07	-			
13. 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	
14. Electric power (kWh/ton-MS)	414	430	416	417	408	423	406	405	423	425		
15. 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		
16. 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	
17. 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	
18. 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	
19. 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	
20. 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	

Souce: IDC

Table 10-3 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
1. LF operation time (minutes/heat)	32	32	31	33	32	34	32	32	33	34		
2. Burnt lime (kg/t-MS)	8.1	7.9	7.8	8.2	8.0	8.1	7.9	8.1	8.2	7.9	8.0	
3. Fluorspar (kg/t-MS)	1.2	1.4	1.2	1.2	1.0	1.2	1.1	1.6	1.7	1.76	1.1	
4. Dolomite (kg/t-MS)	2.5	2.2	1.8	2.3	2.3	3.2	2.6	2.6	3.4	3.1	2.9	
5. Fe-Mn (kg/t-MS)	0.43	0.54	0.28	0.74	0.80	0.55	0.37	0.86	0.89	1.7	0.94	
6. Si-Mn (kg/t-MS)	11.7	11.7	10.9	10.4	9.2	9.2	9.6	9.7	8.1	10.6	11.7	
7. Fe-Si (kt/t-MS)	2.7	2.0	2.7	2.6	2.3	2.5	2.5	2.5	2.9	2.0	2.2	
8. Al (kg/t-MS)	0.11	0.12	0.10	0.10	0.10	0.02	0.01	-	0.07	0.04	0.06	
9. Electric power (kWh/ton-MS)	35	37	33	31	32	35	35	34	36	35		
10. 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	

Source: IDC

Table 10-4 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
1. Sound billets (tons/month)	54,032	49,038	39,940	54,369	50,466	50,115	59,390	53,557	48,503	49,496		
2. 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		
3. Avarage casting time (minutes/heat)	51	52	50	51	49	52	47	48	50	50		
4. Sound billets (%)	99.5	99.6	99.8	99.9	99.9	99.9	99.9	99.6	99.7	99.7		
5. 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		

Source: IDC

Table 10-5 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
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. Fuel oil (kg/ton-product)	26	26	22	25	26	25	26	24	26	22	33	
3. Electric power (kg/ton-billet)	68	84	84	70	83	73	71	77	75	82	89	
4. Effective rolling ratio (%)	69.82	52.11	68.43	68.92	71.82	60.59	69.12	69.72	71.29	29.29	57.91	

Source: IDC

Table 10-6 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

10-4-2 Results and Plan for Energy Conservation

The following measures for energy saving are being taken.

1. Scrap preheating utilizing the exhaust gas from the EAF: Power is saved by about 20

kWh per ton, compared with operation without scrap preheating.

2. Preheating of combustion air to the ladle heating by its own exhaust gas is tested.
3. Hot charge of billets to the reheating furnace: About 10 kilograms of fuel is saved per ton of product compared with cold charge.
4. The exhaust heat from the reheating furnace is used to preheat the combustion air to the reheating furnace, production of hot water and steam for heating the buildings, and preheating of fuel oil

In addition to the above measures, IDC has employed the following state-of-the-art technologies. This contributes to energy saving.

1. Use of large capacity transformer for EAF
2. Application of high power and long arc operation to the EAF, resulting in reducing melting time, or short tap-to-tap time.
3. Use of oxy-fuel burners in the EAF makes it possible to reduce melting time and ensures uniform temperature distribution, or elimination of cold spots.
4. The foamy slag operation is applied to the EAF to use the arc heat more efficiently and to prevent radiation of heat from damaging the furnace wall enveloping the arcs.
5. The EBT system (slag-free tapping) of the EAF results in shorter tapping intervals and heat loss.
6. Use of the ladle furnace (LF) contributes to increasing production of steel by relieving the EAF of the load of refining. The EAF is operated for the sole purpose of melting scrap and the LF for refining of the heat.
7. Slit rolling contributes to increasing the production and energy saving.
8. Application of frequency converters to controlling the speed of large motors.

As shown in Table 10-9 IDC has been improving productivity by expansion of the capacities of the relevant equipment and by adopting state-of-the-art technologies. IDC furthermore plans to improve productivity. Tap-to-tap time has been remarkably improved from 80 to between 52 and 55 minutes; this will be further reduced to 45 minutes in the near future. Consequently, electric power consumption has also been reduced from 490 to 420 kWh per ton. This is also expected to be reduced to 360 kWh per ton.

Table 10-7 Improvement of SMP Operation

	Design basis ('87)	'93 - '95	Future
Specification of EAF			
Capacity (tons/heat)	60	70	80
Shell diameter (meters)	5.3	5.5	5.5
Transformer (MVA)	45	72	72
Operation Parameters			
Tap-to-tap time (minutes)	80	50 - 55	45 -50
Electric power (kWh/ton)	490	405- 430	360
Oxygen gas (Nm^3/ton)	23	30 -35	45
Electrode (kg/ton)	3.5	1.6 - 2.3	1.5
Refractories (kg/ton)	20	10	8
Burnt lime (kg/ton)		30	25
Steel yield (%)		89	92

Source: IDC

10-5 Current Condition and Problems with Facilities

10-5-1 Major Energy Consuming Facilities

1. Electric arc furnace: 630,000 tons per year of molten steel
   Electric power consumption: 408 kWh per ton, 257,000 MWh per year
   Oxygen consumption: 32 Nm^3 per ton, 20,000,000 Nm^3 per year
   Fuel oil consumption: 5 kilograms per ton, 3,200 kilograms per year
2. Ladle furnace: 630,000 tons per year of molten steel
   Electric power consumption: 35 kWh per ton, 22,000 MWh per year
3. Rolling mill: 510,000 tons per year of rebar
   Electric power consumption: 80 kWh per ton, 41,000 MWh per year
4. Reheating furnace: 510,000 tons per year of rebar
   Fuel oil consumption: 25 kilogram per ton, 12,800 kilogram per year

10-5-2 Identification of the Current Problems

(1) Problem with Major Energy Consuming Facilities

As mentioned in section 10-4-2, IDC has also been improving productivity and energy saving by expanding capacity and introducing state-of-the art technology. IDC has achieved superb operation results, of which the following are particularly outstanding:

1. Electric power consumption of the electric arc furnace (400 to 420 kWh/ton-MS)
   There is some room to further reduce electric power consumption.
2. Utilization of the scrap preheater
   Use of the scrap preheater is limited; half the exhaust gas is used and 70 percent of scrap is preheated in a short period due to equipment capacity and configuration.
3. Hot charge
   Application is limited to low temperature billets due to metallurgical problems.

(2) Problems in Energy Consumption Already Recognized, Items Requested for the Audit

To set a definite target for energy conservation and confirm the results of energy saving activities, it is important to determine the heat balance of the arc furnace operation, regarding it as an integral system. Determination of the exact heat balance involves enormous amounts of measurement and calculation. Nevertheless, IDC has desired to determine the heat balance of the electric arc furnace.

(3) Major Items and Points of Factory Audit

The study team understands IDC's aspiration and agrees with IDC that determination of the heat balance is the cornerstone for promotion of energy saving. Consequently, major items for audit concern determination of the heat balance of the arc furnace.

10-6 Method and Procedure of Energy Audit

The original basic plan was proposed by the study team. Through repeated discussions and cooperation between IDC and the study team, the plan was modified and finalized to fit the actual situation. The proposed methods for measurement and analysis were based on NKK's experience which is commensurate with JIS (Japanese Industrial Standards) including the data processing after the measurements.

The plan for analysis and measurement for energy audit is summarized in Table 10-11, and Figures 10-8 and 10-9 show the flow diagram around EAF and layout around EAF, respectively.

Table 10-8 Plan of Analysis and Measurement for Energy Audit (IDC) 1/3

Major Items of Energy Audit	Methods of Analysis and Measurement											Remarks	
	Subject Items and points	Measurement or Estimate	Equipment of Analysis and Measurement						Personnel Allocation				
			Required Equipment	Factory	EIE	JICA	Local Labo	Additional	JICA	EIE	Factory	Measuring Interval	Measuring Points
Electric Arc Furnace	(Heat input)												
	1. O_2, for two lances										A		
	1) Time (hr-min)	M	Clock	x								Start & Finish	Control room
	2) Consumption (Nm^3)	M	Integrator	x								Integration	Control room
	2. O_2, for each of 4 furnace/1 door burners										B		
	1) Time (hr-min)	M	Clock	x								Start & Finish	Control room
	2) Consumption (Nm^3)	M	Integrator	x								Integration	Control room
	3. Oil, for each of 4 furnace/1 door burners										B		
	1) Time (hr-min)												
	2) Consumption (kg)	M	Clock	x								Start & Finish	Control room
	3) Calorie (kcal)	M	Integrator	x								Integration	Control room
		E	(Standard)	-								Heat	-
	4. Carbon injection										A		
	1) Time (hr-min)	M	Clock	x								Start & Finish	Control room
	2) Consumption (kg)	M	(Calculation)	x						-		Heat	-
	3) Composition (%)	E	(Standard)	-								-	
	5. Additives, each										A		
	1) Time (hr-min)	M	Clock	x								Start & Finnish	Control room
	2) Consumption (kg)	M	Weigher	x								Heat	Heat report
	3) Composition (%)	E	(Standard)	-								Heat	-
	6. Scrap (Scrap bucket)										C		
	1) Consumption (kg)	M	Weigher	x		-					-	Each charge	Heat report
	2) Composition (%)	E	(Standard)	x		-					-	-	-
	3) Temperature (°C)	M	Thermocouple	-		x						Before charge	Scrap bucket
	7. Hot heel												
	1) Weight (kg)	E	(Estimation)									-	-
	2) Composition (%)	M	Analyzer	x								Heat	Heat report
	3) Temperature (°C)	E	(Estimation)									-	-
	8. Electric power										E		
	1) Time (hr-min)	M	Clock	x								Start & Finish	Control room
	1) Consumption (kWh)	M	kWh meter	x								Every 1 min. & integration	Control room
	9. Electrode												
	1) Consumption (kg)	E	(Standard)	-								Heat	-
	10. Slag												
	1) Weight (t/heat)	E	(Calculation)	-								Heat	Heat record
	2) Composition (%)	M	Analyzer	x								Champion heats	heat record

Table 10-8 Detailed Plan of Analysis and Measurement for Energy Audit (IDC) 2/3

Major Items of Energy Audit	Methods of Analysis and Measurement											Remarks	
	Subject Items and points	Measurement or Estimate	Equipment of Analysis and Measurement						Personnel Allocation				
			Required Equipment	Factory	EIE	JICA	Local Labo	Additional	JICA	EIE	Factory	Measuring Interval	Measuring Points
Electric Arc Furnace	(Heat output)												
	1. Exhaust gas, C/C inlet								A.B,	A.B.C	D		
	1) Time (hr-min)	M	Automatic meter			x			C			Continuously	C/C inlet
	2) Temperature (°C)	M	Thermocouple			x						Continuously	C/C inlet
	3) CO/CO_2 in gas (%)	M	Automatic meter			x						Continuously	C/C inlet
	4) O_2 in gas (%)	M	Automatic meter			x						Continuously	C/C inlet
	5) N_2 in gas (%)	E	(Calculation)			-						Continuously	C/C inlet
	2. Exhaust gas, C/C outlet								A.B.C	A.B.C	D		
	1) Time (hr-min)	M	Automatic meter			x						Continuously	C/Coutlet
	2) Temperature (°C)	M	Thrmocouple			x						Continuously	C/Coutlet
	3) Static pressure (mmH_2O)	M	Digital manometer			x						Continuously	C/Coutlet
	4) Flow rate (Nm^3/min)	M	Pitot tube			x						Continuously	C/Coutlet
	5) CO/CO_2 in gas (%)	M	Automatic meter			x						Continuously	C/Coutlet
	6) O_2 in gas (%)	M	Automatic meter			x						Continuously	C/Coutlet
	7) N_2 in gas (%)	E	(Calculation)			-						Continuously	C/Coutlet
	3. Cooling water								C		F		
	1) Time (hr-min)	M	Clock	x		-						One time a heat	Control room
	2) Flow rate (m^3/min)	M	Magnetic flow meter	x		-						One time a heat	Control room
	3) Temperature, inlet (°C)	M	Thermocouple	x		-						One time a heat	Inlet
	4) Temperature, outlet (°C)	E	Thermometer	-		x						Continuously	Outlet
	4. Furnace body								D				
	1) Time (hr-min)	M	Clock	-		x						Continuously	Heat report
	2) Temperature of 12 points of wall (°C)	M	Thermocouple	-		x						Continuously	Heat report
	3) Temperature of 4 points of bottom (°C)	M	Thermocouple	-		x						Continuously	Heat report
	4) Temperature of roof (°C)	E	(Standard)	-		x						One time during test	-
	5. Molten steel including hot heel												
	1) Temperature (°C)	M	Thermocouple	x								Heat	Heat report
	2) Weight (kg)	E	(Calculation)	-								Heat	Heat report
	3) Composition (%)	M	Analyzer	x								Heat	-
	6. Slag												
	1) Temperature (°C)	E	(Estimation)	-		-						Heat	Heat report
	2) Weight (kg)	E	(Calculation)	-		-						Heat	Heat report

Table 10-8 Detailed Plan of Analysis and Measurement for Energy Audit (IDC) 3/3

Major Items of Energy Audit	Methods of Analysis and Measurement											Remarks	
	Subject Items and points	Measurement or Estimate	Equipment of Analysis and Measurement						Personnel Allocation				
			Required Equipment	Factory	EIE	JICA	Local Labo	Additional	JICA	EIE	Factory	Measuring Interval	Measuring Points
Electric Arc Furnace	(Others)												
	1. **Operation results**								E	D	G		
	2. **Surrounding condition**								D				
	1) Weather					x							
	2) Atmospheric pressure (hpa)					x						Start of heat operation	Around EAF
	3) Outdoor temperature (°C)					x						Start of heat operation	Outside
	4) Indoor temperature (°C)					x						Start of heat operation	Around EAF
	5) Humidity (%)					x						Start of heat operation	Around EAF

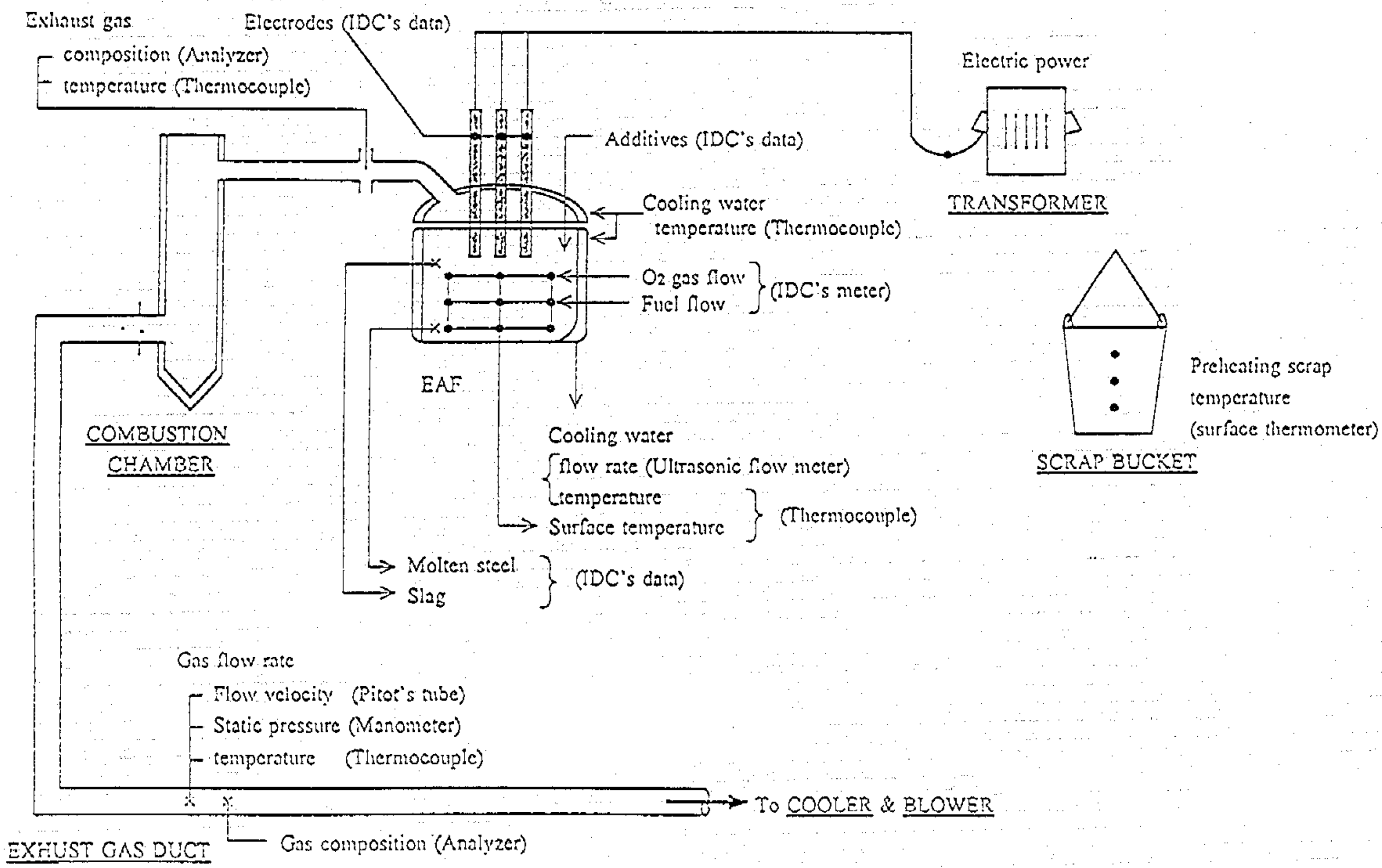

Figure 10-1 Flow Diagram around FAF

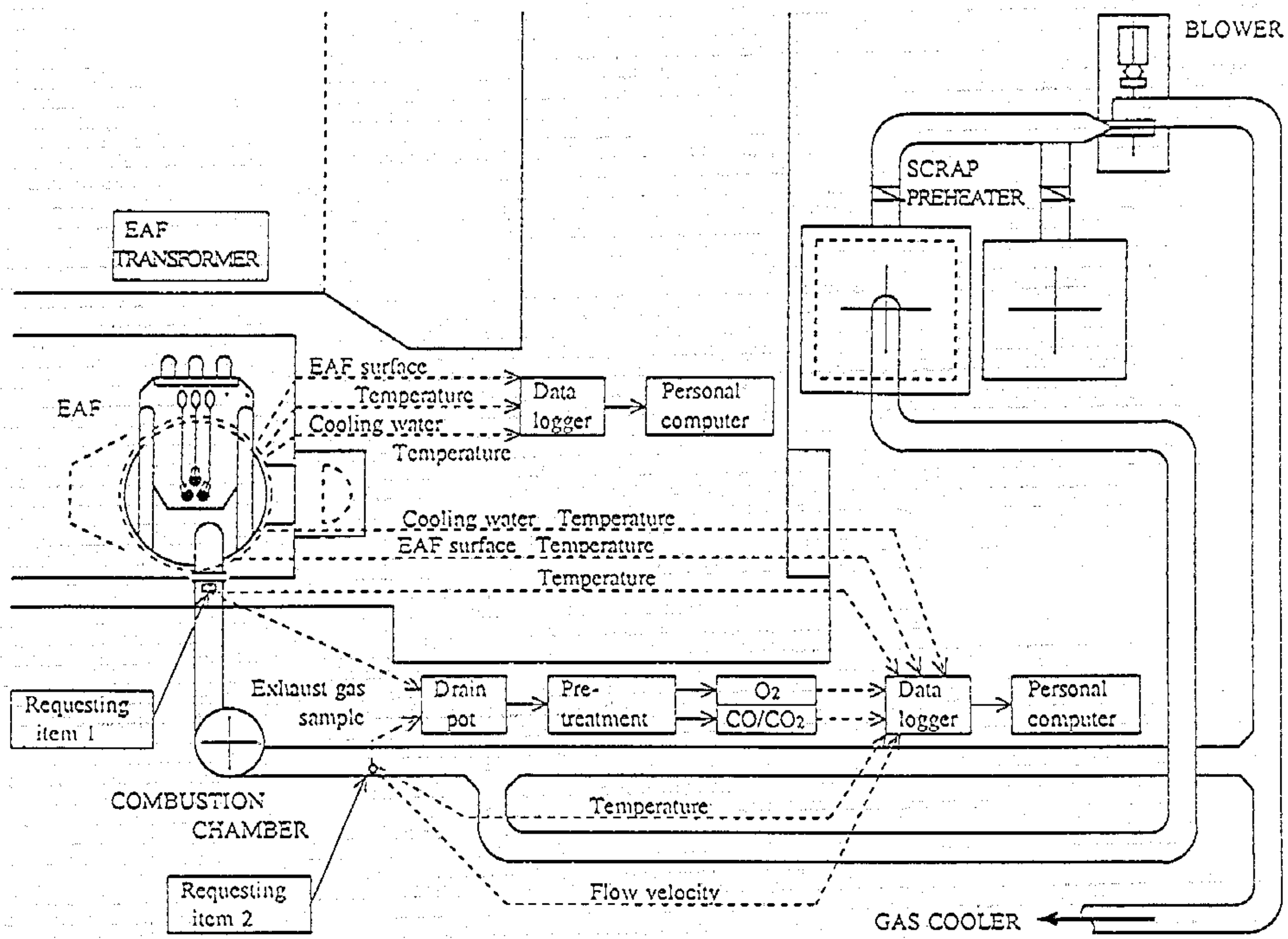

Figure 10-2 Layout around FAF

10-7 Execution of Measurement

The measurement schedule is shown below.

	Aug. 12 th	13 th	14 th	15 th	16 th	17 th	18 th	19 th
Instrument Preparation	—							
Instrument Installation	—							
Adjustment / Rehearsal		—						
Measurement			—	—				
Instrument Removal					—			
Data Treatment						—	—	—

10-8 Results of Measurement and Analysis

Measurement for the EAF heat balance was executed for the following 11 heats including one trial.

Aug. 13	Heat No. 965729	trial
Aug. 14	Heat No. 965749	measurement of exhaust gas not completed
Aug. 14	Heat No. 965750	measurement of exhaust gas not completed
Aug. 14	Heat No. 965751	selected for analysis
Aug. 14	Heat No. 965752	selected for analysis
Aug. 14	Heat No. 965753	selected for analysis
Aug. 15	Heat No. 965773	
Aug. 15	Heat No. 965774	measurement of exhaust gas not completed
Aug. 15	Heat No. 965775	measurement of exhaust gas not completed
Aug. 15	Heat No. 965776	
Aug. 15	Heat No. 965777	

According to the JIS (the Japanese Industrial Standards) procedure, three consecutive heats (Heat Nos. 965751, 965752 and 965753) were selected for calculation of the heat balance.

Heat balance sheets are shown in Figures 10-3, 10-4 and 10-5.

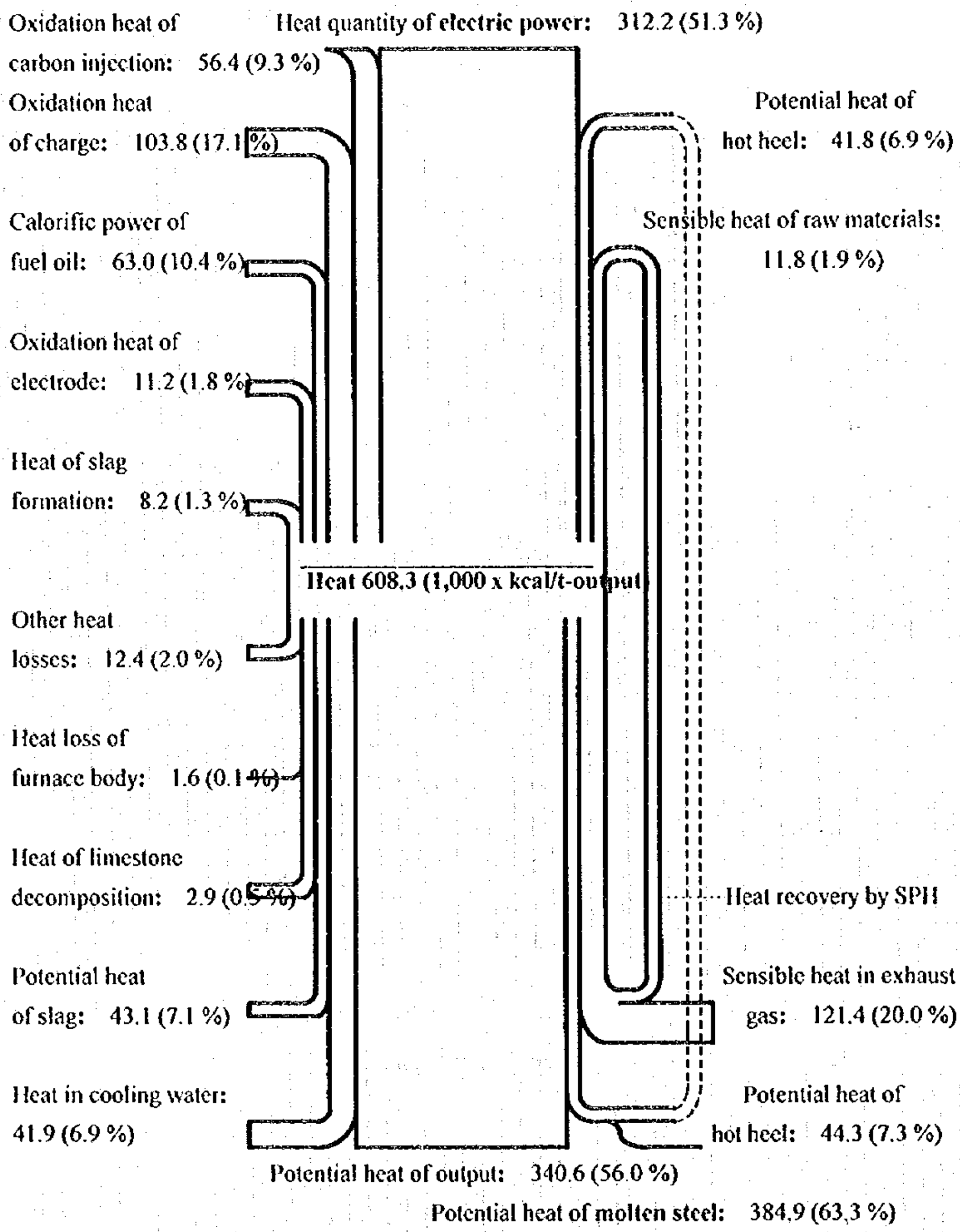

Figure 10-3 Heat Balance of Heat No. 965751

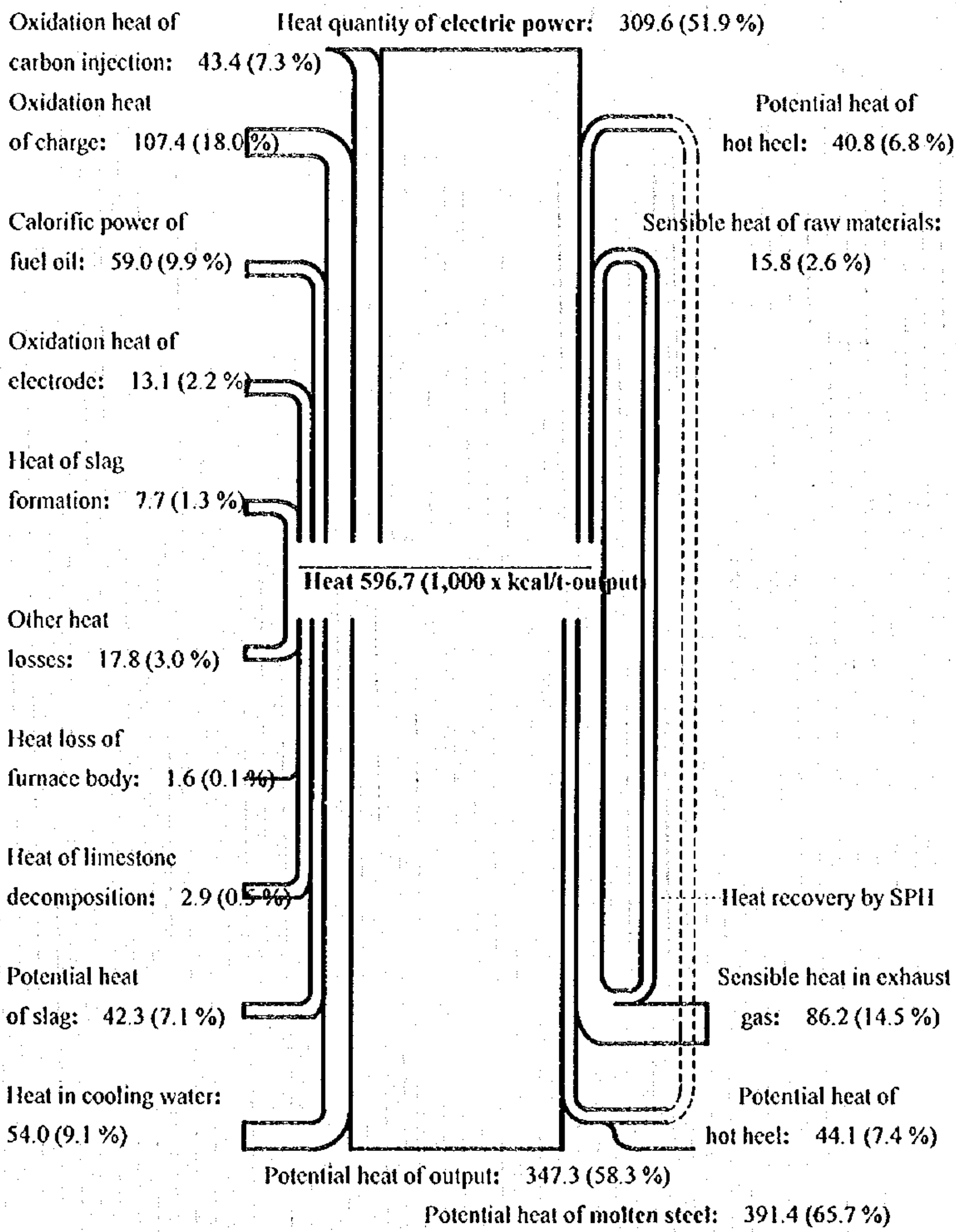

Figure 10-4 Heat Balance of Heat No. 965752

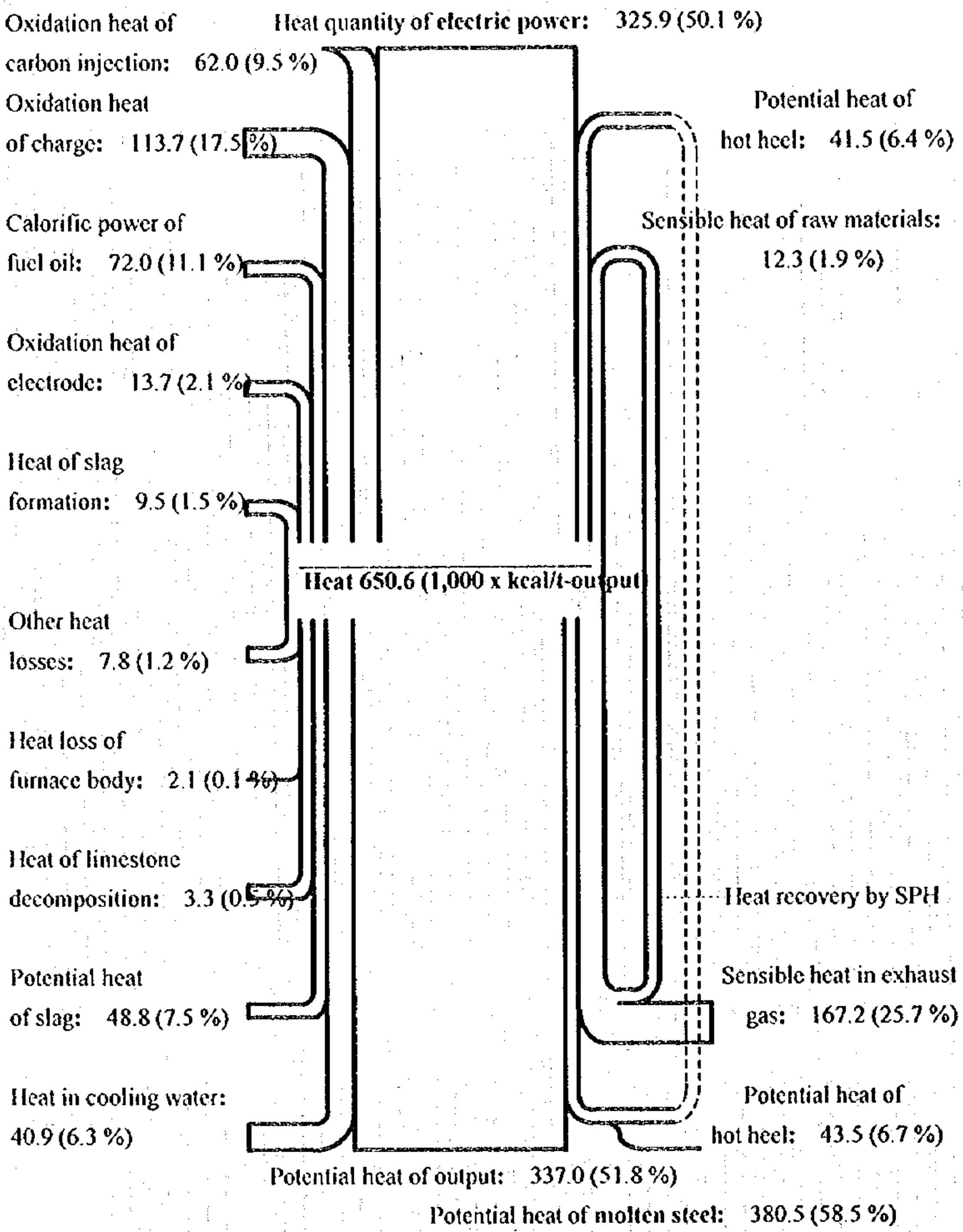

Figure 10-5 Heat Balance of Heat No. 965753

Each heat balance sheet shows a following characteristic.

1. Other heat loss shows almost same value, 2.0 % for Heat No. 965751, 3.0 % for Heat No. 965752 and 1.2 % for No. 965753.
2. Calorific heat to produce one ton of Heat No. 965753 required 650,600 kcal which is approximately 7 - 8 % higher than 608,300 kcal of Heat No. 965751 and 596,200 kcal of Heat No. 965752.

In this measurement the electrical heat loss was not measured. It is usually approximately 2 percent. Therefore, for item 1 above, "other heat loss" of 1.2-3.0 percent is very close to the minimum value which corresponds to the electrical heat loss. This means that the three selected heats were successfully measured. Incidentally, for other heats, Heat Nos. 965729, 965773, 965776 and 965777, "other heat loss" shows 6.6 %, 4.9 %, 11.4 % and minus 0.2 %.
For item 2 above, Heat No. 965753 required longer tap-to-tap time than other heats. Accordingly, heat quantity was increased.

10-9 Overall Evaluation of Countermeasures for Energy Conservation

1. Modification of scrap preheater (SPH) to accommodate preheating the 3rd bucket.
   A new 2nd hood and a new 2nd inlet duct to the existing 2nd chamber, a new 2nd outlet duct from the existing 2nd chamber, a new 2nd damper for a new 2nd outlet duct and two blowers for the existing 1st and a new 2nd outlet duct will be installed so as to simultaneously and independently control SPH operation.
   Saving of electric power: 6.8 kWh/t-MS (Molten Steel).
   Saving of production cost: 0.299 USD/t-MS.
   = 17,900 USD/ M at production of 60,000 t/M.
   Modified budget: 200,000 USD.
   Conclusion: Full recovery of investment is expected within 12 months.

2. Maintenance of oxy-fuel burners of EAF to keep a constant O_2/Oil ratio.
   Saving of electric power: 5.2 kWh/t-output
   Saving of production cost: 0.161 USD/t-MS.
   = 9,700 USD/M at production of 60,000 t/M.

3. Standardization of burnt lime addition into EAF.
   Saving of burnt lime: 12.8 kg/t-MS compared with the 1st half of 1995.

Saving of electric power: 20.5 kWh/t-MS.

Saving of production cost: 87,000 USD/M at production of 60,000 t/M.

4. Decreasing flow rate of cooling water for EAF.

   Saving of flow rate of cooling water: 800 m^3/hr.

   Saving production cost: 6,500 USD/M at production of 60,000 t/M.

5. Introduction of billets cooling system in higher temperature in front of the reheating furnace to prevent cracks generation of cast billet.

   Pumping system, water piping, spray nozzles and control system will be installed.

1) At present: 60 - 70 % (65 %) of billet is hot charged at 300 -600 °C (average 450 °C) and heated to 1,100 - 1,150 °C (1,125 °C).

2) Improvement: 60 - 70 % (65 %) of billet is hot charged at 690 °C and heated to 1,100 - 1,150 °C (1,125 °C).

   Saving of fuel oil: Heat content (100.8 kcal/kg at 690 °C - 58.1 kcal/kg at 450 °C) x Billet weight 1,000 kg/Low heating value of fuel oil 10,000 kcal/kg = oil 4.3 kg/t-BT (billet)/Combustion efficiency 50 % = oil 8.5 kg/t-BT x 65 % = oil 5.6 kg/t-BT

   Saving production cost: 5.6 kg/t-BT x 0.15 USD/kg-oil = 0.84 USD/t-BT = 50,400 USD/M at production of 60,000 t/M.

   Construction cost: 21,300 USD

   Conclusion: Full recovery of investment is expected within one month.

Following recommendations are guidelines for EAF's operation.

6. Turn power on immediately to prevent drop of hot heel temperature.

   If hot heel temperature is higher by 10 °C, 2.4 kWh/t-MS of electricity will be saved.

7. Preheat scrap as long as possible to obtain a higher temperature.

8. Purchase burnt lime as well calcined as possible to prevent heat loss for decomposition of limestone.

10-10 Technical Guidelines for Energy Conservation

The items for measurement and procedure for calculation to determine a heat balance of electric furnaces are as follows.

1. Items for heat balance

(1) Items of heat input

1) heat quantity of electric power

2) Potential heat of hot metal, hot heel of the raw material and residual slag

3) Sensible heat of raw materials

4) Calorific power of fuel oil

5) Sensible heat of fuel oil

6) Oxidation heat of electrode

7) Oxidation heat of charge

8) Oxidation heat of additives

9) Heat of slag formation

(2) Items of heat output

10) Potential heat of output and hot heel of molten steel

11) Potential heat of slag

12) Heat of decomposition of limestone and iron ore

13) Electrical heat loss

14) Heat dissipated in cooling water

15) Sensible heat of exhaust gas

16) Heat loss from the furnace body

17) Other heat loss - Difference between heat input (Items from 1 to 9) and heat output (Items from 10 to 16)

2. Measuring items and equipment/instruments

3. Calculation formulas and reference figures for heat balance and calculation of heat content of exhaust gas

(1) Calculation formulas and reference figures for heat balance

1) Calculation formulas for heat input

2) Calculation formulas for heat output

3) Heat content (iron, steel and slag)

4) Reaction heat

(2) Calculation of heat content of exhaust gas

4. Data sheets for measurement

5. Measurement results

6. Calculation results

7. Detail of measurement for exhaust gas, outlet temperature of cooling water and surface temperature of the furnace body

(1) Layout of measuring equipment

(2) Measurement of flow rate and temperature of exhaust gas

(3) Measurement of CO, CO_2, and N_2 contents in the exhaust gas

(4) Measurement of outlet temperature of cooling water

(5) Measurement of surface temperature of furnace body

8. Site survey and preparatory work

Chapter 11 Socio-economic Evaluation of the Recommendations

Chapter 11 Socio-economic Evaluation of the Recommendations

11-1 Evaluation of the Recommendations on Policy

The medium- and small-scale manufacturing industries that consume less than 2,000 TOE represent only less than 30 percent of the total consumption of energy by the manufacturing industries. If this borderline is reduced to 500 TOE as this study recommends, the medium- and small-scale manufacturing industries consume energy even less. On the other hand the number of medium- and small-scale manufacturing industries is very large and they are scattered throughout the nation. Naturally, effort towards the medium- and small-scale manufacturing industries is destined to be ineffective in terms of achieving energy saving and very laborious. It would take a great deal of work, time, manpower and expense of the government yet the effects in terms of energy saving, ratio of energy saving on the total consumption would not be very great.

The question is whether it is right to spend the limited government resources on cost-ineffective energy saving on the medium- and small-scale manufacturing industries or the government should let the medium- and small-scale manufacturing industries alone for a while until energy saving in more important sectors have almost been achieved to satisfactory levels.

The study team must answer this question as long as this study recommends legal and administrative measures. The study team presents recommendations as enumerated in Chapter 7 of the main report. The recommendations are all modest ones. In light of the small contribution to energy saving in the medium- and small scale manufacturing industries, the policy and administrative measures should not be expensive in workload, time, and cost. The recommendations that the study team presents considers this feature of the medium- and small-scale manufacturing industries. Against such a socio-economic background of the medium- and small-scale industries, the policy recommendation are based on the following ten basic principles so that the recommendations may be well balanced with the expected benefits. The study team exercised extreme caution not to make grand and expensive recommendations. Under such conditions new policy measures to this cost ineffective area may be justified.

Basic Concept for Recommendation

The recommendations for the study of policy and medium- and small-scale manufacturing industries will be based on the following basic concepts. The recommendations intend:

1. To promote rational use of energy in the manufacturing sector in a manner that will contribute to environmental conservation,
2. To enhance awareness of the importance of promoting rational use of energy among those who are associated with manufacturing and administration,
3. To improve the organizational setup of the government so that the roles of the responsible organizations may be clearly defined and so authorized as to implement their roles,
4. To organize an effective system of collecting and processing information of manufacturing industries, the medium- and small-scale manufacturing industries in particular, so that the government may adequately promote rational use of energy,
5. To identify and develop human resources, both in the public and private sectors, that will be needed to promote rational use of energy,
6. To prepare an effective and easy-to-access package of incentives and finance to encourage medium- and small-scale manufacturing industries to promote rational use of energy,
7. To pursue inexpensive but effective strategies and methods in policy implementation,
8. To seek policy measures which the industries will accept and cooperate with willingly,
9. To facilitate development and introduction of technologies that promote rational use of energy, and
10. To establish a legal structure under which rational use of energy in the manufacturing sector may be effectively implemented.

Another important consideration is the fact that a large number of people is involved in the medium- and small-scale manufacturing industries. As a matter of fact the number of people working for medium- and small-scale industries far exceeds that of those working for industries consuming more than 2,000 TOE per year. Enhancement of awareness of the importance of energy saving is very important among all conceivable policy measures. This could not be achieved if this large portion of people in the medium- and small-scale manufacturing industries is neglected. Education and training of those who actually work in the medium- and small-scale manufacturing industries are important in the sense that improper management of energy, combustion of fuel in particular, could lead to environmental hazards, generation of soot, smoke, or even more carbon monoxide for example.

In implementation of this study, the study team put environmental consideration ahead of energy saving, or to harmonized these two issues. For this reason the study team wish to leave the standards for guidelines non-compulsory, because it is up to every installation to achieve energy saving without causing environmental disruption rather than obey the standards simple-mindedly without regard to their effects upon the environment and energy saving. Detailed operating conditions of manufacturing facilities are an area the government should not step in, unless the facilities evidently cause damages to the environment and people. It should be recognized that people who actually operate the facilities know more about their facilities than the government officers or any other organization. As far as the operating conditions are concerned, the role of the government should be limited to provision of information about new technology and good examples, and extension of energy audit service.

The effect of the recommended policies would not be very prompt and large in terms of energy saved, because the consumption of energy by the medium- and small-scale industries is not very large. More energy would be saved in the large-scale manufacturing industries and the transportation sectors. It does not mean in the least that the medium- and small-scale manufacturing industries can be neglected. Efforts should be made to save energy in the medium- and small-scale manufacturing industries along with large-scale manufacturing industries and other sectors, but in a cost effective manner. The medium- and small-scale manufacturing industries are particularly important from the standpoint of enhancing awareness of the importance of energy saving among the whole population.

11-2 Financial and Economic Internal Rates of Return

Chapters 9 to 12 of the main report present evaluations of the recommended modifications by the methods acceptable to each factory. Here, the internationally accepted method for calculating internal rate of return, or rate of return of the discounted cash flow on investment, is used to assess some of the proposed modifications.

The calculation assumes the following basic premises.

1. Project year	10
2. Discount rate, percent/year	To be obtained
3. Construction period, year	within 1
4. Operation period, year	9
5. Depreciation, year	5
6. Depreciation, method	Straight line without residual value

7. Other capital related cost, percent on investment 5
8. Income tax, percent on net income 30
9. Currency United States Dollars

Table 11-1 shows the financial and economic internal rates of return of four selected projects calculated based on the above premises.

The obtained financial and economic internal rates of return indicate that all the selected investment projects except for that in Dev Blok are financially and economically justifiable.

The investment project in Dev Blok could be justifiable if the investment cost is reduced to 502,000 US Dollars. At this investment cost the financial internal rate of return is 20 percent. Dev Blok should reduce the investment cost to this level by using domestic inputs instead of foreign inputs before actually embarking on the project.

Table 11-1 Calculated Financial and Economic Internal Rates of Return

Modification	Financial internal rate of return, percent	Economic internal rate of return, percent
Dev Blok		
Double door	6.48	8.14
MONO gas analyzer		
Surface thermometer		
Increase of dryer		
IBF		
Heat recovery from the open width bleaching range	102.42	138.18
Heat recovery from the Max Goller washing range	31.63	40.34
IDC		
Modification of the scrap preheater	76.91	102.22

Attachment-1

SCOPE OF THE STUDY

This SCOPE OF THE STUDY forms part of the Scope of Work agreed between EIE and JICA on June 30, 1995.

In order to achieve the above objectives, the Study will cover the following items;

1. Study on the energy situation in Turkey
1-1 Government policy on energy
1-2 Present energy situation in Turkey
1-3 Situation of energy use in the field of industrial sector in Turkey

2. Study on the promotion of the rational use of energy int he selected small and medium size industrial sectors
2-1 Relevant laws and regulations
2-2 Current program for the rational use of energy
2-3 To study and evaluate the activities of the authorities concerned
(1) Current activities for the promotion of the rational use of energy
(2) Achievements of past activities
(3) Future plan/program for the promotion of the rational use of energy

3. Study on the situation of energy use in the selected factory of each industrial sector
3-1 Situation of energy use in each factory
(1) Outline of the factory
(2) Situation of energy management
(3) Energy flow chart and production process
(4) Situation of major energy consuming equipment
(5) Problems in each factory and countermeasures that do not involve changing the existing production process
(6) Estimated effects of the countermeasures

4. Recommendation for the promotion of the rational use of energy in Turkey
4-1 Government policy, law and regulation
4-2 Executing organization to promote the rational use of energy
4-3 Activities for the promotion of the rational use of energy

4-4 Measures to promote the rational use of energy in the selected small and medium size industrial sectors

4-5 Countermeasures to solve the problems that do not involve changing the existing production process

4-6 Expected effects after the implementation of the Master Plan

5. Preparation of reference material to be used in technical guidelines for the promotion of the rational use of energy in the selected small and medium size industrial sectors

The objective of the study referred to in the fourth line is stated as follows:

OBJECTIVE OF THE STUDY

The objective of the Study is to contribute to the promotion and strengthening of the rational use of energy in the fields of industries in the field of industries in the Republic of Turkey (hereinafter referred to as "Turkey") by studying the technical and managerial applicability of the rational use of energy and formulating the report for the promotion of the rational use of energy in the industrial sectors stated below:

1. Brick
2. Textile
3. Metallurgy (Steel rolling mil, Arc furnaces)
4. Food (Vegetable oils)
5. Cleaning material