3.2.3 Production balance

Table II.3-10 shows the balance of sinter product between 1992 and 2002.

In 2002, the plan of producing by only the three large sintering plants, Nos.5 to 7, is selected to raise the efficiency of energy-saving and pollution control effects.

The required quantity of sinter product will increase from 4.332 Mt/y in 1992 to 7.022 Mt/y in 2002. Therefore operational availability should be increased from 70 % to 90 % as in Japan by installing yard stock system for sinter product to avoid unscheduled shutdowns due to unbalance between BF and sintering plant.
It is necessary that max.productivity is 26 $t/d/m^2$ according to max. production of BF. Therefore quick lime adding system as measures of increasing productivity should be installed to improve the permeability of sintering bed.

3.2.4 Analysis of the problems found

1) Energy balance

As the heat balance in Table II.3-11 shows, the energy consumption in SIDEX was 596 Mcal/t, about 1.4 times the Japanese consumption of 417 Mcal/t in 1992.

In the input column, consumption of coke breeze and COG is high. In the output column, sintered ore sensible heat, waste gas sensible heat, and decomposition heat of lime stone are high.

2) Energy-saving themes

(1) To decrease consumption of coke breeze

To decrease the consumption of coke breeze, a heat pattern should be established to transmit the combustion heat to the sintering bed efficiently, and then optimization of the grain size of coke breeze and coke breeze distribution in the sintering bed are required. The sensible heat of waste gas will lower at the same time.

(2) To decrease consumption of COG

To decrease the consumption of COG, the ignition system of the ignition furnace should be changed from the present atmosphere ignition type to the combination type of atmosphere ignition and flame ignition, thus obtaining quick ignition at high temperature. Together with this revamping of the ignition system, waste heat should be utilized to preheat the combustion air, thus raising the flame temperature, and also to preheat the raw material, all leading to the improvement of ignition efficiency.

(3) To lower sensible heat of sintered ore

To lower the sensible heat of sintered ore, the sensible heat escaping to the return fine should be decreased by improving the product yield. This improvement of product yield also decrease consumption of various energies.

(4) To decrease consumption of electric power

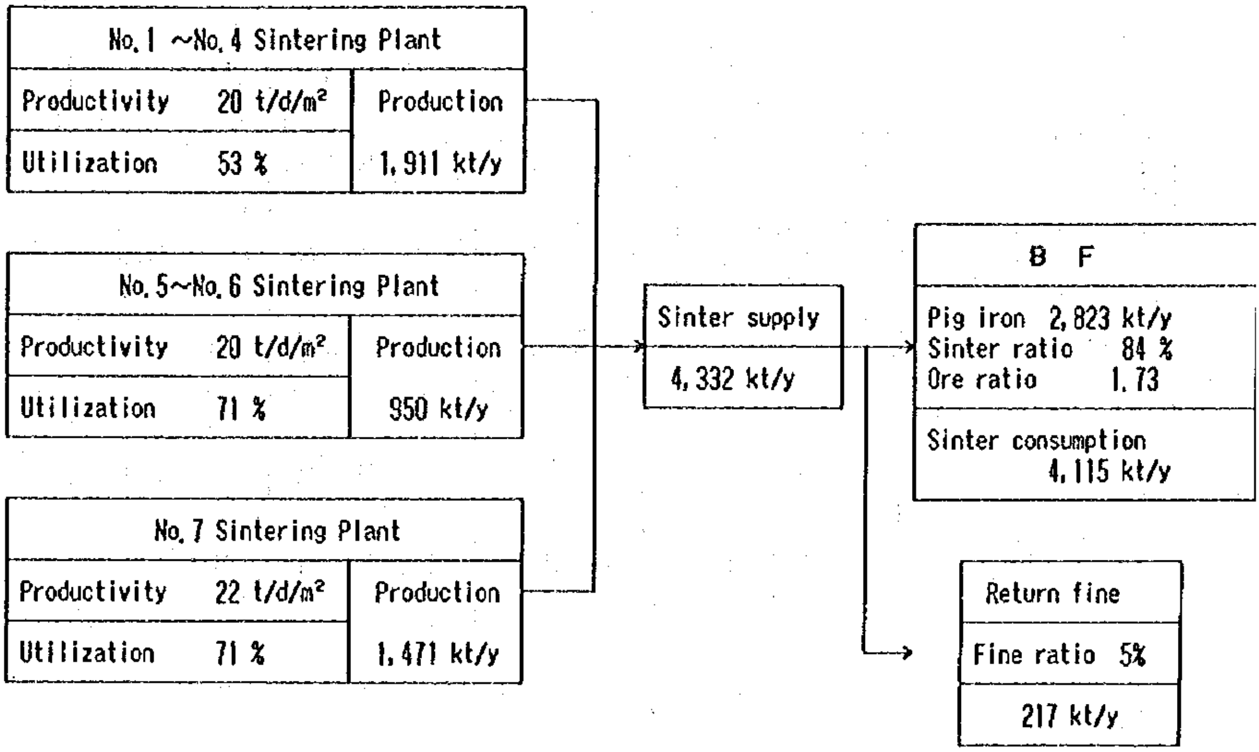
As Fig. II.3-7 shows, the unit consumption of electric power changes in reverse proportion to the change of productivity and yield. To decrease the consumption of electric power, therefore, the high air leakage ratio of main exhaust gas, 66%, should be restrained in addition to the improvement of yield, thus decreasing the consumption of electric power for the main blower.

(5) To recover waste heat

The waste heat from the cooler should be recovered efficiently. The cooler for the No.7 sintering plant is of circular bin type and since the temperature of exhaust gas is low, it is not suitable for the recovery of steam and had better be applied to preheating of combustion air and raw materials for the ignition furnace. The cooler for the No.6 sintering plant is of straight-line trough type and can recover the waste heat by steam from the high-temperature waste gas in the upstream in the cooler.

Table II.3-10. Sinter Product Balance

(1) Sinter Product Balance in 1992



(2) Sinter product balance in future (2002)

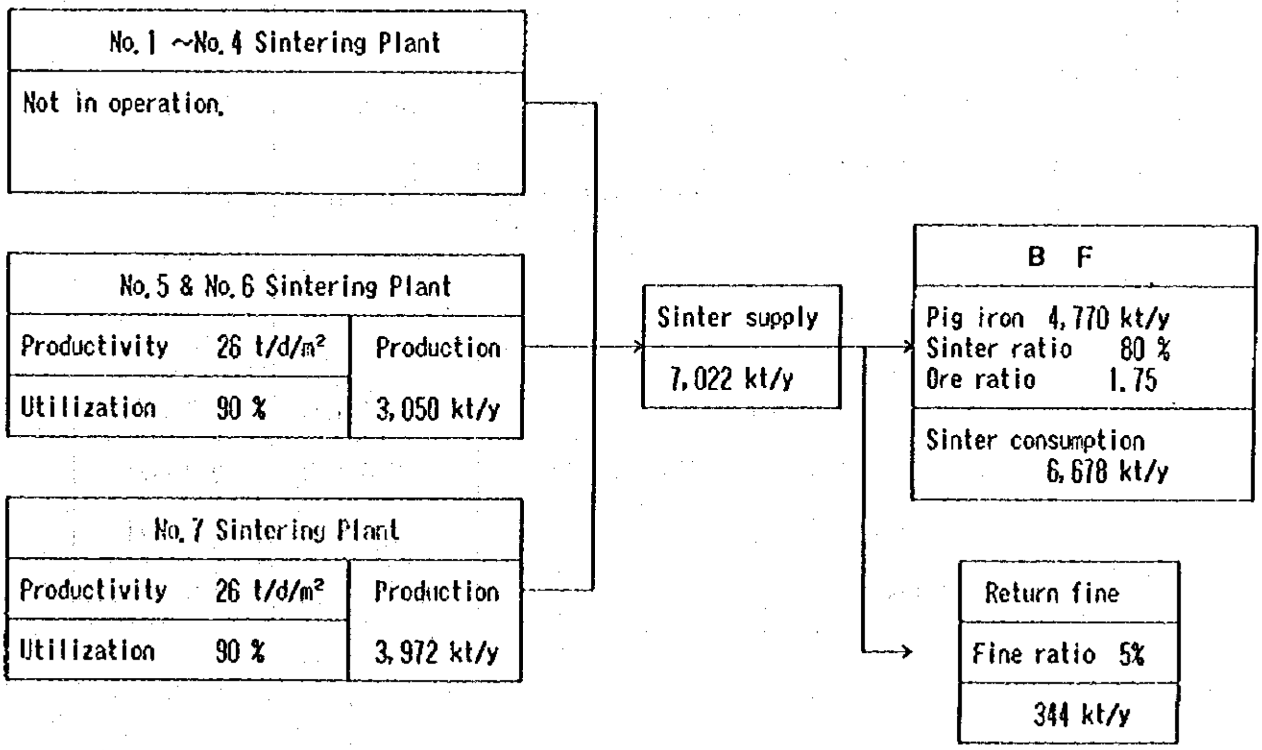
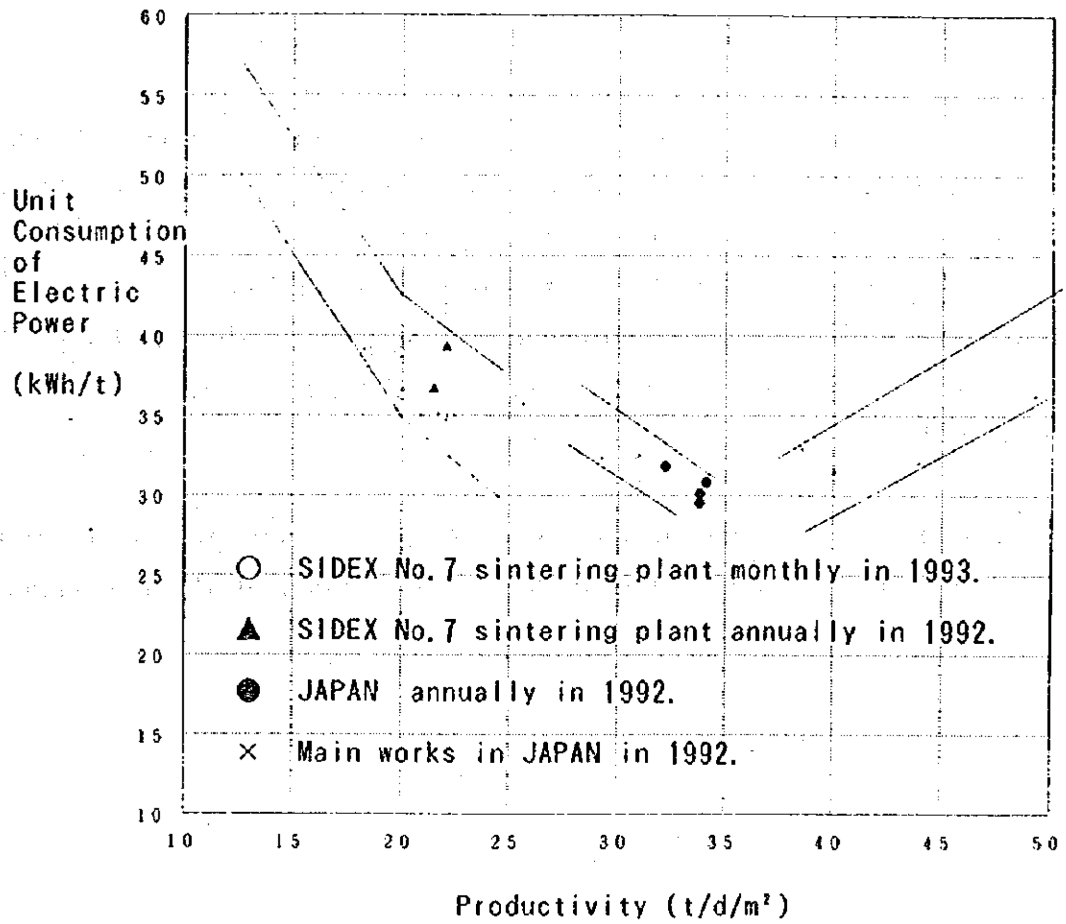


Table II.3-11. Heat Balance for Sintering Process(1992)

Items		SIDEX Remarks	SIDEX Mcal/t-sinter	Japan
INPUT	Coke breeze	Coke consumption 67 kg/t Calorific value 6,800 kcal/t	455 Mcal/t	355 Mcal/t
	COG	COG consumption 9 Nm³/t Calorific value 4,250 kcal/Nm³	38 Mcal/t	8 Mcal/t
	Sulfur oxidizing heat	Sulfur unit value 1.1 kg/t-s Calorific value 2,500 kcal/kg	3 Mcal/t	1 Mcal/t
	Sensible heat of material	Material volume 1,747 kg/t-s Specific heat 0.22 kcal/kg ℃ Mean temp 11 ℃	4 Mcal/t	4 Mcal/t
	Total		500 Mcal/t	368 Mcal/t
OUTPUT	Sinter cake sensible heat	Sinter cake 1,470 kg/t Specific heat 0.22 kcal/kg ℃ Temperatuer 450 ℃	146 Mcal/t	119 Mcal/t
	Waste gas sensible heat	Waste gas volume 3,000 Nm³/t Specific heat 0.32 kcal/Nm³℃ Waste gas temp 94 ℃	90 Mcal/t	53 Mcal/t
	Resolution heat of limestone	Limestone consumption 270 kg/t Resolution heat 426 kcal/kg	114 Mcal/t	76 Mcal/t
	Resolution heat of combined water	Combined water 1.5 % Raw material 940 kg/t-s Resolution heat 1,200 kcal/kg	17 Mcal/t	23 Mcal/t
	Latent heat of sinter mix H_2O	Moisture in sinter mix 6 % Sinter mix volume 1,747 kg/t-s	57 Mcal/t	46 Mcal/t
	Latent heat of CO waste gas	CO % in waste gas 0.6 % Waste gas volume 3,000 Nm³/t-s CO burning heat 3,000 kcal/Nm³	55 Mcal/t	45 Mcal/t
	Heat loss		21 Mcal/t	6 Mcal/t
	Total		500 Mcal/t	368 Mcal/t
Electric consumption		39.3 kWh/t× 2,450 kcal/kWh	96 Mcal/t	79 Mcal/t
Heat recovery		None	0 Mcal/t	-30 Mcal/t
Total energy consumption			596 Mcal/t	417 Mcal/t



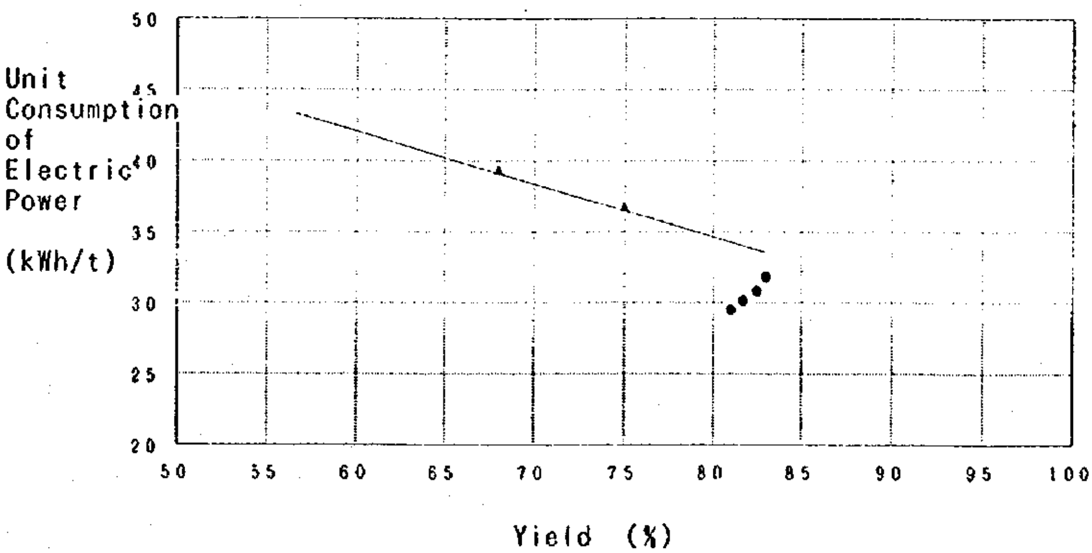


Fig. II.3-7. Change in Unit Consumption of Electric Power

3.2.5 Measures and estimated effects

Table II.3-12 shows the energy-saving measures for the model plant and their estimated effects. Operational measures will save energy by 5Mcal/t, improvement of facilities by 16 Mcal/t, and facilities expansion by 90 Mcal/t, amounting to 111 Mcal/t of energy saved in total. And the energy unit consumption in 2002 is estimated to be about 485 Mcal/t. Though this effect is based on the production quantity of 1992, the similar effect can be expected for 2002.

Table II.3-13 shows the heat balance of the sintering process in 2002, which will be roughly similar to the level in Japan if the raw material conditions are compensated for.

Table II.3-12. Energy-Saving Measures for Sintering Plant and Estimated Effects (1/2)

1) Overall

Ranking of measures		Outline of measures		Estimated effects	
I	Improvement of operation	1. Improvement of burning			
		(1) Avoidance of excessive air at the pallet sides	Enhancement of the compaction of the sinter bed at the pallet sides	Yield 0.2%	(Coke 0.1 kg/t) (ΔE 0.1 kWh/t)
		(2) Avoidance of large coke breeze sizes	Enhancement of the crushing of coke breeze		
		2. Prevention of air leakage			
		(1) Prevention of the air leakage around the pallets	Maintenance of the pallet side walls and grate bars	Air leakage 3% decrease Yield 0.5%	(ΔE 0.6 kWh/t) (Coke 0.2 kg/t) (ΔE 0.3 kWh/t)
		(2) Prevention of the air leakage around the EP	Maintenance of the seal portions	Air leakage 2% decrease	(ΔE 0.4 kWh/t)
II	Partial modification of equipment	1. Improvement of burning Avoidance of excessive air at the pallet sides	Mounting of blind grate bars to the sides	Yield 0.5% Air leakage 1% decrease	(Coke 0.2 kg/t) (ΔE 0.3 kWh/t) (ΔE 0.2 kWh/t)
		2. Improvement of the ignition furnace Prevention of the penetration of cold air into the ignition furnace	Enhancement of the seal of the ignition furnace Improvement of the control of the air volume sucked under the ignition furnace		(COG 2.0 Nm3/t)
		3. Prevention of air leakage			
		(1) Modification of the pallet seal mechanism	Seal bar construction Dead plate construction Construction of seals between pallets	Air leakage 5% decrease	(ΔE 1.0 kWh/t)
		(2) Modification of various kinds of valves	Main exhaust pipe, EP dust valve, etc.	Air leakage 5% decrease	(ΔE 1.0 kWh/t)
III	Expansion and renewal of equipment	1. Enhancement of the operation control system			
		(1) Enhancement of the operation control system	Measurement of the cold strength of sinter product	Yield 2.0%	(Coke 1.0 kg/t) (ΔE 1.2 kWh/t)
		(2) Partial renewal of each weighing machine	Improvement of the weighing-out accuracy of raw materials and fuels	Coke breeze	(Coke 2.0 kg/t)
		2. Improvement of burning			
		(1) Improvement of the burden distribution	New-type charging device	Yield 3%	(Coke 1.5 kg/t) (ΔE 1.8 kWh/t)
		(2) Enhancement of the sizing of coke breeze	Installation of a recrushing system for large coke breeze	Coke breeze	(Coke 3.5 kg/t)
		3. Ignition furnace Great heat loss because of atmosphere ignition	Replacement with a small-size ignition furnace	Decrease of COG	(COG 4.0 Nm3/t)
		4. Recovery of cooler waste heat			
		(1) Preheating of the raw material mix and the combustion air for the ignition furnace		Yield 0.5% Decrease of COG	(Coke 0.2 kg/t) (ΔE 0.3 kWh/t) (COG 0.5 Nm3/t)
		(2) Installation of new equipment for recovering the sensible heat of waste gas at about 300°C in the No.6 sintering plant			(Steam 15 kg/t)
		(5) Production increase			
		(1) Improvement of operational availability	Yard stock system for sinter product	Production increase	(ΔE 1.4 kWh/t) (Coke 0.6 kg/t)
		(2) Improvement of permeability	Quick lime adding system	Yield 1% increase Production increase	(Coke 1.0 kg/t) (ΔE 2.0 kWh/t)

Table II.3-12. Energy-Saving Measures for Sintering Plant and Estimated Effects (2/2)

2) Results of improvement in energy consumption

Energy item	Unit	SIDEX		Japan
		Before the improvement	After the improvement	
Coke breeze	kg/t	67 (72)	56.7 (-10.3)	50
COG	Nm³/t	9	2.5 (-6.5)	1.5
Electric power	kW/t	40	29 + 5* (-6)	32
Yield	%	(68)	(76) (+8)	(84)
Air leakage	%	(66)	(50) (-16)	(33)
Energy consumption	Mcal/t	596	485 (-111)	417

Difference between SIDEX after the improvement and Japan

Coke breeze
- Difference in calorie 2.8 kg/t
- Difference in yield 2.4 kg/t
- Difference in scale consumption 2.9 kg/t (Japan 21 kg/t)

Yield
- Difference in slag content of raw material 5% (Sv/T.Fe: 0.6/0.4)
- Difference in quick lime consumption 1% (Japan 13 kg/t)

* Increase due to installation of energy saving and environmental facilities

3) Summary of improvement in energy consumption

	Coke breeze Mcal/t (kg/t)	COG Mcal/t (Nm³/t)	Electricity Mcal/t (kW/t)	Total Mcal/t
Improvement of operation	2.0 (0.3)		3.4 (1.4)	5.4
Partial modification of equipment	1.4 (0.2)	8.5 (2.0)	6.1 (2.5)	16.0
Expansion and renewal of equipment (Increase in electric power)	66.6 (9.8)	19.1 (4.5)	16.4 (6.7) -12.0	90.1
Total	70.0	27.6	13.9	111.5

Table II.3-13. Heat Balance for Sintering Process(2002)

	Items	SIDEX Remarks	SIDEX Mcal/t-sinter	Japan
INPUT	Coke breeze	Coke consumption 56.7 kg/t Calorific value 6,800 kcal/t	385 Mcal/t	355 Mcal/t
INPUT	COG	COG consumption 2.5 Nm³/t Calorific value 4,250 kcal/Nm³	10 Mcal/t	8 Mcal/t
INPUT	Sulfur oxidizing heat	Sulfur unit value 1.0 kg/t-s Calorific value 2,500 kcal/kg	3 Mcal/t	1 Mcal/t
INPUT	Sensible heat of material	Material volume 1,747 kg/t-s Specific heat 0.22 kcal/kg ℃ Mean temp 11 ℃	4 Mcal/t	4 Mcal/t
INPUT	Total		402 Mcal/t	368 Mcal/t
OUTPUT	Sinter cake sensible heat	Sinter cake 1,313 kg/t Specific heat 0.22 kcal/kg ℃ Temperatuer 450 ℃	130 Mcal/t	119 Mcal/t
OUTPUT	Waste gas sensible heat	Waste gas volume 2,000 Nm³/t Specific heat 0.32 kcal/Nm³℃ Waste gas temp 90 ℃	58 Mcal/t	53 Mcal/t
OUTPUT	Resolution heat of limestone	Limestone consumption 213 kg/t Resolution heat 426 kcal/kg	91 Mcal/t	76 Mcal/t
OUTPUT	Resolution heat of combined water	Combined water 1.5 % Raw material 987 kg/t-s Resolution heat 1,200 kcal/kg	18 Mcal/t	23 Mcal/t
OUTPUT	Latent heat of sinter mix H_2O	Moisture in sinter mix 6 % Sinter mix volume 1,580 kg/t-s	51 Mcal/t	46 Mcal/t
OUTPUT	Latent heat of CO waste gas	CO % in waste gas 0.8 % Waste gas volume 2,000 Nm³/t-s CO burning heat 3,000 kcal/Nm³	48 Mcal/t	45 Mcal/t
OUTPUT	Heat loss		6 Mcal/t	6 Mcal/t
OUTPUT	Total		402 Mcal/t	368 Mcal/t
Electric consumption		(29 +5)kWh/t × 2,450 kcal/kWh	83 Mcal/t	79 Mcal/t
Heat recovery		--	(3 Mcal/t)	-30 Mcal/t
Total energy consumption			485 Mcal/t	417 Mcal/t

3.3 Blast Furnace

3.3.1 Outline of the facilities and present situation of the energy-saving facilities

The blast furnaces consume the maximum energy in SIDEX, and since the fuel ratio is high compared with that in Japan, energy saving of blast furnaces will bring about the largest energy-saving effect on the whole SIDEX.

The main specifications of the blast furnaces are shown in Table III.3-14. Four small BFs of about 1,800 m^3, one medium BF of about 3,000 m^3, and one large BF of about 4,000 m^3 (No.6 BF, model plant). In this No.6 BF, natural gas is blown in as auxiliary fuel.

As energy-saving facilities, top pressure recovery turbines (TRT) are usually installed in Japanese high-pressure large BFs, but not in SIDEX. Hot stove waste gas recovery equipment is not installed in SIDEX, either.

3.3.2 Operational status

1) Production quantity

The annual production of about 6 million tons by six BFs in 1989 has lowered because of the decline of demand to the present 2.5 million tons by three BFs (Nos. 2, 3, and 6).

2) Life of BF

BFs started up in succession at intervals of a few years, starting with No.1 BF in 1968 and coming to No.6 BF in 1981. The life of BF is, however, as short as 6 to 7 years, compared with 10 to 16 years of the latest model.

3) Life of hot stoves

No.6 BF is equipped with four hot stoves of DIDIER external combustion type, but the life is as short as 6 to 7 years, compared with more than 20 years of Japanese one. The life of ceramic burners is also as short as 2 to 3 years, compared with about 20 years of Japanese one.

4) Life of tuyeres

The life of tuyeres is as short as 60 to 80 days, compared with about 1 year of Japanese one. To raise the operational availability of BF, elongation of the tuyere life is inevitable.

5) Raw materials for BF

Sintered ore made of mainly the iron ore from Krivoirog in Ukraine occupies about 80%, and the remaining 20% is the oxide pellets from Krivoirog. The purchase of raw materials, however, is presently unstable and the pellet mixing ratio greatly fluctuates between 0% and 40% every month. Furthermore, T.Fe of sintered ore is as low as around 50%, which explains why the BF slag ratio is as high as 450 kg/t, higher than that of Japan by as much as 150 kg/t. To target stable operation of BF, long-term stable procurement of BF raw materials should be secured.

6) Operational parameters

The operational parameters between SIDEX No.6 BF and Japanese one are compared in Table II.3-15.

There are many differences. The parameters that deserve the most careful attention for energy saving are the fuel rate and the productivity.

The fuel rate of No.6 BF is higher than that of Japan by about 60 kg/t. Decrease of this high fuel rate naturally leads to large energy saving and energy cost reduction. Since the high fuel rate increases the BFG recovery as shown in Fig. II.3-8 but at the same time increases the blast air as shown in Fig. II.3-9, decrease of the fuel rate is needed.

The productivity is as low as about a half of that in Japan mainly due to the present reduction of production.

In terms of energy saving, however, this should be avoided as much as possible and efforts should be made to improve the productivity through sufficient study of the operation plan.

For high productivity, the furnace top pressure has to be increased. If more than 6,000 t of daily production is desired, the furnace top pressure should be higher than 2 kg/cm^2 as shown in Fig. II.3-10.

Table II.3-14. Specification of Blast Furnace

	No.1 BF	No.2 BF	No.3 BF	No.4 BF	No.5 BF	No.6 BF
Present Status	Operating	Banking	Operating	Relining	Relining	Operating
Working Volume	1,700 m3	1,700 m3	1,700 m3	1,700 m3	2,700 m3	3,500m3
Inner Volume	1,824 m3	1,824 m3	1,824 m3	1,824 m3	3,124 m3	4,102 m3
Hearth Diameter	9.1 m	9.1 m	9.1 m	9.1 m	11.6 m	13.2 m
Tuyere	22	22	24	24	32	36
Tap Hole	1	1	2	2	2	4
Cast Floor	1	1	2	2	2	2
Type	Girder	Girder	Girder	Girder	Free-standing	Free-Standing
Fuel Injection	-	-	-	PCI(1996)	PCI(1996)	Natural Gas
Charging Equipment	2 Bell&Valve seal	2 Bell&Valve seal	2 Bell&Valve seal	2 Bell&Valve seal	2 Bell&Valve seal	PW
Charging Conveyor	Skip	Skip	Skip	Skip	Skip	Belt Conveyor
Movable Amour	Movable Amour	Movable Amour	Movable Amour	Movable Amour	Movable Amour	PW
Top Pressure (kg/cm2)	1.5 (1.2)	1.5 (1.2)	1.5 (1.2)	1.5 (1.2)	2.0 (1.5)	2.5 (1.7)
TRT	-	-	-	-	-	-
Cooling Equipment	Stave Cooler	Stave Cooler	Stave Cooler	Stave Cooler	Stave Cooler	Stave Cooler
Cast House:Main Runner	12 x 2.6	12 x 2.6	12 x 2.6	12 x 2.6	14 x 2.8	14 x 2.8
Slag Treatment	Granulation 98 %	Granulation 98 %	Granulation 98 %	Granulation 98 %	Granulation 98 %	Granulation 98 %
HOT STOVE						
Type						
Pressure (kg/cm2)	3	3	3	3	4	5
Blast Temperature (°C)	1,200	1,350	1,350	1,350	1,350	1,350
Blast Volume (Nm3/min)	3,700	3,700	3,700	3,700	5,000	6,000
Gitter Brick (t)	3,800	3,600	3,600	3,700	3,800	4,000
Shell	4.4 m2 x 35 m	4.4 m2 x 26 m	4.4 m2 x 26 m	D 4.2 x 27 m	D 4.2 x 30.5 m	D 4.2 x 35 m
	D 9.0 x 35 m	D 9 x 26 m	D 9 x 26 m	D 8 x 27 m	D 8 x 30.5 m	D 8 x 35 m
Heating Surface (m2/st)	35,000	43,000	43,000	56,420	48,730	56,700
Dome Temperature (°C)	1,300	1,450	1,450	1,550	1,550	1,550
Burner Type	Ceramic	Ceramic	Ceramic	Ceramic	Ceramic	Ceramic
Combustion Air Blower	71,000 Nm3/hx1	71,000 Nm3/hx1	71,000 Nm3/hx1	71,000 Nm3/hx1	136,000 Nm3/hx1	136,000 Nm3/hx1
(Pressure: mmH2O)	510	510	510	510	850	850
Recuperater	-	-	-	-	-	-
GAS CLEANING EQUIP.						
Dust Catcher	-	-	-	-	-	-
Venturi Scrubber	220,000 Nm3/h	220,000 Nm3/h	220,000 Nm3/h	220,000 Nm3/h	360,000 Nm3/h	720,000 Nm3/h
Electric Precipitator	-	-	-	-	-	-
COMPUTER CONTROL						
Process Computer	-	-	EC881x2	EC881x2	AEG8020	AEG8020
					SPOT85	EC881x2

Note: The values in parentheses show max. operating data.

Table II.3-15. Comparison of Data among SIDEX, Japan, and Kobe Steel in 1992 (Average Value)

		Unit	SIDEX No.6 BF	Japan (Av.)	Kobe Steel (Av.)
Productivity		t/cum	0.97	1.86	1.82
Coke Rate		kg/t	539	432	382
Aux. Fuel Rate		kg/t	39.5 (NG)	81 (PCI)	132 (PCI)
Sinter Ratio		%	85	77	54
Pellet Ratio		%	14	8	31
Blast Volume		Nm^3/min	4,611	4,928	4,812
Blast Temperature		℃	961	1,095	1,097
Blast Pressure		kg/cm^2	2.46	3.72	3.91
Top Pressure		kg/cm^2	1.32	2.27	2.28
Slag Rate		kg/t	455	310	282
Si in Hot Metal		%	0.89	0.44	0.36
BFG		Nm^3/t	2,033	1,673	1,680
TRT Recovery		kWh/t	-	39.8	42.8
HS Recovery		Mcal/t	-	17.8	23.5
H S	BFG	Nm^3/t	661	384	374
	COG	Nm^3/t	3	19	5
	Other Fuels	Nm^3/t	14 (NG)	16 (LDG)	59 (LDG)
HS Heat Efficiency		%	78	85	88

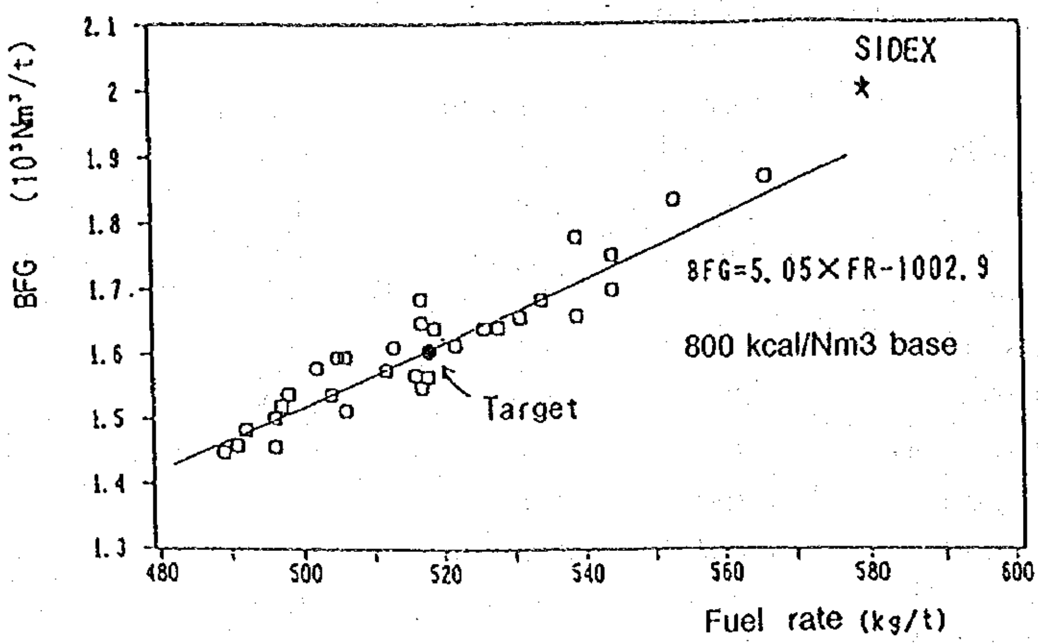


Fig. II.3-8. Relationship between Fuel Rate and BFG

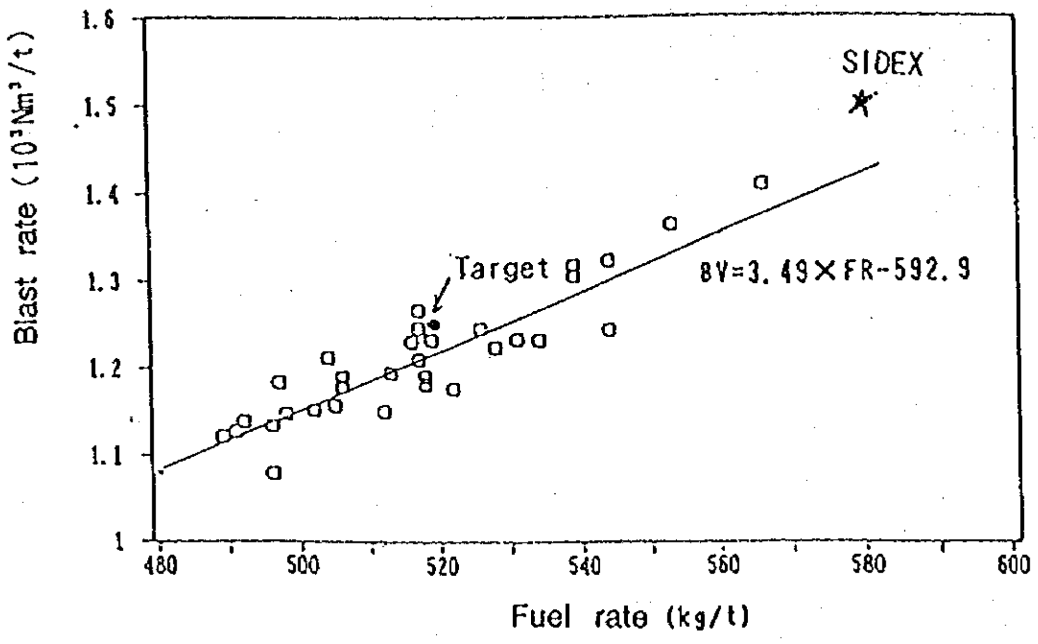


Fig. II.3-9. Relationship between Fuel Rate and Blast Rate

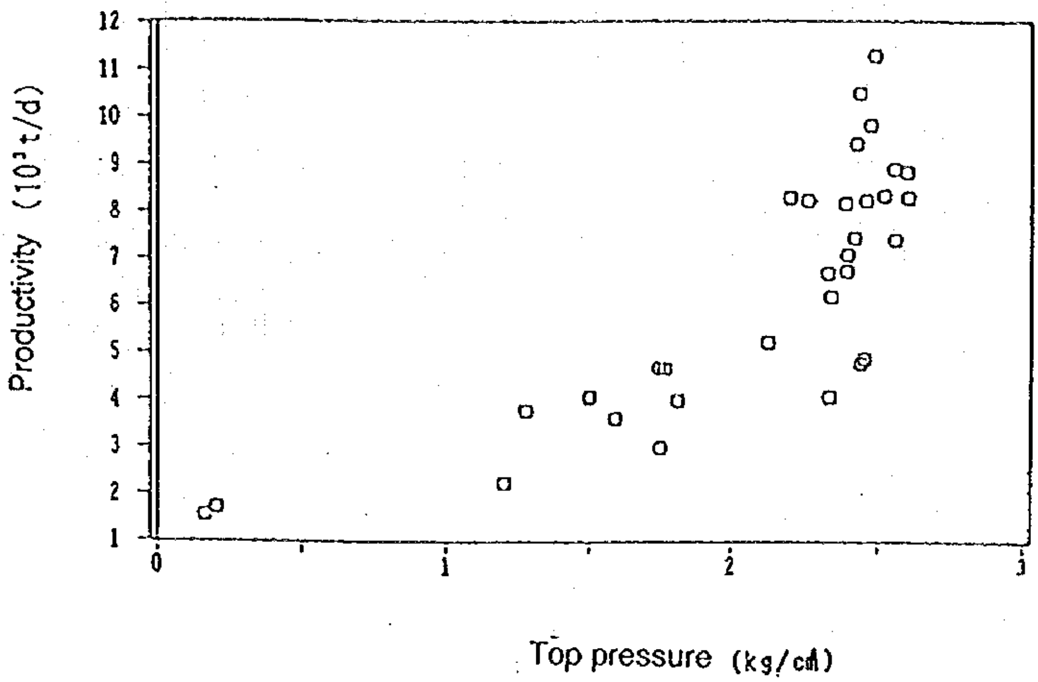


Fig. II.3-10. Relationship between Top Pressure and Productivity

3.3.3 Production balance

The production balance in 2002 as the basis for the study of energy-saving measures is shown in Table II.3-16.

Table II.3-16. Production Condition in 1992 and 2002

	Item	No.1 BF	No.2 BF	No.3 BF	No.4 BF	No.5 BF	No.6 BF	Total
	Capacity (m^3)	1,824	1,824	1,824	1,824	3,128	4,102	14,526
1992	Operation Status	Stop	Operating	Operating	Stand-by	Stand-by	Operating	-
	Productivity	–	0.82	0.83	–	–	0.97	-
2002	Operation Status	Stop	Stop	Stand-by	Stand-by	Operating	Operating	-
	Coke Rate PC Ratio	–	–	–	–	370 kg/t 150 kg/t	370 kg/t 150 kg/t	-
	Productivity	–	–	–	–	1.8	1.8	-
	Production (kt/y)	–	–	–	–	2,063	2,707	4,770

1) BF fuel rate

SIDEX plans to lower the BF fuel rate from the present 580 kg/t to 480 kg/t in 2002, which may be difficult considering the present operating techniques, raw material conditions, and furnace top pressure.

To be more practicable, after measures such as installation of PCI system, revamping of blowers, and installation of sensors for confirmation of furnace conditions are taken at the relining of No.6 BF in 1996, the fuel rate should aim at 520 kg/t in 2002 (PCI rate 150 kg/t and coke rate 370 kg/t, almost similar to Japanese BF), which is slightly higher than the expected lowest level 510 kg/t.
See Section II.3.3.5 for the measures.

2) BF operation plan

SIDEX plans to use Nos. 4, 5, and 6 BFs for 2002. Because the average productivity is 1.44 (tapped quantity per day/inner volume), which is around the lower limit in Japan, BF operation will be even insufficient compared with other steelworks such as those in the West in terms of productivity and energy saving. The relationship between productivity and fuel rate in Japanese Blast Furnaces is shown in Fig. II.3-11. As shown in this figure, there is an inverse proportion with productivity and fuel rate. For obtaining fuel rate below 520 kg/t, productivity has to be more than 1.7. Therefore, at the average production in 2002, use of large Nos. 5 and 6 BFs at the productivity 1.8 is preferable. However if the present operational availability is maintained, productivity 2.0 has to be attained. Therefore measures for raising the operational availability recommended in Section II.3.3.5 are required.

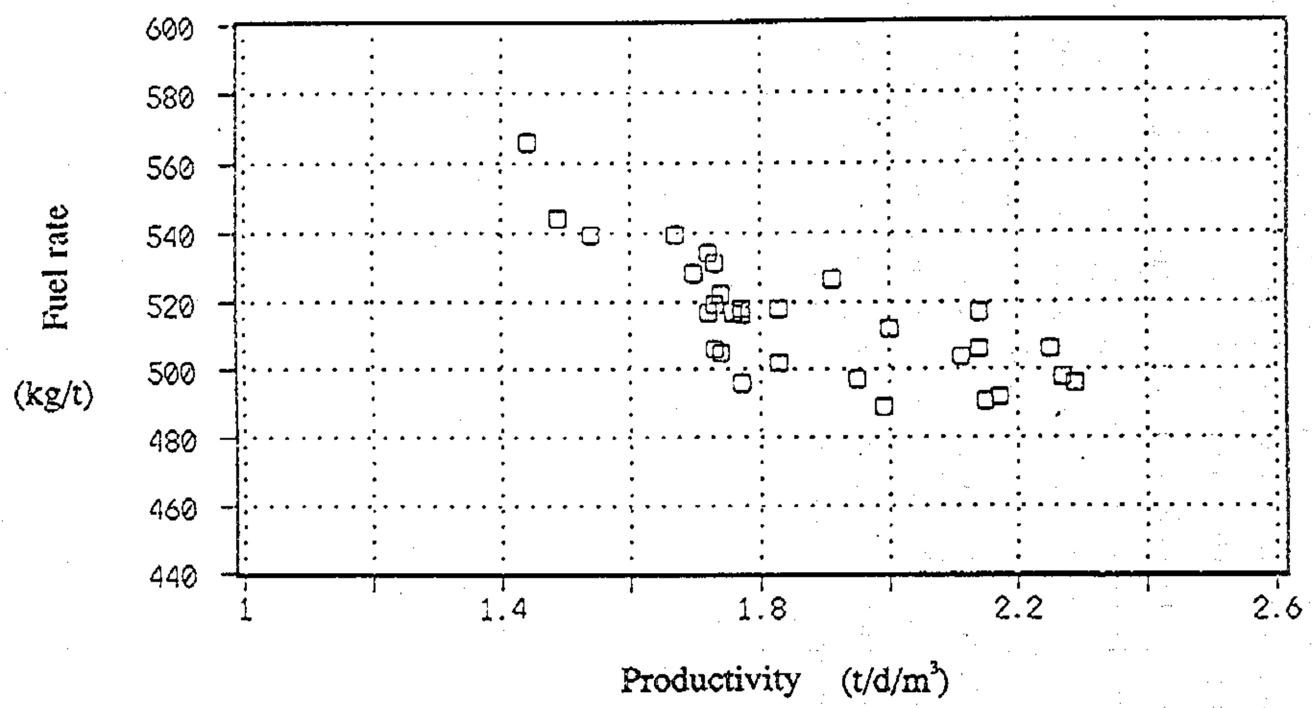


Fig.II.3-11. Relation between productivity and fuel rate for Japanese BF in '92

3.3.4 Analysis of the problems found

3.3.4.1 Analysis of heat loss in the heat balance

Table II.3-17 shows the heat balance for the BF and hot stove.

1) BF proper

The input heat in No.6 BF is 4.6 Gcal/t, higher than that of Japan by about 400 Mcal/t, mostly because the fuel rate in SIDEX is higher than that of Japan by about 60 kg/t. Blast input heat is also higher than Japan by about 45 Mcal/t, because the high fuel rate raises the blast air unit consumption higher than that of Japan by about 300 Nm^3/t. (The blast air temperature in SIDEX is lower than that of Japan by 130°C.) Because the input heat is higher, the recovery of sensible heat of BFG is larger than that of Japan by 350 Mcal/t, while the heat loss from the BF shell is larger by 90 Mcal/t.

2) Hot stove (HS)

The input heat to the hot stove in No.6 BF is higher than that of Japan by 110 Mcal/t. As seen in terms of the output heat, the difference 45 Mcal/t is caused by the higher blast air unit consumption, while the difference 85 Mcal/t is caused by the differences of heat loss from waste gas or HS body. The difference 20 Mcal/t is caused by existence/nonexistence of waste gas recovery facilities. The difference in heat loss of waste gas and HS body is possibly caused by (1) excess air combustion as seen in the O2 concentration as high as 4-5% in waste gas, compared with 1-2% in Japan, (2) larger radiation heat from hot stove due to long flame, and (3) no application of heat-insulating material to the hot stove shell.

3.3.4.2 Analysis of the operating data

The most effective energy-saving measure is to decrease the fuel rate as judged from the operating data. The operating condition of the No.6 BF using RIST model is as analyzed below (see Fig. II.3-11):

(1) The inclination is larger because of the higher fuel rate. The gas reduction efficiency, shown in point A, is lower, and the input oxygen rate shown in point B is larger.

(2) The shaft efficiency, shown by the difference between the point W (equilibrium point with Wustite) and the operation line, is as low as 79.2% compared with the Japanese 95.6%, showing a quite low BF reduction efficiency.

Considering the above, since the direct reduction rate shown by point D is high in spite of the high fuel rate, improvement of reducibility of raw materials and BF gas distribution control technique is important.

Based on the above, improvement plan should be framed. The decrease of fuel rate will be as follows compared with that of Japan:

Item	Decrease of fuel ratio	Method
• Decrease of slag ratio	29 kg/t	Increase of T.Fe in iron ore
	10 kg/t	Decrease of ash content of coke
• Decrease of moisture in blast air	- 17 kg/t	

• Improvement of heat loss	17.5 kg/t	• Optimization of BF gas distribution (improvement of burden distribution and optimization of circumferential blasting condition) • Improvement of permeability and high pressure operation • Improvement of reducibility of raw materials
• Improvement of operational availability	7.6 kg/t	Modification of tuyere

The above improvement of heat loss will lead to the improvement of shaft efficiency from the present 79% to the level as high as in Japan, which will bring about the following decrease of fuel rate:

Item	Decrease of fuel rate
• Increase of blast air temperature	13.9 kg/t
• Decrease of Si in hot metal	10 kg/t

Conclusively, the target fuel rate of No.6 BF should be around 520 kg/t considering the present situation of SIDEX. This affords operation at the fuel rate 510 kg/t, which decreases the fuel rate by about 70 kg/t.

Table II.3-17. BLAST FURNACE & HOT STOVE ENERGY BLANCE (SIDEX JAPAN)

Hot Stove

Hot Stove	SIDEX 6 BF(93)	JAPAN (92)
HS Input	628	518

	Items	Mcal/t	%	Mcal/t	%
Cold blast (sensible heat)	Dry air	46	7.3	67	12.9
	Moisture	1	0.2	3	0.6
	O_2 enrichment	0	0	1	0.2
Combustion heat	BFG	499	75.1	293	56.6
	COG	16	2.6	91	17.6
	Natural gas	47	7.5	LDG 32	6.2
Fuel gas and combustion air (sensible heat)	BFG	10	1.7	7	1.3
	COG	0	0	0	0
	Natural gas	0	0	-	-
	Combustion air	7	1.1	6	1.1
	Preheater recovery heat	0	0	18	3.5

HS

Blast Furnace

Blast Furnace	SIDEX 6 BF(93)	JAPAN (92)
Heat Input	4604	4178

	Items	Mcal/t	%	Mcal/t	%
Combustion heat	Coke	3731	81.0	3061	73.2
	PC	0	0	605	14.5
	Oil/Natural gas	318	6.9	20	0.5
	Slag formation	64	1.4	43	1.0
	Burden material (sensible heat)	7	0.2	7	0.2
	total	4119	89.5	3736	89.4

	Items	Mcal/t	%	Mcal/t	%
Hot Blast (sensible heat)	Dry air	479	10.4	414	9.9
	Moisture	6	0.1	21	0.5
	O_2 enrichment	0	0	7	0.2
	total	485	10.5	442	10.6

	Items	Mcal/t	%	Mcal/t	%
Heat-loss	Heatloss from HS	75	11.9	24	4.6
	Exhaust gas	68	10.8	34	6.6
	Total	143	21.9	58	11.2
	Preheater recovery heat	0	0	18	3.5

BF

	SIDEX 6 BF(93)	JAPAN (92)
Heat Output	4604	4178

	Items	Mcal/t	%	Mcal/t	%
	BFG (Latent heat)	1626	35.3	1269	30.4
Reduction heat	Fe	1614	35.1	1639	39.2
	Si, Mn, P	81	1.8	44	1.1
Sensible heat	Hot metal	300	6.5	318	7.6
	Slag	192	4.2	138	3.3
	Carbon in metal	356	7.7	384	9.2
	Decomposition heat(lime stone)	0	0	1	0
	total	2543	55.2	2524	60.4
	Carbon in dust	33	0.7	53	1.3
Heat-loss	Top gas (sensible heat)	77	1.7	97	2.3
	Heat loss from furnace	325	7.1	235	5.6
	total	402	8.8	332	8.0

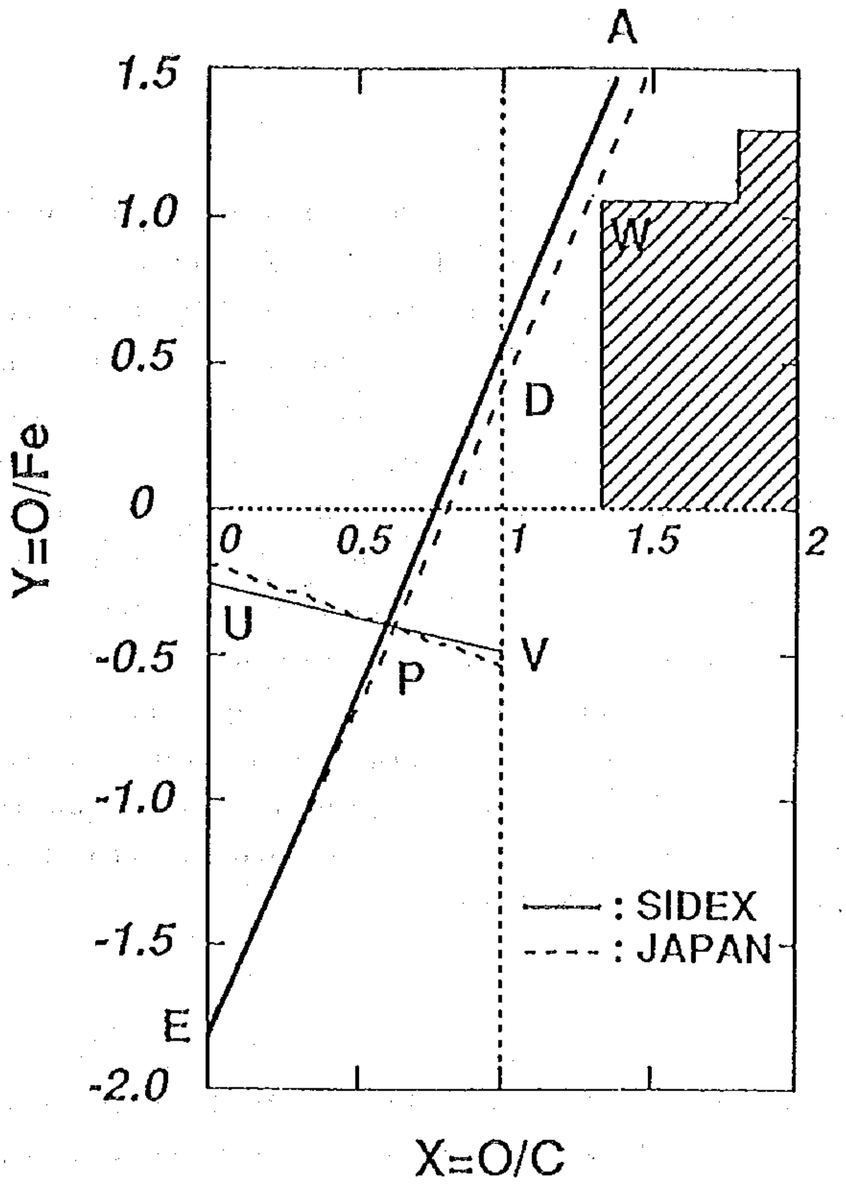


Fig.II.3-12. Rist Diagram

3.3.5 Countermeasures and estimated effects

3.3.5.1 Philosophy of countermeasures

1) Fuel rate

In order to lower the fuel rate, the stable operation of BF is indispensable for improving the performance of BFs. This can be achieved by increasing the availability of facilities and securing the furnace permeability, and stabilization of the raw material and intensifying of tapping and slagging control. Furthermore it is important to obtain the improvement of reductivity and heat efficiency. For this purpose, it is necessary to check the in-furnace state of the cohesive zone, the gas flow in furnace, the deadman coke by using the daily sensors, and on the base of these information it is inevitable to use the control system adjusting the burden distribution at the throat and blast condition. And it is important not only of the increasing the reliability and replacing of controller and monitor for the operation of BF, but also renewal the cooling equipment of BF body and the cast house equipments and layout to intensify of tapping and slagging at the rebuilding of BF.

2) PCI

After achieving the PCI rate of 150 kg/t, the big energy saving effect will be obtained by stopping the now operating small coke ovens (No.1-4 CO) on the balance of coke supply. PCI 150 kg/t is not easy to inject, which is rather high even if in Japan. However, before injecting at the No.6 BF, the small BFs No.4, 5 BF is injected. By the experience of PCI operation and below mentioned countermeasures, it will be able to achieved the level of this PC rate.

: Application of above mentioned monitoring and controlling

: Application of the operation and equipment technique (ref. 3)

: Increasing the strength of coke

: Renewing the blower

The capacity of PC injecting at No.6 BF is decided 200 kg/t in order to apply the future capability of increasing the amount of PCI and reduction of the purchased coke in future and decreasing the coke product capacity in future by the life of coke oven.

3) Technique of massive PC injection

Fig. II.3-14 shows the phenomenon in the furnace as all coke operation (Left Fig) and PCI operation (Right Fig). This means that increased PC rate changes not only Ore/Coke ratio but also increasing of top gas temperature by decreasing the heat flux ratio, increasing the heat-loss from the furnace body by increasing of peripheral gas flow and inactivation of the deadman coke by increasing of unburnt PC. Therefore, the countermeasures as shown in the right column in Fig. II.3-14 must be necessary. As the concept of the coke center charging method which is the most important countermeasure, is shown in Fig. II.3-15, Kobe Steel, Kakogawa No.1 BF is stably continuing injecting more than 190 kg/t PC by the technique of the center coke charging and the control of PC injecting position. In SIDEX, it is inevitable to apply the operation technique for PCI. And it is able to introduce the center coke charging method by bell-less charging in No.6 BF and by newly installed one in No.5 BF.

4) Renewing the blower for BF

As shown in Table II.3-18, the capacity of now installed blower is 3.3 kg/cm2 for the design capacity of 5.0 kg/cm2. Therefore, this causes the decreasing the capacity of productivity and the increasing fuel rate by increasing the gas velocity in BF. On the other hand, the blast pressure is predicted to be increased till 4.25 kg/cm2 for future increasing productivity and increasing PC rate. Then it is desired to renew the whole installation.

Table II.3-18. Blower of Blast Furnace

		Present	Future (2002)	
Productivity (t-p/d)		5,000	8,000	8,000
PCI (kg/t-p)		0	0	200
	Blast Press. (kg/cm²)	2.6	3.6	4.0
	Top Press. (kg/cm²)	1.5	2.0	2.0
	ΔP (kg/cm²)	1.1	1.6	2.0
Blower Press. (kg/cm²)		2.85	3.85	4.25

5) Reduction of energy consumption in the hot blast stoves

The facilities for the hot blast stoves have outstanding features as given below thanks to the incorporation of regenerative-type heat exchangers, using some refractory material to withstand temperature as high as 1,200° - 1300°C in its heating blast.

: Reciprocal operation of heating(combusting) and cooling (blasting) periods.

: Variation of temperatures in the waste gas and the checker chamber outlet.

: Some operating temperature limitations imposed according to structural and heat resisting capacity.

As a result, the above will be enumerated in detail for the sake of planning the facilities of the hot blast stoves, further study of facilities, and general improvement in operation.

As for blast systems in which the blast temperature is to be kept constant against variation of the hot air temperature at the checker chamber outlet, both the single blast system and the staggered parallel blast system are incorporated. Figs. II.3-16, 3-17 give the variation of blast quantity through the checker chamber, variation of outlet blast temperature, variation of waste gas temperature, and temperature distribution of checker chamber bricks respectively for each of the blast systems. Since the checker chamber outlet temperature will be gradually lowered, the mixed cold blast quantity will be reduced in the case of a single blast system, eventually letting the quantity of blast through the checker chamber maximized at the end of the blasting period; but in the staggered parallel blast system, the quantity of blast through the checker chamber will be increased up to a specified amount in the former half of the blasting period, and then reduced so as to supplement the blast quantity of the former half when it enters the latter half of the blasting period. The heat accumulation in the combusting period can be maintained uniformly in the overall checker chamber in the single blast system, because of the temperature variation range of the upper part of the checker chamber being kept between the dome temperature and the blast temperature; but in the staggered parallel blast system, a combination of two units of the blast allows the heat accumulation in the upper part of the checker chamber to be utilized at a temperature lower than the blast temperature. Heat accumulation in the bottom part of the chamber will thus be reduced so that the waste gas temperature will also be lowered. This naturally lead to improved thermal efficiency. The blast temperature vs. thermal efficiency is shown in an arranged form, taking the dome temperature as parameter in Fig. II.3-18, where it is noticed that as the differential between the dome temperature and blast temperature increases, so the utilization of accumulated heat on the upper part of the checker chamber also may increase, resulting in decrease of the waste gas temperature, greatly improving thermal efficiency; on the other hand the available range of blast temperature variation will be limited in accordance with factors such as the upper limit of the waste gas temperature being restricted by the thermal resistivity of the brick-supporting metal,the upper limit of dome temperature being decided by the thermal resistivity of the bricks, etc., and the lowest operating temperature of silica brick.

The flow chart of improvement by the fundamental characteristics is shown in Fig. II.3-19 on the viewpoint from the energy saving in Hot Stove. On the basis of this figure, the improvement of HS in SIDEX is shown below.

Now the heat efficiency of HS is 78%, but it will increase till 83% by the installation of waste gas recuperator. On the other hand it will be necessary to increase the blast temperature, in order to decrease the fuel rate of BF. Then it must be changed from the single blast system to the parallel blast system or staggered parallel blast system which is high heat-efficiency and is able to blast to high temperature. And in order to increase the heat efficiency for combustion period of HS it is necessary to be installed that the introduction of new control system, the oxygen concentration monitoring sensor for waste gas, the quantity control of combustion fuel gas and air, and the gas holder which decreases the variation of BFG pressure.

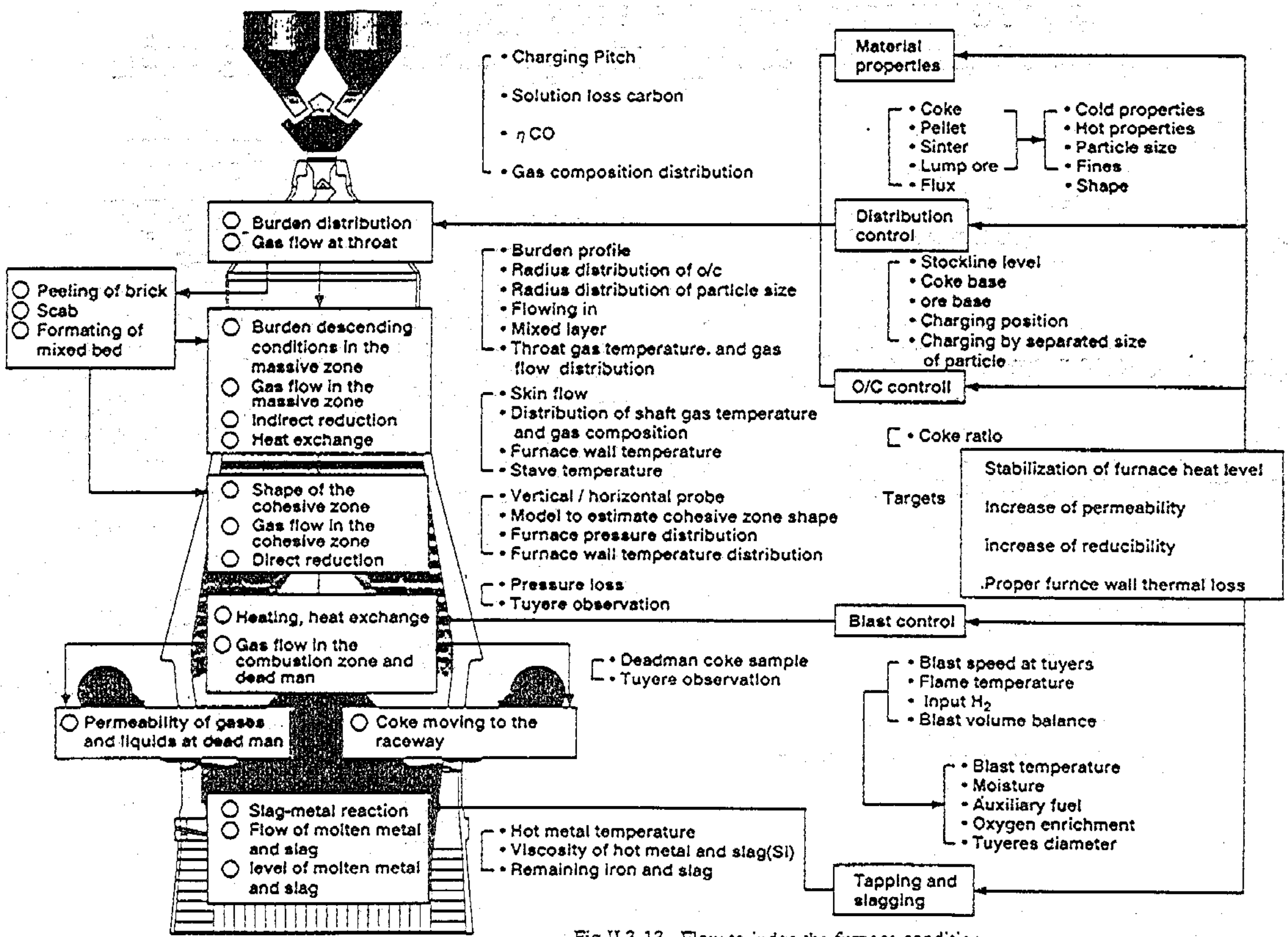


Fig.II.3-13. Flow to judge the furnace condition

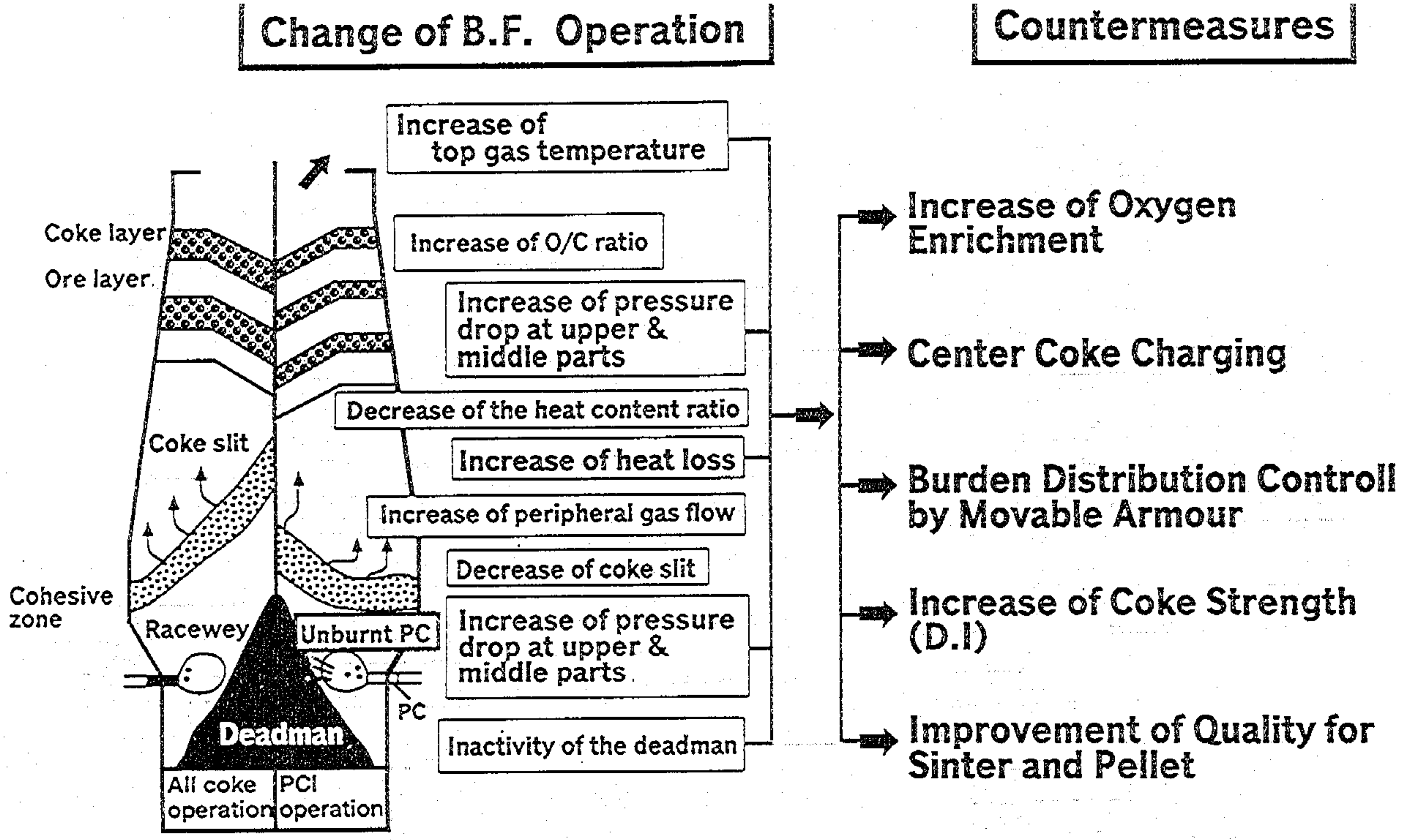


Fig.II.3-14. **Change of Blast Furnace Operation with high PCI Rate and Countermeasures**

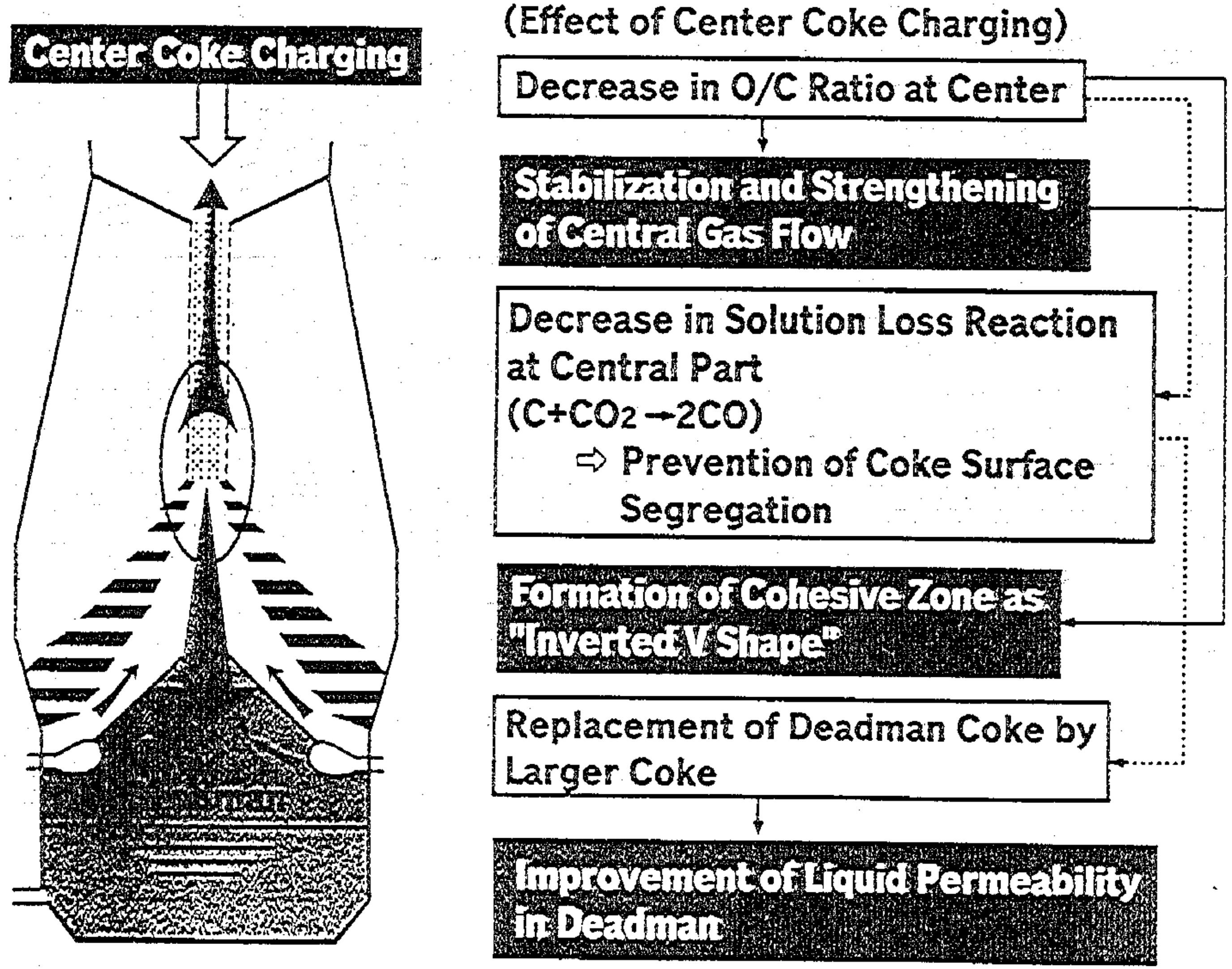
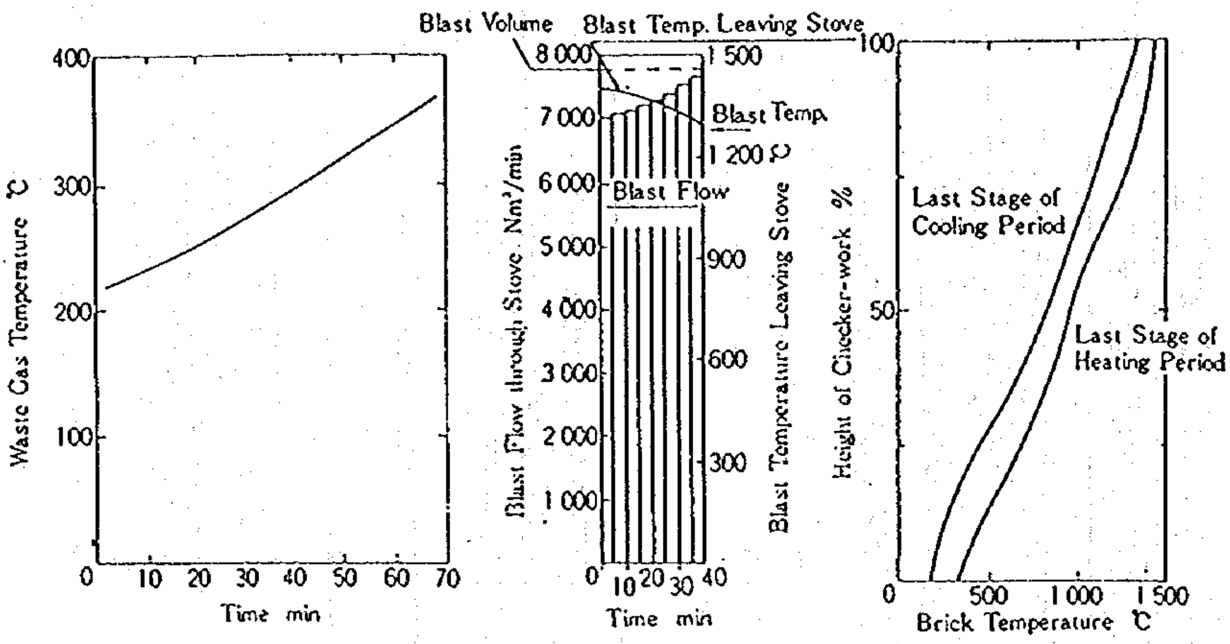
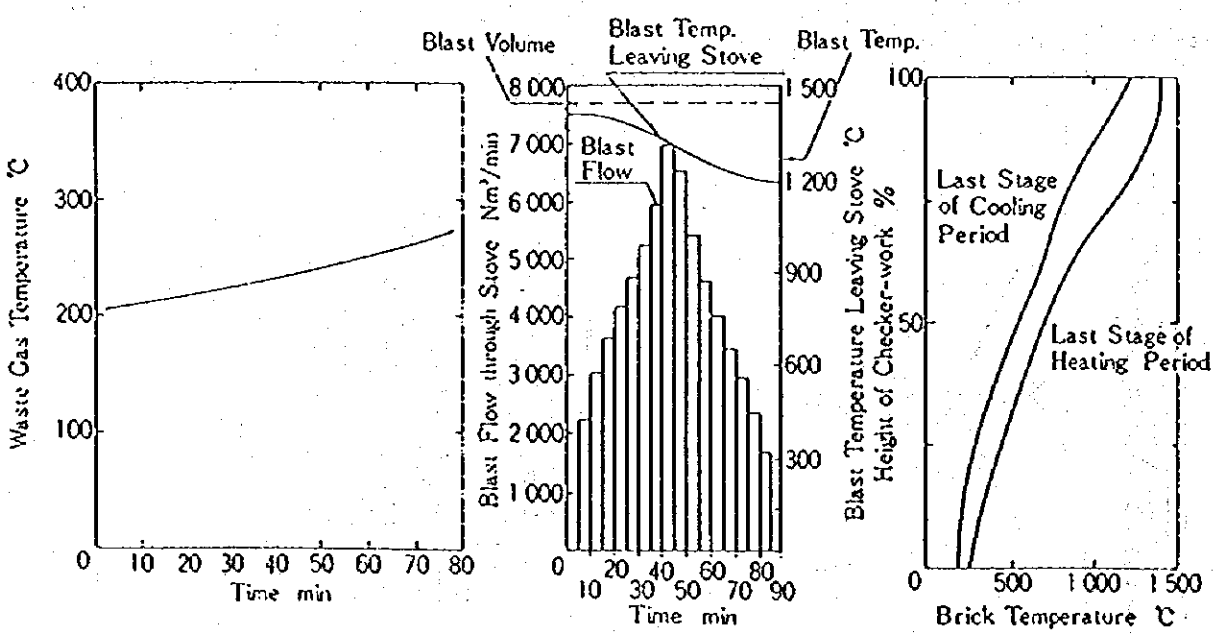


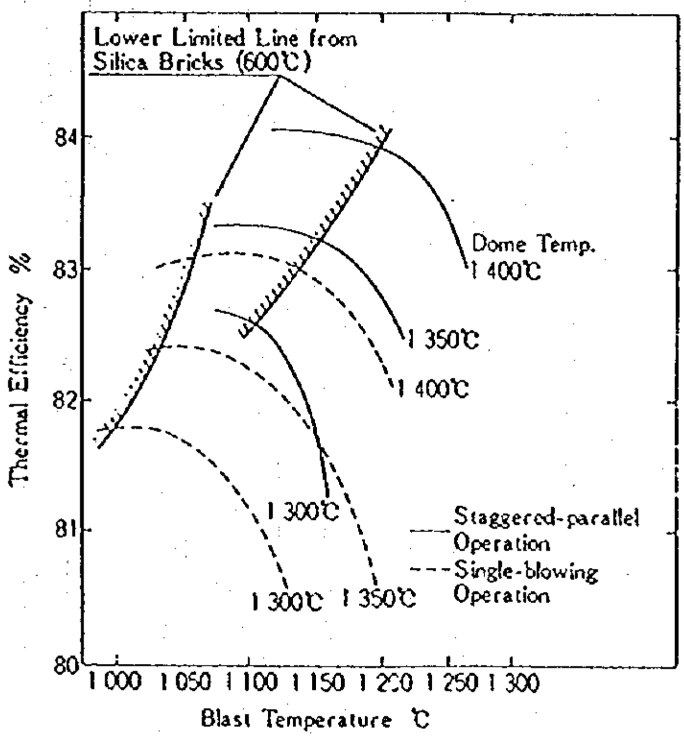
Fig.II.3-15. **Control of in-furnace process using center coke charging method**



シングル送風時の特性
Fig.II.3-16. Characteristics in single-blowing operation

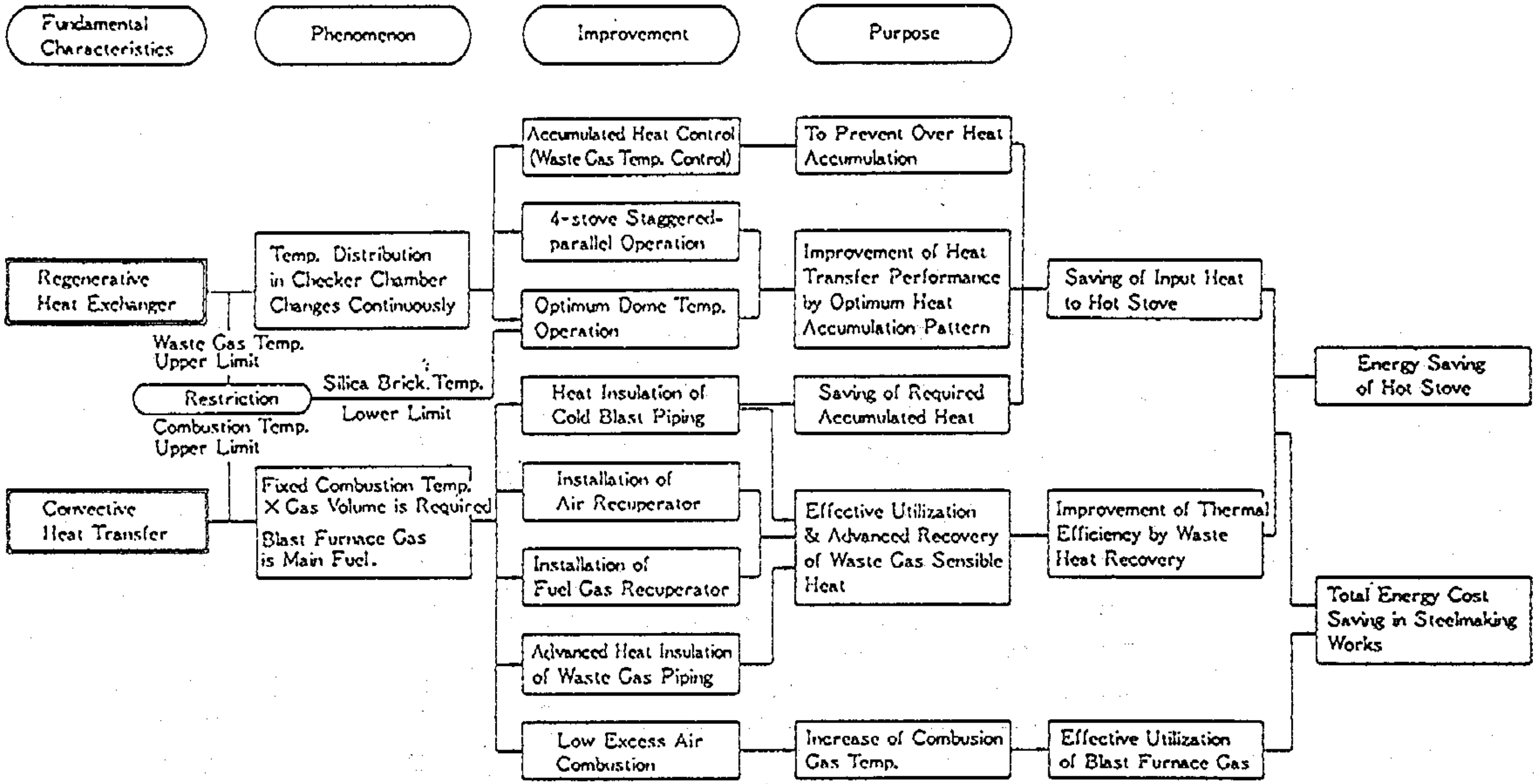


スタッガードパラレル送風時の特性
Fig.II.3-17. Characteristics in staggered-parallel operation



送風温度と熱効率の関係

Fig.II.3-18. Relation between blast temperature and thermal efficiency



基礎特性と改善フロー

Fig.II.3-19. Fundamental characteristics and improvement flow

3.3.5.2 Measures and estimated effects

This section shows the energy-saving measures for the model plant and their estimated effects. As explained so far, the most important in energy saving is to lower the fuel rate and to raise the productivity, which require facility improvements and operational optimization. Accordingly, it is inevitable to establish the optimum operation by introduction of proper operating techniques and training for high PCI, high pellet-ratio operation, etc.

Execution of the energy-saving measures will manifest the effects shown in Table II.3-19.

Table II.3-19. Estimated Operation of BF after Execution of Energy-Saving Measures

	Present	After measures in 2002
BF input heat	4.6 Gcal/t	4.2 Gcal/t
Productivity	1.0	1.8
Fuel rate	580 kg/t	520 kg/t
Coke rate	580 kg/t	370 kg/t
BFG generation	2,000 Nm^3/t	1,570 Nm^3/t
HS input heat	630 Mcal/t	460 Mcal/t
HS efficiency	78%	85%
TRT recovered electric power	-	29 kWh/t

3.3.5.3 Energy saving by improving the operation (including enhanced control of operation and maintenance)

Purposes	Measures	Details of Measures	Estimated Effects in 2002
1. To decrease fuel rate of blast furnace	1. To optimize furnace gas distribution by improving the burden distribution (decreasing the heat loss from furnace body and improving the gas utilization efficiency)	• To secure stable central gas flow by burden distribution control using PW system • To install sensors, such as gas sampler and profile meter, for detection of gas radius distribution	△41.4 kg/t (high-pressure operation base)
	2. To optimize furnace gas distribution by optimizing the blast condition (decreasing the heat loss from furnace body and improving the gas utilization efficiency)	• To secure the raceway depth by optimizing the tuyere wind velocity • To secure the balance of circumferential blast	
	3. To increase the reducibility of raw materials	• To stabilize the blending ratio of sinter and pellet • To stabilize the basicity of sinter at high level • To stabilize the FeO content of sinter at low level • To decrease the size of sinter • To blend small coke into iron ore • To use flux pellet	
	4. To increase furnace permeability	• To increase the cold strength of coke • To improve the high-temperature properties of sinter and pellet (such as making the pellet into flux pellet) • To decrease the fines of iron ore	
	5. To supply high-temperature blast to BF	To increase sensible heat of blast due to decrease of fuel rate	
	6. To decrease Si content in hot metal	To decrease Si content in hot metal (secondary effect)	
	7. To increase operational availability of equipment	To conduct preventive maintenance (utilizing the scheduled BF shutdown)	

Purposes	Measures	Details of Measures	Estimated Effects in 2002
1. To decrease fuel rate of blast furnace (Contd.)	8. To decrease the blast humidity	To decrease the blast humidity in order to lower the moisture decomposition heat	- 17 kg/t
	9. To decrease the slag rate	• To purchase and blend iron ore whose Fe content is higher (to blend iron ore whose SiO_2 content is lower) • To purchase coke whose ash content is lower	△29 kg/t △10 kg/t
2. To decrease the supply volume of blast to BF	To decrease the supply volume of blast per ton of hot metal by decreasing the fuel rate	To decrease the fuel rate by the above measures, which increases the productivity allowing the number of operating BFs to be decreased	1,500 → 1,200 Nm^3/t

3.3.5.4 Energy saving by modifying or improving the equipment (including auxiliary equipment)

Purposes	Measures	Details of Measures	Estimated Effects in 2002
1. To decrease the fuel consumption of hot stove	To improve HS control system	To adopt the staggered parallel blasting method • To conduct lower air ratio combustion (to lower the O2 concentration of HS waste gas by adopting the dome temperature control and selecting optimum blending ratio of fuel gas) • To decrease the waste gas temperature by controlling accumulated heat in hot stove • To adopt the pressure control of fuel gas • To select optimum dome temperature related to blast temperature	4-5% → 1-2%
2. To increase the operational availability of blast furnace	1. To increase the life of tuyere 2. To increase cooling ability	• To change the structure of tuyere for increasing the cooling ability (to increase the velocity of cooling water at tuyere nose, to improve water channel inside tuyere, to improve material of tuyere, to apply lining to upper part of tuyere, etc.) • To increase supply pressure and volume of cooling water (to increase the water pressure at tip of tuyere to 20 kg/cm^2)	△7.6 kg/t

3.3.5.5 Energy saving by adding new functions or renewing the equipment

Purposes	Measures	Details of Measures	Estimated Effects in 2002
1. To lower BF energy cost	To install PCI system	To install PCI system: • Coal injection capacity : 45 t/h • PC rate : 150 kg/t The coke rate can be decreased from 520 kg/t to 370 kg/t and so the coke consumption will be 2.2 million t/y in 2002, allowing one COB to be shut down. (Introduction of operating technique for PCI system is required.)	• Shutdown of one COB • Decrease of purchased coke • Decreased emission of pollutants from COB
2. To recover top gas pressure	To install TRT	To install axial flow type TRT with 8.6 MW (2.0 bar) capacity	Generation of electric power: 29 kWh/t
3. To increase productivity of blast furnace	To adopt the higher pressure operation	To change to new higher pressure BF blower and to set up the technique of high pressure operation Refer to Section 3.5.	
4. To increase HS efficiency	To install fuel preheater and combustion air preheater	• To install fuel preheater and combustion air preheater in order to recover more sensible heat of waste gas	HS efficiency from 78% to 83% 25 Mcal/t

3.4 Reheating Furnace

3.4.1 Outline of the facilities and present status of the energy-saving facilities

The main specifications of the reheating furnace No.3 are shown in Table II-3.20. It is a pusher type, not a walking-beam type commonly used in Japan. As energy-saving facilities, recuperators, though the capacity is not sufficient, are installed to preheat combustion air. Fuel gas preheating facilities, however, are not installed. Waste heat boilers are installed to recover waste heat by plant steam. Hot charging or hot direct rolling, as operational energy-saving measures, is not conducted.

Note: No.3 reheating furnace, of the same type and capacity as those of No.1 reheating furnace, was studied this time because the model plant, No.1 reheating furnace, was shut down.

3.4.2 Operational status

According to the data obtained, the fuel unit consumption in 1992 was 1,059 Mcal/t, four times as high as that of latest Japanese steelworks of 260 Mcal/t. At the time of the first site survey (continuous operation), it was 463 Mcal/t, about 200 kcal/t higher than that of Japan in spite of stable operation. See Table II.3-21.

In this table, the heat loss 293 Mcal/t (except latent heat of oxide scale) is diffused during idling time and large amount of lost heat requires combustion of much fuel for idling, which possibly explains this high fuel unit consumption.

The following analysis aims at obtaining expected effects of energy-saving measures at the operational availability in 2002 based on the fuel unit consumption 830 Mcal/t that is before execution of energy-saving measures. The rated capacity 200 t/h seems difficult due to slab sizes and actually, the operation is at around 110 t/h and the maximum will be 160 t/h.

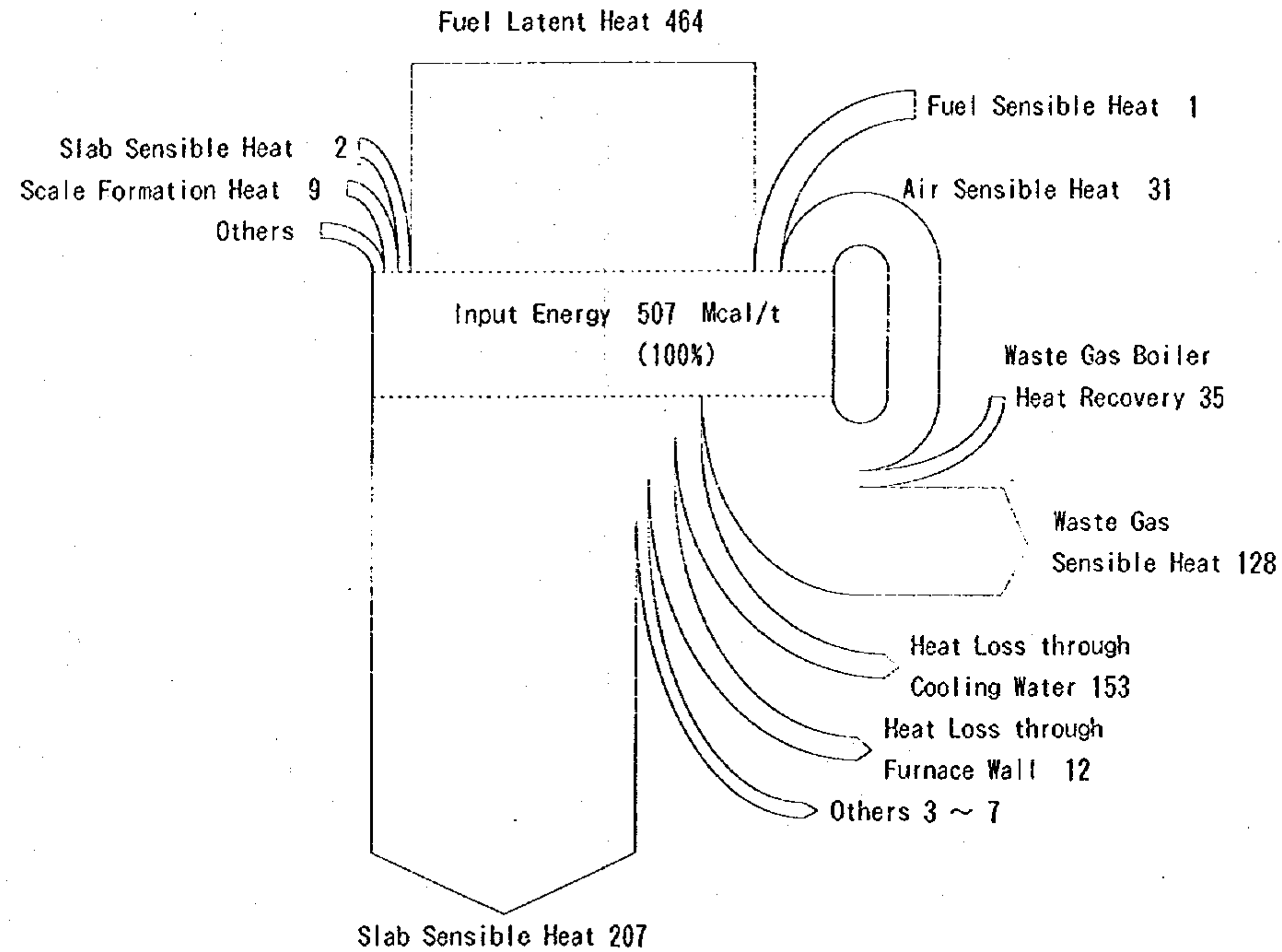
Table II.3-20. Specification of Reheating Furnace

		Unit	Design Data	Actual Data
Size of Reheated Hot Materials				
	Length	mm	3,500-9,500-9,500	3,500-9,500-7,500
	Width	mm	700-1,550-1,250	700-1,550-1,250
	Thickness	mm	130-250-200	150-250-200
Material Properties		Low carbon steel, Low alloy, Si non-oriented		
Reheating Temperature		°C	1,250	1,250-1,320
Reheating Capacity		t/h	200	100-125
Fuel & Combustion Capacity				
• Kind of gas		vol.%	Mixed Gas	Natural Gas
• Supply condition	Pressure	mmH2O	800	600
	Temperature	°C		20
• Combustion capacity	Soaking zone	Mcal/h	9,000	
	Heating zone	Mcal/h	52,500	
	Preheating zone	Mcal/h	75,000	Total 64,000
• Combustion air	Pressure	mmH2O	1,400	1,000
	Temperature	°C	20	20
	Preheated temp.	°C	400	140
Material Transfer System		Pusher, Stock Extractor Type		
Energy Recovery Equipment				(Max.-Av.)
1. Air Recuperator				
• Exhaust gas	Inlet temp.	°C	980	1,100-550
	Outlet temp.	°C	600	850-420
	Flow rate	Nm3/h	110,000	170,000-76,000
	Pressure loss	mmH2O	25	
• Heated air	Inlet temp.	°C	20	20-20
	Outlet temp.	°C	400	400-140
	Flow rate	Nm3/h	2 x 45,000	78,000-75,500
	Pressure loss	mmH2O	300	
	Heat transfer area	m2	2 x 146	2 x 146
2. Waste Heat Boiler	Steam generation	t/h	2 x 2.5	2 x 7
	Steam pressure	bar	13	5
	Steam temp.	°C	280	190

Table II.3-21. Heat Balance for Reheating Furnace

(SIDEX No.3 REHEATING FURNACE OF HOT ROLLING MILL; 8 DEC 1993)

	Items		Remarks	Mcal/t-slab (%)
INPUT	Fuel Latent Heat		Fuel Flow Rate 6.330 Nm³/h Calorific Value 8.050 kcal/Nm³	463.3 Mcal/t-slab (50.960 Mcal/h)
INPUT	Fuel Sensible Heat		Fuel Temp. 20 ℃	0.4 Mcal/t-slab
INPUT	Combustion Air Sensible Heat		Air Temp. 160 ℃ 20℃ Air Flow Rate 67.840Nm³/h 11.970Nm³/h	31.4 Mcal/t-slab (3.450 Mcal/h)
INPUT	Input of Slab Sensible Heat		Charging Temp. 20 ℃	2.2 Mcal/t-slab
INPUT	Scale Formation Heat		0.7% × 1.335 kcal/kg	9.4 Mcal/t-slab
INPUT	Others			
INPUT	Total			506.7 Mcal/t-slab
OUTPUT	Output of Slab Sensible Heat		Discharging Temp. 1.276 ℃	207.2 Mcal/t-slab
OUTPUT	Waste Gas Sensible Heat	Furnace Outlet	Waste Gas Temp. 470 ℃ , 8 % Waste Gas Flow Rate 86.140 Nm³/h	127.7 Mcal/t-slab
OUTPUT	Waste Gas Sensible Heat	Air Recuperator Outlet	Waste Gas Temp.	
OUTPUT	Waste Gas Sensible Heat	Waste Gas Boiler Outlet	Waste Gas Temp. 190 ℃	
OUTPUT	Heat Loss through Cooling Water		Water Temp.(inlet/outlet) Δ12℃ Water Flow Rate 1.400 t/h	152.7 Mcal/t-slab
OUTPUT	Heat Loss through Furnace Wall		Furnace Wall Temp.	11.7 Mcal/t-slab
OUTPUT	Others (Sensible heat of scale)		0.7% 0.215 kcal/kg ℃	2.5 Mcal/t-slab
OUTPUT	Total			501.8 Mcal/t-slab
	Productivity			110 t/h



3.4.3 Production balance

The production balance of reheating furnaces in the hot strip mill for 2002 as the basis for the study of energy-saving measures is shown in Table II.3-22.

Table II.3-22. OperationalStatus in 2002

		1992	2002	
Production (1,000 t/y)		901	1,880	1,880
Reheating Furnace	Capacity	160 t/h	160 t/h	250 t/h
	Number of operating units	2	2	1 (New)
	Operational availability*	32%	75%	86%

*Production (t/y)/(Total capacity (t/y) x 8,760 h) x 100

Note: As energy-saving measures, modification of the existing 160 t/y x 2 and new installation of 250 t/y are available. Both are shown.

3.4.4 Analysis of the problems found

3.4.4.1 Analysis of heat loss in the heat balance

Heat loss items in the heat balance shown in Table II.3-21 are taken up and analyzed by comparison of design values and those of latest Japanese steelworks. See Fig. II.3-20.

The heat loss is 293 Mcal/t, about 2.4 times as high as that of Japan. Especially, the heat loss by cooling water and excess air occupies most of the total heat loss. Recovery of heat is as low as 65% of that of Japan.

1) Waste gas

(1) Waste gas temperature

The heat loss by theoretical waste gas volume is about 85 Mcal/t, similar to that of Japan.

(2) Analysis of waste gas

O_2 is 4-11%, much larger than the design 2.5%, and fairly high compared with the Japanese 1.1%, showing excess air combustion. This heat loss due to excess air is about 43 Mcal/t. On the other hand, in spite of the excess air combustion, incomplete combustion occurs (CO 0.1% remains). This is because the pressure and calorie fluctuation in fuel gas cannot be followed up by the combustion device and the combustion controller.

2) Cooling water

The heat lost by the cooling water is as large as 153 Mcal/t, the largest in the heat loss items. Also, the flow rate and temperature of cooling water for the in-furnace skid are quite above the design values (design 900 t/h, Δt = 10°C; actually 1,400 t/h, Δt = 12°C). The structure and heat insulation of the skid has problems.

3) Radiation heat from furnace body

The furnace shell temperature is 170-370°C, quite high compared with 60-140°C in Japan. There is a possibility of fallen down of refractories in the soaking zone.

4) Waste heat recovery system

(1) Entry of air into clearances from the furnace body to the waste gas duct is large, which causes the large temperature drop of waste gas at the inlet of recuperator, and so the planned air temperature 400℃ is actually as low as 140℃. (In Japan, recovery is at 514℃ of air.)

(2) The recuperator, of radiation heat transfer type, has a small heat transfer area, giving small recovery of waste heat.

(3) Waste heat boiler, installed in the downstream of the recuperator, does not recover the heat as planned (only 2-3 t/h against the design steam recovery 25 t/h). The recovery steam pressure is also as low as 4-5 kg/cm^2 against the design 13 kg/cm^2. The present steam recovery system is not necessarily good. Review is required.

(4) Combustion air for the soaking zone is not preheated. Preheating equipment for fuel gas is not installed.

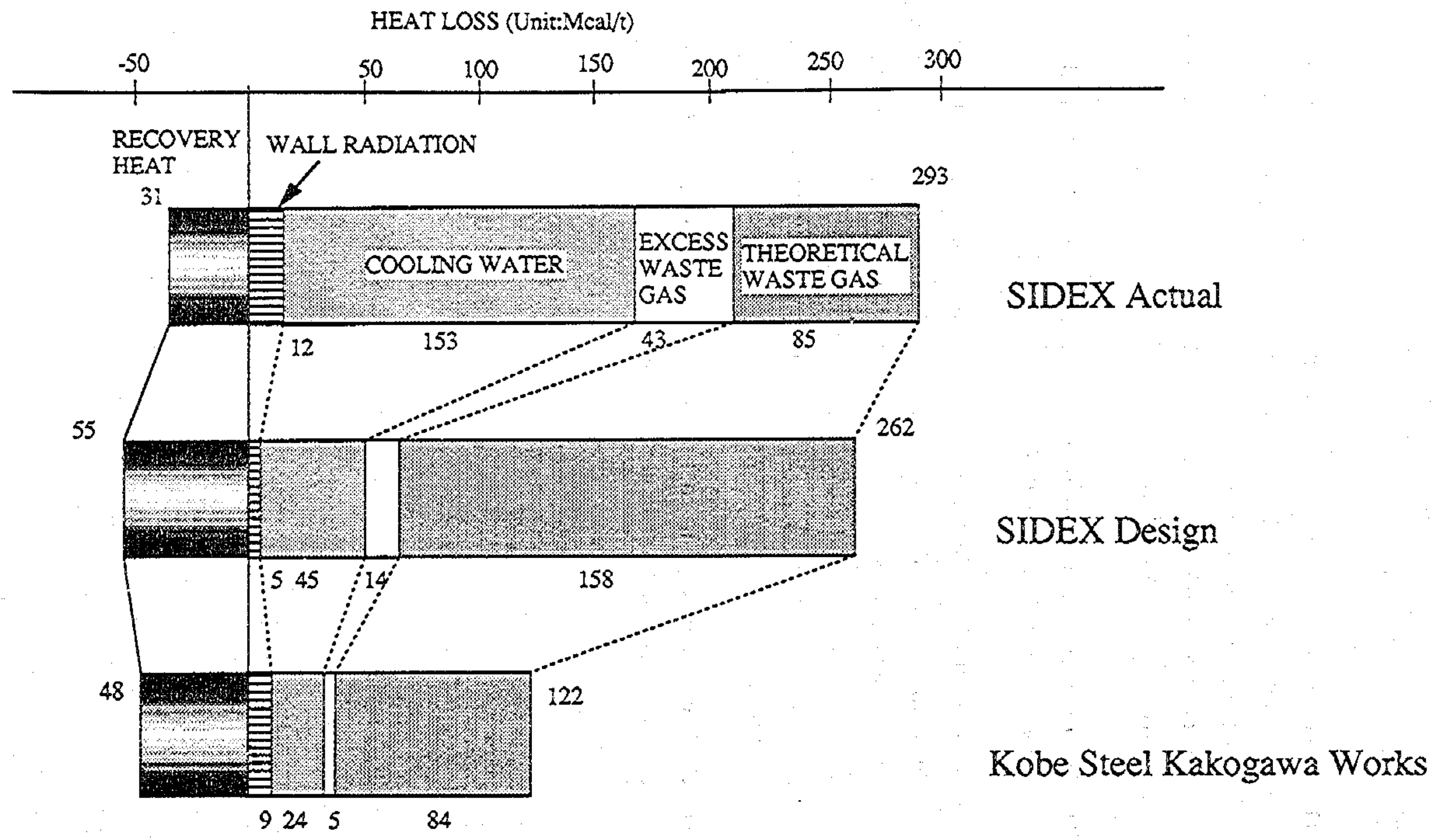


Fig. II.3-20. Comparison of Heat Loss between SIDEX and Kobe Steel Kakogawa Works in 1992

3.4.4.2 Analysis of the operating data

1) Analysis of heat pattern of slab

The heat pattern of slab, quite related with energy saving of the reheating furnace, was measured during the site survey as follows:

Outlet of preheating zone	Outlet of heating zone	Extraction temperature
Max. 975°C	Max. 1,264°C	Max. 1,284°C
Min. 697°C	Min. 1,188°C	Min. 1,257°C
Av. 836°C	Av. 1,226°C	Av. 1,271°C

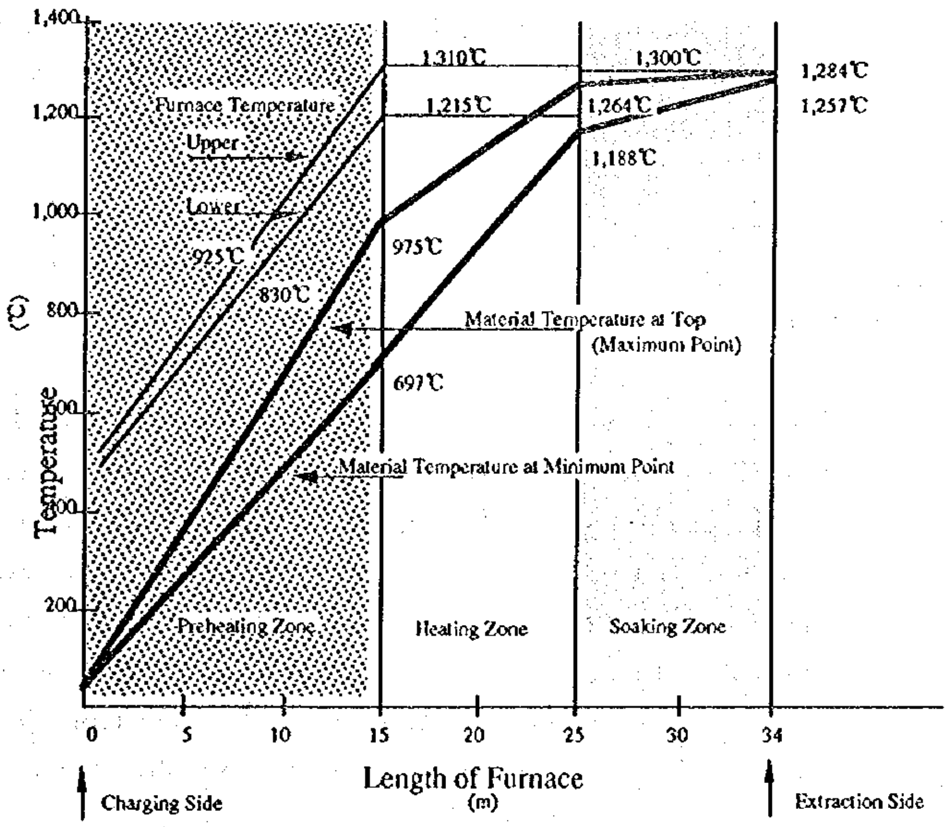


Fig. II.3-21. Analysis of Heating Pattern for Reheating Furnace of Hot Strip Mill (Data from SIDEX dated Dec. 09 '93)

As seen from the graph, we can say the following:

(1) The extraction temperature is as high as average 1,271°C (target of SIDEX is 1,250 °C).
Especially, the upper face of slab is 1,284°C and this is excessive.

(2) The temperature in the lower part of the preheating zone and the heating zone are low, delaying the heating of lower face of slab.

(3) The temperature of upper face of slab at the outlet of the heating zone is already as high as 1,264°C, which is in excess of the target extraction temperature. Therefore, employment of high-load heating at later stage by lowering the temperature of upper part of the heating zone will contribute to the decrease of fuel consumption.

2) Other themes

(1) To decrease the consumption of natural gas

The reheating furnace is designed with the use of mixed gas (NG + BFG) at 3,000 kcal/Nm^3. Because the supply pressure of natural gas fluctuates between 600-1,000 mmH2O and that of BFG between 600-2,000 mmH2O, the present flow rate control cannot cope with the situation, causing much fluctuation of calories. Therefore, the gas mixer is not used and operation depends on the expensive natural gas purchased from the outside. Accordingly, it is necessary to decrease the consumption of natural gas. See Section 3.5.

(2) To study the possibility of hot charging and hot direct rolling

Though hot charging and direct rolling of slab are not employed in SIDEX, the hot charging ratio is as high as 70% and the average charging temperature is 600℃ in Japan.

Therefore, the possibility of hot charging and hot direct rolling in SIDEX should be studied.

3.4.5 Measures and estimated effects

This section shows the energy-saving measures and their estimated effects.

The energy-saving measures can broadly be either of the following two:

- To modify the existing two reheating furnaces
- To install a new reheating furnace

Each has advantages and disadvantages. Conclusively, it is recommended to install a new reheating furnace.

3.4.5.1 Energy saving by improving the operation (including enhanced control of operation and maintenance)

<table>
<tr><th>Purposes</th><th>Measures</th><th>Details of Measures</th><th>Estimated Effects in 2002</th></tr>
<tr>
<td rowspan="2">1. To decrease input fuel by optimizing the heat pattern</td>
<td>1. To decrease fuel consumption by decreasing the discharge temperature</td>
<td>To change furnace temperature in each zone at follows and to change extraction temperature of slab from 1,271 to 1,250℃ to decrease fuel consumption
<table>
<tr><th>Furnace temp.</th><th>Heating zone</th><th>Soaking zone</th></tr>
<tr><td>Upper (right)</td><td>1,310</td><td>1,300</td></tr>
<tr><td>Lower (left)</td><td>1,215</td><td>1,255</td></tr>
<tr><td>Fuel con-sump-tion</td><td>5,380</td><td>950</td></tr>
</table>
Improving ⇒
<table>
<tr><th>Furnace temp.</th><th>Heating zone</th><th>Soaking zone</th></tr>
<tr><td>Upper (right)</td><td>1,290</td><td>1,280</td></tr>
<tr><td>Lower (left)</td><td>1,195</td><td>1,255</td></tr>
<tr><td>Fuel con-sump-tion</td><td>5,138</td><td>1,019</td></tr>
</table>
</td>
<td>Heat unit consumption: 14 Mcal/t decrease</td>
</tr>
<tr>
<td>2. To intensify heating in the soaking zone and to decrease waste gas by accumulated heating of slab</td>
<td>1. To change each zone temperature as follows with more fuel used in the soaking zone and thus to decrease total fuel consumption
2. Also, to increase furnace temperature at the lower side of heating zone and to decrease temperature difference between upper side and lower side of slab
<table>
<tr><th>Furnace temp.</th><th>Heating zone</th><th>Soaking zone</th></tr>
<tr><td>Upper (right)</td><td>1,310</td><td>1,300</td></tr>
<tr><td>Lower (left)</td><td>1,215</td><td>1,255</td></tr>
<tr><td>Fuel con-sump-tion</td><td>5,380</td><td>950</td></tr>
<tr><td colspan="2">Max. slab temp</td><td>1,284</td></tr>
<tr><td colspan="2">Min. slab temp</td><td>1,257</td></tr>
</table>
Improving ⇒
<table>
<tr><th>Furnace temp.</th><th>Heating zone</th><th>Soaking zone</th></tr>
<tr><td>Upper (right)</td><td>1,240</td><td>1,320</td></tr>
<tr><td>Lower (left)</td><td>1,210</td><td>-</td></tr>
<tr><td>Fuel con-sump-tion</td><td>4,155</td><td>1,903</td></tr>
<tr><td colspan="2">Max. slab temp</td><td>1,289</td></tr>
<tr><td colspan="2">Min. slab temp</td><td>1,270</td></tr>
</table>
</td>
<td>Heat unit consumption: 22 Mcal/t decrease</td>
</tr>
</table>

Purposes	Measures	Details of Measures	Estimated Effects in 2002
2. To decrease input fuel by applying hot charging of slab	To effectively use sensible heat by applying hot charging of slab	1. To establish interface between upstream & downstream technology: • High temperature/non-defective casting technology at continuous casting shop • Consistent schedule making between continuous casting process and rolling process 2. To establish the technology to make hot charging into reheating furnace possible: • Expanding the range of burner combustion control (individual burner, separation of zone, control method) • Predicting technology of slab temperature inside the furnace	Heat unit consumption: 45 Mcal/t decrease
3. To decrease heat loss by enhancing the furnace heat control	To enhance heat control as well as trend control by installing and making good use of monitoring instruments of the furnace	1. To control constant heat loss by waste gas analysis meters (waste gas O2 meter, CO meter): • Decreasing the rate of excessive air and prevention of loss caused by incomplete combustion • Optimizing the furnace pressure by trend control over intruding air and implementation of proper maintenance • Maintenance of recuperator performance and preventing malfunction such as leak • Control of waste gas balance through the right and left fume ducts by monitoring the waste gas temperature 2. To periodically diagnose the heat: • Periodic measurement of loss of waste gas, loss of cooling water, heat radiation from furnace, etc. • Preventing the deterioration of performance by trend control and also by comparing the measured data with designed values • Periodic inspection of temperature distribution and heat pattern of slab	Heat unit consumption: 5 Mcal/t decrease

3.4.5.2 Energy saving by modifying or improving the equipment (including auxiliary equipment)

Purposes	Measures	Details of Measures	Estimated Effects in 2002
1. To improve heat unit consumption by decreasing heat loss	1. To improve the temperature and control accuracy of combustion by modification of combustion control system	To modify the present combustion control system (fuel flow rate control precedence type) into the control system with cross limit function for fuel and air and thus to improve the control accuracy of air-fuel ratio at the change of flow rate	Heat unit consumption: 5 Mcal/t decrease
	2. To decreasing the intruding air by modification of in-furnace pressure system and prevention of blowing out of waste gas	To modify the present control system (cascade method of differences control of the pressure in two waste gas ducts as well as in-furnace pressure control) into simplified pressure control system and thus to improve the control accuracy of in-furnace pressure: • Direct control by damper at the outlet of recuperator (to remove inlet damper that causes air penetration) • Employing the master-control method to control the balance of waste gas through two waste gas ducts	Heat unit consumption: 5 Mcal/t decrease
	3. To decrease the loss of cooling water by reinforcing the insulation for skid pipe	To repair damaged part of insulation on skid pipe, to reinforce insulation, and to decrease cooling water volume in order to decrease heat loss Cooling water flow rate: 1,400 t/h → Improving → 1,400 t/h Temperture difference: 12°C → Improving → 8°C (Installation: ceramic fiber 80 mm)	Heat unit consumption: 51 Mcal/t decrease
	4. To decrease heat radiation from furnace wall	To repair damaged parts of refractories/insulation material of furnace body and to check specifications of insulating material in terms of material, thickness, etc. to decrease radiation heat from the furnace wall	-

Purposes	Measures	Details of Measures	Estimated Effects in 2002
2. To improve heat unit consumption by modifying in-furnace heat transfer performance	1. To prevent gas drifting upward or downward by installing partition wall in the preheating zone	To install partition wall at the upper part of preheating zone to control gas flow and to decrease the temperature difference (95℃ at present) between upper part and lower part of furnace, thus improving the heat pattern	Heat unit consumption: 22 Mcal/t decrease
	2. To expand the heat transfer area in the preheating zone by extending the length of furnace	To extend the inlet of preheating zone by 3 m to increase the preheating temperature of slab, thus decreasing the fuel consumption Preheating zone outlet slab temp: 772°C → (Expanding) → 925°C Fuel comsumption rate: 6,330 Nm^3/h → (Expanding) → 5,802 Nm^3/h	Heat unit consumption: 42 Mcal/t decrease
	3. To review the arrangement and specifications of skid pipes	To review the arrangement and specifications of skid pipes used at the moment and to shift the skid position by 4.5 m at the latter side of heating zone	Heat unit consumption: 7 Mcal/t decrease
	4. To optimize the heat pattern by introducing temperature prediction system for slab laid inside the furnace	To introduce computer to calculate on-line heat transfer based on heat transfer model about slab charged inside the furnace, thus clarifying the difference between the predicted temperature of each slab on the basis of the existing furnace conditions and the target extraction temperature, in order to provide the optimum operational guidance	Heat unit consumption: 20 Mcal/t decrease

<table>
<tr><th>Purposes</th><th>Measures</th><th>Details of Measures</th><th>Estimated Effects in 2002</th></tr>
<tr><td rowspan="4">3. To increase waste heat recovery and thus to decrease heat unit consumption</td><td>1. To increase the recuperator preheating temperature by decreasing the intruding air</td><td>Along with modification of control over furnace pressure, to improve sealing performance of furnace door, waste gas duct, etc., and thus to decrease the intruding air in order to increase waste heat recovery
<table>
<tr><td>Intruding air rate</td><td>30 %</td><td rowspan="3">Improving →</td><td>10%</td><td>Up-to-date technology</td></tr>
<tr><td>Recuperator inlet waste gas temp.</td><td>380°C</td><td>447°C</td><td>67°C increase</td></tr>
<tr><td>Temp. of preheating air</td><td>140°C</td><td>160°C</td><td>Present recuperator</td></tr>
</table></td><td>Heat unit consumption: 5 Mcal/t decrease</td></tr>
<tr><td>2. To utilize preheated air for combustion in the soaking zone</td><td>To replace combustion air (room temperature) for soaking zone by preheated air from recuperator</td><td>Heat unit consumption: 18 Mcal/t decrease</td></tr>
<tr><td>3. To replace with high performance air recuperator</td><td>To replace the present radiation type recuperator with convection type, and thus to improve heat transfer performance, leading to the increase of the preheated air temperature
<table>
<tr><td></td><td>Items</td><td rowspan="8">Renewing →</td><td>Items</td></tr>
<tr><td>Type</td><td>Radiation, 2 sets</td><td>Convection, 2 sets</td></tr>
<tr><td>No. of passes</td><td>2</td><td>4</td></tr>
<tr><td>Area of heat transfer</td><td>146 m²</td><td>2,020 m²</td></tr>
<tr><td>Transfer heat coefficient</td><td>39 kcal/m²h°C</td><td>23 kcal/m²h°C</td></tr>
<tr><td>Inlet waste gas temp.</td><td>380°C</td><td>380°C</td></tr>
<tr><td>Air flow rate</td><td>41,000 Nm³/h</td><td>48,200 Nm³/h</td></tr>
<tr><td>Temp. of preheating air</td><td>140°C</td><td>322°C</td></tr>
</table></td><td>Heat unit consumption: 56 Mcal/t decrease</td></tr>
<tr><td>4. To install fuel gas recuperator (stop of waste gas boiler)</td><td>To remove the present the waste heat boiler having low performance of heat recovery, and instead to install fuel gas recuperator to preheat the fuel gas (mixed gas)
<table>
<tr><td></td><td>Items</td></tr>
<tr><td>Waste gas temp.</td><td>420°C</td></tr>
<tr><td>Gas flow rate</td><td>68,100 Nm³/h</td></tr>
<tr><td>Evaporation rate</td><td>3 t/h x 2 sets</td></tr>
</table>
Renewing →
<table>
<tr><td></td><td>Items</td></tr>
<tr><td>Type</td><td>Convection, 2 sets</td></tr>
<tr><td>No. of passes</td><td>2</td></tr>
<tr><td>Area of heat transfer</td><td>785 m²</td></tr>
<tr><td>Transfer heat coefficient</td><td>10 kcal/m²h°C</td></tr>
<tr><td>Inlet waste gas temp.</td><td>314°C</td></tr>
<tr><td>Gas flow rate</td><td>68,100 Nm³/h</td></tr>
<tr><td>Temp. of preheating gas</td><td>250°C</td></tr>
</table></td><td>Heat unit consumption: 6 Mcal/t decrease</td></tr>
</table>

3.4.5.3 Energy saving by adding new functions or renewing the equipment

<table>
<tr><th>Purposes</th><th>Measures</th><th>Details of Measures</th><th>Estimated Effects in 2002</th></tr>
<tr>
<td rowspan="3">1. To improve performance such as heat unit consumption by replacing with high performance reheating furnace</td>
<td>1. To improve heat transfer function by optimizing the profile including extension of furnace length</td>
<td>To change from the existing pusher type to walking beam type to improve heat transfer performance
<table>
<tr><th></th><th>Furnace length</th><th>Furnace height</th><th>Type</th><th></th><th>Furnace length</th><th>Furnace height</th><th>Type</th></tr>
<tr><td>Preheating</td><td>15 m</td><td>3 m</td><td>Axial</td><td rowspan="5">Renewing</td><td>10 m</td><td>1 m</td><td></td></tr>
<tr><td rowspan="2">Heating zone</td><td rowspan="2">10 m</td><td rowspan="2">3 m</td><td rowspan="2">Axial</td><td>9 m</td><td>2.8 m</td><td>Side</td></tr>
<tr><td>9 m</td><td>2.8 m</td><td>Side</td></tr>
<tr><td>Soaking zone</td><td>9 m</td><td>1.4 m</td><td>Side</td><td>8 m</td><td>2 m</td><td>Side</td></tr>
<tr><td>Total</td><td>34 m</td><td></td><td></td><td>36 m</td><td></td><td></td></tr>
</table>
</td>
<td rowspan="3">New reheating furnace:
• Capacity: 250 t/h
• Heat unit consumption: 282 Mcal/t</td>
</tr>
<tr>
<td>2. To improve the heating performance by optimizing the heating method and type & specifications of burners</td>
<td>Along with renewal of furnace, review the specifications and position of burners to increase heating performance
<table>
<tr><th></th><th>Capacity</th><th>No.</th><th></th><th>Capacity</th><th>No.</th></tr>
<tr><td>Preheating zone</td><td>5,000 Mcal/h</td><td>8+7</td><td rowspan="5">Renewing</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Heating zone</td><td rowspan="2">3,500 Mcal/h</td><td rowspan="2">8+7</td><td>2,600 Mcal/h</td><td>10+10</td></tr>
<tr><td>1,400 Mcal/h</td><td>10+10</td></tr>
<tr><td>Soaking zone</td><td>450 Mcal/h</td><td>10+10</td><td>390 Mcal/h</td><td>9+9</td></tr>
<tr><td>Total</td><td>136,500 Mcal/h</td><td></td><td colspan="2">Total: 87,000 Mcal/h</td></tr>
</table>
</td>
</tr>
<tr>
<td>3. To use walking beam and also to optimize location and specifications of walking beam, and thus to obtain uniform heating and to decrease the loss of cooling water</td>
<td>To review specifications of skid pipe, try to increase heat transfer to slab, obtain uniform heating and reduce the heat loss of cooling water
<table>
<tr><th></th><th>Movable beam</th><th>Fixed beam</th></tr>
<tr><td>No./diameter</td><td>4 x 160 mm</td><td>5 x 160 mm</td></tr>
<tr><td>Spec. for insulation</td><td>Fiber</td><td>Fiber</td></tr>
<tr><td>Cooling water flow rate</td><td>4 x 40 t/h</td><td>5 x 40 t/h</td></tr>
<tr><td>Difference of cooling water temperature</td><td>15°C</td><td>15°C</td></tr>
</table>
</td>
</tr>
</table>

<table>
<tr><th>Purposes</th><th>Measures</th><th>Details of Measures</th><th>Estimated Effects in 2002</th></tr>
<tr>
<td>1. To improve performance such as heat unit consumption by replacing with high performance reheating furnace (Contd.)</td>
<td>4. To decrease radiation of heat from furnace wall by reinforcing insulation on the furnace body</td>
<td>To intensify insulation on the furnace body, thus to reduce radiation of heat from furnace wall and improve thermal response
<table>
<tr><th colspan="2"></th><th>Preheating zone</th><th>Heating zone</th><th>Soaking zone</th></tr>
<tr><td rowspan="2">Specification of insulation</td><td>Wall & ceiling</td><td>Fiber 350 mm</td><td>Fiber 350 mm</td><td>Fiber 50 mm
Plastic 300 mm
Brick 115 mm
Insulation board 30 mm</td></tr>
<tr><td>Floor</td><td colspan="3">Fire brick 180 mm + Insulation brick 200 mm + Insulation board 85 mm</td></tr>
</table>
</td>
<td>As stated above</td>
</tr>
</table>

<table>
<tr><th>Purposes</th><th>Measures</th><th>Details of Measures</th><th>Estimated Effects in 2002</th></tr>
<tr>
<td rowspan="4">2. To improve performance such as heat unit consumption by replacing with high performance reheating furnace (auxiliary equipment)</td>
<td>1. To install high efficient air recuperator</td>
<td>To replace the present radiation type recuperator by convection type, and also to improve heat transfer performance and try to increase the preheating air temperature
<table>
<tr><th></th><th>Items</th><th></th><th>Items</th></tr>
<tr><td>Type</td><td>Radiation, 2 sets</td><td rowspan="7">Renewing</td><td>Convection, 2 sets</td></tr>
<tr><td>No. of passes</td><td>2</td><td>4</td></tr>
<tr><td>Area of heat transfer</td><td>146 m²</td><td>1,685 m²</td></tr>
<tr><td>Transfer heat coefficient</td><td>39 kcal/m²h°C</td><td>23 kcal/m²h°C</td></tr>
<tr><td>Inlet waste gas temp.</td><td>380°C</td><td>750°C</td></tr>
<tr><td>Air flow rate</td><td>41,000 Nm³/h</td><td>32,800 Nm³/h</td></tr>
<tr><td>Temp. of preheating air</td><td>140°C</td><td>614°C</td></tr>
</table>
</td>
<td rowspan="4">As stated above</td>
</tr>
<tr>
<td>2. To install fuel gas recuperator (stop of waste heat boiler)</td>
<td>To remove the present waste heat boiler of low recovery rate, and to install a fuel gas recuperator in order to preheat the fuel gas (mixed gas)
<table>
<tr><th></th><th>Items</th></tr>
<tr><td>Waste gas temp.</td><td>420°C</td></tr>
<tr><td>Gas flow rate</td><td>68,100 Nm³/h</td></tr>
<tr><td>Evaporation rate</td><td>3 t/h, 2 sets</td></tr>
</table>
Renewing
<table>
<tr><th></th><th>Items</th></tr>
<tr><td>Type</td><td>Convection, 2 sets</td></tr>
<tr><td>No. of passes</td><td>2</td></tr>
<tr><td>Area of heat transfer</td><td>300 m²</td></tr>
<tr><td>Transfer heat coefficient</td><td>10 kcal/m²h°C</td></tr>
<tr><td>Inlet waste gas temp.</td><td>296°C</td></tr>
<tr><td>Gas flow rate</td><td>36,400 Nm³/h</td></tr>
<tr><td>Temp. of preheating gas</td><td>252°C</td></tr>
</table>
</td>
</tr>
<tr>
<td rowspan="2">3. To renew the instrumentation control system:
• Combustion temperature control
• Furnace pressure control</td>
<td>1. To modify the present combustion control system (fuel gas flow rate precedence control) into the control system with cross limit function for fuel and air and thus to improve control accuracy of air-fuel ratio at the change of flow rates</td>
</tr>
<tr>
<td>2. To modify the present control system (cascade method of differences control of the pressure in two waste gas ducts as well as in-furnace pressure control) into simplified pressure control system and thus to improve the control accuracy of in-furnace pressure:
• Direct control by damper at the outlet of recuperator (to remove inlet damper that causes air penetration)
• Employing the master-control method to control the balance of waste gas through two waste gas ducts</td>
</tr>
</table>

3.4.5.4 Summary of energy-saving measures

To prepare the energy-saving measures for the hot strip mill in SIDEX, the present problems such as fuel supply, heat loss, and heat transfer performance were studied. As a result, measures from viewpoints of heat unit consumption and merit considering investment cost will be:

- To improve the operation (including enhanced control of operation and maintenance)
- To modify or improve the equipment (including auxiliary equipment)
- To add new functions or renew the equipment

The following summarizes the points of the above three:

1. As for improving the operation, 14 Mcal/t of energy-saving effect is estimated and the main measures are to improve the heating pattern and to enhance the control of furnace heat.

2. As for modifying or improvement the equipment, 149 Mcal/t of energy-saving effect is estimated and the main measures are to decrease the heat loss, to reinforce waste heat recovery, and to improve heat transfer performance.
   Because two-furnace operation should be done due to shortage of heating capacity in 2002, the above measures should be done for two furnaces.
   In addition to the lower performance of reheating furnace in SIDEX, heat consumption at idle time is also a big problem and heat unit consumption in rated and continuous operation by one furnace is smaller than that in averaging operation by two furnaces.
   Consequently, in addition to energy-saving effect, decrease of idling time due to one-furnace operation is required, then,

3. Installation of a new reheating furnace with higher performance is the most effective measure, this will bring about 181 Mcal/t of energy-saving effect.
   See Table II.3-23 for the summary.

Table II.3-23. Summary of Energy-Saving Measures for Reheating Furnace

Item		In 1992
Heat unit consumption	Continuous operation	463 Mcal/t
	Yearly average	1,059 Mcal/t
Production	Average	110 t/h
	Year	901,000 t
Operational availability	Production capacity	160 t/h per furnace
	Operational availability	2 furnaces x 32 %

Energy-Saving Measures

Item		After implementation of energy-saving measures in 2002		
		By improving operation	By modifying or improving the equipment	By adding new functions or renewing the equipment
Heat unit consumption	Continuous operation	449 Mcal/t	314 Mcal/t	282 Mcal/t
	Average	816 Mcal/t	560 Mcal/t	292 Mcal/t
Energy-saving effect (continuous operation base)		14 Mcal/t	149 Mcal/t[1]	181 Mcal/t
Operational availability		2 furnaces x 67%	2 furnaces x 67%	1 furnace x 86%
Measures in detail		• To decrease input fuel by 9 Mcal/t by optimizing the heat pattern[2] • To decrease heat loss by 5 Mcal/t by enhancing the furnace heat control	• To decrease heat unit consumption by 61 Mcal/t by decreasing heat loss • To decrease heat unit consumption by 42 Mcal/t[3] by modifying in-furnace heat transfer performance • To decrease heat unit consumption by 46 Mcal/t[3] by increasing waste heat recovery	To improve performance such as heat unit consumption by 181 Mcal/t by replacing with high performance reheating furnace

Notes:

1) Application of these measures can decrease the heat loss during idle time at the same time, and so further decrease can be expected.
2) Probability of heat pattern is estimated at 25%.
3) Decrease of waste gas temperature due to decrease of heat loss is considered.

3.5 Energy supplying facilities

Stable and efficient supply of energy is essential as the most fundamental measures, besides the promotion of energy saving in each process, in actually taking the measures for energy saving in SIDEX. In this section, stable supply of fuel gas for the model plants and renewal of the blower for No.6 Blast Furnace are especially, out of major important items, described.

Note)
Energy supplying facilities and the blower for blast furnace, initially, were not covered in the scope of site survey. However, in the second site survey, SIDEX claimed "In order to take the suggested measures (improving the air-fuel ratio, raising the productivity in blast furnace, injecting the pulverized coal in much quantity, etc.), facilities of fuel gas supply should be stabilized and the blower for blast furnace should be renewed. Without those realization, the measures for energy saving for the model plants will not be accomplished satisfactorily. Therefore, surveying the facilities and the blower should be covered in the scope of site survey carried out by the investigation committee." The investigation committee also recognized the necessity for achieving the purpose, i.e. saving energy in the model plants, and made out a draft of site survey and of measures to be taken for improvement.

3.5.1 Improvement in supply of mixed gas and of byproduct gas

Though COG or natural gas is often mixed to efficiently use BFG, the byproduct gas line does not have a gas holder and the piping for connection plays a part of the gas holder at the present. Taking an example of pressure variation of BFG line, the pressure largely varies from 800 mmH2O to 2,000 mmH2O, and the gas mixing device which is separately allotted in plants can not adjust it to assure a certain calorie. Because of such reason, the combustion device in each furnace can not sufficiently work and sometimes burns with too much air and discharges unburnt fuel, and the fuel unit consumption in each burning device is degenerating.

Under such circumstances, an expensive natural gas is applied to a part where the mixed gas can be applied by itself.

As countermeasures, BFG and COG gas holders should be installed first of all and the variation of gas pressure in BFG pipe should be within 50 mmH_2O.

Further, by concentrating the gas mixing facilities which have been separately installed, enlarging them, and installing the gas analyzer so that Wobbe index and the theoretical air amount index can be automatically controlled, the calorie of mixed gas will be stabilized. With this method, the percentage of air excess in each plant will be reduced to approximately 1.1 from 1.6 ~ 1.4.

3.5.2 Renewal of blower for blast furnace

3.5.2.1 Present status and countermeasure

A great deal of pulverized coal will be injected in No.6 BF in the future, as explained in Section 3.3, and in that case the blowing pressure should be increased. However, the blower for blast furnace, which is installed at the present, can not produce the necessary pressure and some renewal is demanded. While, the current unit consumption of the blower for BF is 0.12 kWh/Nm^3, which is high about twice the 0.07 kWh/Nm^3 of a Japanese plant, because the capacity of blower is smaller and the efficiency is lower. In addition, since the boiler, turbine, etc. are also small in capacity and the equipment efficiency is unfavorable, the fuel unit consumption (heat rate) of blower is 4,060 kcal/kWh, which is extremely low in efficiency comparing to the Japanese mean value 2,658 kcal/kWh. Taking the above into consideration, renewal of the whole power station of BF blower seems the most efficient way.

3.5.2.2 Image of a new power station

Since construction of a new power station needs a huge investment, it will be recommended to image first the power station that SIDEX should have in the future and to frame the concrete concept by steps. Namely, facilities of BF blower for No.6 BF should be renewed first, and then facilities of BF blower for No.5 BF and the common auxiliary facilities (ordinarily they generate electric power.) should be built up in the second stage of construction. The new power station is imaged as Fig. II.3-22.

Present

No.2 Station	
Boiler	7 units
Blower	5 units
Generator	———

No.3 Station	
Boiler	7 units
Blower	3 units
Generator	2 units

After modernization

(Final stage)

New station	
Boiler	3 units
Blower	3 units
Generator	1 units

Features
- Large-scale-plant
- High efficiency
- High flexibility
- Combined system

Schematic diagram

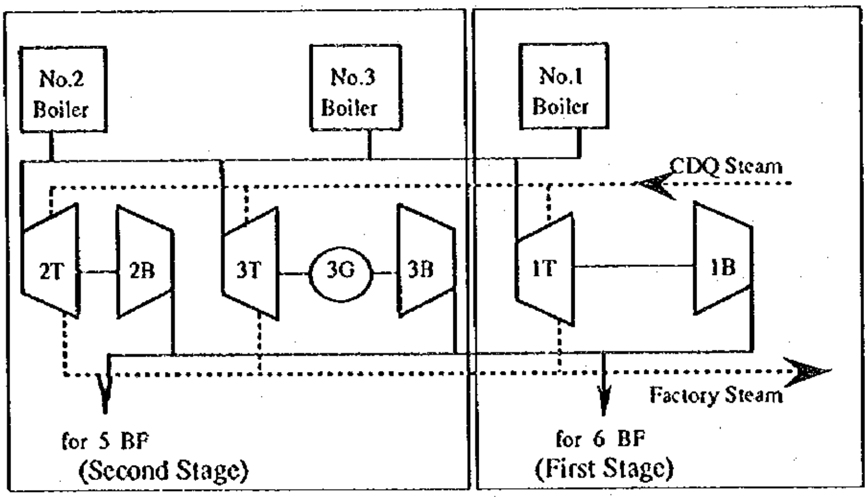


Fig. II.3-22. Image of new power station

3.5.2.3 Introduction of new power station for blower

A new power station for blower is specified as follows:

Equipment	Specifications	Capacity		
		No.1	No.2	No.3
Boiler	Main steam ; 100 atg, 540℃ Fuel ; BFG, COG, NG, and Mixed gas, Feed water temperature; 200 ℃ Boiler efficiency; 89 %	140 t/h	140 t/h	140 t/h
Turbine	Heater ; 4 stage feed water heater Exhaust pressure ; 0.16 ata	30 MW	30 MW	30 MW
Blower	Type ; Axial-flow-multi-stage Blower efficiency; 85 %	30 MW	30 MW	(30 MW)
Generator		—	—	30 MW
Factory steam supply	Supply condition; 8 atg, 180 ℃ (turbine extracted steam)	20 t/h	20 t/h	20 t/h
CDQ steam usage *	Usage condition; 35 atg, 410 ℃	10 t/h	10 t/h	10 t/h

* : Turbine would supply the steam alternatively when CDQ is stopped.

Items	New power station	Present status
Thermal unit consumption	2,600 ~ 2,900 kcal/kWh	4,060
Electric power unit consumption of blow	0.07 kWh/Nm^3-air	0.12

The typical heat balance of a new power station is shown in Fig. II.3-23.

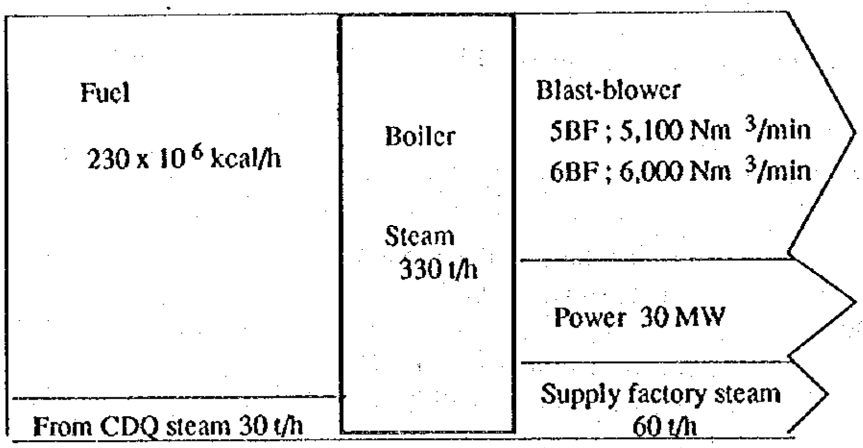


Fig.II.3-23. Typical heat balance of new power station

3.5.3 Summary of measures for energy saving

Measures for energy saving and the effects in relation to energy supplying facilities are summarized in the following table.

Energy saving measures and estimated effects

Purposes		Measures	Detail of Measures	Estimated Effects in 2002
To add new functions or to renew the equipment	Stabilization of gas supply facilities and use of byproduct gas	1. Install the gas holder in BFG and COG lines, and reduce the pressure variation of byproduct gas. 2. Build the concentrated gas mixing device, and supply the stabilized gas to every plant.	1. BFG gas holder 1 unit (100,000 m^3) 2. COG gas holder 1 unit (50,000 m^3) 3. Gas mixing device 1 set	1. Decrease of gas diffusion (5 % → 0.5 %) $\Delta NG = 56 \times 10^6 Nm^3/y$
	Increase of discharging pressure of blower for No.6 BF and of heat efficiency	1. Install the steam turbine and boiler which drive the blower, at the same time when relining No.6 BF. 2. Renew the power station by steps.	1. Blower for No.6 1 unit (7,250 Nm^3/min, 4.25 kg/cm^2) 2. Steam turbine for blower 1 unit 30MW, 5,180 rpm 3. Boiler 1 unit 140 t/h, 100 ata, 540 ℃ BFG and combustion of natural gas	1. Improvement of unit consumption of blowing steam 635 → 290kg/t 2. Improvement of fuel efficiency in power station 4,060 → 2,650-2,950 kcal/kWh (unit consumption of blowing electric power 0.12 → 0.07 kWh/Nm^3)

III. ENVIRONMENTAL POLLUTION CONTROL

1. PRESENT STATUS OF ENVIRONMENTAL POLLUTION CONTROL IN ROMANIA

1.1 General

After the liberalization in 1989, aimed at improvement of the environmental pollution in Romania in line with the EU countries, survey and study were conducted as a joint venture of the Romanian Government, the United States Agency for International Development (US AID), US-EPA (Environmental Protective Agency), EU-PHARE (Program for Restructuring Assistance), WHO, and the World Bank and compiled into the Romanian Environmental Strategy Paper in July 1992. This strategy paper, after review of the present status of the economy, energy consumption, environmental pollution in Romania, and the existing environmental protection laws and regulations, proposes the environmental control measures and strategy that the Romanian Government should take in 10 points of action. Of which, the improvement is the establishment of environmental protection laws and regulations, environmental standards, and wastes restrictions in compliance with the EU Directives. The following 14 industrial areas and the Donau delta are shown in the strategy paper as priority areas for priority execution of pollution control measures, in which SIDEX is not included:

Priority areas

1. Copsa Mica (nonferrous)
2. Baia Mare (nonferrous)
3. Zlatna (nonferrous)
4. Ploiesti-Brazi (petrochemical)
5. Borzesti-Onesti (petrochemical)
6. Bacau (fertilizer)
7. Suceava (paper and pulp)
8. Pitesti (oil refining)
9. Tg. Mures (chemical)
10. Turnu Magurele (fertilizer)
11. Tulcea (alumina)
12. Isalnita (alumina)
13. Brasov (chemical)
14. Govora (agricultural medicine)

According to the Romanian Environmental Strategy Paper, new policies are issued mainly by the Ministry of Water, Forestry, and Environmental Protection and are under discussion and establishment.

1.2 New Romanian Environmental Protection Law and Environmental Standards

As the basis of the national environmental protection, there exists the Law of the Environmental Protection established in 1973. Then a new Romanian Environmental Protection Law, has been under discussion in parliament. The outline is as follows.

The New Law consist of 5 sections with 104 articles and has many provisions for general duty imposed on economic enterprises concerning with environment protection.

(1) to equip facilities with highly efficient processing in order to reduce pollutant, as clean as possible, below the legal limits.

(2) to find solutions for recovery, recycling and turning to account of useful substances and of residual energy from wastes, resulting from the production processes belonging to their own activities.

(3) to ensure, through qualified staff and by its own monitoring systems, the control of the treatment processes and of pollutants discharged in the environment and to keep their record

(4) in the case of important pollution sources, they shall carry out at their own expenses, an ecological analysis of the impact zone through independent experts. The results of the ecological analysis and the countermeasures established shall be submitted to the environmental authorities and they shall be released to mass media.

(5) to pay the penalties according to the law for discharging NOx into the environment, over the maximum admissible limits.

The implementation for the ecological impact studies and approval procedure for new investments by economic and social activities are prescribed in Articles from 8 to 19. (The procedure is charted in Fig.III.1-1.)

Articles from 20 to 24 prescribe for toxic substances and hazardous wastes and from 25 to 35 for usage of chemical fertilizer and pesticide.
Chapter 2 prescribe for Air, Water, Soil, Ecosystem and Residential Protection.

It is worthy of note that Article 51 says that the environmental or public health authorities can order the temporary stopping of the activities at the pollution sources or technical measures for abating noxious emissions over the period that the unfavorable meteorological conditions persist if the generation of local accumulation of pollutant substances have been ascertained over maximum admissible limits.

Chapter 3(Art.84～94) prescribes prerogatives and responsibilities of central and local authorities of public administration, Chapter 4(Art.95 ～ 101) does sanctions and Chapter 5(Art.102 ～104) does final and transitory provisions.

Atmosphere and river water quality standards are already issued as shown in Tables III.1-1 and III.1-2.

1.3 Standards for Waste Gas

Concerning the emission of SOx, NOx, and soot in chimney waste gas that were not restricted, standards were issued in September 1993 as Order 462/1993 on the Technical Conditions for the Approval of Atmospheric Protection and Methodological Regulations for the Emission of Pollutants from Stationary Sources. Outline of this Order 462/1993 is as follows.

(1) Standards are applicable not only to selected areas but also to all the sources throughout Romania.
(2) Standards cover stationary sources such as plants.
(3) Calculation procedure for determining minimum stack height required for emission and technical standards for sampling and analysis methods of waste gas.
(4) Allowance of 7 years is given to the existing facilities for installations of depollution systems to observe their emissions with the legal limits. It is also obliged to have monitoring systems to ensure their emission is below the limit values, especially big stationary sources affect on their regional atmosphere should carry out continuous measurement by their own monitoring system and inform the results to the local environmental authority.

The standards stipulated in the Order 462/1993 are quite satisfactory compared with the EU Directives as seen from Table III.1-4, and satisfaction of these standards will eventually secure the environment similar to that of the EU countries.

The limit values of the Order 462/1993 are for new facilities, therefore the limit values to the existing facilities ,in period until the new limitation will be applied, will be determined within 3 months after enforcing of this Order by discussing about proposal in each sector of industry between its competent authorities and MOE. For metallurgical industry, temporary limit values under discussion will be set in the near future.

1.4 Standards for Waste Water

Different from waste gas, there are no nationwide waste water standards, but restriction is placed through agreement with the Water Resources and Protection of MOE and the Local Environmental Control Agency.

1.5 Standards for Solid Wastes

As standards for landfill using solid wastes, there exists only the Basel Treaty that restricts cross-border transportation of harmful industrial wastes, and there are no detail restrictions on the storage, transportation, and disposal of wastes according to properties. Establishment of corresponding standards are desired in future.

1.6 Environmental Assessment System

This procedure, issued in 1992, needs to obtain approval of the Local Agency for construction and operation, which requires forecast and preliminary assessment of environmental impact due to expansion or new facilities.

Orders and Governmental Decision(G.D) related this matter are as follows.

Order 170/1990 -On the issuance of environmental approval
; It prescribes the Environmental Agreement Values.
Order 113/1990 -On the documents to be submitted for obtaining the environmental approval
Order 437/1991 -On the environmental permit
Order 619/1992 -On the issuance of the ecological impact study for the investments
G.D. 435/1992 -Approval for using water

Approval will be issued only when results of the technical report conform to the Environmental Agreement Values in Order 170/1990.

1.7 Tax Reduction for Investment in Environmental Protection Facilities

The Order No.12 enacted in 1991 stipulates the tax reduction in the case of investment in production facilities and to promote the installation of environmental protection facilities as follows:

> In the case of investment for the purpose of expansion or modernization of production facilities, similarly in the case of the investment for the purpose of environmental protection facilities, 50% of tax for the investment cost shall be reduced.

That is, for the environmental protection facilities, 50% of the tax on the investment cost will be cut.

1.8 Monitoring System for Waste Gas and Waste Water

The Ministry of Water, Forestry, and Environmental Protection is promoting a plan for monitoring the general environmental conditions throughout the nation. For the discharges, the company owner will have to measure by himself and report to the Local Agency according to the execution of the New Romanian Environmental Protection Law.

1.9 Execution System of Environmental Pollution Control

The Ministry of Water, Forestry, and Environmental Protection controls overall environmental activities in Romania. All the country is divided into 40 areas and one special area (Bucharest), and its Local Environmental Control Agency in each area takes charge of execution, supervision, and monitoring of the regal activities. Each of these Agencies is authorized to conclude agreements of particular restrictions with the individual enterprises in addition to the national standards.

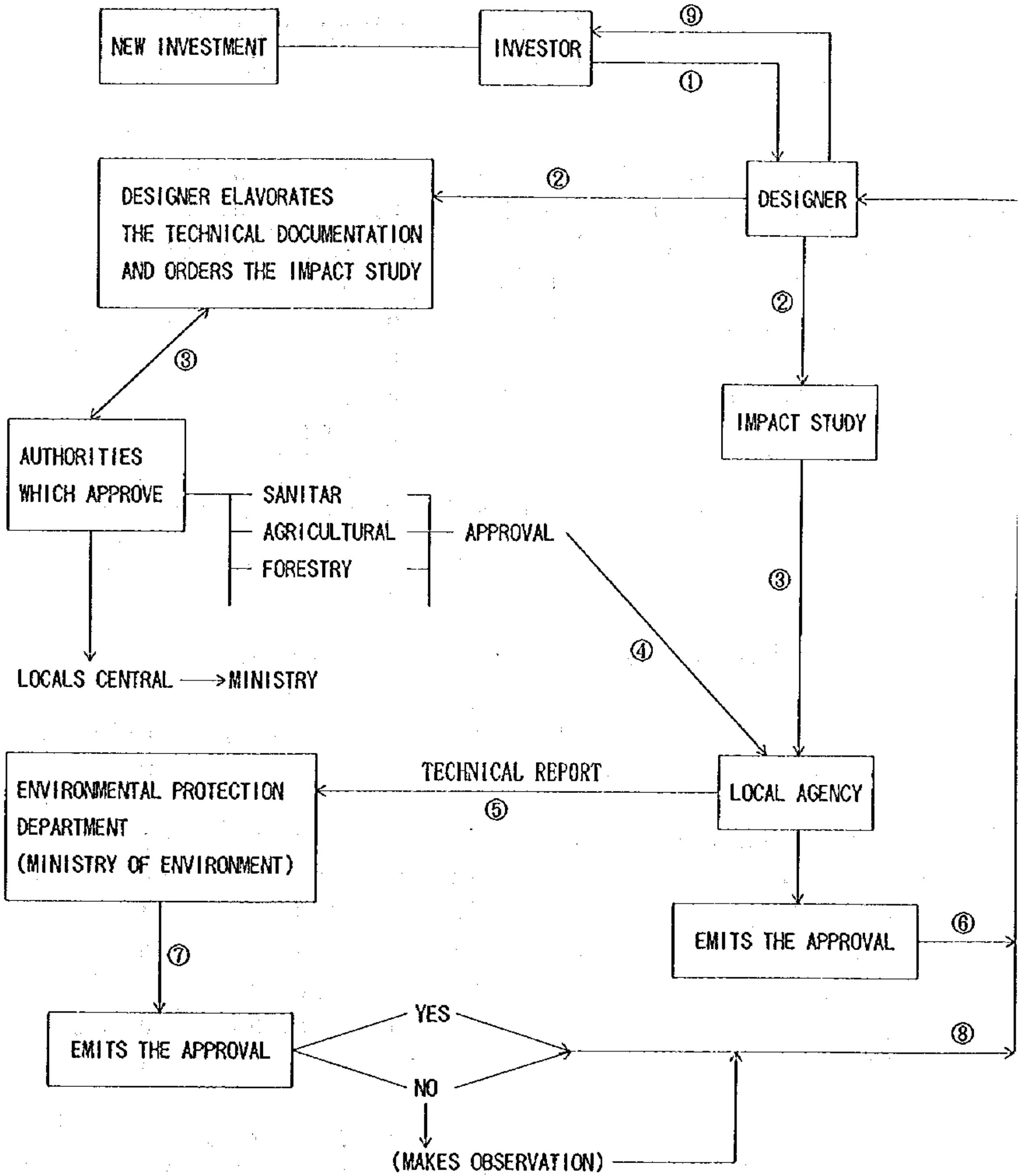


Fig. III.1-1. Procedure of Environmental Assessment and Approval

Table III.1-1. Ambient Air Quality Standard (Main Indicators)

Pollutants	Admitted Concentration (mg/m^3) short term medium 30min.	long term medium 24hours	Yearly
Sulfur dioxide:SO_2	0.75	0.25	0.06
Nitrogen dioxide:NO_2	0.3	0.1	0.04
Suspended powders	0.5	0.15	0.075
CO	6.0	2.0	–
Ammonia	0.3	0.1	–
Phenol	0.1	0.03	–
Oxidants(O_3)	0.1	0.03	–
Lead	–	0.0007	–
Sedimented dust	17g/m^2/month		

Table III.1-2. Water Quality Standard (Main Indicators)

Indicator	Admitted Values in Quality Categories (mg/l) I	II	III
Biochemical Oxygen Consumption:CBO_5	5	7	12
Chemical Oxygen Consumption:CCO	10	15	25
Dissolved Oxygen	6	5	4
Ammonium ion(NH^{4+})	1	3	10
Nitrates(NO_3^-)	10	30	–
Phenols	0.001	0.02	0.05
Total iron	0.3	1	1
pH	6.5 ~ 8.5		
Oil	0.1		
Free residual chlorine(Cl_2)	0.005		
Cyanides(CN^-)	0.01		
Cadmium(Cd^{2+})	0.003		
Lead(Pb^{2+})	0.05		
Hexavalent Chromium(Cr^{6+})	0.05		

Table III.1-3. Limit Values of Waste Gas in Romania(Main Indicators)

ANNEX I

Pollutants	Limit Values (mg/Nm^3)
SOx (as SO_2)	500
NOx (as NO_2)	500
Soot	50

ANNEX II

Liquid Fuel	Unit	Thermal Capacity(MW/t) <100	100 - 300	300 - 500	>500
Soot	mg/Nm^3	50	50	50	50
CO	mg/Nm^3	170	170	170	170
SOx (as SO_2)	mg/Nm^3	1700	1700	400	400
NOx (as NO_2)	mg/Nm^3	450	450	450	450
Oxygen conc.	%, vol	3	3	3	3

Solid Fuel (Coal, Wood)	Unit	Thermal Capacity(MW/t) <100	100 - 300	300 - 500	>500
Soot	mg/Nm^3	100	100	100	100
CO	mg/Nm^3	250	250	250	250
SOx (as SO_2)	mg/Nm^3	2000	2000-400(linearly variation)		400
NOx (as NO_2)	mg/Nm^3	500	400	400	400
Total Carbon(C)	mg/Nm^3	50	50	50	50
Oxygen conc.	%, vol	6	6	6	6

Natural Gas	Unit	Thermal Capacity(MW/t) <100	100 - 300	300 - 500	>500
Soot	mg/Nm^3	5	5	5	5
CO	mg/Nm^3	100	100	100	100
SOx (as SO_2)	mg/Nm^3	35	35	35	35
NOx (as NO_2)	mg/Nm^3	350	350	350	350
Oxygen conc.	%, vol	3	3	3	3

Note: The limit value is calculated after the following formula when multiple fuels are used: $C=\Sigma(Ci*Qi)/\Sigma Qi$

Table III.1-4. Comparison in Limit Values of Waste Gas, Thermal Capacity >500MW

Pollutants	ROMANIA Type of fuel	ROMANIA Limit (mg/Nm³)	EC Directive (NEW PLANT) Type of fuel		EC Directive (NEW PLANT) Limit (mg/Nm³)
SO_2	Gas: Natural gas	35, O_2 3%	Gaseous fuel in general		35, O_2 3%
			Liquefied gas		5, O_2 3%
			Low calorific gases from coke oven gas, BF gas		800, O_2 3%
			Gas: gasification of coal		not determined
	Liquid	400, O_2 3%	Liquid fuels		400, O_2 3%
	Solid : Coal, Wood	400, O_2 6%	Solid fuels		400, O_2 6%
NO_2	Gas : Natural ga	350, O_2 3%	Gaseous		350, O_2 3%
	Liquid	450, O_2 3%	Liquid		450, O_2 3%
	Solid : Coal, Wood	400, O_2 6%	Solid	general	650, O_2 6%
				volatile <10%	1300, O_2 6%
DUST [illegible]	Gas: Natural gas	5, O_2 3%	Gaseous	steel industry	50, O_2 3%
				BF gas	10, O_2 3%
				as a rule	5, O_2 6%
	Liquid	50, O_2 3%	Liquid	ash > 0.06% < 500MW	100, O_2 3%
				all plants	50, O_2 3%
	Solid : Coal, Wood	100, O_2 6%	Solid	≧ 500MW	50, O_2 6%
				< 500MW	100, O_2 6%
CO	Gas	100, O_2 3%			
	Liquid	170, O_2 3%			
	Solid	250, O_2 6%			

2. PRESENT STATUS OF ENVIRONMENTAL POLLUTION IN AND AROUND SIDEX AND MEASURES

2.1 Waste Gas and Dust

In this Report, "soot" refers to the particulate emitted from chimneys and "dust" refers to the particulate emitted from other sources.

2.1.1 Present status of waste gas emitted

1) Standards for emission of SOx, NOx, and soot on SIDEX

The nationwide standards for emission of waste gas are effective by the Order 462/1993. Those limit values, as described above, are for new facilities and the practical values applied to existing facilities of iron and steel industry will be fixed in the near future.

The new expert organization, ECOSIDER has been established in January of 1994, which makes plans and designs depollution systems in order to prevent air, water and soil pollution by iron and steel plants.

The procedure of determination for the limit values of waste gas emitted by existing iron and steel plants is as follows; ECOSIDER makes a proposal for the limitation, then the limit values will be determined through discussion among MOI(Ministry of Industry), ECOSIDER and MOE (Ministry of Environment).

We have set the target values of depollution system for waste gas as the same of the limitation by Order 462/1993 because grace period is 7 years and the production plan of SIDEX is in 2002.

- SOx : 500 mg/Nm^3 as SO_2
- NOx : 500 mg/Nm^3 as NO_2
- Soot : 50 mg/Nm^3
- O_2 concentration : 3%

It should be noted here that, because the combustion mechanism of the sintering plant is different from that of common combustion facilities, the O_2 concentration in waste gas is 15~16% on average. Accordingly, application of the same 3% O_2 restriction may not be practical.

If this 15% is tentatively used as the restriction on O_2 concentration, the restriction for SOx and NOx will be :

- SOx : 167 mg/Nm^3 as SO_2
- NOx : 167 mg/Nm^3 as NO_2

These application are too severe compared with western Europe countries as following table.

As for the limitation of soot and dust, the actual concentration of the gas is regulated without conversion of O_2 concentration in western Europe and Japan.

It is expected that the proper limit values will be determined through the discussion among the competent authorities.

Thus, we have assumed that the 15% of O_2 concentration is applied to SOx and NOx, and conversion by O_2 concentration is not applied to soot and dust of the main exhaust gas of sintering plant and investigated the measures for the waste gas on the basis of this assumption.

The emission targets of sintering plant in 2002 are as follows:

- SO_2 and NO_2 : 500 mg/Nm^3 (O_2 15%)
- Soot and dust : 50 mg/Nm^3 (actual)

	SOx as SO_2	NOx as NO_2	Soot	O2 concentration(actual)
Germany (new plant)	500 mg/Nm^3	400 mg/Nm^3	50 mg/Nm^3	none (15-16%)
French (new plant)	750 mg/Nm^3	750 mg/Nm^3	100 mg/Nm^3	none (15-16%)
Japan	K value regulation	450 mg/Nm^2	100 mg/Nm^3	15% (NOx limitation)

Re) K value regulation:

The system to regulate concentration of SOx on the ground and load of SOx emitted from a stack by the following equation. K value is given legally according to the regional atmosphere concentration.

$q = K \times 10^{-3} \cdot He(Nm^3/hr)$ He:effective stack height(m)

2) Present emission of waste gas

The instruments and methods used for measurement of waste gas concentrations are shown in Table III.2-1. The measurements in the model plants are shown in Table III.2-2. The soot of waste gas emitted from the coke oven batteries and BF hot stoves could not be measured directly by sampling the real waste gas because of no suitable holes for measuring on the sites, but in case of hot stove it is possible to estimate concentration of the soot by measuring that of BFG, because BFG is mainly used as fuel.
The limit values of waste gas for SO_2 and NO_2 of the sintering plant in Table III.2-2. are calculated on the basis of 15% of O_2 concentration, and the limit value of soot and dust is not converted by O_2 concentration.
SOx and NOx of the reheating furnace were measured for confirmation.

As the measurements show, problems lie in the SOx, NOx and soot of the coke oven batteries, SOx and soot of the sintering plants, and soot of the hot stoves.

For the soot of coke oven batteries, although the actual concentration could not be measured it is necessary to study the measures to improve combustion because black smoke was almost always observed from stacks during the survey and it is clear to be over the limit value $50mg/Nm^3$. As Table III.2-3 compares the concentrations between SIDEX and Japan, the concentration of

SOx, NOx, and soot except NOx from hot stoves are a little higher than the averages of Japan but there exist no extreme differences. The concentration of soot at the sintering plant in SIDEX, however, is ten times as high as that of Japan, requiring improvement.

3) Emission rate of SOx and NOx per ton of crude steel

Table III. 2-4 shows the emission rate of SOx and NOx per ton of crude steel in the sintering plants, coke plants, and others in SIDEX. The total emission of SOx in SIDEX is calculated from the estimated content of S in the consumed volume of COG, BFG, and natural gas and from the balance of S in the sintered ore. The volume of NOx is calculated from the multiplication of the combustion waste gas volume obtained from the consumed volume of fuel gas by the measured or estimated NOx concentration and also from the N balance of sintered ore.

According to the calculation, the percentage of the sintering plant in the SOx unit rate of emission is as large as 81% of the whole, and reaches 91% together with the coke plants. For NOx also, the sintering plants occupy 59%, and reaches more than 70% together with the coke plants. That is, decrease of SOx and NOx should be focused on the coke plants and sintering plants.

The situation is compared with that of Japan in Fig. III.2-1. The unit rate of SOx and NOx emission is 1.3 times as high as that of Japan in which no desulfurization or denitration is applied, suggesting the need of improvement in SIDEX.

4) Present status of dust

Generation of dust at charging of coal and discharging from the coke ovens, at discharging of sintered ore in the sintering plant, and at tapping in BF were conspicuous. These are attributable to no installation of dust collectors or not proper functioning of dust

collectors and form one of the main improvement items.
And it was found that fine ore and dust have been accumulated on the roads and the ground around the sintering plants and severe dispersion of dust usually occurred when automobile has passed. Measures for these secondary dispersion such as pavement and sweep of roads are necessary for the prevention of dust dispersion from SIDEX.

Table III.2-1. Measurements and Instruments

Pollutants	Measurement	Instruments
SOx, CO, CO_2	none-dispersive infrared absorption method	HORIBA VIA-510
NOx	chemiluminescent method	HORIBA CLA-510S
O_2	magnetic method	HORIBA MPA-510
Soot	JIS Z8808	–

JIS: Japan Indusrial Standard

Table III.2-2. Results of Measurements in Model Plants and Limit Values

Model Plants	Pollutants	Emitted Concentration ppm	Emitted Concentration mg/Nm³ (as SO_2, NO_2)	O_2 in waste gas:%	O_2 3% converted	Limit Values in SIDEX mg/Nm³ (as SO_2, NO_2)	Limit Values in SIDEX O_2 (%)
No.5	SOx	70~80	200~230	8	280~320	500	3
COKE OVEN	NOx	170	350		480	500	
	Soot [1]	–	–		–	50	
No.7	SOx	75~100	215~290	18	430~ 580	500	15 [3]
SINTERING	NOx	100~130	205~270		410~ 540	500	15
PLANT	Soot	–	280~330		280~ 330	50	–
No.6BF	SOx	30~60	86~172	5	97~194	500	3
HOT STOVE	NOx	1~2	2~4		2~5	500	
	Soot	–	65 [2]		–	50	
No.3	SOx	<10	29	13	65	500	3
HOT STRIP	NOx	50	103		232	500	
MILL R.F.	Soot	–	–		–	50	

Notes: 1) Black smoke is sometimes seen discharging from COB stacks, which suggests the need for improvement of combustion.

2) The concentration of soot emitted from hot stove is estimated from the concentration of soot in BFG(105mg/Nm³).

3) The converted values for SO_2 and NO_2 of No.7 Sintering Plant are calculated under the assumption that O_2 concentration of limitation is 15%, and the values of soot and dust are not converted.

Table III.2-3. Comparison in Emitted Waste Gas between SIDEX AND JAPAN

		SOx (ppm)	NOx (ppm)	Soot (mg/Nm^3)	O_2 (%)
COKE OVEN	SIDEX data	70~80	170	–	8
	(O_2 converted)	75~86	183	–	7
	JAPAN	30	150(70~320)	10	7[1)]
SINTERING PLANT	SIDEX data	75~100	100~130	280~330	18
	(O_2 converted)	150~200	200~260	560~660	15
	JAPAN(not De-SOx)	160(150~200)	190(160~220)	50(25~73)	15[2)]
BLAST FURNACE HOT STOVE	SIDEX data	30~60	1 ~2	–	3~5
	JAPAN	20	30	10	4
HOT STRIP MILL REHEATING FURNACE	SIDEX data	<10	50	–	10~13
	(O_2 converted)	<13	63	–	11
	JAPAN	10	54(30~120)	10	11[3)]

1) Limit value of O_2 concentration of waste gas in NOx and Soot regulations.
2) Limit value of O_2 concentration of waste gas in NOx regulations.
3) Limit value of O_2 concentration of waste gas in NOx and Soot regulations.
Notes: Figures in down line of SIDEX and JAPAN are the converted figures with O_2 concentration of JAPAN's regulation.

Table III.2-4. Emission Rate of SOx and NOx in SIDEX

	SIDEX (kg/t-steel)	
	SOx as SO_2	NOx as NO_2
Coke Plant	0.18 (10%)	0.24 (13%)
Sinter Plant	1.50 (81%)	1.10 (59%)
Others	0.17 (9%)	0.54 (28%)
Total SIDEX	1.85	1.88

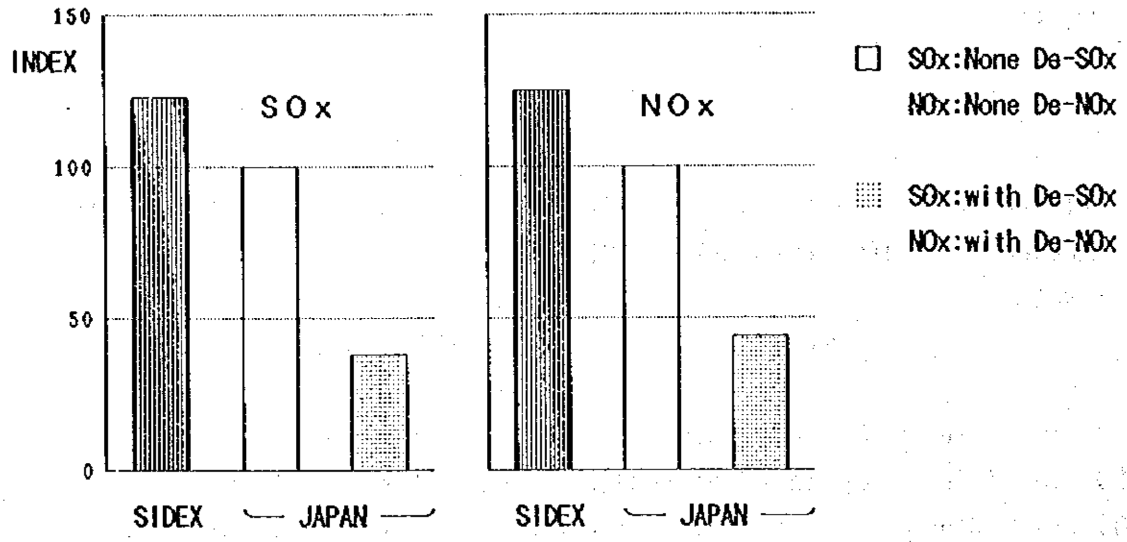


Fig. III.2-1. Comparison of Emission Rate of SOx and NOx between SIDEX and Japan

2.1.2 Analysis of the problems found in the model plants and measures

In the study of the problems and measures, the situation in 2002 should be considered. It is supposed that SIDEX will violate the limitation for waste gas emission or/and discharged effluent and affects severely on the status of sedimented dust in Galati city than now, judging from the present status of operation and emission, if the production only will increase as it is, without measures for pollution prevention.

The items of environmental measures in this study are listed in Table III.2-5. The details in each plant will be mentioned in Section III-3.

Table III.2-5. Items of Measures for Air Pollution Prevention

Plants	Items of Measures
Coke Oven Batteries and Coke Chemical Plants	(1) Intensive operation by No.5, 6 and 7 COB (2) Combustion by mixed gas (3) Automatic combustion control (4) Installation of desulfurization equipment for COG of No.7 COB (5) Manufacturing plant of sulfuric acid (6) Dust collector for guide car and CDQ (7) Replacement of high pressure pumps for ammonia liqure (8) Improvement of ascension pipe sealing
Sintering Plants	(1) Reduction of coke breeze in sintering (2) Installation of moving electrode EP (3) Installation of desulfurization equipment for main exhaust gas (4) Improvement of dust collection at feeding & discharging part of sintering
Blast Furnaces	(1) Improvement in operation of RSW (2) Installation of dust collector for casthouse

1) Problem of waste gas and measures

In 2002, the following are supposed to exceed the limit values if measures are not taken:

(1) SOx from coke plant : 420 ~460mg/Nm^3 ≒ 500mg/Nm^3 (O_2 3%)

(2) NOx from coke plant : 665 ~ 810mg/Nm^3 > 500mg/Nm^3 (O_2 3%)

(3) Soot from coke plant : 100 ~ 150mg/Nm^3 > 50mg/Nm^3 (O_2 3%)

(4) SOx from sintering plant : 950mg/Nm^3 > 500mg/Nm^3 (O_2 15%)

(5) Soot from sintering plant : 280 ~ 330mg/Nm^3 > 50mg/Nm^3 (actual)

(6) Soot from hot stove : 73mg/Nm^3 > 50mg/Nm^3 (O_2 3%)

Re) O_2 concentration in sintering plant is assumed to be applied 15% in the limitation.

The status after the measures for waste gas is estimated as follows:

The concentration of SOx as SO_2 from the coke plant will lower to 120 ~150 mg/Nm^3(O_2 3%) for No.5 and 6 batteries, 10~15mg/Nm^3(O_2 3%) for No.7 battery, below the limit value, due to improve desulfurization efficiency of COG from No.5&6 COB caused by stop of No.1 to No.4 COB with consolidation of coke oven batteries, and due to newly installed desulfurization plant for COG from No.7 COB. SOx emission will be also reduced in the other plant in which COG is used as fuel because of these measures for desulfurization.

The NOx concentration from coke oven batteries will lower to 400~490mg/Nm^3 as NO_2(O_2 3%), below the limit value, due to lowered furnace temperature because of combustion improvement as energy-saving measures and also due to change of COG to mixed gas with BFG.

The soot from the coke plant will lower below the limit value as the result of measures carried out in COBs such as combustion improvement, fuel change to mixed gas and the consolidation of COB's operation, particularly combustion improvement is main measure.

It will be necessary to install newly desulfurization equipment in the sintering plant for main exhaust gas in order to observe the limit value of SOx. The reason is as follows:

Although the content weight of sulfur will be reduced due to the decrease of coke breeze which will be the result of the energy-saving measures, the SOx concentration of waste gas will increase more than the present, due to increase of the conversion rate from sulfur to SOx gas by measures of combustion improvement and reduction of the waste gas volume by a measure for air leakage around sintering machines.(It means the reduction of excess air.)

The SOx concentration of waste gas after the desulfurization will be predicted to be about 240mg/Nm^3(O_2 15%) as SO_2 and satisfy the limit value.

For NOx concentration of sintering plants, it will be predicted to satisfy the limit value due to reduction of the content weight of nitrogen which resulted by the decrease of coke breeze unit consumption by energy-saving measures and maintenance of conversion rate from nitrogen to NO(nitrogen monoxide) as same as the present by improvement of ignition, though the waste gas volume will be reduced by a measure for air leakage like the measures in SOx.

The future concentration of NOx will be about 460mg/Nm^3(O_2 15%) as NO_2 and be similar as the present(470mg/Nm^3, O_2 15%).

The soot from the sintering plant exceeds the limit value in the concentration even now and thus urgent measures are needed.

It will be necessary to change the existing dust collector of the fixed electrode-type electrostatic precipitator for moving electrode-type one, which is effective for high alkaline dust caused decrease of the efficiency of dust collection in the existing precipitators.

The high concentration of BFG dust is caused by low efficiency in the RSW, therefore, it will be able to satisfy the limit value by lowering the dust concentration in BFG by means of RSW efficiency improvement as judged from the actual situation in Japan.

2) Problems of dust and measures

Though it is difficult to quantitatively grasp the effect of dust, the sedimented dust around SIDEX exceeds the standard value. Contribution of SIDEX in this matter is not certain, but its effect cannot be denied. Therefore, in addition to the decrease of generated soot, strengthened collection of dust mentioned above(installation of dust collector at COB and CDQ, strengthened collection of dust at discharging of sintered ore and renewal of dust collector at BF's casthouse) should be required as soon as possible.

2.2 Waste Water

2.2.1 Present status of waste water discharged

1) Drainage outlets and volume of waste water

SIDEX has three final drainage outlets (C8, C4, and C7). The waste water at C8 is discharged via Malina Lagoon and that at C4 and C7 is discharged via Catusa Lagoon into the Siret, which combines into the Donau a few kilometers downstream. Flow rate of effluent is 45,900m^3/day at outlet C8, 29,900m^3/day, 3,200m^3/day at C4 and C7, respectively. The present status of waste water discharge at SIDEX is shown in Fig. III.2-2. Water for living in Galati and for industrial use in SIDEX is taken from the Donau in the upstream of the confluence with the Siret.

Industrial water of about 10,000m^3/hr is taken from the Donau and supplied to each plant after the treatment of decarbonation and coagulation sedimentation, and also to the power plant of RENEL adjacent to SIDEX.

For drinking water, 1,300m^3/hr of raw water is taken from the Donau and supplied after the treatment of sedimentation, filtration and chlorination in the steelworks.

2) Outline of standards for waste water

Different from waste gas, nationwide standards for waste water are not enacted. For the waste water discharged from SIDEX, however, the Agreement on the concentration and discharge loads is concluded per the drainage outlet, reaching a maximum of 18 items per outlet. This Agreement includes the penalty system but this seems not so binding such as ordering of operational stop against exceeding of the Agreement values.

The present restriction values were concluded between SIDEX and the National Council for Water before establishment of the Ministry of Water, Forestry, and Environment Protection based on a plan prepared by IPROMET, the planning and design institute for steel plants, in 1986, and are handed over as the Agreement No.18/1986 with General Department for Water Resources Conservation and Management of MOE and the Environmental Control Agency of Galati.

Accordingly, the quality and volume of waste water are measured by SIDEX once a week at the three final drainage outlets, which provides fairly enough data.

If a discharge load, calculated by multiplying the month average concentration of each pollutant in waste water by the average volume of waste water, exceeds the stipulated value, SIDEX has to pay the penalty, calculated by multiplying the excess volume by the unit price.

The values of the Agreement are quite satisfactory by comparison with those of the EU countries and Japan, proving no problems.

As there is large difference in the steel production between the present and the period when settled the Agreement No.18/1986, the negotiation has been continuing to revise the limit values in the Agreement which will be suited to the present status of the operation.

The draft of the new Agreement has not been opened yet.

3) Concentration of pollutants in waste water

Table III.2-6 compares the measurements in 1992 with the values of the Agreement.

For the average concentration, the values of the following exceed the values of the Agreement:

- At C8 : Dissolved iron, sulfate ion, ammonia, cyanide ion, and phenol
- At C4 : Dissolved iron, ammonia, cyanide ion, phenol, suspended solids (SS), and total sulfur

The result of ammonia, cyanide ion, phenol, and total sulfur seems to be affected by the gas liquid (ammonia liquor) from the coke plant.

The result of sulfate ion, SS, and dissolved iron may be caused also by other water treatment systems. Determination of the causes for exceeding the values of the Agreement requires survey and study of each water treatment system including the model plants.

Outline of water quality at each drainage outlet is as follows:

(1) The water treatment system for the No.2 coke plant area, No.7 and 8 COB located, is connected to C8, but the system is not operated when the survey has carried out, and so the cause for values of ammonia, cyanide ion, and phenol exceeding the Agreement values may be the mixture of drain from the COG piping, but its amount and concentration have not investigated by SIDEX.

(2) The water treated at the water treatment system for the No.1 coke plant area is discharged into C4. Since the concentration of ammonia, cyanide ion, phenol, and total sulfur is 10 to 100 times as high as the value of the Agreement, the efficiency of this water treatment system can be said to have fairly lowered. The main causes are analyzed in Section III.3.1.3.

(3) For the outlet C7, the flow rate is small, 3,200m³/day due to low operation of plants connected to this outlet and the concentration of pollutants is also low.

4) Discharge loads

The stipulated discharge load (kg/day) of each item is set per drainage outlet as the discharge volume multiplied by concentration and the penalty is calculated per month with the following equation. Actual results and Agreement values are compared in Table III.2-7.

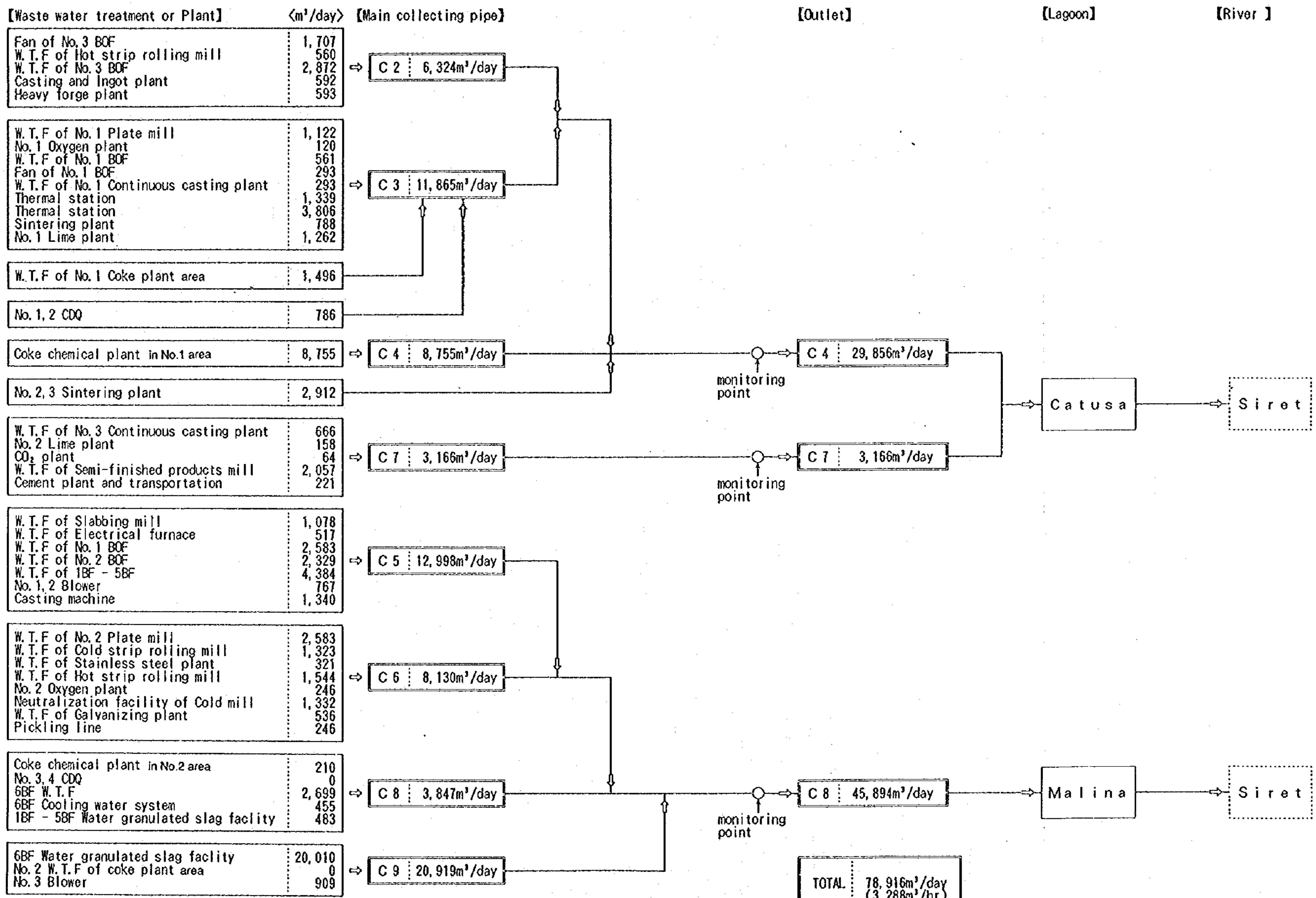
Penalty
= {Av. monthly discharge volume (m^3/day) x Av. monthly concentration (mg/lit) x 1,000 - Stipulated discharge load (kg/day)} x Unit price

The penalty seemed to reach about 85,000,000 Lei in 1993, which is about US$77,000 (US$1 = 1,100 Lei). Ammonia, cyanide ion, phenol, soluble iron, and total sulfur exceeded the values of the Agreement, of which phenol occupied about 60%.

5) Other pollution

Restriction on discharge of waste water by means of COD or BOD that shows organic pollution is not applied and not measured in SIDEX. But, as these COD and BOD are stipulated in the water quality item in the Environmental Quality Standard for Water and the Environmental Control Agency of Galati checks these in the Siret and in the Donau, they may be placed under restriction in future. And so SIDEX had better measure these voluntarily.

The largest source of organic pollutants is the ammonia liquor. The present concentration after water treatment is about 200 mg/lit. The Japanese average is 100 mg/lit, suggesting the need of improvement. As another source of pollution, living water, is discharged not only from SIDEX but also from the whole Galati without treatment into the Donau. Accordingly, improvement of river water quality requires measures against discharge from plants and also installation of sewage treatment plants.



Re. W.T.F : Waste water treatment facility

Fig. III.2-2. Flow Diagram of Waste Water in SIDEX

Table III.2-6. Concentration of Effluent and Agreement Values (mg/l)

Indicator	Drainage Outlet C8 Agreement	Data	(max.)	Drainage Outlet C4 Agreement	Data	(max.)	Drainage Outlet C7 Agreement	Data	(max)
Quantity (m^3/day)	102,384	45,894		120,096	29,856		239,328	3,166	
1. pH	7~8	7.9	(8.9)	7~8.5	7.9	(9.6)	6.5~8		
2. Ca ion	207	144	(198)	155	59	(100)	134	59	(80)
3. Mg ion	26	21.2	(58.4)	36	26	(51)	20	27	(48)
4. Soluble iron	0.3	0.96	(3.9)	0.5	2.2	(13)	0.3		
5. Cl^- ion	320	166	(248)	296	184	(320)	80		
6. SO_4^{2-} ion	198	274	(379)	152	137	(172)	104	94	(145)
7. NO_3^- ion	18	7.1	(14.5)	5	3.6	(10)	5	4.6	(5.6)
8. Ammonium ion	3	3.6	(11.1)	3	31.2	(197.5)	-	1.6	(3.3)
9. Cyanides	0.08	0.23	(3.02)	0.03	0.58	(2.24)	-	0	(0)
10. Phenols	0.15	0.87	(4.16)	0.14	20.03	(99.1)	-	0.048	(0.09)
11. Suspended solid	30	26	(155)	40	43	(84)	41	26	(62)
12. Total sulfur	0.3			0.27	1.9	(3.54)	-		
13. Na^+ ion	128			121			25		
14. Total chromium	-			-			2.8		
15. Cr^{6+}	0.006			-			-		
16. Zn^{2+} ion	0.009			0.12			-		
17. Free Cl_2	0.004			0.016			-		
18. Oil	0.5			0.4			0.3		

Re. Blank in each indicator means that SIDEX has not analysed.

Table III.2-7. Discharge Loads and Agreement (kg/day)

Indicator over Agreement	Drainage Outlet C8 Agreement	Data	Drainage Outlet C4 Agreement	Data	Outlet C7 Agreement	Total Agreement	Data	Unit Price (Lei/kg)
4. Soluble iron	35	124	57	129	5	97	253	57.77
6. SO_4^{2-} ion	20,100	35,249	18,300	8,014	1,740	40,100	43,263	4.35
8. Ammonium ion	300	464	340	1,823	-	640	2,287	173.30
9. Cyanides	8	30	4	34	-	12	64	1,733.70
10. Phenols	15	112	17	1,172	-	33	1,284	2,889.52

2.2.2 Analysis of the problems found in the model plants and measures

The target of SIDEX for the year 2002 will be not to discharge waste water whose restriction items exceed the values of the Agreement, and thus to decrease the discharge loads and corresponding penalty as much as possible.

Especially, as described later, the urgent measures is necessary for the reduction of phenol which is considered to affect the water quality of the Donau and the Siret. The proposed measures for water pollution prevention are indicated at Table III.2-8.

Table III.2-8. Items of Measures for Water Pollution Prevention

Plants	Items of Measures
Coke Chemical Plants	(1) Improvement of pH Control in Ammonia Stripping (2) Improvement of Activated Sludge Process (3) Installation of Coagulation Precipitator

1) To clear the values of the Agreement

Urgent measures are needed for the items that now exceed the Agreement values.

If measures would not be carried out, the concentration of pollutants exceeding the values of the Agreement will stay at the present level and the loads of them will increase more than the present according to the production increase.

A large decrease of ammonia, cyanide ion, phenol, and total sulfur can be possible by improvement of the coke plants and recovery of COG drain to or below the Agreement values.

As measures for decreasing sulfate ion, soluble iron, and SS, the causal relation with the plants not within the scope of the Study should be pursued and efforts of SIDEX are desired.

2) To decrease the discharge loads

As shown in Fig. III.2-2., the total flow rate of effluent from SIDEX at the present status of the steel production is 79,000m^3/day and its flow rate per ton of crude steel is 9.9m3/t-steel.

Integrated iron and steel works in Japan the average flow rate per ton of crude steel is 4.2m^3/t-steel(2.0~9.1m^3/t-steel), and circulation rate of industrial water is over 90%. Therefore, it is generally effective for SIDEX to reuse wastewater still more than now by sedimentation and filtration for the reduction of pollutant loads, because the reduction of discharging effluent means to reduce the loads.

2.3 Solid Wastes

2.3.1 Present status of solid wastes discharged

1) Standards for solid wastes

As standards on the disposal of solid wastes such as by landfill, there exists only the Basel Treaty which restricts cross-border transportation of harmful wastes, and no detailed standards for the storage, transportation, and disposal according to the properties of wastes. Correspondingly, there are no special restrictions applied in SIDEX. Establishment of treatment standard, regulation and promotion scheme for solid wastes are desired in the future.

2) Outline of disposal of solid wastes

Solid wastes generated in SIDEX such as slag, dust, and waste refractories are basically thrown away to the special disposal area (slag yard) to the west of the works. Since the start-up of the works, the disposal area is expanding and now it is about 100 hectares, and may reach Marina Lagoon nearby in several years. The slurry and sludge generated at the water treatment are not dehydrated and are simply sent by pressure piping to the slurry ponds next to the disposal area. Three ponds are placed as partitioning off a part of Marina Lagoon.

One is for slurry generated at wastewater treatment facilities in rolling mill plants, the other are in blast furnace and coke chemical plants, respectively.

As seen above, maybe because of more availability of disposal areas compared with Japan, most solid wastes and byproducts except part of slag and dust are disposed of by throwing away.

3) Present recovery and disposal of main solid wastes

The generated volumes of the main solid wastes and recovery for reuse in 1992, shown in Table III.2-9, are as outline below:

(1) BF slag

SIDEX has six producing facilities for water granulated slag(W.G. slag) in every blast furnaces, but only one in No.6 BF of them has full capacity to produce W.G. slag from all molten slag generated in the blast furnace.

SIDEX sold 0.6 million tons of W.G. slag as a raw material of cement in 1993. In Romania, 2.5 million tons of blast furnace slag cement has been produced, in which W.G. slag is mixed, and the total cement production is 4.7 million tons in 1993. As the average mixture proportion of W.G. slag in blast furnace slag cement is 25%, it is considered that W.G. slag needed in the production of it is almost provided by SIDEX. Regardless of that fact, the recycling ratio of blast furnace slag in SIDEX stays low level, about 50%, and the residue is dumping out to slag yards of SIDEX as air cooled slag.

Romanian standard in cement production prescribes mixture proportion of raw materials in each kind of cement and there is the standard PA35 for blast furnace slag cement production.

For export of cement, 2.5 million tons is produced, and which is produced according to British standard without using W.G. slag.

The utilization status in Japan is shown in Fig. III.2-3.

(2) BOF slag

The generated volume of BOF slag is the next largest to that of BF slag.

The apparent recovery rate is as high as 78% in Table III.2-9 but this is because of recovery of grain iron from slag. And actually, after recovery, it seems to be stored in the yard, then disposed of by throwing away. The recovery situation in Japan is shown in Fig. III.2-4 for reference.

(3) Dust and sludge

All the dry dust is recovered and reused as material. But the analysis system for checking the chemical composition such as alkali and zinc that adversely affects the operation of sintering plants and BF should be reviewed and improved. Most sludge, generated from the waste water treatment systems and thrown away to the slurry ponds, is not recovered and reuse of it as iron source is one requirement. But a trial to reuse sludge dried up by sunshine as iron source of sintering has just started, it is desired that this will be spread to other sludge in the future. The tar sludge, though disposed of by throwing away, can be mixed with coal for use in the coke oven batteries. As shown in Fig. III.2-5, much of collected dust and sludge is reused as raw material for sintering plants in Japan.

The discussion between SIDEX and CEPROCIM(National Institute for Cement) has just started, which aimed collaboration of investigation on the comprehensive utilization of solid wastes like slag and coke dust, and it is desired to progress.

2.3.2 Analysis of the problems found in the model plants and measures

Though SIDEX has a vast disposal area, expansion of the existing disposal area and ponds should be limited in terms of environmental protection. More concretely, the following are recommended:

1) Utilization of air cooled slag

The air cooled slag generated in BF and BOF hardly is reused now, but as shown in the status of Japan, they can be reused as materials in road construction or civil engineering fields.

Therefore, the theme for the utilization of air cooled slag is to reuse widely in this field, although cost competition may happen to occur with natural sand and gravel.

For the wide reuse of water granulated slag, it depends on the demands in the production of blast furnace slag cement, but it should be considered that the wide reuse of water granulated slag can contribute energy saving in cement production. In addition, it can be reused as materials in civil engineering.

The integrated scheme among slag suppliers, users and administrative support by authorities is very important to promote wide utilization of slags as follows :

That is, SIDEX as a supplier of slag must expand the water granulated slag facility, install plant for crushing and screening of air-cooled slag and establish quality management system for slag.

On the other hand, users such as cement producers and constructors for civil engineering are requested to study or reuse for wide utilization of slag, and next for authorities, it is desired to authorize quality standard on slag in each field of utilization and approve or promote to use slag as materials for civil engineering carried out under the admission by authorities.

2) Treatment and reuse of dust and sludge

The theme for dust and sludge is to reuse widely as iron source in sintering process. In Japan, the utilization ratio of dust and sludge(except mill scale) is 1.4% to 3.0% to the production of sintering ore, but SIDEX stays at the level of 1.1%.

Therefore, SIDEX can reuse them more than the present by investigating of influence to operations and analyzing of the chemical components.

In addition, SIDEX has to install dehydration equipments in order to limit expansion of the present ponds and retain its long period of dumping area.

3) Control of disposal

Not to allow careless disposal of solid wastes, a control system which requires efforts at recovery and reuse of solid wastes at the generation source should be established. One good starting point is to expand the present system in SIDEX's Modernization and Environmental Control Department, in which the kinds, volume, generation source, the plant in charge, recovery cost, etc. of the waste to be brought into the slag yard are required to be recorded in a card and submitted to the Department.

Table III.2-9. Generation and Utilization of Solid Wastes (1992 FY)

Solid Wastes	Generation (ton/year)	Recovery (%)	Outline of Utilization
1. BF slag	1,632,024	35	Production of Granulated slag ⇨ Sale to Cement Plant
2. BOF slag	448,060	78	Recovery of iron and dump out to slag yard
3. BF dust(dry)	24,650	100	Reuse as raw material in sinter plant
4. Sinter dust	24,611	100	Reuse as raw material in sinter plant
5. Iron scrap	23,650	100	Reuse as raw material in BOF
6. Scale	9,500	100	Reuse as raw material in sinter plant
7. Sludge	40,150	0.4	Dump out to north and south slurry pond in Malina Lake
8. COB sludge	1,065	94	Partial reuse in BF and storage in coal yard
9. Residue iron	7,300	100	Reuse as raw material in BOF
10. COB dust	2,642	7	
11. Coal dust	86,478	100	Reuse as raw material in COB
12. Lime dust	11,775	100	Dump out to slag yard
13. Oily sludge	1,000	0	Dump out to slag yard
14. Tar sludge	1,200	0	Dump out to slag yard
15. Acid tar	4,000	0	Dump out to slag yard
16. Residue nozzle	1,000	0	Dump out to slag yard

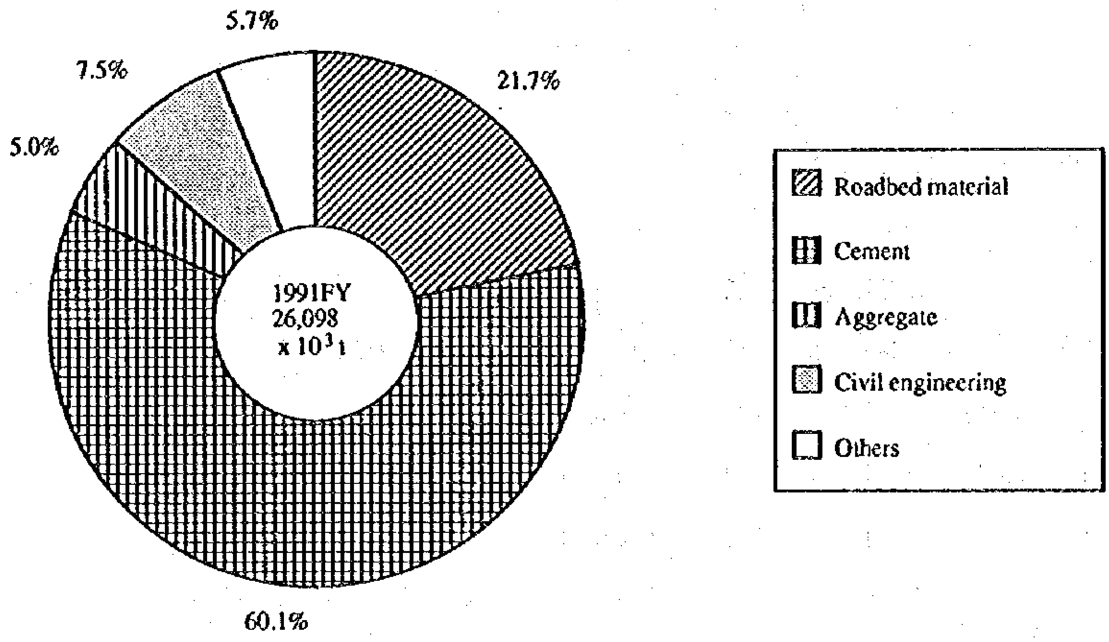


Fig. III. 2-3. Use of BF Slag in Japan

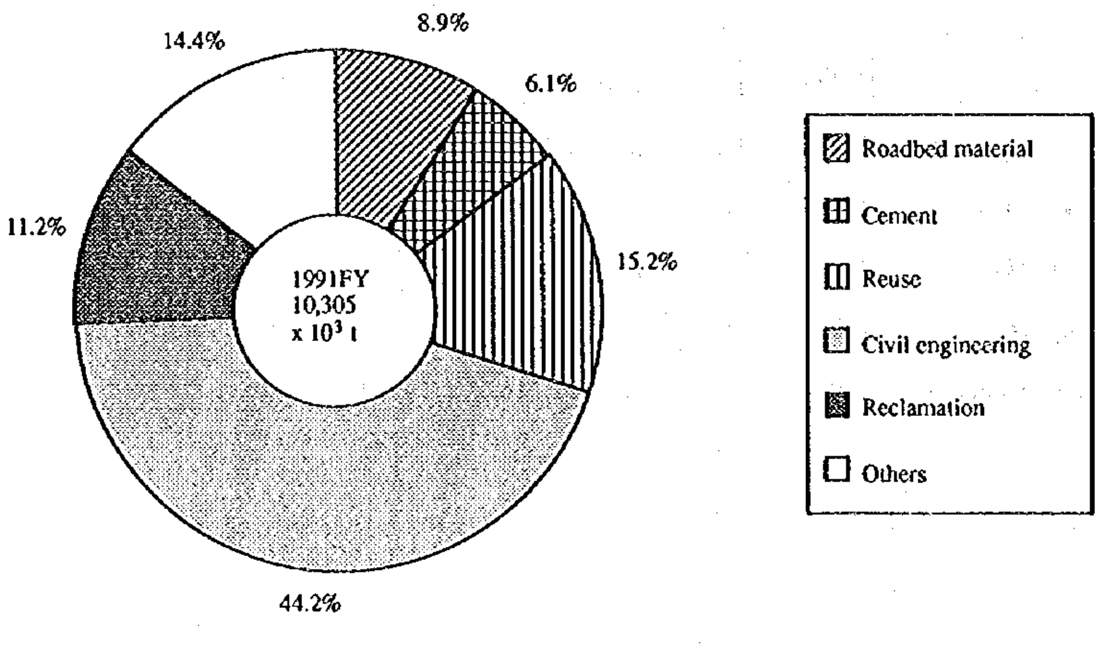
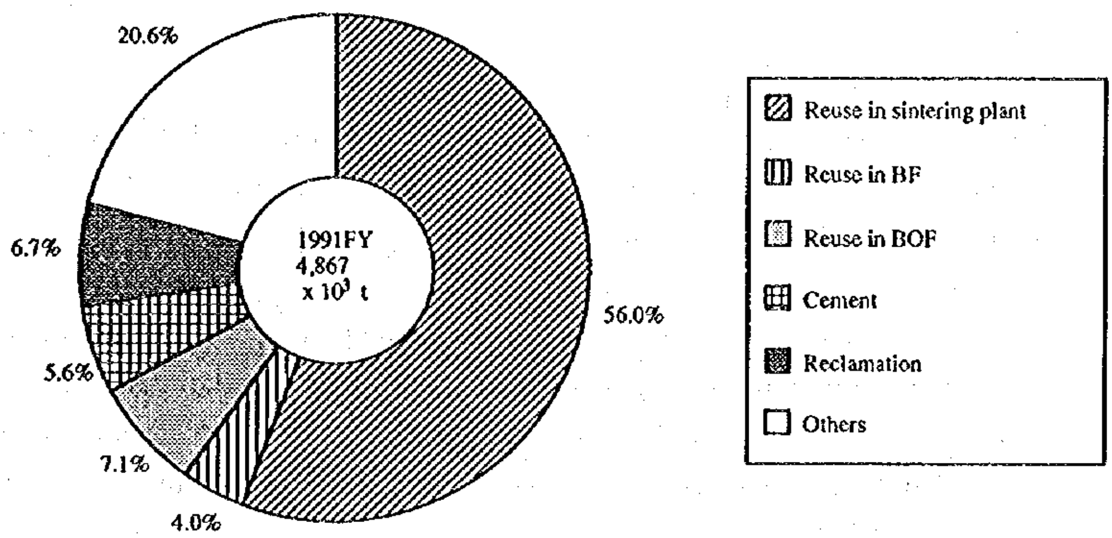
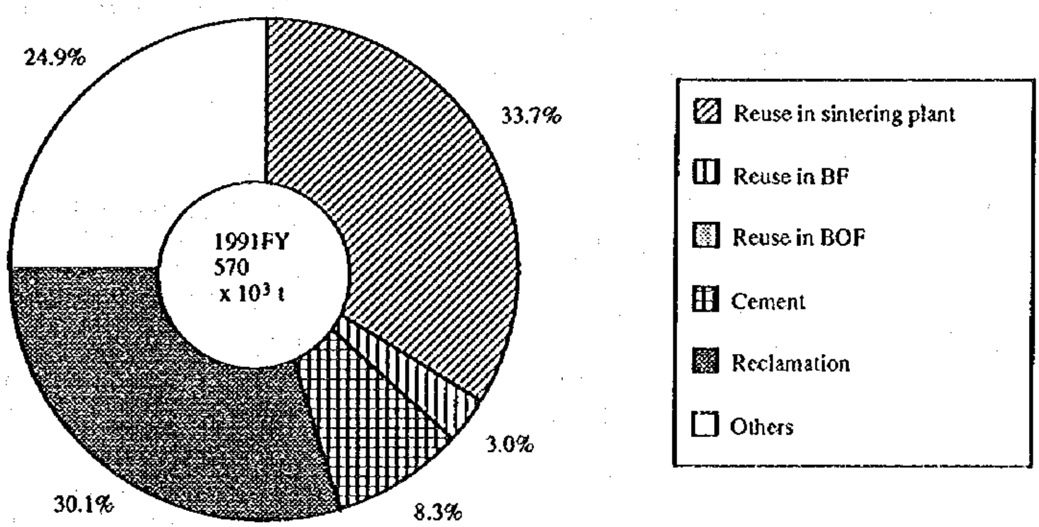


Fig. III. 2-4. Use of BOF Slag in Japan



Dust collected by dust collector



Sludge

Fig. III. 2-5. Use of Dust and Sludge in Japan

2.4 Measures for Incidental Pollution

There are new generations of dust, sulfur and sludge according to installations of dust collectors, desulfurization facilities and dehydration equipments for the environmental protection measures in 2002.

Dust will be reused in sintering process except a small part of it, sulfur will be recovered as hydrosulfuric acid and dehydrated sludge of wastewater treatment facility in coke chemical plants will be incinerated at coke oven batteries mixing with coal. Each solid wastes and their treatment are listed in Table III.2-10.

Table III.2-10. Outline of utilization of dust, sulfur and sludge generated from new depollution facilities in 2002

Plant	Depollution facilities	Solid wastes	Generation	Utilization or treatment
Coke oven batteries and coke chemical plants	No.2, 3 CDQ : Dust collector No.5, 7 COB : Dust collector of guide car	Coke dust	(total) 14,500 t/y	Reuse as raw material in sintering plant
	No.7 COB : COG-Desulfurization equipment	Sulfur	2,200 t/y	Recover as sulfuric acid of 6,300 t/y
	No.5 & 6 COB, No.7 COB : Sludge from activated sludge process	Dehydrated sludge	(total) 5,400 t/y 85 % hydrated	Incinerate by COB mixing with coal
	No.5 & 6 COB, No.7 COB : Sludge from new precipitator	Dehydrated sludge	(total) 5,600 t/y 85 % hydrated	
Sintering plants	No.5 & 6, No.7 : Desulfurization equipments	SOx gas	3,335 kNm³/y	Recover as sulfuric acid with sulfur of COG desulfurization
	No.5 & 6, No.7 : New electric precipitator of main exhaust gas	Collected dust	13,600 t/y	Reuse 12,600 t/y in sintering plant, but the residue (1,000 t/y) is dumped because its high alkalinity
Blast furnace	No.5, 6 BF : Dust collector of casthouse	Collected dust	36,500 t/y	Send as slurry to thickener and precipitator

2.5 Management of Environmental Protection in SIDEX

2.5.1 Management system in SIDEX

As shown in Fig. III.2-6, under the Board of Management, the Modernization and Environmental Control Department manages the whole of environmental measures, then comes the Environmental Laboratory in charge of analysis and measurement, the Environmental Control Office in charge of managing the nine plants, and the Environmental Police in charge of monitoring. In these nine plants, the chief engineer in charge of machine operation and energy control is authorized as the responsible person for the management of environmental problems in each plant.

The central committee for all the plants is held at intervals of six months and the plant committee every month in each plant. Activities for prevention of atmospheric, water, and soil pollution are reviewed and discussed at the Board of Management quarterly.

Concerning accidents that accompany environmental pollution, the communication route between the environmental departments and the plant and also between SIDEX and the Environmental Control Agency of Galati is established. Education and technical training of the employees are conducted since 1993.

The management system of SIDEX has sufficiently been established. Further excellent activities are therefore expected.

2.5.2 Monitoring system in SIDEX

The monitoring system cannot be said to be properly established in SIDEX maybe because the standards are not certain. As described former, in future, an official duty to have monitoring system and report on emission situation toward big stationary sources like SIDEX may be imposed, and so it is desired that SIDEX should install automatic continuous analyzers for main gas emission sources and process measuring data for management such as making hourly, daily and annual report by computer. And it is desirable to measure flow rate and water quality of effluent automatically. Japanese examples are shown in Table III.2-11 for reference. SIDEX will be desired finally to monitor the environmental pollution up to the levels shown in this table. The main measures as the monitoring will be as follows and a example on a monitoring system for the model plants in this study are indicated in Fig. III.2-7.

(1) To install instruments that can measure SOx, NOx, and O_2 at the main generation sources such as coke plants and sintering plants.

(2) To establish soot measuring system for the facilities in (1) above.

(3) To include COD as the control item in the coke waste water treatment system.

(4) To establish analysis system for chemical composition of dust and sludge.

(5) To establish analysis system for BOD and COD at the drainage outlets.

(6) To expand the checking system for disposal of solid wastes.

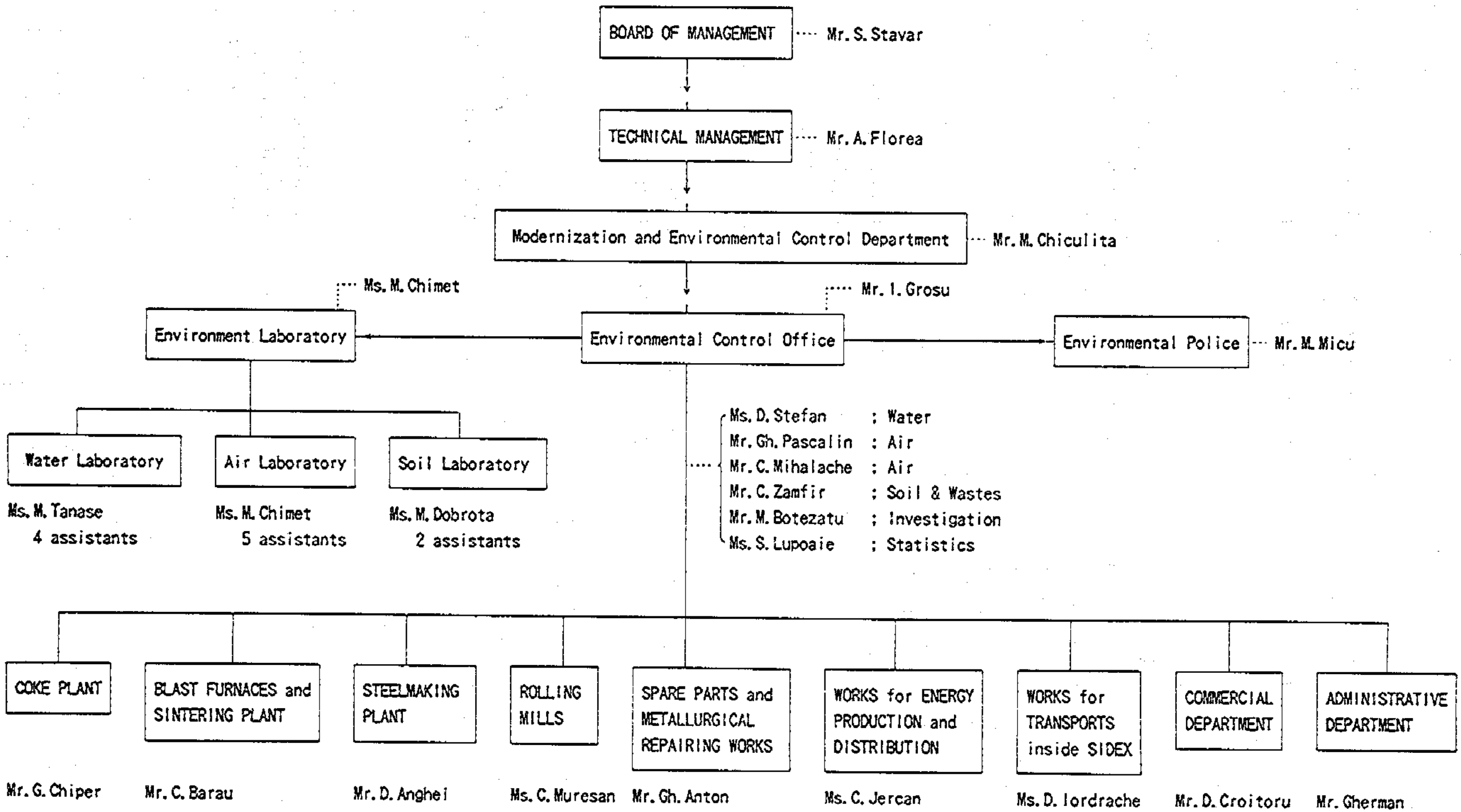


Fig. III.2-6. Environmental Management System in SIDEX

Table III. 2-11. Monitoring of Waste Gas, Waste Water and Solid Wastes (Example)

	Plant, Facility	Automatic Analyser	Outline of Mesurement
Waste Gas R.F =reheating furnace	Sinter Pellet Boiler (No. 1 ~6) Slabbing mill R.F Plate mill R.F (Total 10 sources)	SO_x, NO_x, O_2 analyser	Manual sampling and analysis in a month (SO_x, NO_x, O_2, Soot)
	BF Hot Stove Slabbing mill R.F. Hot strip mill R.F. Lime plant Plate heat-treatment F. Cold annealing furnace CGL annealing furnace (Total 10 sources)	not installed	Manual sampling and analysis in a month (SO_x, NO_x, O_2, Soot)
Waste Water	Outlet 3points	Flow meter, pHmeter Automatic sampler	Weekly analysis (COD, SS, Fe, oil, N, P)
W.T.F =waste water treatment facility	Cold strip mill W.T.F BOF W.T.F (clarifier) Final W.T.F BF W.T.F (clarifier) Clarifier of fine ore wash Sewerage in Works (Total 7 sources)	Flow meter pH meter COD meter	Weekly analysis (COD, SS, Fe, oil, N, P)
Solid Wastes	Sludge 6kinds Dust 3kinds	—	monthly: Zn, carbon annual: hazardous substances in law

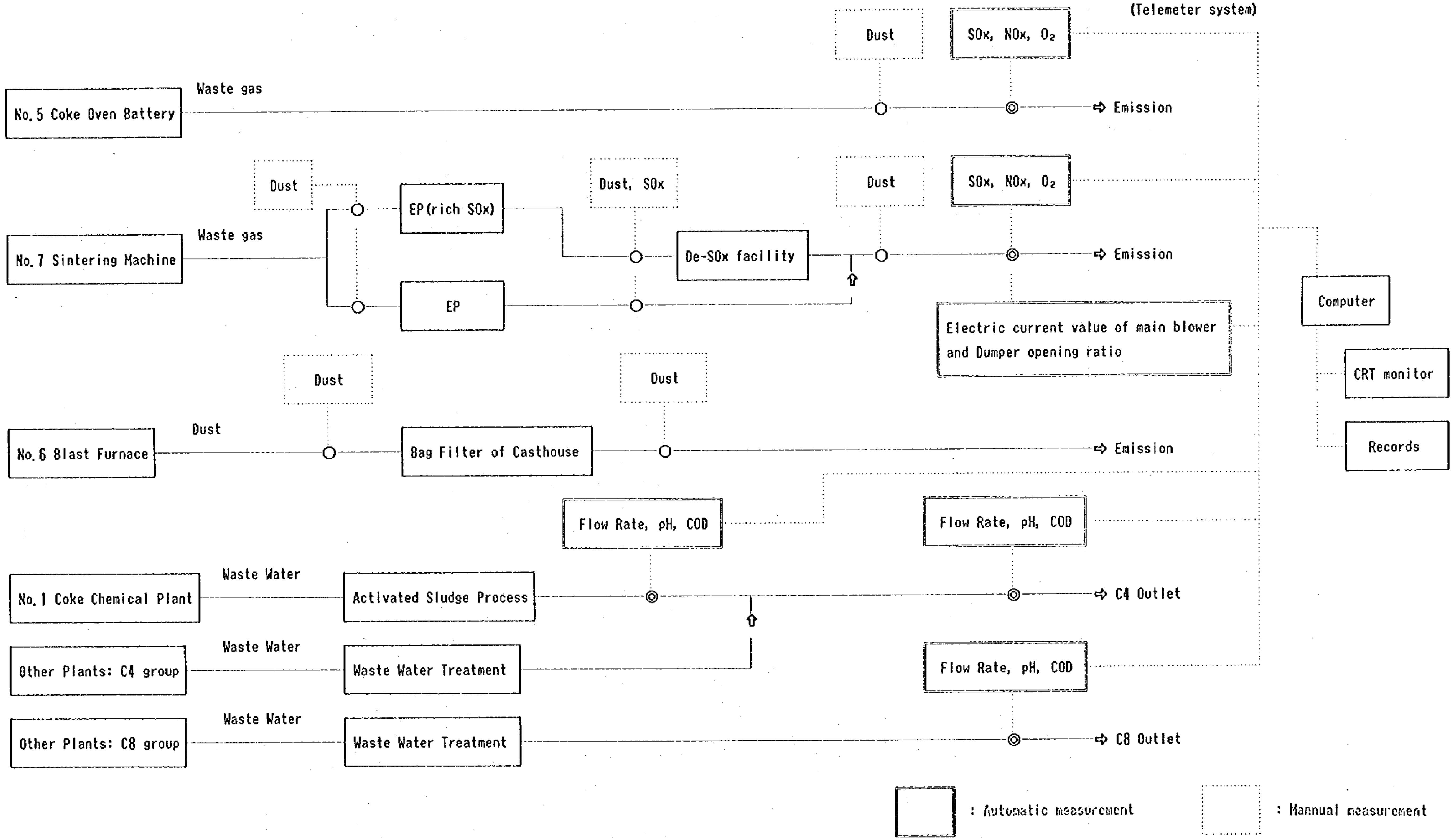


Fig. III.2-7. Example of Monitoring System in Model Plants