7-3. Iron ore and sinter

7-3-1. Summary

In order to stabilize operation of blast furnaces in the modernization of BURNPUR Works, improvement of raw materials charged into the furnaces is extremely important.

Drastic improvement is required to solve the problems as listed in Chapter 5-2 including "Material size", "Inclusion of adhered fine ore", "Unstable quality of raw materials", "Productivity of blast furnace" and "Utilization of unused fine ore."

(1) Iron ore

To ensure raw materials of optimum size (10-30 mm) for blast furnace charge, sizing plant is to be installed. This plant makes it possible to achieve optimum size of iron ores from the captive mines, GUA and CHIRIA, and imported ores and prevent inclusion of adhered fine ore.

For flux materials such as limestone and dolomite which are delivered in lump, crushing plant is to be installed to crush them in size (3 mm or less) desirable for use in sintering plant. (Part of them is charged into blast furnaces in lump.)

In order to stabilize quality of the raw materials, ore bedding system is introduced for lump ore and fine ore.

(2) Sintering

Introduction of sintering facilities is considered to improve and stabilize quality of the raw materials to be charged into blast furnaces. By adding flux to sinter, it becomes possible to lower heat loss at blast furnaces.

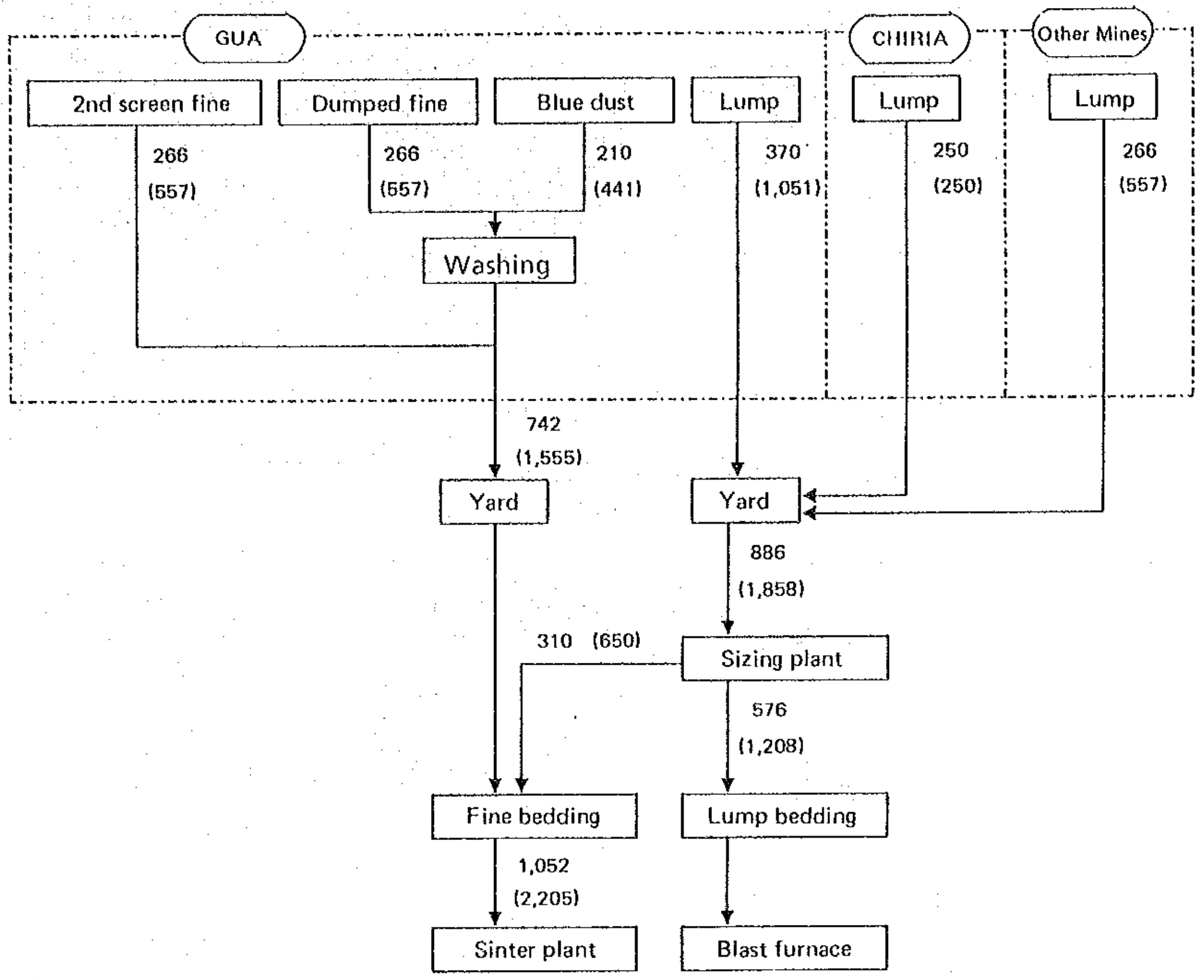
It is also contemplated that part of dumped fine ore and blue dust accumulated as it is at GUA mines is, after washing and screening at the mines, is used as materials for sinter.

7-3-2. Facilities plan

(1) Basic condition of facilities plan

Plans for consumption of raw materials at 1st step and 2nd step of the modernization plan are given in Figs. 7.3.1 through 7.3.3 and Tables 7.3.1 through 7.3.4.

Lump ore consists of high grade ore (purchased ore) 30% and general ore (GUA and CHIRIA) 70%. As regards fine ore, GUA fine ore is mainly used in the blend. It will be blend consisting of fine ore from secondary screening being 25%, fine ore from primary screening and dumped fine 25%, blue dust 20% and fine ore from sizing plant 30%.

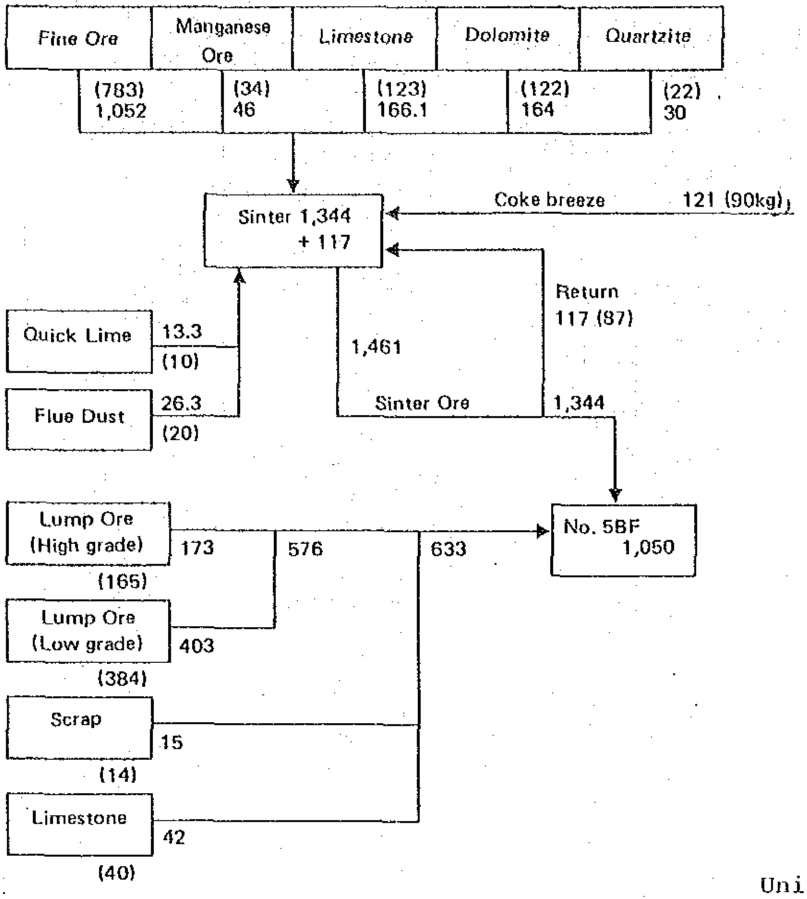


Unit: 1,000T/Y

Note: 1. Figures in () show that of 2nd stage.
2. Consumption base at BURNPUR Works

Fig. 7.3.1 Iron ore flow

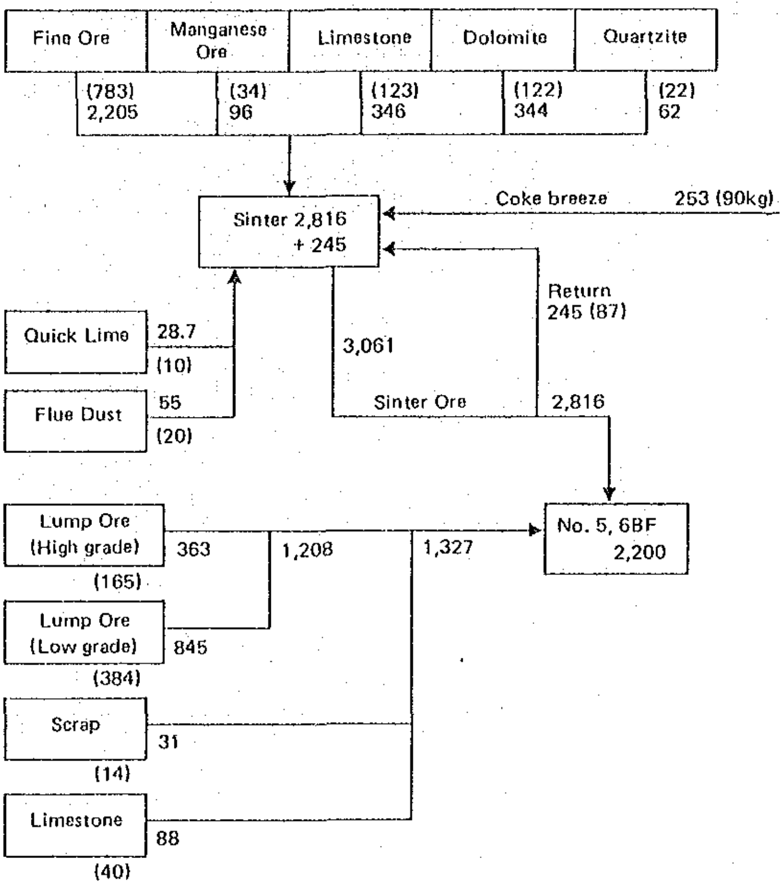
Figures in ( ) show unit consumption



Unit: 1,000T/Y

Fig. 7.3.2 Material flow diagramme (1.05MT (Hot metal)/Y)

Figures in ( ) show unit consumption



Unit: 1,000T/Y

Fig. 7.3.3 Material flow diagramme (2.2 MT (Hot metal)/Y)

Table 7.3.1 For sinter plant

Item	Unit consumption kg/T-sinter	Quantity (T/D)		Remarks
		1st	2nd	
Sinter production		5,003	10,482	Ope. ratio = 80%
Fine ore	783	3,917	8,207	
Sinter fine	87	435	912	
Mn ore	34	170	356	
Limestone	123	615	1,289	
Dolomite	122	610	1,279	
Quartizite	22	610	231	
Quick lime	10	50	105	
Flue dust	20	100	210	
Total raw material supplied	1,201	6,007	12,589	

Table 7.3.2 For blast furnace

Item	Unit comsumption kg/T-pig iron	Quantity (T/D)		Remarks
		1st	2nd	
Pig iron production		3,028	6,345	Ope. ratio = 95%
Lump ore	549	1,662	3,483	
Limestone	40	121	254	
Sinter ore	1,280	3,876	8,122	
Scrap	14	42	89	
Total	1,883	5,701	11,948	

Table 7.3.3 Sizing plant

Item	Lump yield	1st (T/D)			2nd (T/D)		
		BF Consumpt.	Sizing Q'ty	Under size	BF Consumpt.	Sizing Q'ty	Under size
Lump ore	65%	1,662	2,557	895	3,483	5,358	1,875

Table 7.3.4 Flux crushing plant

Item	1st (T/D)	2nd (T/D)
Limestone	615	1,289
Dolomite	610	1,279
Quartzite	110	231
Total	1,335	2,799

(2) Particulars of facilities

1) Yards

These facilities are for receiving, storage, sizing, blending and feeding iron ore, limestone and other raw materials required by blast furnace and sintering plant and comprise receiving yard facilities, sizing facilities, flux crushing facilities, blending yard facilities and stacking and reclaiming conveyors.

The receiving facilities include wagon tippler which is used to handle bottom dump type and side open type railway cars.

All raw materials such as ore, limestone and miscellaneous materials are placed in the same receiving yard to utilize the yard space most effectively.

The number of days of storage in the receiving yard and blending yard are assumed to be about 20 days and 10 days, respectively, as the source of raw materials is relatively near. Storage capacity of the yards is shown in Table 7.3.5. (Storage efficiency is assumed 60% for yards and 50% for beds.)

Table 7.3.5 Material Stock Capacity

Item	Unit capacity T/m²	1st				2nd			
		Area m²	Capacity T	Consumption (T/D)	Days	Area m²	Capacity T	Consumption (T/D)	Days
Yard	8.4	16,000	134,400	5,800	23	24.000	201,600	12,140	17
Bed (Fine)	5.25	12,000	63,000	4,100	15	18,000	94,500	8,590	11
Bed (Lump)	5.25	6,000	31,500	1,580	20	6,000	31,500	3,310	10

Receiving from and delivering to yards and beds are by stackers and reclaimers to increase efficiency of handling.

Sizing facilities crush and screen the raw materials by combination of screens and crushers to sizes (10-30 mm) suitable for blast furnace charge.

Crushing of flux (limestone, dolomite, etc.) is done by crushing and screening facilities centered on impeller breakers and those facilities are planned to provide products, 90% of which is in size less than 3 mm.

Table 7.3.6 shows details of yard facilities.

Table 7.3.6 Yard equipment

	Equipment	Type	Specification	Quantity
1.	Material receiving line			
1)	Receiving hopper	RC structur, W/Roof	100 m^3	20
2)	Feeder	Apron	600 T/h	20
3)	Belt conveyer		1200 T/h	5
4)	Stacker	Boom slewing	1200 T/h, boom 35mL	2
5)	Ore yard		40mW x 200mL x 14mH	3
6)	Wagon tippler	Car dumping		
2.	Material reclaiming line			
1)	Reclaimer	Slewing, bucket wheel	1,000 T/h, boom 40mL	2
2)	Belt conveyer		1,000 T/h	6
3.	Ore sizing plant			
1)	Surge Bunker	Steel structure	100 m^3	2
2)	Feeder	Apron	600 T/h	2
3)	Screen	Ripl-Flo	8'x20', 9'x20',7'x16' 7'x20', 6'x12'	14
4)	Crusher	Hydro-Cone	300 T/h, 210 T/h	4
5)	Belt conveyer		10~600 T/h	25
4.	Lime crushing plant			
1)	Surge bunker	Steel structure	100 m^3	1 x 2
2)	Feeder	Apron	200 T/h	1 x 2
3)	Screen	Low-head	6'x14', 7'x18'	5 x 2

(continued)

	Equipment	Type	Specification	Quantity
4)	Crusher	Impeller breaker	150 T/h, 125 T/h	3 x 2
5)	Belt conveyer		100 ~ 600 T/h	14x1,15x1
6)	Lime hopper	Steel structure	600 m^3	4
7)	Feeder	Apron	600 T/h	4
8)	Hopper discharge BC		600 T/h	3
5.	Fine ore bed line			
1)	Ore bed bunker	Steel structure	600 m^3	4
2)	Feeder	Apron	1,000 T/h	4
3)	BC		1,000 T/h	4
4)	Stacker	Wing type	1,000 T/h	2
5)	Fine ore bed		30mW x 200mL x 12mH	3
6)	Reclaimer	Double wheel	1,000 T/h	1
7)	BC		1,000 T/h	4
6.	Lump ore bed line			
1)	Ore bed bunker	Steel structure	600 m^3	4
2)	Feeder	Apron	600 T/h	4
3)	BC		600 T/h	2
4)	Stacker	Double wing type	600 T/h	1
5)	Lump ore bed		30mW x 200mL x 12mH	1
6)	Reclaimer	Double wheel	600 T/h	1
7)	BC		600 T/h	5
7.	BF feeding line			
1)	Belt conveyer		600 T/h	4

(continued)

	Equipment	Type	Specification	Quantity
8.	Dust collector (Sizing plant)	Bag filter	5,000 Nm^3/min -500 mmAq	1
9.	Electrical equipment			1
10.	Instrumentation equipment		Belt weigher	7
11.	Accessories		Metal detector, Metal remover, Elec. hoist, Vibrator, Sampling eq't.)	1

2) Sinter

Sintering plant is to have effective sintering area of 210 m^2 on the basis of sinter accounting for 70% of raw materials charged into blast furnaces and also by taking into consideration operating rate, productivity and returned fine from screen at BF ore bin. The grounds are as given below, but 5% allowance is given to the grate area of the sintering machine to cope with fluctuation in iron production by the blast furnaces.

1st step:

Required quantity of sinter (Million tonnes)

1.05 x 1.829 x 0.7 ÷ 0.92 = 1.461
(Pig iron)(Ore ratio)(Sinter ratio)(Skip ratio)

Required grate area

1.461 x 10^3 ÷ 365 ÷ 24 ÷ 0.8 ÷ 1.1 x 1.05 = 200 m^2.
(Op. ratio) (Surplus)
(Productivity)

2nd step:

Required quantity of sinter (Million tonnes)

2.20 x 1.829 x 0.7 ÷ 0.92 = 3.061

Required grate area

3.061 x 10^3 ÷ 365 ÷ 24 ÷ 0.8 ÷ 1.1 x 1.05 = $\underline{210\ m^2 \times 2}$

Details of equipment of sintering plant are given in Table 7.3.8 and their characteristics are as follows:

a. There will be 10 -500m^3 blending hoppers which are equipped with constant feed weighers, to feed constant amount of fine materials, return fines and coke breeze. Storage capacity is shown in Table 7.3.7.

Table 7.3.7 Storage capacity of blending hopper

Brand	Unit vol.	Q'ty	Vol.	Specific capacity	Storage capacity
Fine ore	500 m^3	6	3,000 m^3	2.0 T/m^3	6,000T
Return fine	500	2	1,000	1.6	1,600
Coke breeze	500	2	1,000	0.6	600

b. Coke breeze is received from wagons in sintering plant and transported by belt conveyor to coke breeze stock yard (capacity 5,000T). As required in sintering plant, coke breeze is crushed in rod mill and sent to blending hopper.

c. Mixing and rerolling of raw materials is done by one unit of mixing drum.

d. Ignition furnace is made compact as much as possible and of line burner type to reduce unit fuel consumption.

e. Sintering machine is Dwight-Lloyd type and is 3.5 meter wide to ensure adequate length of the machine as against the effective grate area of 210 m^2.

f. Height of side wall can be raised to 550 mm max. to improve quality of sintered ore.

g. To minimize air leakage between sintering machine and wind box, grease seal is contemplated as air seal method.

h. Crusher is single spike roll type and crusher bar is mounted on wagon to facilitate maintenance.

i. Cooler is of pressure type circular to facilitate energy saving (waste heat recovery) in future.

j. Electrostatic precipitator is installed to main exhaust dust collecter for pollution control.

k. Main blower is of turbo type which is efficient and easy to maintain. Pressure is - 1,450 mm H_2O corresponding to 550 mm bed height of sintering machine.

l. Main exhaust stack is of concrete which is easy to build.

m. Room dust collecter is EP for better collection at feed & discharge portion, cooler portion and sinter product screening line.

n. There are two product screening lines for a plant to improve quality and facilitate maintenance.

o. Though sinter product is usually sent directly to ore bin at BF, sinter product storage yards (each holding 16,000T or 3-day supply) are planned to cope with shutdown of BF or fluctuation of demand and supply balance.

p. It is contemplated to introduce micro processors measurement and control to about 50 items.

q. As auxiliary facilities, belt weigher, metal detecter & remover, vibrater, crane, sampling & test plants, and compressor and others are contemplated. Those facilities are to support smooth and stable operation of the sintering plant.

Table 7.3.8 Sintering Plant

	Equipment	Type	Specification	Quantity
1.	Material line			
1)	Blending hopper	Steel made	500 m^3	10 x 2
2)	Constant feed weigher	Load cell		10 x 2
3)	Mixing drum	Single rotary drum	4mφ x 21mL 500 T/h (Max 750 T/h)	1 x 2
2.	Material feeding eq't			
1)	Raw material hopper	Steel made	40 m^3	1 x 2
2)	Drum feeder	Rotary drum	1.324mφ 500 T/h (Max 700 T/h)	1 x 2
3)	Hearth layer hopper	Steel made	40 m^3	1 x 2
3.	Ignition eq't			
1)	Ignition furnace	Bottom open, top burner	3.6mW x 3mL	1 x 2
2)	Burner	Line burner		1 x 2
3)	Combustion air fan	Single suction turbo	250 Nm^3 /min 500mmAq	1 x 2
4.	Sintering eq't			
1)	Sintering machine	Dwight-Lloyd	210 m^2 , 3.5mW, Bogi-flex Drive	1 x 2
2)	Pallet body	One piece W/Insulation	3.5mW x 1.5mL	102 x 2
3)	Side wall	Hexaparite	550 mmH	204 x 2
4)	Grate bar		20/25 mmW	42228x2
5)	Wind box	Double suction	3.5mW x 4mL	15 x 2
5.	Crushing eq't			
1)	Primary crusher	Single spike roll	Crushed size: < 150mm Cutter: three blade 2mφ x 70mmT Bar: wagon-mounted 120mmWx13pcs	1 x 2
2)	Support beam cooling fan	Single suction roll	120 m^3 /min x 175mmH$_2$O	1 x 2

(continued)

	Equipment	Type	Specification	Quantity
6.	Cooling eq't			
1)	Cooler	Pressure circular	Cooling area: 210m^2 Trough: 3.5mW x 1.5mH x 36sets Cap: 430T/h (Max.600T/h)	1 x 2
2)	Cooling air fan	Double suction, turbo	7800m^3/min at 30°C 410mmH$_2$O	3 x 2
3)	Discharge pan feeder		1.5mW x 0.6mH x 10mL	1 x 2
7.	Main exhaust equipment			
1)	Wind leg		0.7m x 1.0m/0.9mφ	30 x 2
2)	Gas main duct		3.4m/4m/4.6m/5.2mφ	1 x 2
3)	Main EP	Dry	18,000m^3/min 150°C 0.5~2g/Nm^3→0.08g/Nm^3	1 x 2
4)	Main exhaust blower	Double suction, turbo	18,000m^3/min 150°C -1450mmH$_2$O	1 x 2
5)	Double damper	Pneumatic	600mm x1300mmH	19 x 2
6)	Main stack	RC made	70mH	1 x 2
8.	Room dedusting eq't			
1)	Room DP	Dry	15,000m^3/min 100°C 5~15g/Nm^3→0.1g/Nm^3	1 x 2
2)	Dedusting fan	Double suction, turbo	15,000m^3/min 100°C, 390mmH$_2$O	1 x 2
3)	Dedusting stack		4mφ x 20mH	1 x 2
9.	Centralized lub. eq't			
1)	Transfer pump	Pneumatic	650cc/min 100kg/cm^2	1 x 2
2)	Grease pump		500cc/min 210kg/cm^2	2 x 2
10.	Crushing & screening eq't			
1)	Secondary crusher	Double spike roll	1.2mφ x 1.8mL, grain size 50mm Cap: 200 T/h	2 x 2

(continued)

	Equipment	Type	Specification	Quantity
2)	Stationary grizzly		2.1mW x 4.8mL 600 T/h	2 x 2
3)	1st screen	Ripple flow	2.4mW x 6mL 20mm Slit 600 T/h	2 x 2
4)	2nd screen	Ripple flow	2.4mW x 6mL 10mm Slit 450 T/h	2 x 2
5)	3rd screen	Ripple flow	2.4mW x 7.2mL 5mm Punch 300 T/h	2 x 2
11.	Coke handling facility			
1)	Coke receiving hopper	RC made	100 m^3	4 x 1
2)	Apron feeder		50 T/h	4 x 1
3)	Coke yard		5,000 T (70mL x 22mW)	1 x 1
4)	Apron feeder		20 ~ 80 T/h	6 x 1
5)	Rod mill		40 T/h, 2.7mφ x 4.4mL -10mm→-3mm	2 x 2
12.	Belt conveyer system			
1)	Raw material line		750 T/h	4 x 2
2)	Coke line		100 ~ 200 T/h	7 x 1 3 x 1
3)	Sinter product line		150 ~ 640 T/h	21 x 2
4)	Hearth layer line		100 T/h	2 x 2
5)	Return fine line		250 T/h	3 x 2
6)	Dust spillage line		10 ~ 30 T/h	4 x 2
7)	Fine sinter return line		100 ~ 400 T/h	4
8)	Coke breeze receiving line		200 T/h	2
13.	Lifting eq't			
1)	Overhead crane		25T, 10T, 3T	6 x 2
2)	Elec. hoist		5T, 3T	2 x 2
3)	Elevater		600 kg	1 x 2

(continued)

	Equipment	Type	Specification	Quantity
14.	Water facility			
1)	Drinking water system		Booster 5m^3/h	2 x 2
2)	Circulating water system		Supply 160 T/h, Return 140 T/h	6 x 2
3)	Strainer for circulate water		70 T/h	4 x 2
4)	Hot well		8mW x 20mL x 3mD	1
5)	Cold well		8mW x 20mL x 3mD	1
6)	Cooling tower		280 T/h	1 x 2
15.	Sampling eq't			
1)	Sampler	Box sampler	50kg/increment	1 x 2
2)	Sample test plant		Screen analysis, Component analysis Shatter test	1
16.	Accessories			
1)	Metal detector	Iron loss type		2 x 2
2)	Metal remover	Cross belt type		2 x 2
3)	Vibrator			28 + 20
4)	Belt weigher	Load cell type		7 x 2
5)	Air compressor	Reciprocating	For eq't 9m^3/min x 7kg/cm^2 For instrument 2.5m^3/min x 7kg/cm^2	2 x 2 2 x 2
17.	Sinter stock yard			
1)	Yard	RC made	16,000 T	1 x 2
2)	Feeder	Vibrating	200 T/h	10 x 2
18.	Electrical facility			
19.	Instrumentation facility		W/Microprocessor (50 items)	1 x 2

3) Equipment flow chart and layout

Entire material flow of ore yards and sinter plant is shown in Fig. 7.3.4, flow in lump ore sizing plant in Fig. 7.3.5, that in limestone crushing plant in Fig. 7.3.6 and flow sheet of sintering plant in Fig. 7.3.7. In addition, layout of ore yards and that of the sinter plant are shown in Fig. 7.3.8 and Figs. 7.3.9, respectively, and elevation and additional flow sheets of the sinter plant in Figs. 7.3.10 thru 7.3.16.

As regards yards, it is contemplated to install the major part of facilities at the 1st step and add one ore yard, one limestone crushing plant, one fine ore bed and accessory facilities at the 2nd step.

The sinter plant is installed each one at the 1st step and 2nd step for efficient use of the site.

4) Investment for facilities

Capital investment will be discussed in the financial analysis in Chapter 8. However, though pretreatment (washing and screening) of dumped fine ore and blue dust at GUA mines for use as raw materials for sinter is required, required capital investment at GUA mines is not included in the present study.

7-3-3. Construction schedule

Construction schedule of yards and sinter plant is shown in Fig. 7.3.17 for information only as detailed schedule has to be decided by taking into consideration various related conditions such as availability of manpower, heavy machinery, equipment fabrication schedule and work efficiency. As a matter of course, they will be studied as part of overall schedule (See Chapter 7-1).

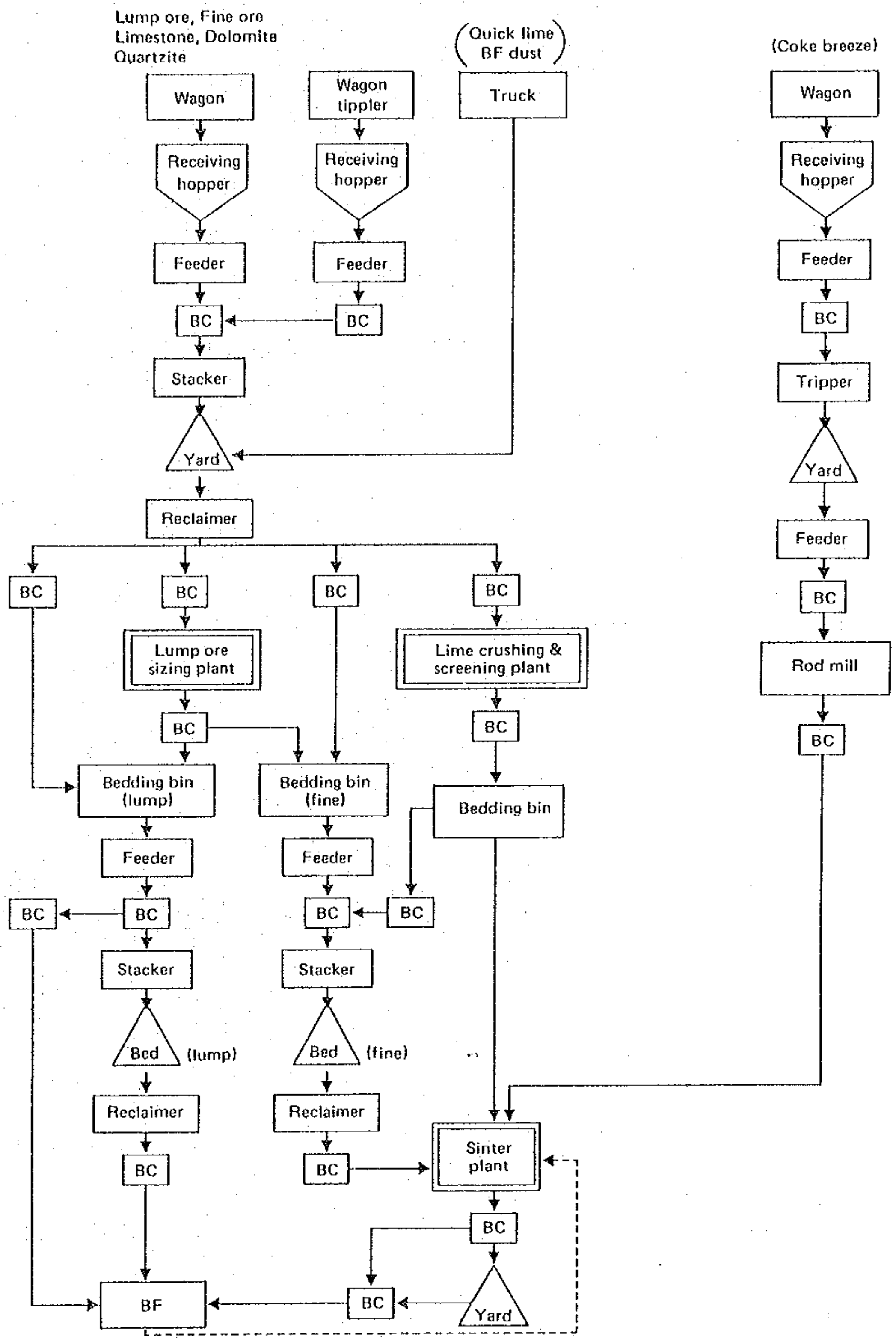


Fig. 7.3.4 Material flow of ore yard & sinter plant

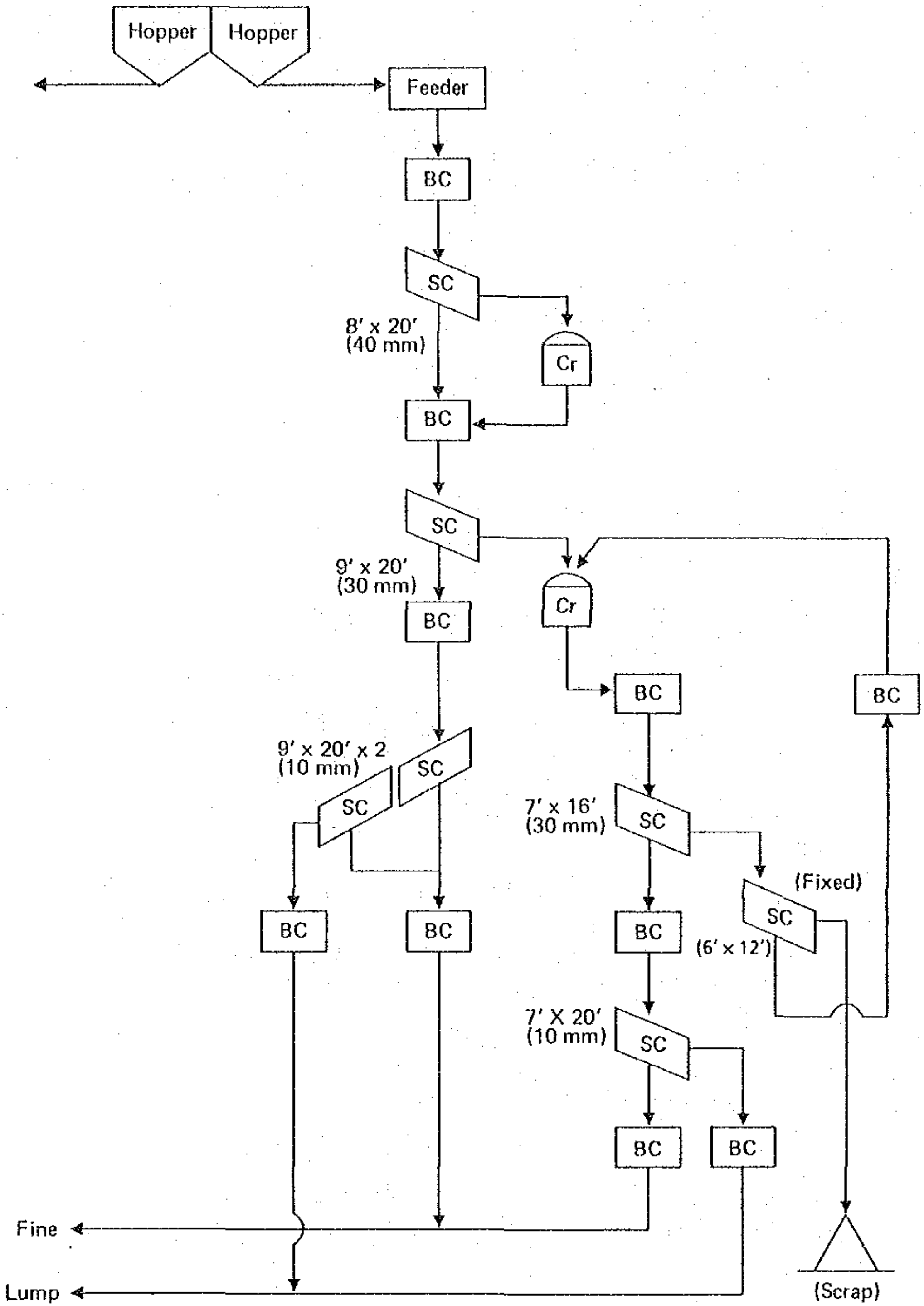


Fig. 7.3.5 Lump ore sizing plant (300 T/h x 2 Line)

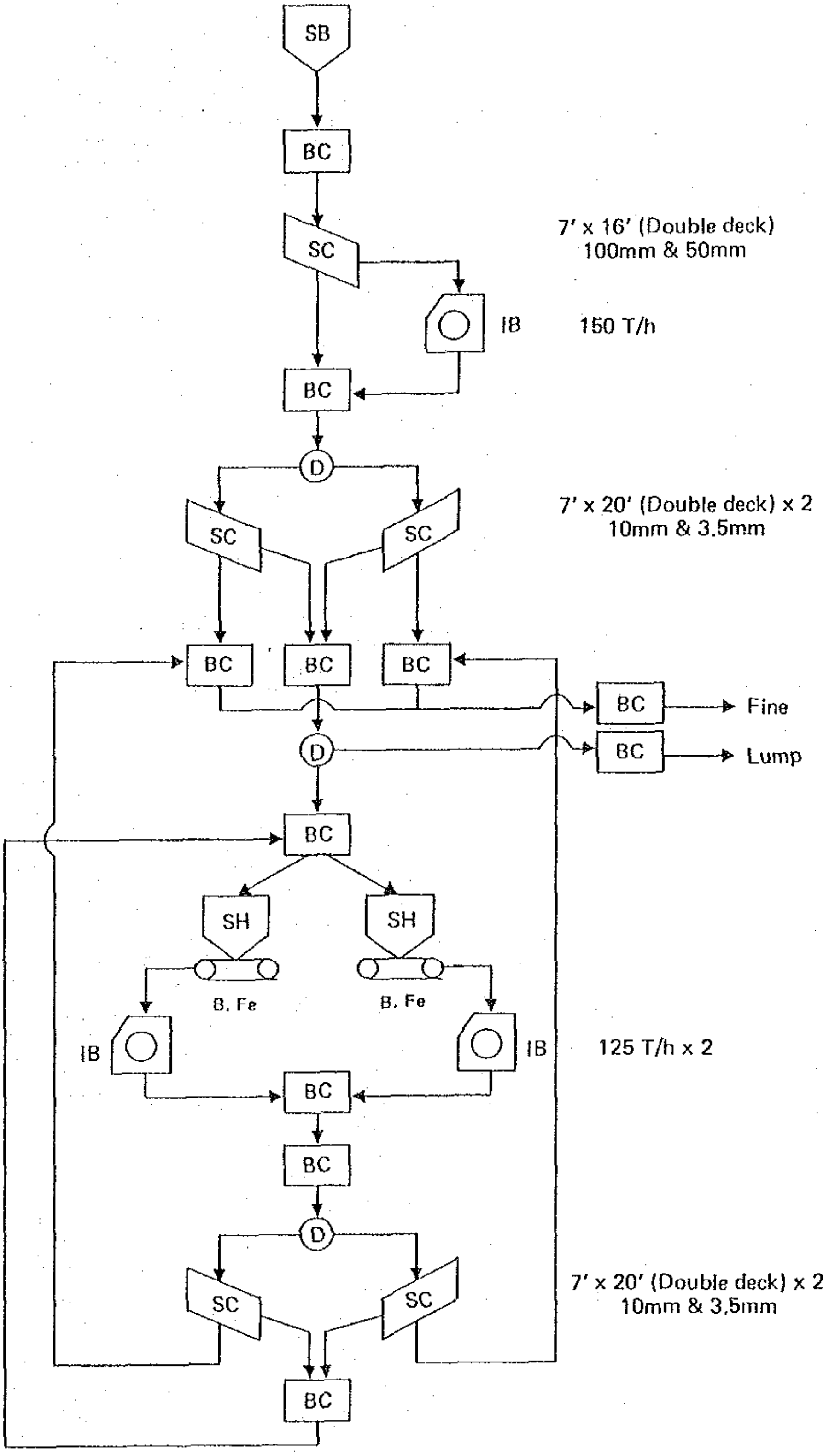


Fig. 7.3.6 Limestone crushing plant (200 T/h)

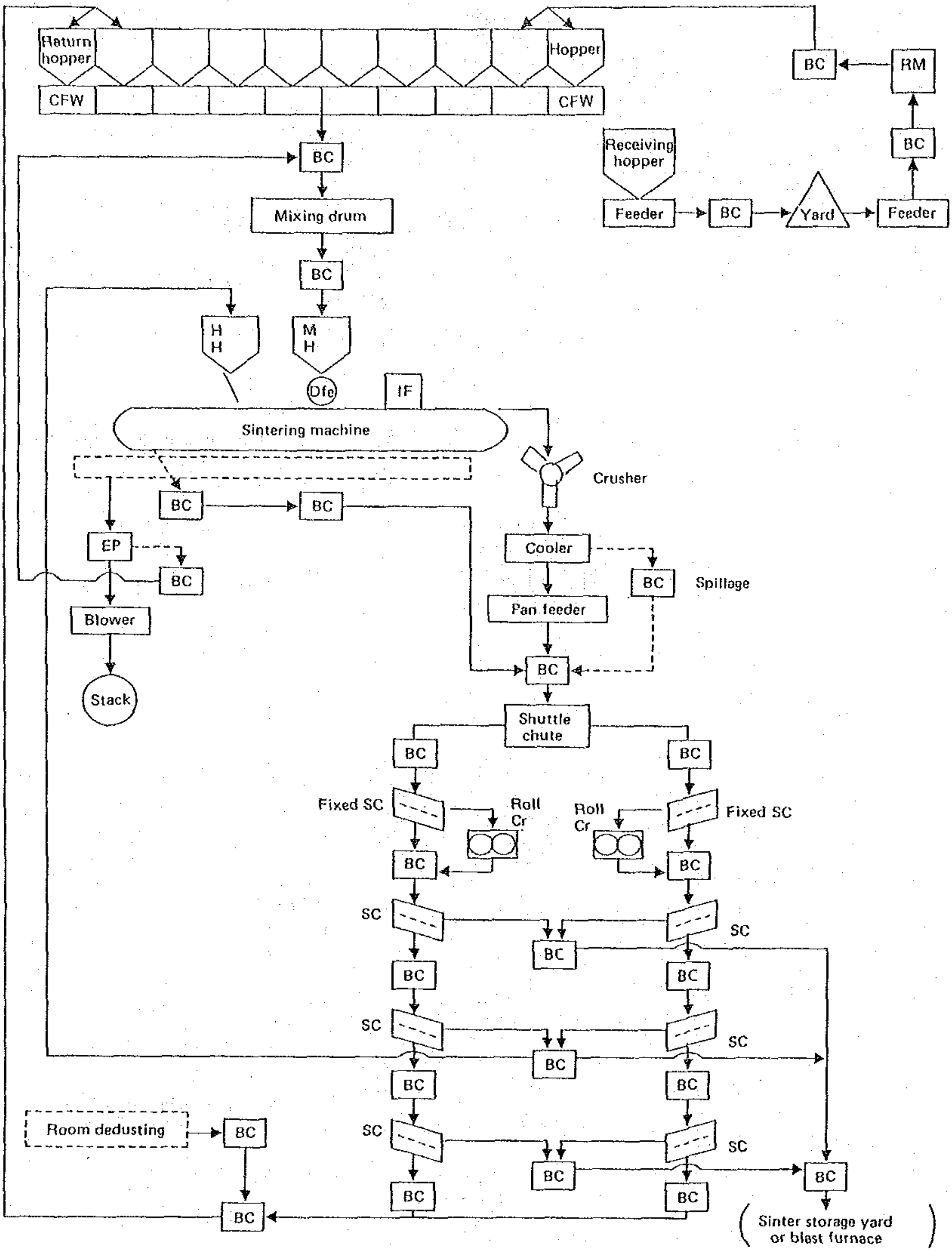


Fig. 7.3.7 Flow sheet of sinter plant

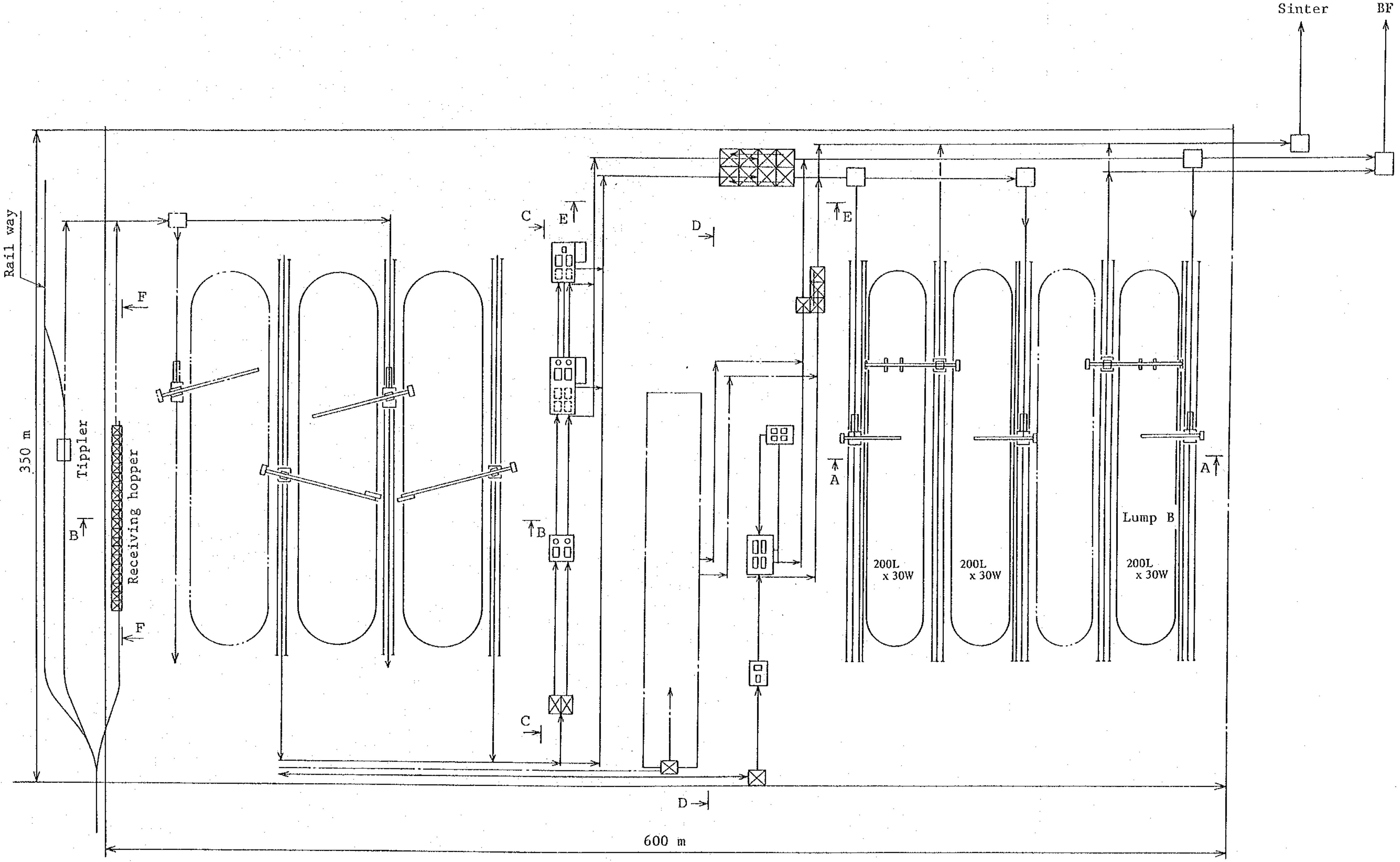


Fig. 7.3.8 Ore yard layout

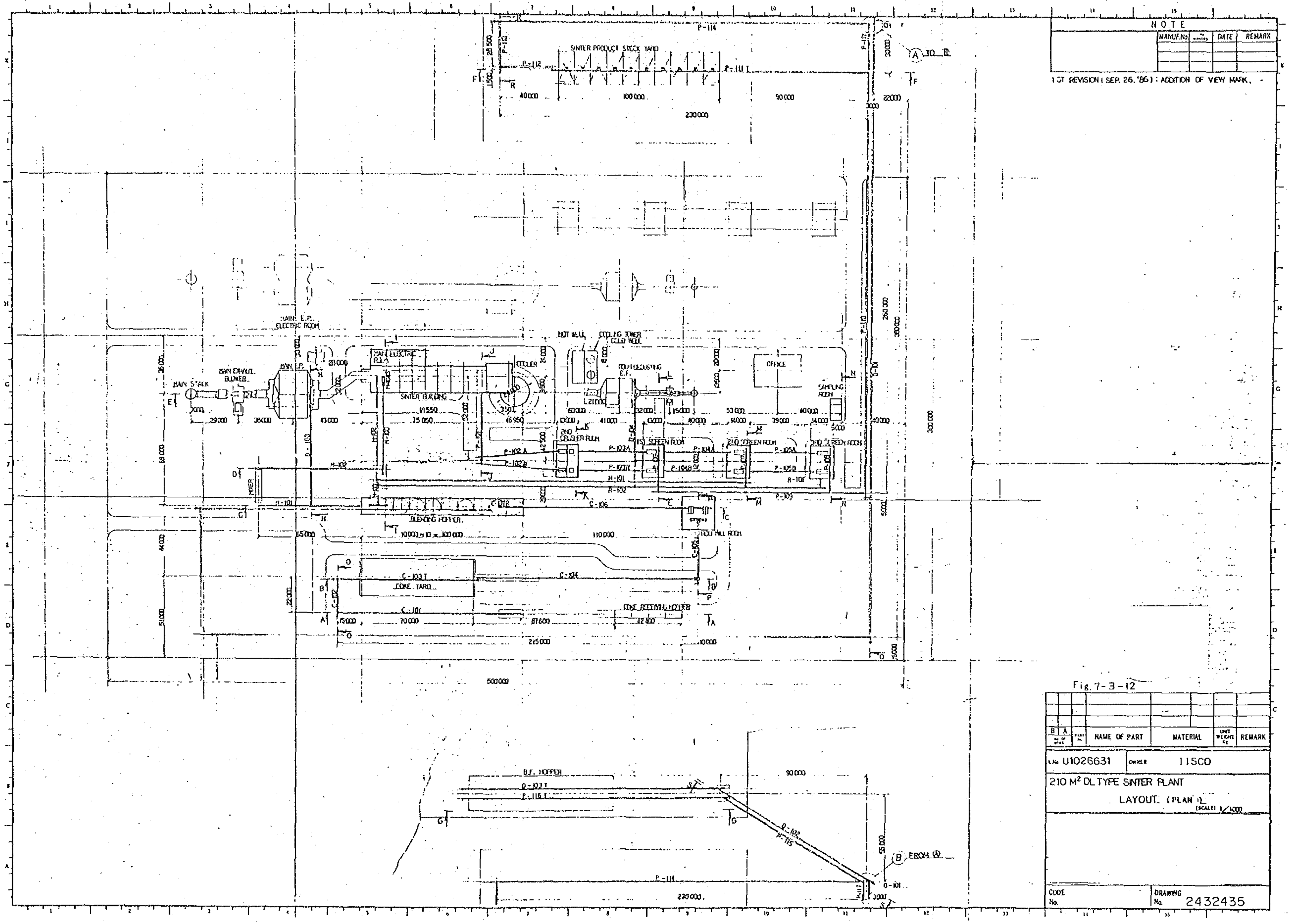


Fig. 7.3.9 210m² DL type sinter plant layout (plan)

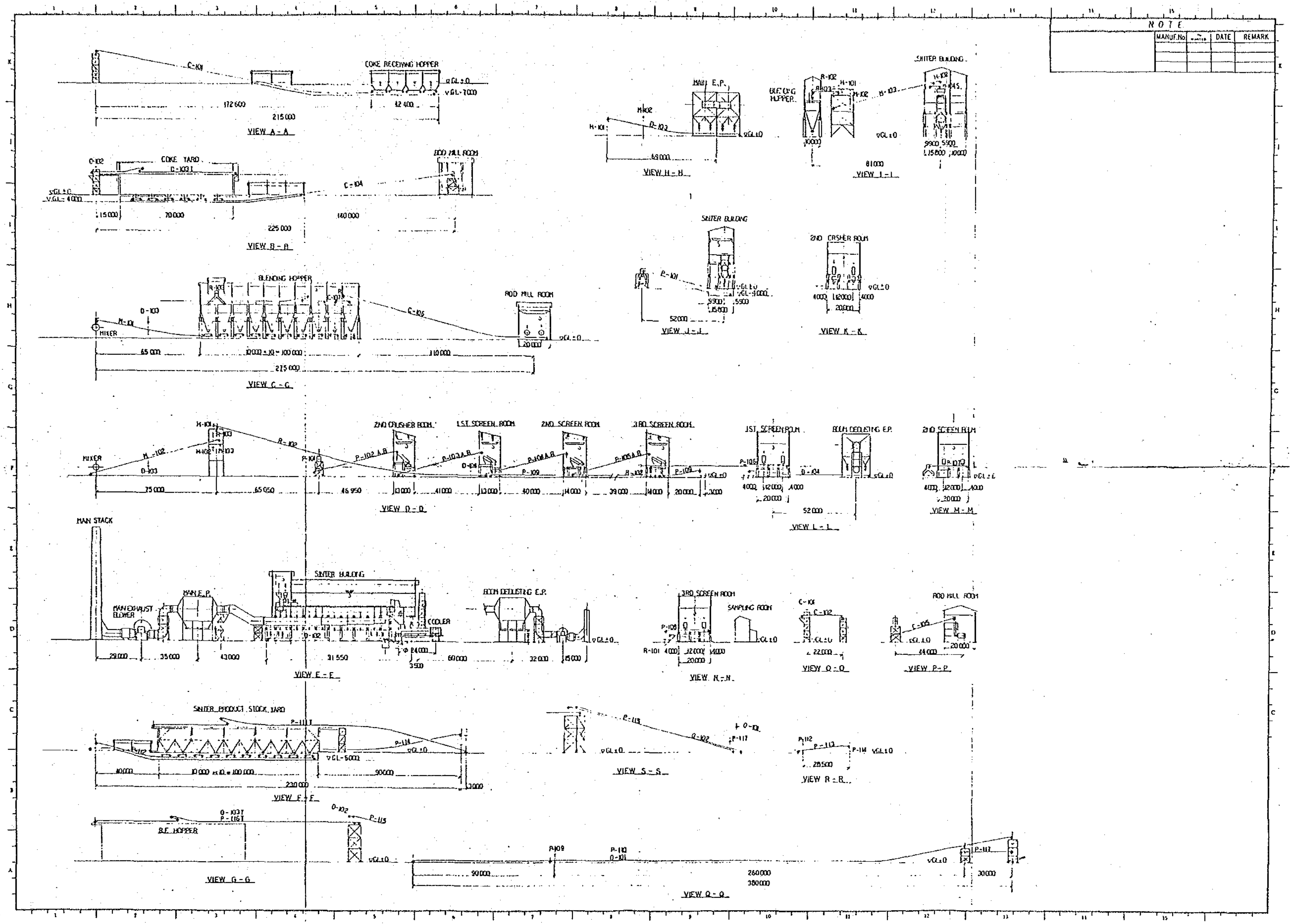
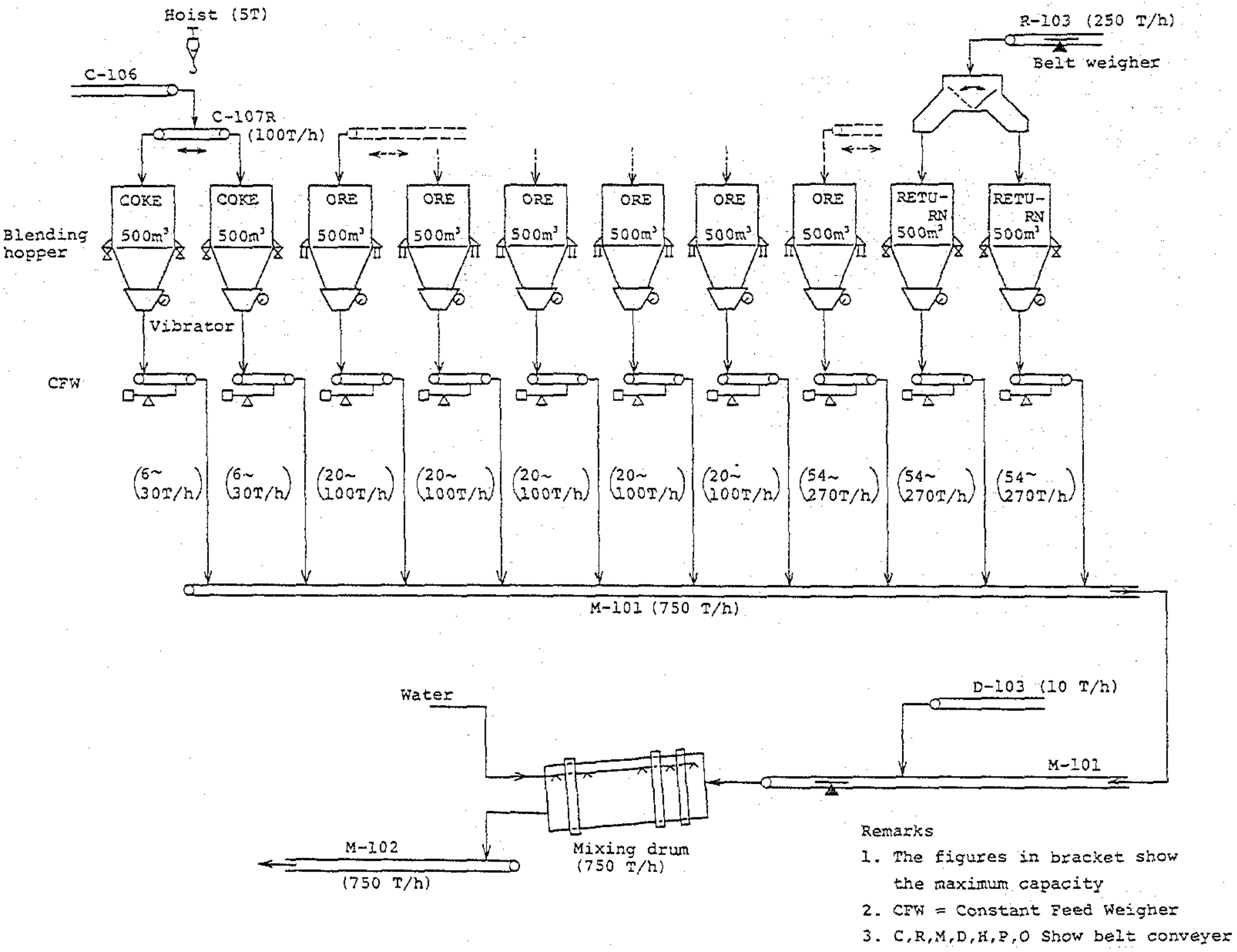


Fig. 7.3.10 210m² DL type sinter plant elevation (Section)



Remarks

1. The figures in bracket show the maximum capacity
2. CFW = Constant Feed Weigher
3. C,R,M,D,H,P,O Show belt conveyer

Fig. 7.3.11 Sinter plant flow sheet (1/6)

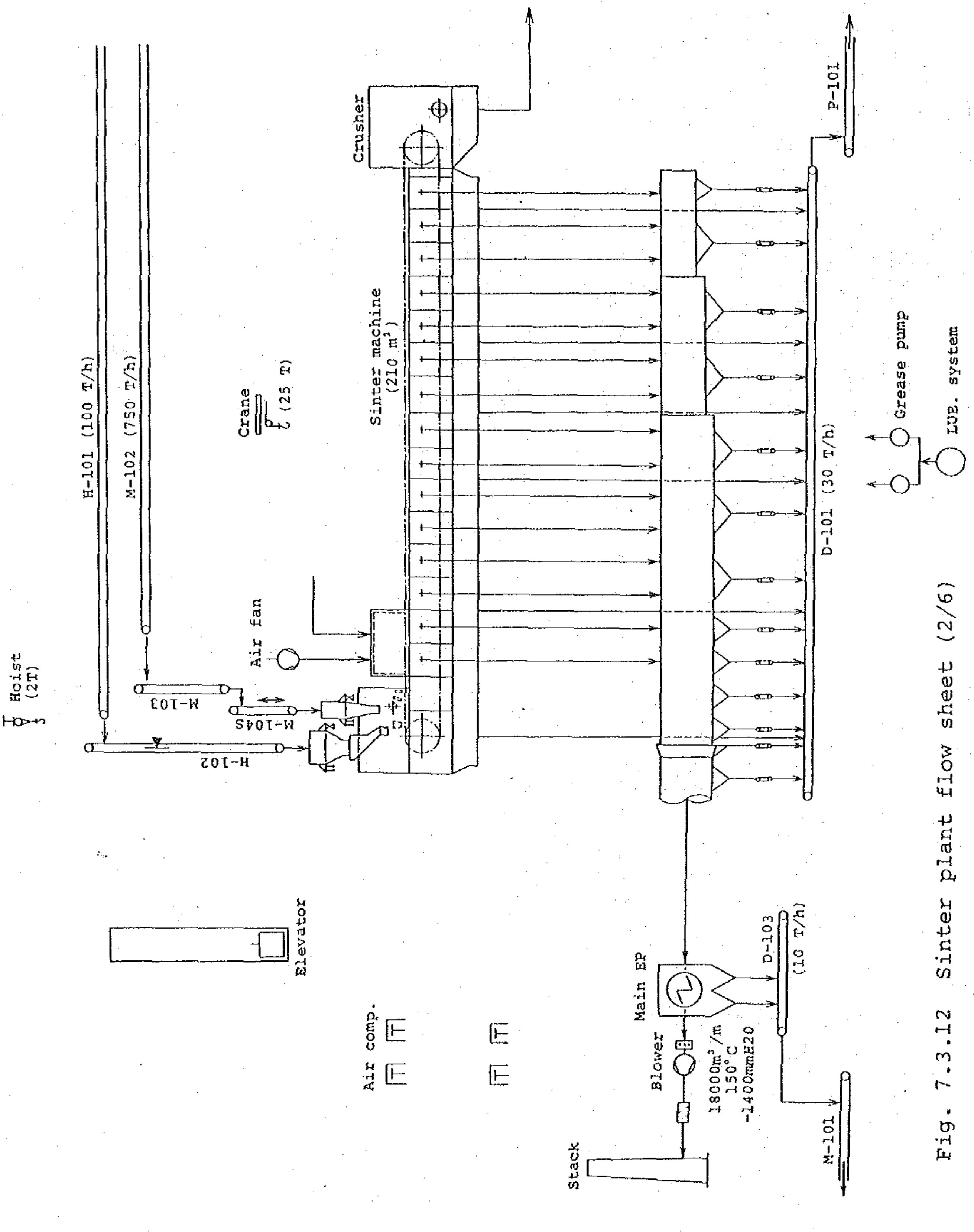


Fig. 7.3.12 Sinter plant flow sheet (2/6)

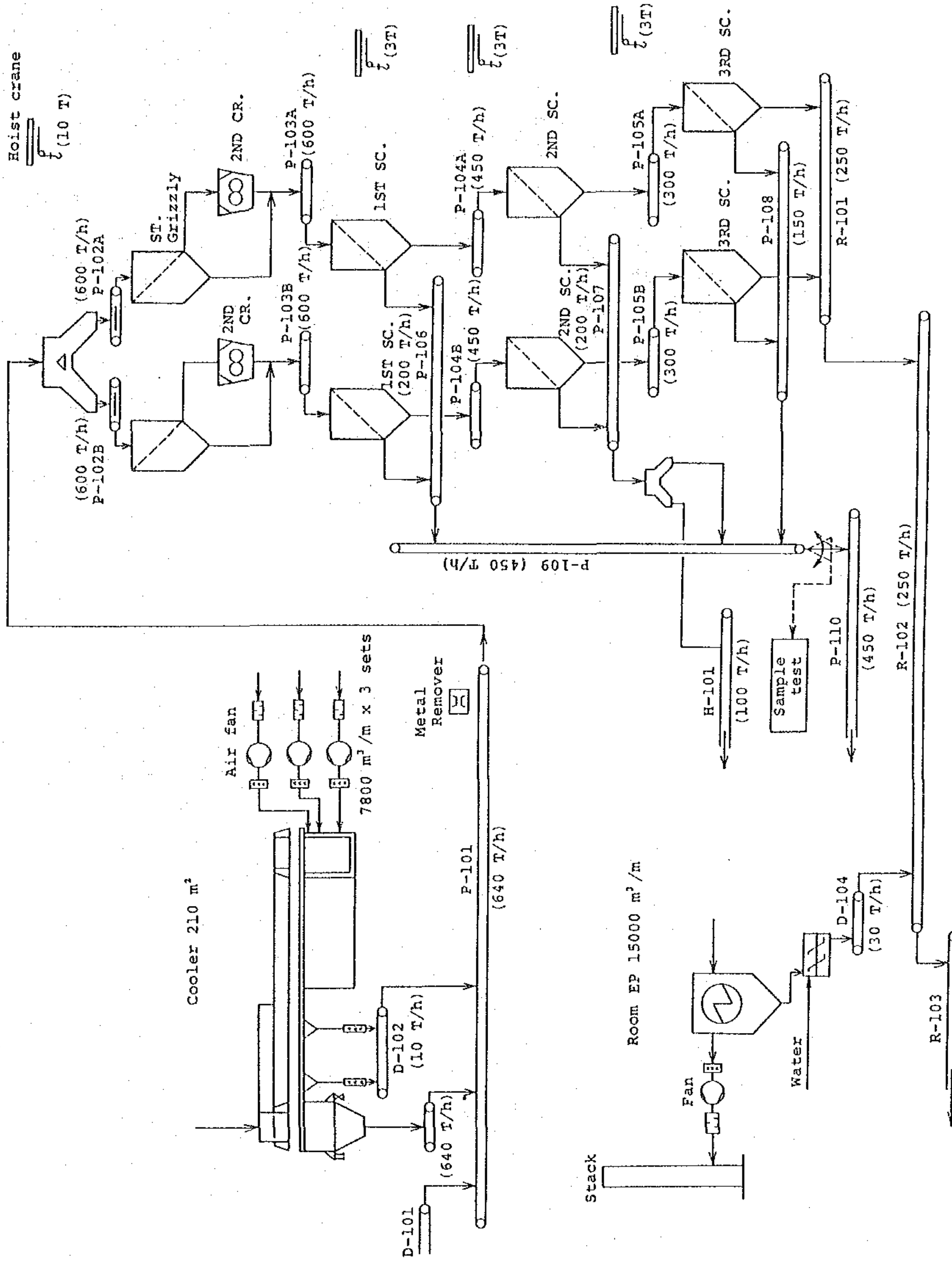


Fig. 7.3.13 Sinter plant flow sheet (3/6)

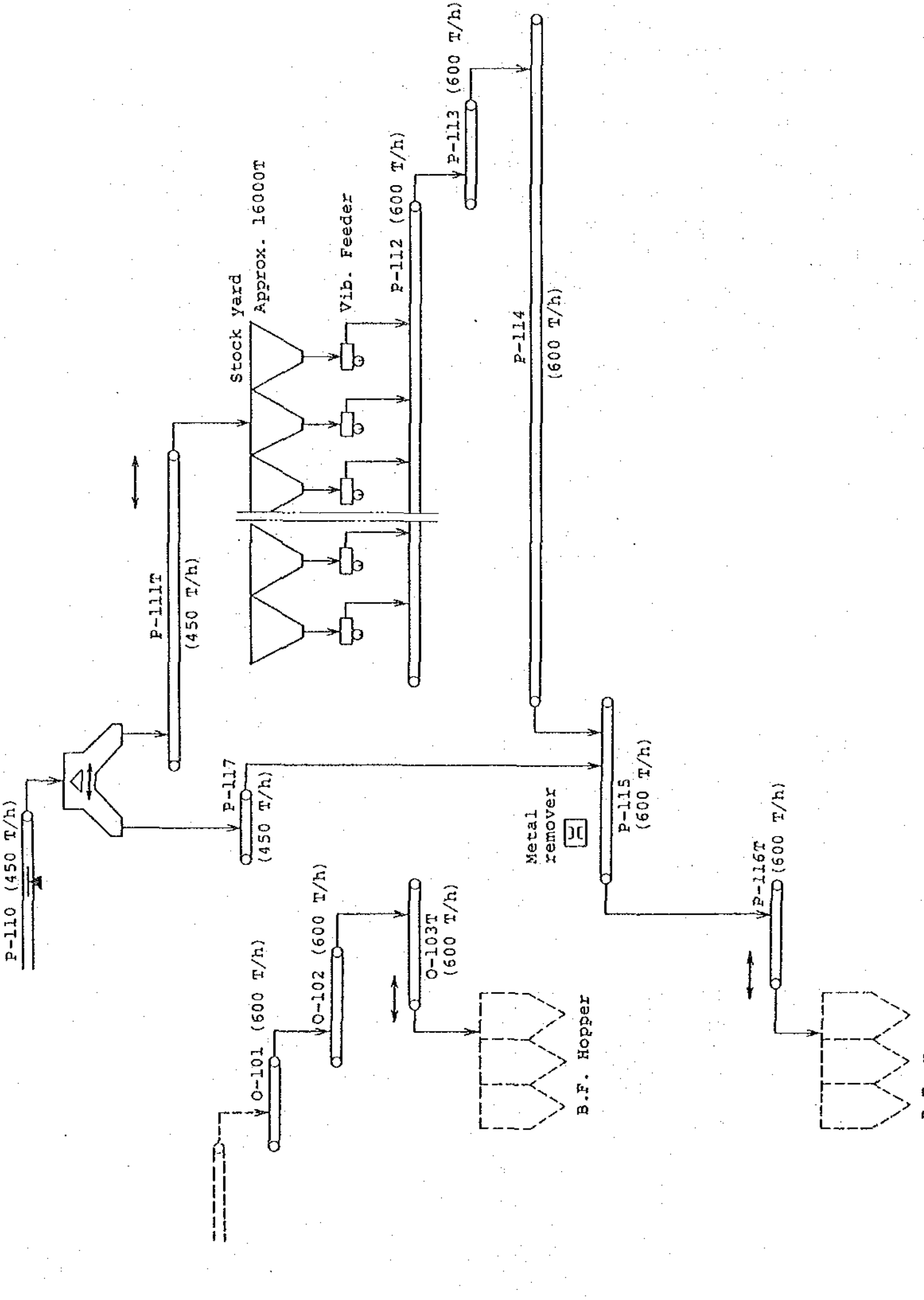


Fig. 7.3.14 Sinter plant flow sheet (4/6)

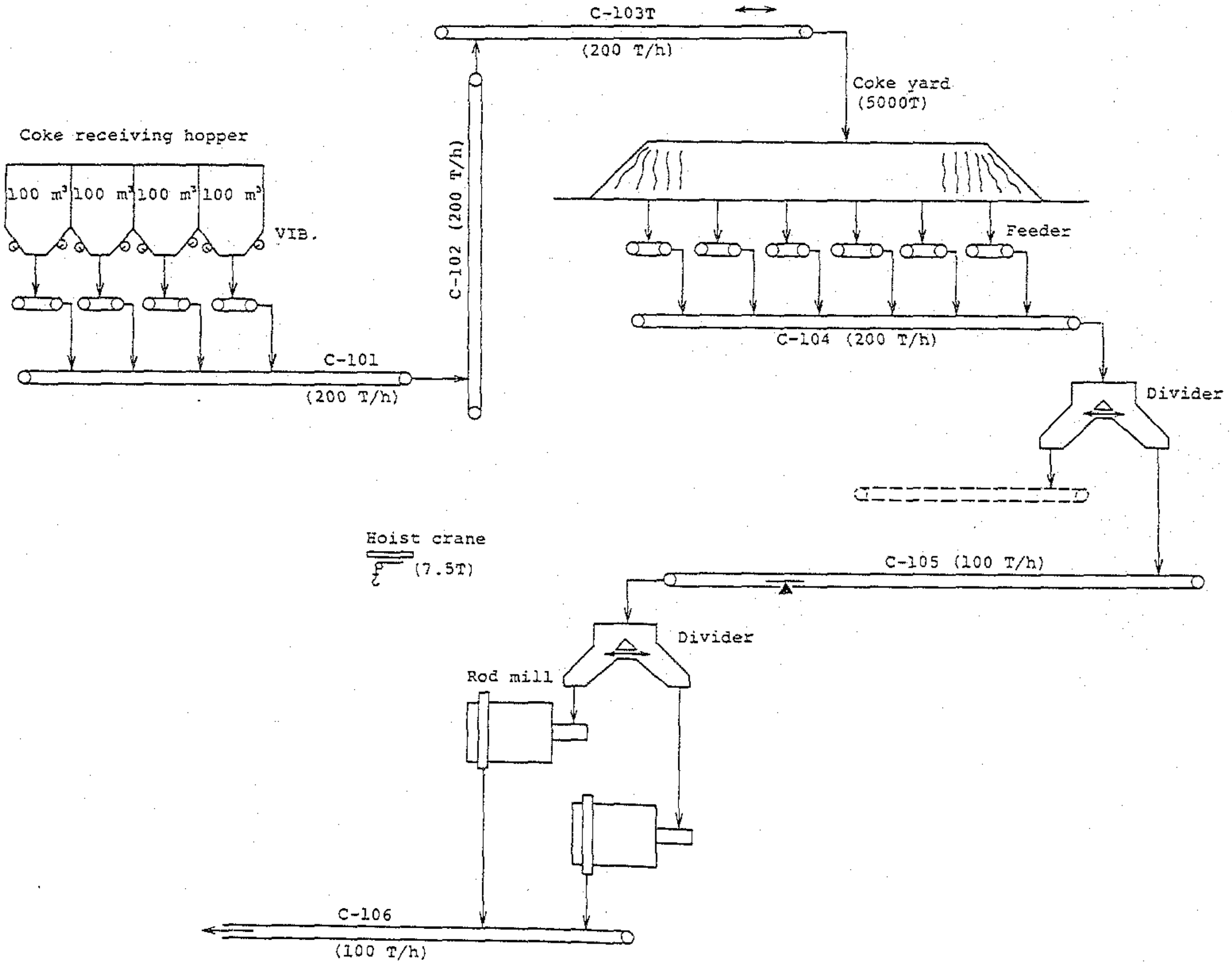


Fig. 7.3.15 Sinter plant flow sheet (5/6)

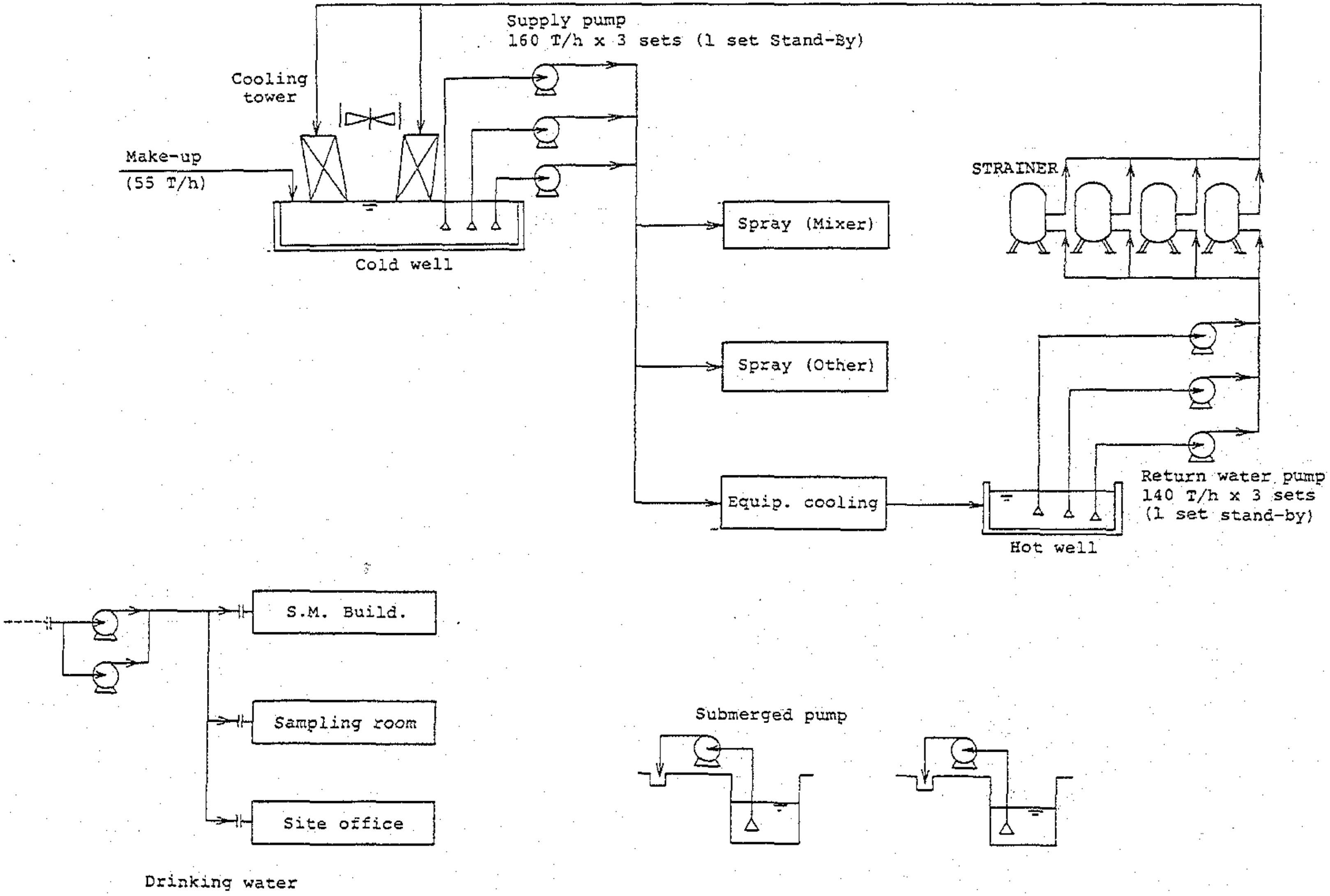
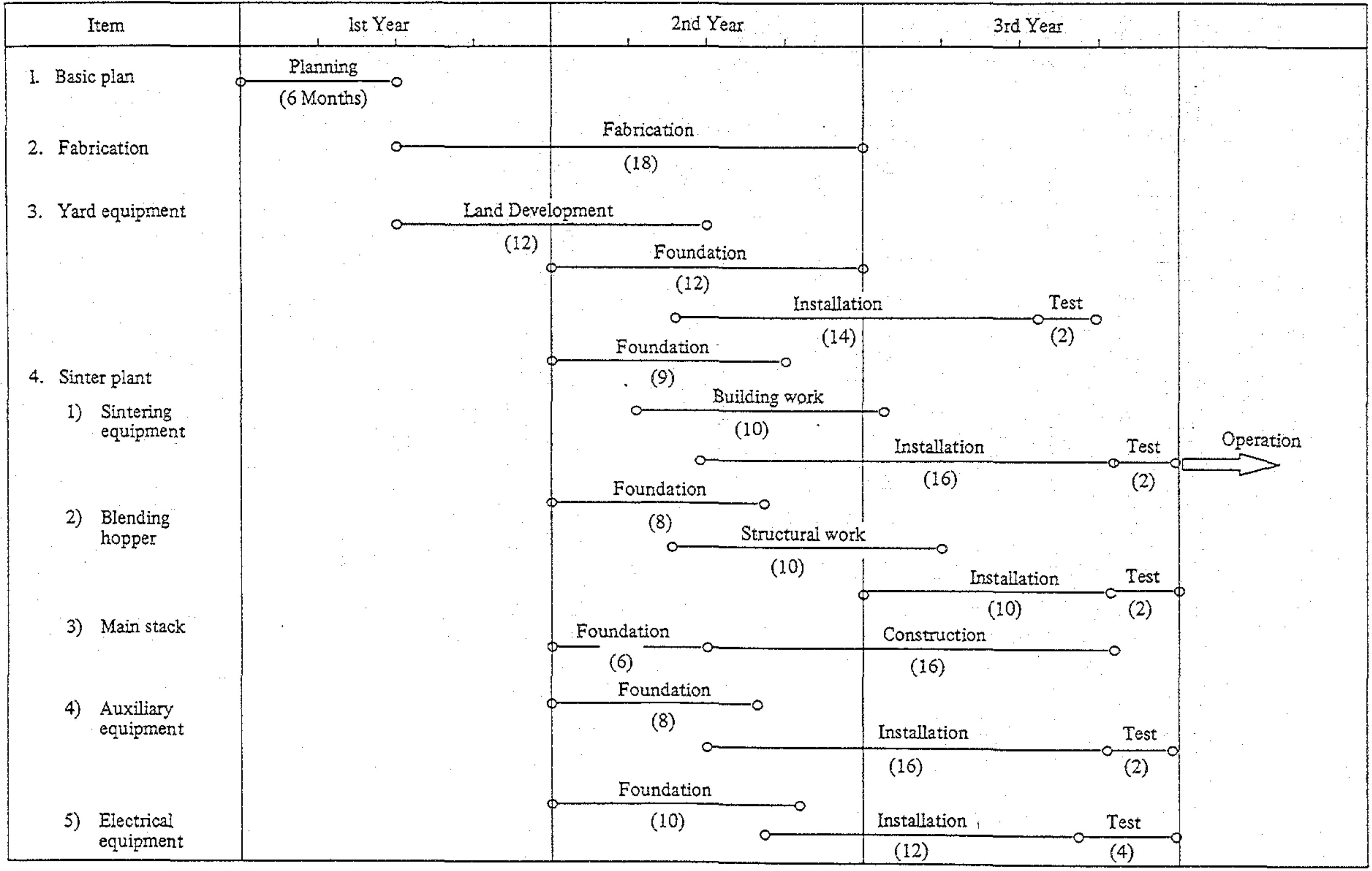


Fig. 7.3.16 Sinter plant flow sheet (6/6)

(for reference only)



Note: figures shown in ( ) show Nos. of months

Fig. 7.3.17 Construction schedule (Yard & sinter plant)

7-3-4. Operation plan

Operation condition of sinter plant is determined by a number of factors.

As IISCO did not have sinter plant in the past and have no experience in its operation, various unit consumptions in sinter plant operation had to be decided by studying actual condition of sinter plants in other steel plants and taking into consideration possible raw materials condition, labour condition and facilities condition. Fig. 7.3.18 shows basic specification for operation, and Fig. 7.3.19 a material flow model in the sinter plant contemplated.

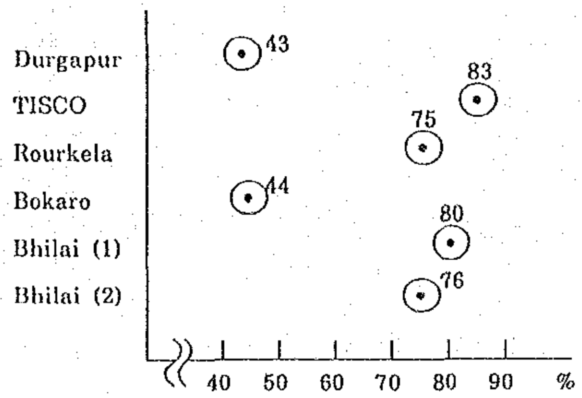
In this study operating rate is assumed to be 80%, but adequate training for knowledge and skill is necessary for keeping this operating rate and more so for achieving higher rates.

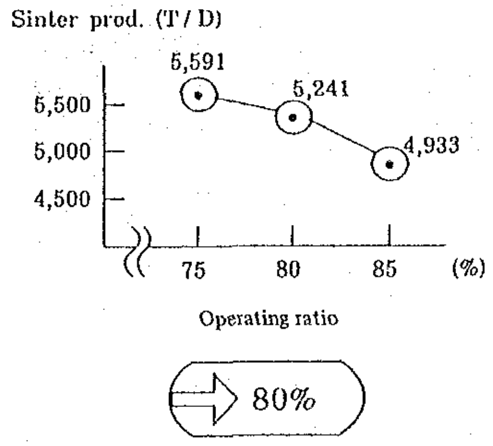
With respect to raw materials, the Works is compelled to use iron ore mined at its captive mines, and dolomite and quartzite have to be used to adjust composition of sinter. This will affect productivity and this study planned it to be somewhat lower. As regards various unit consumptions such as coke, power and ignition fuel, target values which should be achievable if efforts are made are adopted.

Yield is fixed at 84% (Pot yield 51%) considering raw materials condition, but in making operation plan pot test of assumed blended materials is necessary, and assumed composition of raw materials and sinter product is shown in Table 7.3.9.

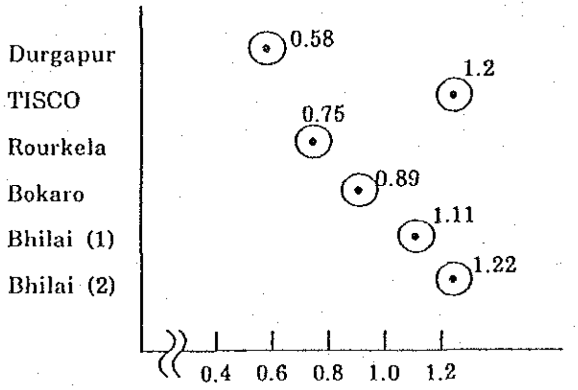
1. Sinter production Phase I 1,461 (Skip sinter 1,344 x 10^3T)
Phase II 3,061 (Skip sinter 2,816 x 10^3T)

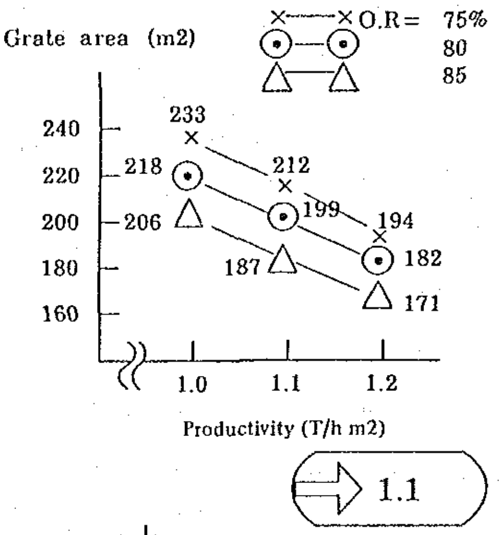
2. Operating ratio





3. Productivity





4. Unit energy consumption

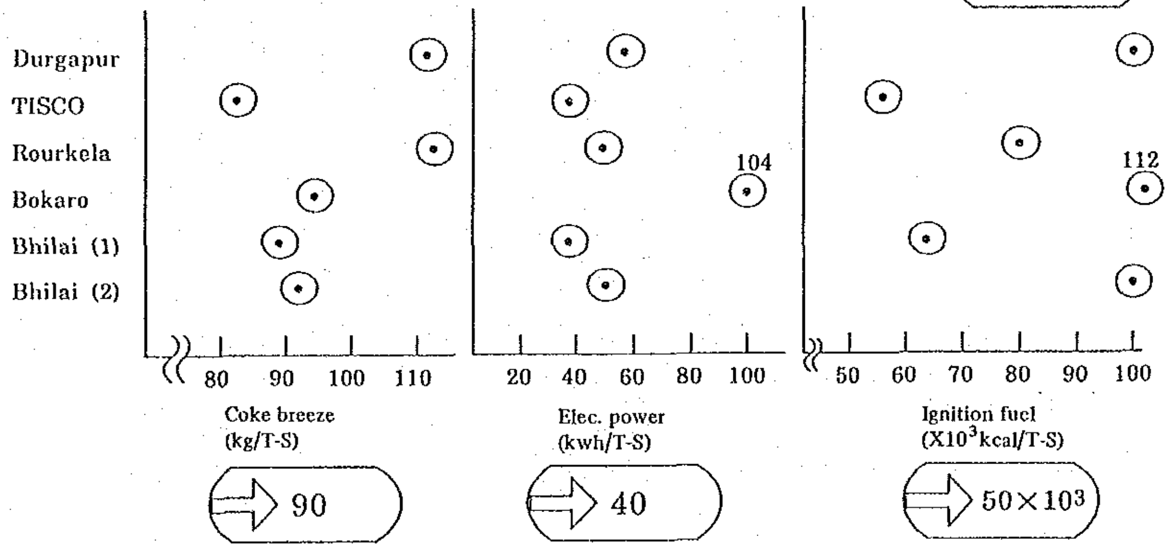
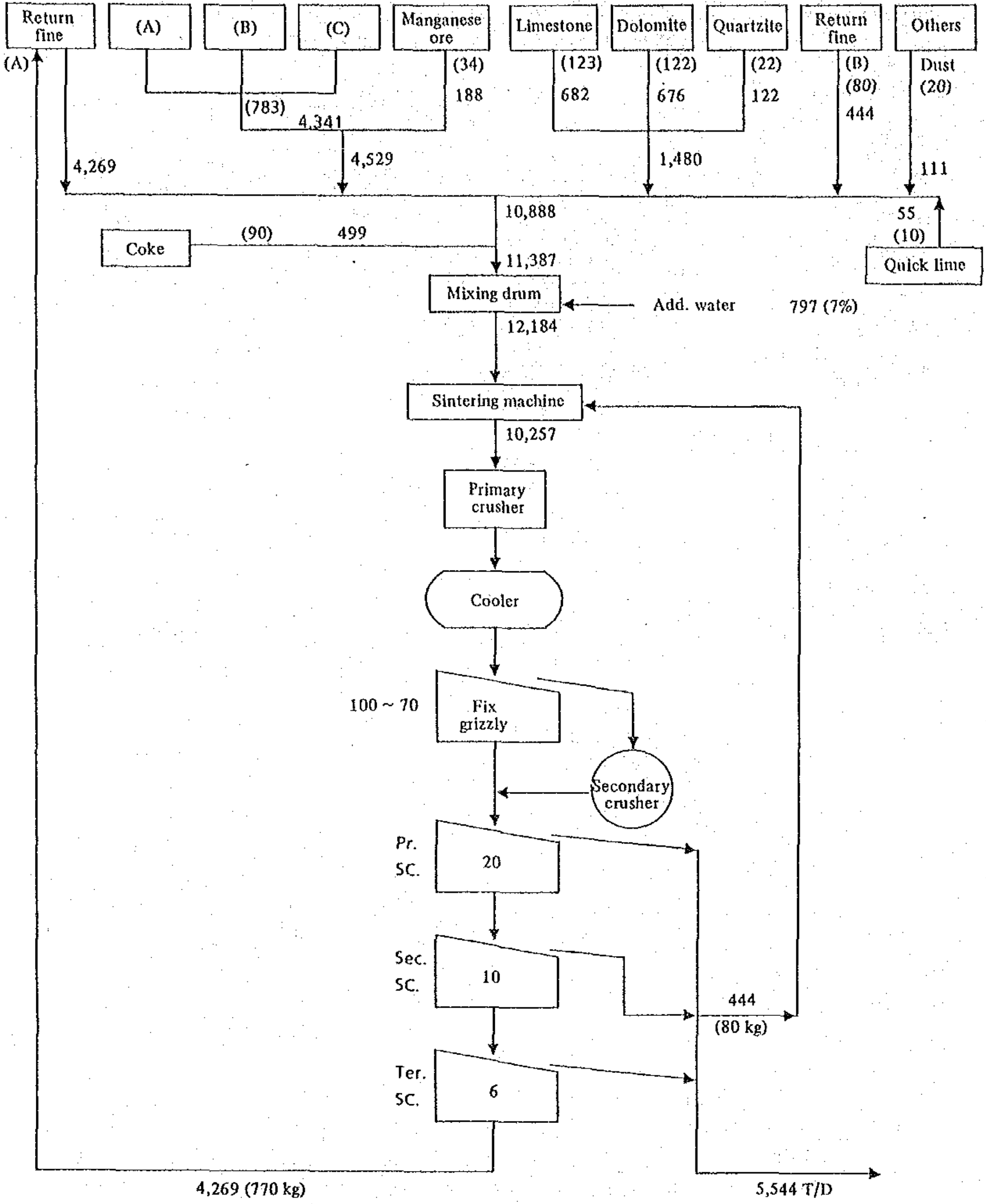


Fig. 7.3.18 Study of basic specification



(○ Grate area 210 m^2
○ Productivity 1.1 T/h. m^2)

(Yield 84%
Pot yield 51%)

Fig. 7.3.19 Sinter material flow (T/D)

Table 7.3.9 Chemical composition of material & product (plan)

Component	Mixed material	Sinter product
T. Fe	50.58 %	47.08 %
Mn	0.92	0.90
SiO_2	4.34	5.34
Al_2O_3	3.25	4.46
S	0.02	0.01
P	0.11	0.10
CaO	4.30	9.36
MgO	2.43	2.68
TiO_2	0.19	0.21
Si/Al	1.33	1.20
CaO/SiO_2	0.99	1.75
ExCaO	----	3.85

7-4. Iron making (Blast furnaces)

7-4-1. Modernization of blast furnaces

Even when the production of the Works is to be kept to the maximum of one million tonnes a year level in future in terms of crude steel, partial remodelling is necessary to ensure production for some years to come. But in planning production for 20 years starting from 1993 as envisaged in this feasibility study, not only improvement of raw materials and operation of blast furnaces is necessary but numbers of problems related to facilities as discussed in Chapter 5-3 must be fully solved. Besides, as complete replacement of deteriorated facilities is also planned, the modernization of blast furnaces will inevitably be accompanied by extensive modification and replacement of facilities.

This feasibility study envisages doubling production capacity of the Works beginning from 1994 to 2.15 million-tonne/year scale in terms of crude steel.

7-4-2. One million-tonne/year crude steel production scale

(Production of the Works is to be limited to 1 million tonnes a year in terms of crude steel in future too.)

(1) Total inner volume of existing four blast furnaces is 3,340 m^3 (2 x 500 + 2 x 1,170) and annual hot metal production is about 862,000 tonnes a year (actual production in 1985/86).

Present annual furnace availability:	About 94.4%
Present productivity:	About 0.75T hot metal/ Inner volume x Day

If improvement is made on raw materials and operation of blast furnaces (use of sinter and low-ash coke, better size control of raw materials, and higher hot blast temperature, etc.), increase of production to the original rated capacity will be possible.

Productivity: 1.0-1.15 THM/m³.D

Annual production of hot metal:

Min. 3340 x 1.0 x 365 x 0.955 = 1,150,000 THM/Y

Hot metal required for producing crude steel 1 million tonnes a year: 1,050,000 THM/Y (can be fully covered.)

If productivity is assumed to be 1.07 THM/m³·D, the original capacity of 1,240,000 THM/Y can be attained.

(2) Remodelling of facilities

Existing four blast furnaces are to be relined and remodelled one after another and each becomes a refreshed furnace. For example, of the four furnaces, it may be contemplated that smaller ones (500 m^3 x 2) are to be discarded and Nos. 3 and 4 BFs are to be reborn as two units of modern 1,225-m³ furnaces.

To find optimum plan for the 1 million-tonne crude steel production scale, detailed study and review of each furnace would be required.

7-4-3. 2.15 million-tonne/year crude steel production scale (Main object of this feasibility study)

(1) The final goal of production by BURNPUR Works under this feasibility study is 2.15 million tonnes/year of crude steel. In consideration of overall construction schedule, early realization of the 2.15 million-tonne scale and period required for familiarization with modernized facilities, the overall schedule would be to establish

> One million-tonne scale in crude steel in 1993 as 1st step, and 2.15 million-tonne scale in crude steel in 1994 as 2nd step.

Financial and economic analyses cover 20 years from 1993 to 2012.

Therefore, the one million-tonne scale in the 1st step is in effect for only one year and is nothing but a transition period to the final 2.15 million-tonne scale.

(2) Basic plan and alternative plans

(Refer to tables 7.4.1 and 7.4.2)

Basic plan - No.5 BF + No.6 BF (2250 m^3 x 2)

1) The basic plan is a modernization plan most desirable from the viewpoint of long-term perspective.

Assuming that existing furnaces need relining in the period of 1993-1996 or thereabout, the following steps are contemplated.

A new BF No.5 (2250 m^3) is blown-in in 1993 to ensure the 1 million-tonne production scale in crude steel.

A new BF No.6 (2250 m^3) is blown-in in 1994, and with No.5 BF and No.6 BF, the 2.15 million-tonne scale is established. The total inner volume of BFs is 2250 m^3 x 2 = 4500 m^3, and at furnace productivity (THM/m^3/D) of 1.41, annual hot metal production is about 2.2 million tonnes. The existing 4 BFs are planned to be discarded in the end of 1992 or early 1993.

2) In the alternative plans discussed below, the new BFs are assumed to be operated under the same raw material condition and at the same production rate in the 2nd step as that of the basic plan. Planned total annual production of hot metal by new and old BFs is

1st step: 1,050,000 T/Y, and
2nd step: 2,200,000 T/Y.

Alternative 1 (No.1 BF + No.5 BF/No.5 BF + No.6 BF)

1) The idea about No.5 BF and No.6 BF is same as in the basic plan.

If only No.5 BF is available in the 1st step, any trouble of the furnace will impede gas balance and production plan of the entire Works, and therefore in the 1st step (1993) only, existing No.1 BF will continue to be operated to support No.5 BF. Any other existing BF will do, but No.1 BF is relined in 1990 and has life longer than the others and besides, being small (500 m^3, it provides flexibility in production balance.

2) This plan is one of realistic plans, but coke rate of No.1 BF is higher than that of No.5 BF. Besides, it is necessary to have additional personnel for operation of No.1 BF and this plan, it is clear, is less economical than the basic plan and excluded from the operation plan and financial analysis of this study.

Alternative 2

(No.3BF + No.5BF/No.5BF+No.6BF+No.7BF (1500 m^3 x 3))

1) The basic plan envisages construction of two 2250 m^3 blast furnaces, but the alternative plan 2 involves construction of three 1500 m^3 units. Total inner volume is the same 4,500 m^3.

1st step:	As No.5 BF (1500 m^3) only is short in production, existing No.3 BF (1170 m^3) supports No.5 BF. (No.4 BF is blown out and discarded, otherwise as it needs relining at the time.)
2nd step:	New No.6 BF and new No.7 BF (1500 m^3x2) are blown-in. No.3 BF is blown out.

2) This plan is realistic and attractive. But as in the case of the alternative 1, it needs additional personnel and coke for No.3 BF. Construction cost also is higher than the basic plan. A site for three BFs is necessary.

In the 2nd step also, personnel for three BFs is required and power cost increases. But production decrease in the years of furnace relining is less than the basic plan.

It may be necessary to compare this alternative plan 2 with the basic plan in details when the final plan of implementation is made.

Alternative 3

(No.5BF/No.3BF + No.4BF + No.5BF (1125 m^3x2 + 2250 m^3))

1) In stead of No.6 BF in the basic plan, existing No.3 and No.4 BFs are rebuilt to modern furnaces (1125 m^3) in this plan. No.1 and No.2 BFs are blown out.

Total inner volume of No.3 and No.4 BFs is 2250 m^3 and that of No.5 BF is 2250 m^3.

1st step: No.5 BF blown-in

2nd step: Production by new three BFs, Nos.3+4+5

2) New No.3 and No.4 BFs are rebuilt at existing places and No.5 BF is built on a new site on the west. This results inevitably in double material flows and also double control of iron-making shop. In the long run this is inconvenient and naturally uneconomical.

Some parts of existing facilities may be reused, but cost of construction of main facilities of two furnaces, No.3 BF and No.4 BF, is higher than that of No.6 BF, thereby, total construction cost will be same or a little higher.

Alternative 4 (Time of BF construction is to be delayed.)

1) To avoid concentration of capital investment in 1993 and 1994, existing blast furnaces are to be used as long as possible. Various combination can be assumed, but one representative combination would be

1st step:	1993	Existing 4 BFs in operation (Problem may exist as to No.4 BF and No.1 BF as it is about time to reline them.)
2nd step:	1994	No.5 BF (2250 m^3) blown in Nos.1+2+3+4+5 BFs in operation
	1996	No.6 BF (2250 m^3) blown in Nos.5+6 BFs in operation Nos.1 thru 4 BFs blown out

It is difficult for now to tell how long the existing blast furnaces can be used. Life of shell of blast furnaces, hot stoves and others is normally 20 years or less and 30 years at the longest.

To prolong life of existing BFs, it is necessary to define repair items for each of the 4 furnaces whose repair is performed during the period from 1986 to 1992 and decide the extent of replacement of old and deteriorated facilities.
It can clearly be said that existing BFs have worked long enough.

The target period of this study is 20 years from 1993 to 2012 and it is necessary to ensure required production during the period. Assuming that no major replacement is performed by 1993 and existing furnaces kept in operation to 2012, all parts and facilities are eventually to be replaced one after another in this period (1993 to 2012).

As mentioned in the alternative 3, total investment cost would be equal to or higher than that for new No.6 BF and operation cost also high.

Therefore, shift to No.6 BF should be carried out as soon as possible and so this plan was made.

1996 will be the year when the next but one campaign of No.3 BF is over.

2) The alternative 4 results in investment cost and operation cost higher than the basic plan. However there should be cases in the course of implementation of the modernization plan where construction of blast furnaces has to be somewhat postponed by reason of financing in view of investment timing and interest.

In any case this plan brings about the modernization with No.5 and No.6 BFs, and the financial analysis of this study will be taken up for the basic plan only.

(3) Summary

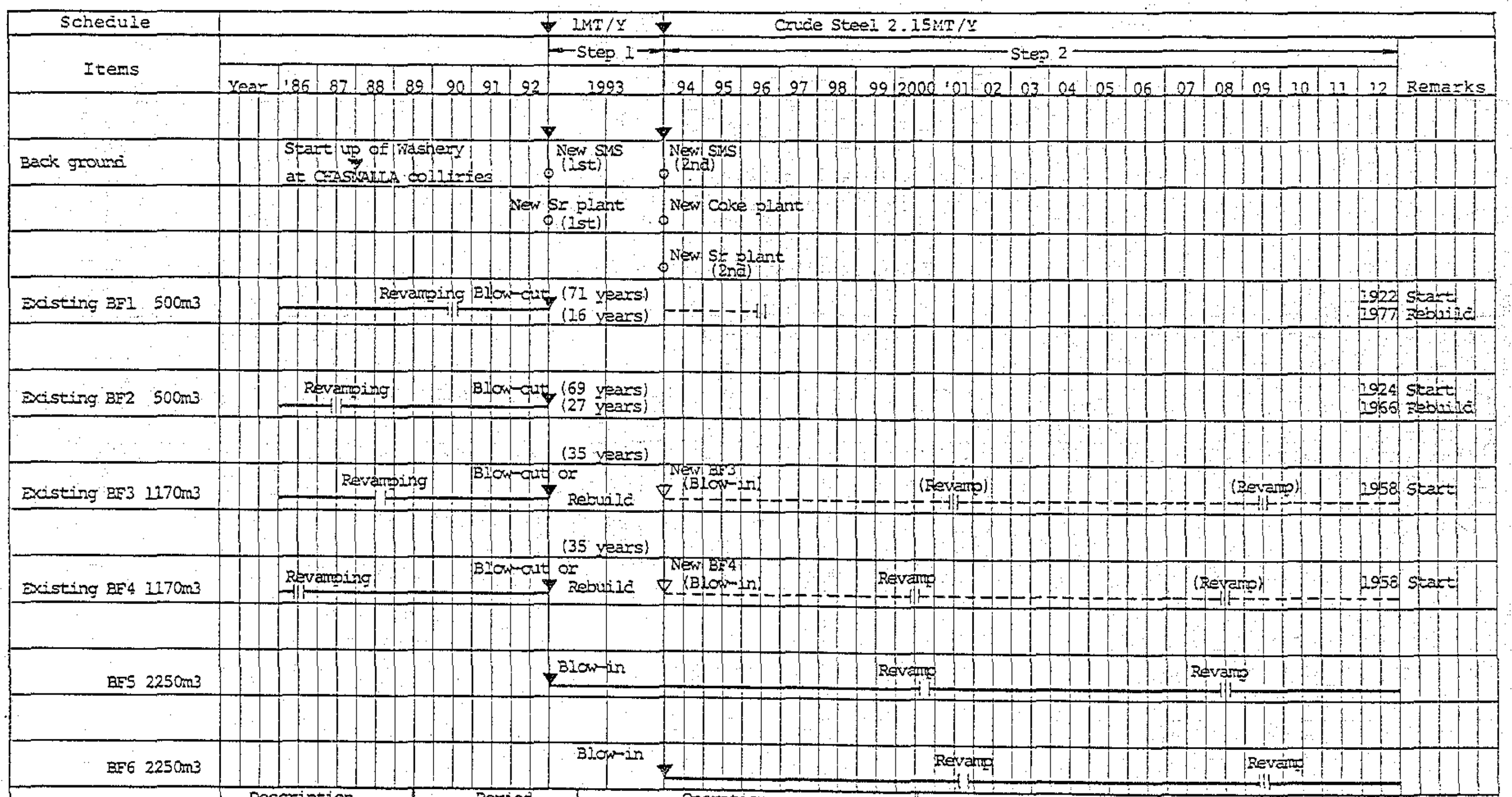
As a result of comparison of the above plans, it was decided that the basic plan should be taken up for consideration in this feasibility study for reasons of the following.

1) Existing blast furnaces and accessories are very old and critically deteriorated and early replacement of all those facilities is necessary.
2) As mentioned in Chapter 5-3, it is difficult and uneconomical to rebuild or newly build complete units of modern blast furnaces in existing limited space.
3) To have blast furnaces both at a new place and at existing place for a long time results in having the double of facilities, for receiving raw materials, transporting hot metal and for motive power and also a doubling of control system, making it inefficient, and merit of common maintenance will also be lost.
4) A series of smooth flows of raw materials, sinter, coke, BF and basic oxygen furnace (BOF) should be realized as soon as possible as shown in the layout at the new site. In particular, decrease of hot metal temperature must be prevented to ensure stable steelmaking operation at BOFs.
5) In making comparison of various plans to decide which is best suited for the modernization of BURNPUR Works in consideration of not only construction cost but also all other factors such as production efficiency (production cost), personnel cost, blast furnace relining or revamping, interest and others, further detailed studies, discussion with the Indian side and a number of detailed planning, designing and financial analysis are required, but the time given to this study does not permit it as mentioned in Chapter 1.

6) When an image of blast furnaces in the Works as modernized is conceived up, the basic plan or alternative plan 2 seems better, but as it is expected that blast furnaces of 2000 m^3 or more will be main type of the furnaces in use in India around 1993 - 2012, the basic plan is adopted in this feasibility study.

7) In India even at present 2000 m^3 class blast furnaces show relatively good performance. Since improvement in sintering technology and coke quality can be expected in 7 to 8 years from now, operation of blast furnaces may be further stabilized enabling higher operation. In addition, as compared with small sized blast furnaces, increase in hot metal temperture can be expected with this size of furnaces.

Table 7.4.1 Modernization shedule of blast furnaces



Description	Period	Operation	Notes
Basic plan	Step 1/ step 2	BF5 / BF5 + BF6	BF5 = 2250m3 BF6 = 2250m3
Alternative 1	Step 1/ step 2	BF1 + BF5 / BF5 + BF6	BF1 = 500m3 BFs 5 & 6 = 2250m3 x 2
Alternative 2	Step 1/ step 2	BF3 + BF5 / BF5 + BF6 + BF7	BFs 5 & 6 & 7 = 1500m3 x 3
Alternative 3	Step 1/ step 2	BF5 / BF3 + BF4 + BF5	BF5 = 2250m3 New BFs 3 & 4 = 1125m3 x 2
Alternative 4	Step 1/ step 2	BF1, 2, 3 and 4/ BF5 / BF5 + BF6	BF5 = 2250m3 BF6 = 2250m3

Table 7.4.2 Basic plan/alternative plans of blast furnace modernication

Plans	Steps	Description		Notes	
Basic plan	Step 1	1993	BF5 (2250m³) blow in. All existing furnaces will stop.	2250m³	(1.05 MT/Y)
	Step 2	1994	BF6 (2250m³) blow in. BF5 + BF6 operate.	2250m³ x 2 = 4500m³	(2.20 MT/Y)
Alt. 1	Step 1	1993	BF5 (2250m³) blow in. Only BF1 (500m³) will support BF5 for the training period of one year.	Or in 1992 BF5 Blow in. Considering training period and at the end of 1982 that all existing furnaces are to stop.	
	Step 2	1994	BF6 (2250m³) blow in. BF5 and BF6 operate. BF1 stops.		
Alt. 2	Step 1	1993	BF5 (1500m³) blow in. Only BF3 continues to operate.		(1.05 MT/Y)
	Step 2	1994	BF6 (1500m³) & BF7 (1500m³) blow in. BF5 + BF6 + BF7 operate.	1500m³ x 3 = 4500m³	(2.20 MT/Y)
Alt. 3	Step 1	1993	BF5 (2250m³) blow in. BF3 and BF4 are completely replaced by this year.		(1.05 MT/Y)
	Step 2	1994	New BF3 (1125m³) & New BF4 (1125m³) blow in. BF3 + BF4 + BF5 operate.	2250+ 2 ≑ 1125 = 4500m³	(2.20 MT/Y)
Alt. 4	Step 1	1993	Existing four(4) BFs (total 3340m³) will operate in this year.		(1.05 MT/Y)
	Step 2	1994	BF5 (2250m³) blow in. Existing four(4) BFs continue to operate.		(2.20 MT/Y)
		1996	BF6 (2250m³) blow in. BF5 + BF6 operate. Existing four(4) BFs stop.	4500m³	(2.20 MT/Y)

7-4-4. Premiss for modernization of blast furnaces

(1) Modernization of blast furnaces are implemented in two steps, 1st and 2nd steps, but in order to satisfy the demand as soon as possible, the 1st step (1 million-tonne/Y production scale) will be only one year, 1993, and the 2nd step (2.15 million-tonne/Y scale) will be achieved in 1994. Therefore the blast furnaces must be such that can ensure supply of hot metal required for production of 2.15 million tonnes of crude steel a year by 1994 and keep hot metal production at the level for 19 years from 1994 to 2012.

(2) Contents and budgets for furnace relining planned for each of existing blast furnace up to 1992 are not a object of this feasibility study. Though existing 4 BFs will be improved somewhat at the time of furnace relining before 1992, they cannot be remodelled for high pressure operation. In addition the facilities as a whole are very much deteriorated and in service for 35 years in 1993. Because of limited space available, addition of modern accessories is difficult. So it is planned that during the period under this study drastic replacement of facilities takes place and they will be reborn as modern BFs as described below.

(3) In this feasibility study, one of modernization plans studied as given below is made the main theme of this study.

1993: No.5 BF (2250 m^3) blown in One million T/Y scale
1994: No.6 BF (2250 m^3) blown in 2.15 million T/Y scale
(With No.5 BF + No.6 BF)

There is a method to keep No.1 BF just relined to support No.5 BF in 1993 only, but it is uneconomical, and so the study and analyses of this study is made assuming that the 1 million T/Y scale is ensured with No.5 BF alone. No.1 to 4 BFs whose lives expired are blown out at the end of 1992 or early 1993.

The construction work of No.5 BF shall not obstruct operation of existing Nos.1 to 4 BFs which shall continue to produce hot metal untill 1992.

(4) To improve stability, productivity and fuel consumption of blast furnace, sized materials, sinter and improved coke shall be prepared.

(5) Layout (Fig. 7.4.3 General layout of No.5 & No.6 BF)

1) Site area for new blast furnaces, No.5 and No.6, will be about 400 m x 400 m tract on the west of Reservoir No.2.
2) Following raw materials, sinter and coke plants, the new BFs will be built near steelmaking shop to ensure stable operation of BOFs. And material flow of ironmaking will be seriated.
3) Consideration is given to the location and direction of BFs so as to ensure smooth operation of hot metal cars.
4) Position of BFs will be adjacent to the present slag granulating facilities at the slag yard, but the slag granulating facilities will remain for slag treatment for existing blast furnaces during the construction of No.5 BF. When No.6 BF is constructed, those facilities will be removed. Slag treament for both No. 5 & No.6 BFs will be done at BF area. All slag will be granulated and shipped out by reilway wagons in this plan.
5) Raw materials will be charged into blast furnace by charging conveyor which is effectively linked with bins for ore, sinter, coke and others.
6) At the stock house, sinter and coke will be screened before weighing, and coke breeze and sinter fine are returned by return conveyors to sintering plant.

7) Blower room, water treatment facilities, dust collector, electric room, iron-making office, and others will be arranged functionally and also designed to give a fine view when seen from the entrance road across the reservoir.

8) A space is reserved around BFs for installation of facilities which are expected to be built later such as furnace top gas energy recovery turbine, silicon removal facilities, desulphurizing plant, slag scraper, fuel (pulverized coal) injection plant, etc.

9) Coke from existing coke ovens is sent by conveyor to new BFs after passing on the south of the reservoir.

10) It is planned to discard existing blast furnaces and even if they are saved, conveyor to transport sinter from the sintering plant to existing blast furnaces will not be installed.

(6) Process flow of a new BF and its profile are shown in Fig. 7.4.1 and Fig. 7.4.2.

(7) Feature of new blast furnaces (No.5 and No.6 BF)

Productivity: Low Nor. 1,346 Nor. 1.41 Max. 1.5
Inner volume: 2,250 m^3 (1.10 MT of Hot metal) x 2

1) With twin cast-house, bell-less top, belt conveyer charging, under-bin screening, automation & computer control

2) Sinter-ave. 70% (max. approx 80%)

3) Coke ash: 23.5% in coke at 10% of imported coal

4) Coke strength: M10 = 12.5 at 10% of imported coal

5) High top pressure: Low Nor. 1.15 Nor. 1.3 Max. 1.5 (kg/cm^2)

6) 100% cast-house slag granulation and emergency dry pit.

7) High duty hot stove: Blast temp. 1100°C by coke oven gas and blast furnace gas mixture

8) High duty gas cleaning with gas pressure control

9) Iron ore size 10-30 mm
Flux size 10-30 mm
Coke size 25-75 mm (Average 50 mm)

10) Tapping 8-10 times/D. furnace (75 ton ladles)

11) Modernized opener, clay gun, splash cover and tilting runner

12) Environmental control equipment

13) Hot metal temp. 1250°C Si≦1.3% at L.D. converter

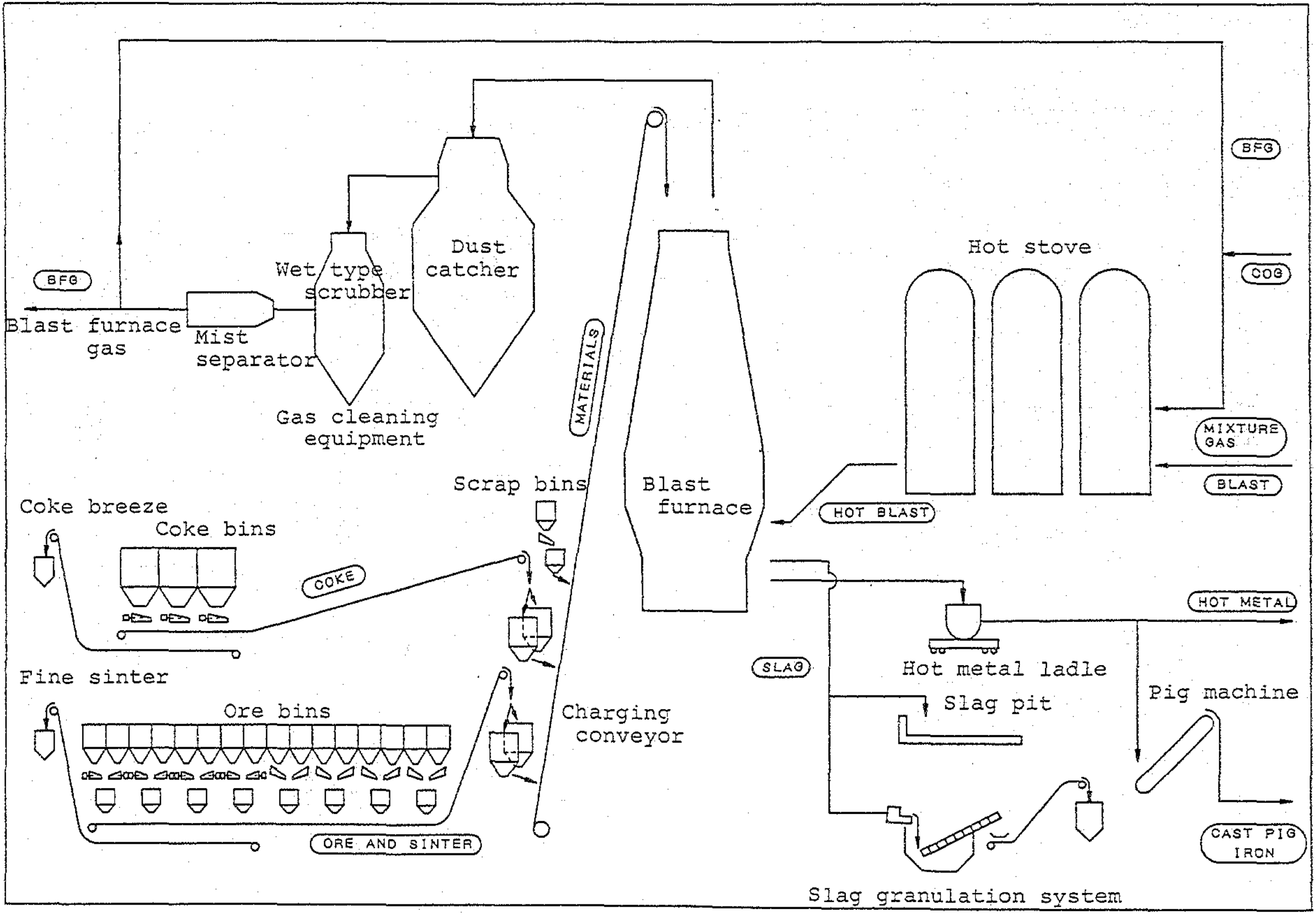


Fig. 7.4.1 Process flow

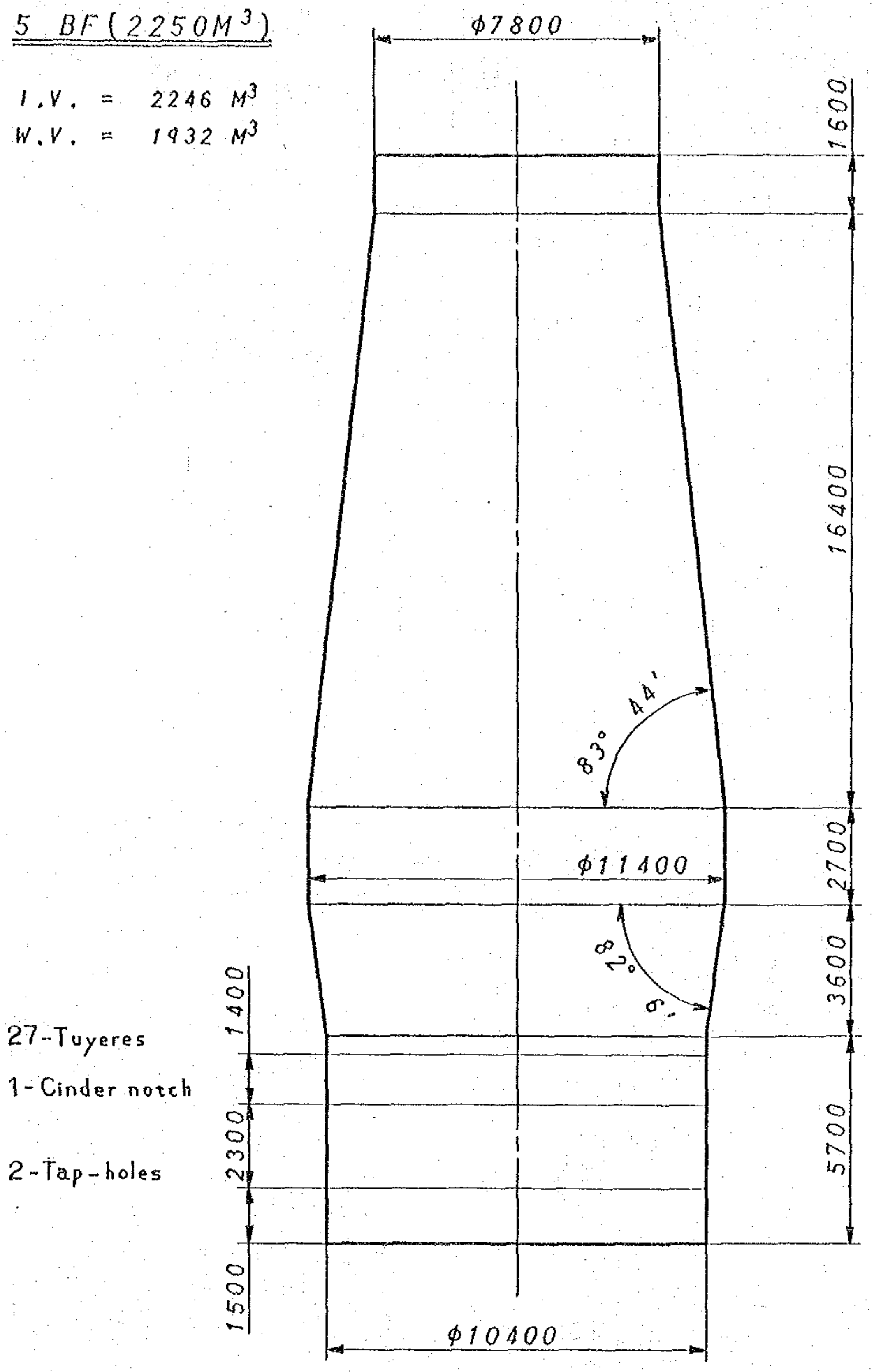


Fig. 7.4.2 Blast furnace profile

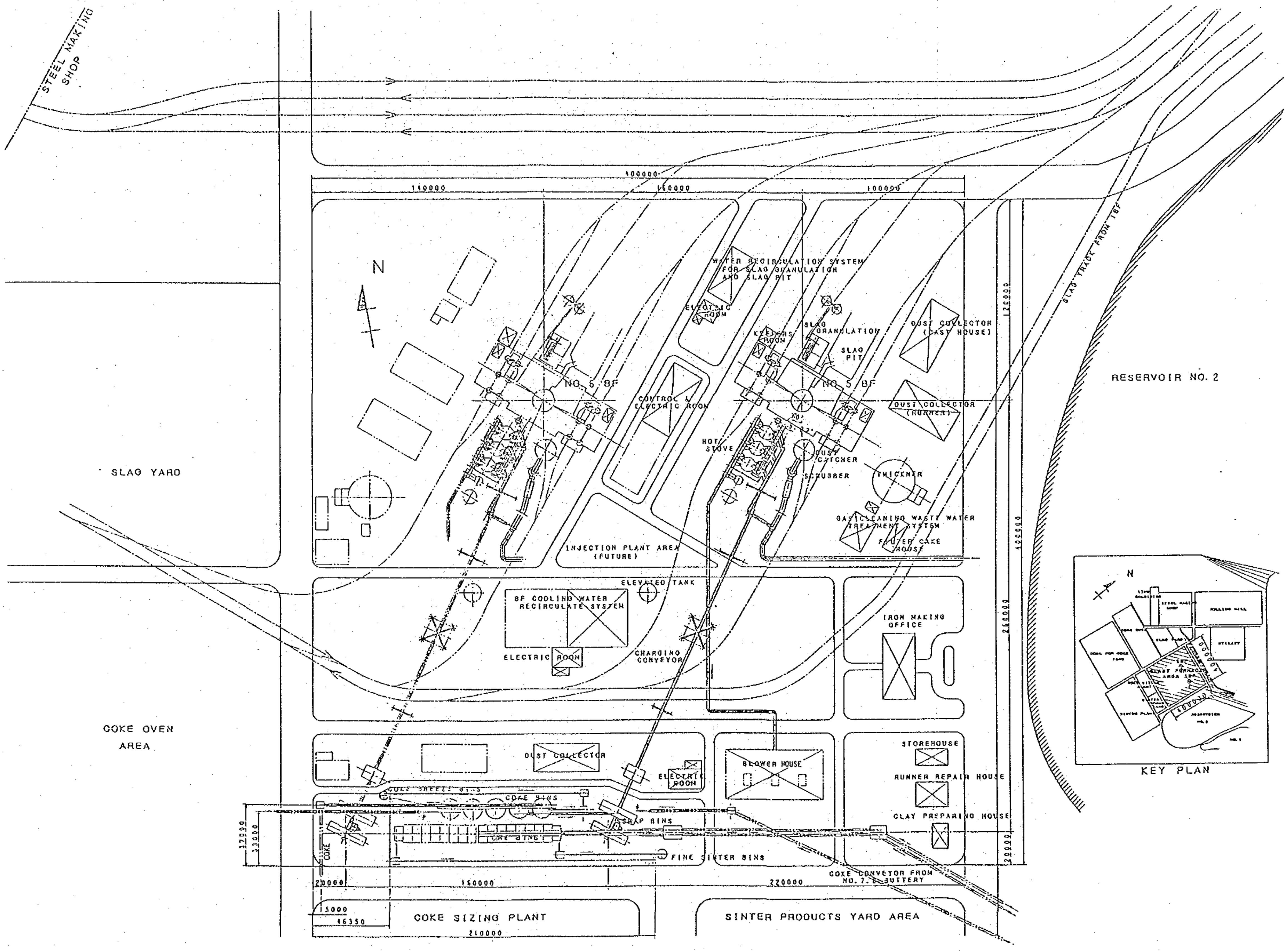


Fig. 7.4.3 Blast furnace No.5 & No.6 general layout

7-4-5. Raw materials conditions

(1) Coke

1) Coal washery at CHASNALLA is to be started up in 1988 and satisfy the requirement of BFs fully from 1993. And high quality coal from deep mine must be available.

2) In addition, imported coking coal is to be used as raw material for coke in 10% of coal blend so as to improve coke quality. Namely, coke ash is decreased from present 28.5% to 23.5% and coke strength at M10 improved from present 17.0 to 12.5.

3) Coke rate: About 589 kg/THM. Required coke will be supplied from old and new coke ovens.

4) Coke size is controlled from 25 mm to 75 mm, averaging 50 mm at blast furnace under-bin screen. Rate of return coke breeze is planned to be about 10%.

(2) Sinter and ore

1) No sinter is available at present, but by the end of 1992 No.1 sintering plant will be completed, and No.2 sintering plant built by the end of 1993, satisfying sinter ratio of 70% for BFs, No.5 & No.6, respectively. Sinter ratio can be raised to 80% when BFs require it.

2) Basicity, CaO/SiO_2, of sinter is to be not more than 1.75 and its Fe content 47.08%.

3) Sizing facilities capable of controlling size of ore including sinter to 10-30 mm are necessary. The rate of fine sinter at blast furnace under-bin screen is planned to be 8%.

4) All of sinter, ore and coke have high Al_2O_3. Though this is the characteristic of Indian ore and coal, the content should be lowered by all means in future.

(3) The above raw materials conditions are applied to No.5 and No.6 BFs. Even if any existing blast furnace (No.1 BF for instance) were used, sinter will not be used for it.

(4) Composition of raw materials and raw materials balance are as discussed later.

7-4-6. Production plan

(1) 1st step (No.5 BF - 2250 m^3)

Hot metal : For steelmaking	966,400 T/Y
Cold pig : For steelmaking	23,300 T/Y
Cold pig : For others	39,300 T/Y
Metal loss: Recovered as scrap	21,000 T/Y
Hot metal total output	1,050,000 T/Y
Crude steel	1,000,000 T/Y

2nd step (No.5 BF - 2250 m^3 + No.6 BF - 2250 m^3)

Hot metal : For steelmaking	2,080,000 T/Y
Cold pig : For steelmaking	50,100 T/Y
Cold pig : For others	26,000 T/Y
Metal loss: recovered as scrap	44,000 T/Y
Hot metal totl output	2,200,000 T/Y
Crude steel	2,150,000 T/Y

Pig iron requirement (hot metal output) at each step is the total of hot metal for steelmaking, cold pig for steelmaking and cold pig sold to KULTI, UJJAIN and other foundries.

Calculation is made on metal loss being 2%.

Crude steel used here means sound steel, namely, good ingot + good cast bloom and billet.

(2) Production of cold pig for sale is smaller than actual production in 1985/86. This is because as continuous casting progresses, the ratio of ingot making decreases and the demand for molds decreases and because as hot metal produced has low silicon content, foundries are likely to purchase pig iron from other suppliers.

(3) Hot metal temperature when charged into BOFs is 1250 °C. Si content in hot metal is 1.3% or less.

(4) Production plan in years when BFs are relined

1) Years when BFs are relined (BFs are supposed to be relined every 7-8 years.)

No.5 BF	End of 2000 and middle of 2008
No.6 BF	End of 2001 and middle of 2009

2) Number of days for reline (110-120 days/relining)

Equivalent days of lost production 140 days/relining

3) Hot metal production 1,800,000 T/Y
(Crude steel production 1,800,000 T/Y)

7-4-7. Operation condition and material balance of BFs

Operation condition and material balance of BFs which satisfy the above production plan are given in Tables 7.4.3 through 7.4.6 and Figs. 7.4.4 through 7.4.6. Some notes on the tables and figures are given below.

Table 7.4.3 CHEMICAL ANALYSIS ON THE MATERIALS FOR BF

Sinter and ores are in figures planned for this study.
For coke ash, present data (SAIL's data informed on September 1, 1986) are adopted.
The other auxiliary materials show analysis of those at present, based on "Operational Statistics 1985-86" of IISCO.

Table 7.4.4 BLAST FURNACE SPECIFICATION

1) The table shows operation data of existing BFs (1985/86), planned values in 1st step and 2nd step in Case G and Case H, respectively, and a sample of max. operation in Case I.

2) Case G shows the average values of No.5 BF in the 1st step, which is only one year of 1993.

This one-year period is used for familiarization with operation of big furnaces under high top pressure and at high production rate = productivity (THM/inner volume/day), and hot blast temperature and pressure in Case G are set somewhat lower than Case H in the 2nd step.
As sufficient coke oven gas is not available in the 1st step, blast temperature is set at 900 °C.

Case H shows planned values in 1994-2012 when both BFs are in normal operation.

Coke is made using imported coking coal 10% and its strength (M10) is 12.5 in Case G and Case H.

3) Case I shows a sample at the time when each No.5 BF and No.6 BF (2250 m^3) is at max. operation.

   In this case, it is assumed that imported coking coal is used 20%, coke ash 21.8% and coke strength (M10) 11.0, and with furnace top pressure of 1.5 kg/cm^2 and blast temperature of 1100 °C, furnace productivity can be 1.5, which is about 6.4% higher than that in the average year (Case H).

4) In India there is seasonal fluctuation in production ranging plus/minus 6% and therefore capacity of BFs and accessories is planned so as to ensure Productivity of 1.5. The average in productivity is planned to be 1.346 in the 1st step and 1.41 in the 2nd step.

5) Case J: This is only reference data. If coke strength is not adequate (M10 = 14.5), blast furnace productivity will drop to 1.38. To ensure annual hot metal production of 2,200,000 tonnes, it is necessary to increase inner volume of BFs to about 2300 m^3. As compared with those of 2250 m^3, construction cost is only slightly higher.

Tables 7.4.5 & 7.4.6 BLAST FURNACE MATERIAL BALANCE

Material balance based on production plan in 1st step, 2nd step and years of relining is shown in Case G, Case H and Case K, respectively, and material flow in each case is shown in the following figures.

Figs. 7.4.4, 7.4.5 & 7.4.6

BLAST FURNACE - MATERIAL FLOW AND BALANCE SHEET

1) When production of crude steel is one million tonnes a year (1st step) and 2.15 million tonnes (2nd step), each BF is operated at annual operating rate (furnace availability) of 0.95 and constant furnace productivity throughout the year. In the years of furnace relining when crude steel production is 1.8 million T/Y, for example, when No.5 BF is relined, hot metal production by No.6 BF is increased during 225 days to minimize 140-days' production loss and stockpile cold pig for steelmaking in 140 days. To achieve such production increase, such measures as maximum productivity by use of higher quality coke and higher top pressure operation in those 140 days and lower percentage of hot metal in the charge for steelmaking are taken. Fig. 7.4.6 shows the annual total.

2) Furthermore, oxygen enrichment of blast by oxygen injection is an effective method to increase the furnace productivity using a surplus oxygen which occurs due to decrease in production of steelmaking shop during the 140 days.

Table 7.4.3 Chemical analysis on the materials for blast furnace

Contents Materials	T.Fe (%)	SiO_2 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)	Mn (%)	P (%)	S (%)	TiO_2 (%)
Sinter	47.08	5.34	4.46	9.36	2.68	0.90	0.10	0.01	0.21
High lump ore	65.20	2.20	2.70	0.00	0.00	0.05	0.03	0.10	0.21
Low lump ore	59.80	2.80	4.70	0.10	0.08	0.06	0.04	0.02	0.20
Scrap	78.00	10.00	2.00	---	---	---	---	---	---
Lime stone	1.00	7.80	2.70	45.70	3.60	---	---	---	---
Dolomite	1.00	6.50	2.10	29.00	19.30	---	---	---	---
Manganese ore	21.40	7.00	10.00	---	---	26.00	0.05	---	---
Coke ash	6.90	57.00	25.80	2.80	1.00	---	0.60	(SO_3=0.80)	1.50

Present specific gravity

Sinter : ---
High grade ore : 2.5
Low grade ore : 2.1
Lime stone : 1.5
Dolomite : 1.4
Coke : 0.6
Slag : 1.5
Granulated slag : 0.8

Table 7.4.4 Blast furnace specification

Cases / Items	Present	Case G	Case H	Case I	Case J	Notes
	* 85/86	1st step	2nd step	A sample of Max. ope.	A sample of Alt.	
1.1 Blast furnace	1BF, 2BF, 3BF, 4BF	5 BF	5 BF + 6 BF	5 BF or 6 BF	5 BF + 6 BF	
1.2 Inner volume (m^3)	500 500 1170 1170	2250	2250 x 2	2250	2300 x 2	Hot metal / Crude steel
1.3 Furnace productivity	3340	Nor	Nor	(1.41 x 106.4)	Nor	1st Step 1.05MT/Y 1.00MT/Y
(THM/Nm^3 of inner Vol/D)	0.75	1.346	1.41	1.50	1.38	2nd Step 2.20MT/Y 2.15MT/Y
1.4 Daily productivity (THM/D)	2,500	3,028.^{5}	3,172.^{5} x 2	3,375	3,174 x 2	Revamp 1.77MT/Y 1.80MT/Y
1.5 Furnace availability (%)	94.4	95	95	(95)	95	
1.6 Annual production (THM/Y)	862,000	1,050,100	1,100,000 x 2	(1,170,000)	1,100,500 x 2	
1.7 Production plan (THM/Y)		1,050,000	2,200,000	——	2,200,000	Used for material balance
2.0 Material and furnace operation condition satisfying the production plan						
2.1 Size of Sr, ore, limestone etc. (mm)		10 ~ 30	10 ~ 30	10 ~ 30	10 ~ 30	
2.2 Sr (rate) (%)	Not used	Nor. 70	Nor. 70	Nor. 70	Nor. 70	Max approx.80%
2.3 Underbins screen	Not used	Applied	Applied	Applied	Applied	
2.4 Sr property	————	Fe 47.^{08}% Basic.1.^{75}	Same as left	Same as left	Same as left	Basicity CaO/SiO$_2$ of Sr = 1.75
2.5 Sr strength (DI $^{150}{}_{50}$)	————	> 80	> 80	> 80	> 80	
2.6 Coke Size (mm)	+80mm 30%	25 ~ 70 (Ave.50)	Same as left	Same as left	Same as left	
2.7 Imported coal (%)	(Trying)	10	10	20	10	CHASNALLA washery completes
2.8 Coke ash (%)	28.^{5}	23.^{5}	23.^{5}	21.^{8}	23.^{5}	by 1988. Ash data from IISCO
2.9 Coke strength (M10)	17 (16.7)	12.^{6}	12.^{5}	11.^{0}	14.^{5}	TELEX dated 1986-9-1
2.10 Top pressure (Kg/cm^2)	0.^{07}	1.^{146}	1.^{316}	1.^{50}	1.^{365}	
2.11 Hot blast temp. (°C)	664	900	1100	1100	1100	
2.12 Coke oven gas mixture(%)	Not used	Approx. 1	5 ~ 7	5 ~ 7	5 ~ 7	
2.13 Additional humidity (g/Nm^3)	10	20	20	20	20	
2.14 Fuel injection	Not used	Not used	Not used	Not used	Not used	
3.0 Material rate (Refer to the material balance sheet as to the detailed data)						
3.1 Sinter unit consumption (Kg/THM)	Not used	1280	1280	1280	1280	Net sinter
3.2 Coke rate (Kg/THM)	1056	640	589	545	580	
3.3 Slag rate (Kg/THM)	749	470	460	430	460	
3.4 Flue dust rate (Kg/THM)	33	20	20	20	20	

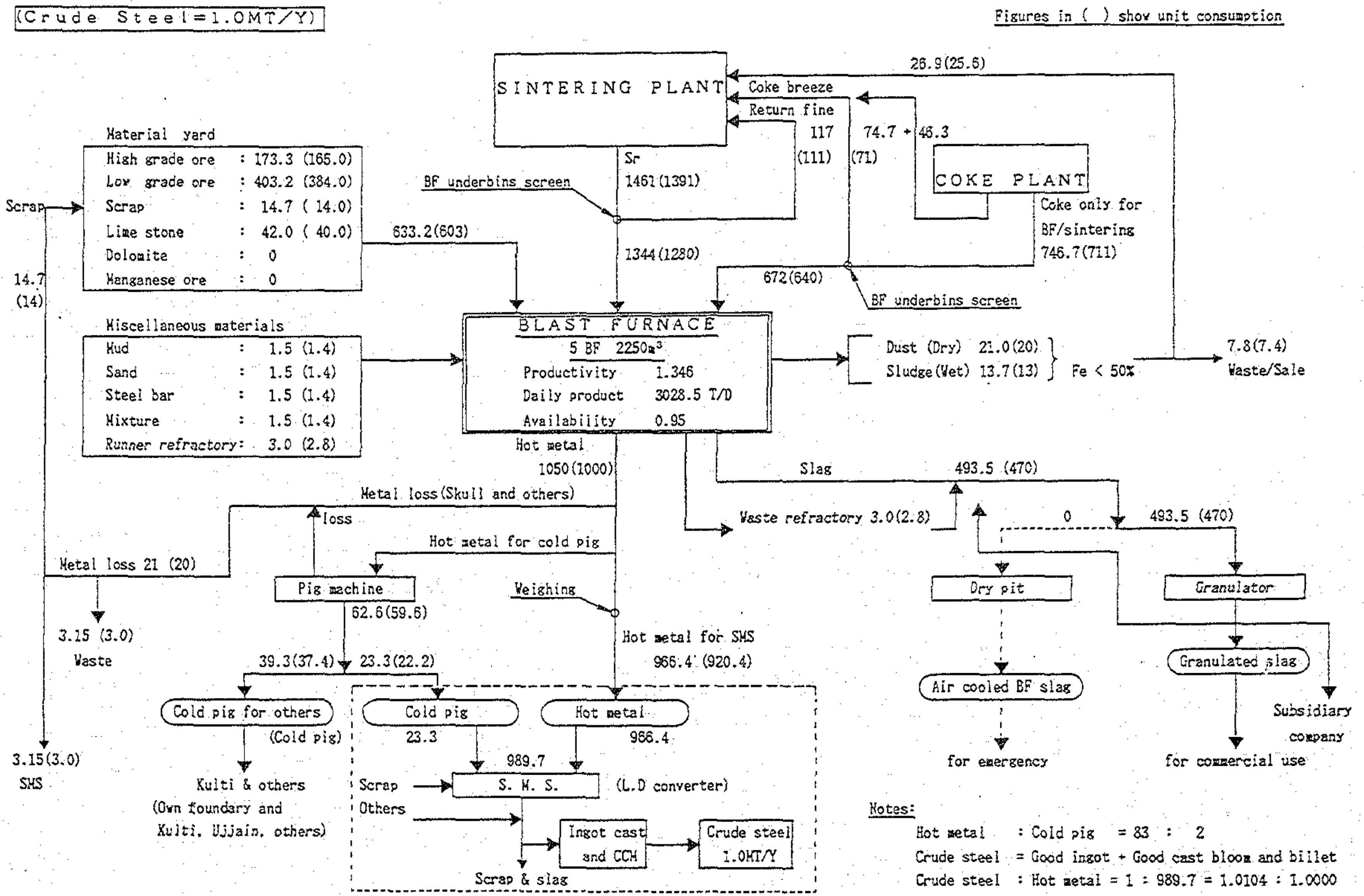
* Note : Data of 85/86 are based on "Operational Statistics 1985-86 IISCO"

Table 7.4.5 Blast furnace material balance

Cases / Items	Present		Case G		Case H		Case K		Notes
	85/86		1st step		2nd step		Revamp. year		
1.1 Blast furnace	1BF, 2BF, 3BF, 4BF		5 BF		5 BF + 6 BF		5 or 6 BF Revamp		Data for revamping year show as a sample
1.2 Inner volume (m^3)	500 500 1170 1170		2250		2250 x 2		(2250)		(m^3) (days)
1.3 Furnace productivity (THM/Km^3 of inner Vol/D)	3340 0.75		Nor 1.346		Nor 1.41		A B C 1.41 1.423 1.467		2250 x 1.41 x 225 x 0.95 = 678,122 T/Y 2250 x 1.423 x 225 x 0.95 = 684,374 T/Y
1.4 Daily productivity (THM/D)	2,500		3,028.^{5}		3,172.^{6}		3172.^{5} 3201.^{8} 3300.^{8}		2250 x 1.467 x 140 x 0.95 = 439.000 T/Y
1.5 Furnace availability (%)	94.4		95		95		95		Total hot metal product = 1,801,496 T/Y
1.6 Annual production (THM/Y)	862,000 (861,556)		1,050,100		1,100,000		1,801,496		During a furnace revamping, hot metal rate in
1.7 Production plan (THM/Y)			$\boxed{1,050,000}$		$\boxed{2,200,000}$		$\boxed{1,800,000}$		converter can be reduced. Then crude steel product
1.8 Crude steel (Ton/Y)			(1,000,000)		(1,150,000)		(1,772,000->1,800,000)		can be 1.8MT/Y
	※1 Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	-
2.0 Consumption of raw material							※2		
2.1 Received sinter	0		1391	1461	1391	3061	<1388>	2499	
2.2 Return fine sinter	0		111	117	111	245	< 111>	200	
2.3 Net sinter	0		1280	1344	1280	2816	<1277>	2299	※1 : Data of unit consumption of present (85/86)
2.4 High grade ore	437 1430	1231.^{742}	165	173.^{3}	165	363	165	297	show "Specific consumption rate" of page 68 to
2.5 Low grade ore	993		384	403.^{2}	384	844.^{8}	384	691.^{2}	page 71 in "Operational Statistics 1985-86".
2.6 Scrap	40	34.^{226}	14	14.^{7}	14	30.^{8}	<17.^{9}>	32.^{2}	Data of Annual Quantity of present (85/86) show
2.7 Lime stone	401	345.^{218}	40	42	40	88	<35.^{2}>	63.^{3}	data of page 58 and page 65 to page 67 in the
2.8 Dolomite	270	232.^{541}	0	0	0	0	0	0	same book.
2.9 Manganese ore	56	48.^{282}	0	0	0	0	0	0	Unit consumption of Ore (85/86) :
									437 + 993 = 1430 (High grade ore is
2.10 Received coke	—	—	711	746.^{7}	654	1439	<646.^{7}>	1164	1430 x 30.58% = 437).
2.11 Return coke breeze	—	—	71	74.^{7}	65	143	< 64.^{7}>	116	
2.12 Net coke (Dry)	1056	907.^{750}	640	672	589	1296	<582>	1048	※2 : Data with < > are weighted averages.
(=Coke rate)	(1056)		(640)		(589)		(582)		

Table 7.4.6 Blast furnace material balance

Cases / Items	Present		Case G		Case H		Case K		Notes
	85/86		1st step		2nd step		Revamp. year		
1.1 Blast furnace	1BF, 2BF, 3BF, 4BF		5 BF		5 BF + 6 BF		5 or 6 BF revamp		Data for revamping year show as a sample
1.2 Inner volume (m^3)	500 500 1170 1170		2250		2250 x 2		(2250)		(m^3) (days)
1.3 Furnace productivity	3340		Nor		Nor		A B C		2250 x 1.41 x 225 x 0.95 = 678.122 T/Y
(THM/Nm³ of inner Vol/D)	0.75		1.346		1.41		1.41 1.423 1.467		2250 x 1.423 x 225 x 0.95 = 684.374 T/Y
1.4 Daily productivity (THM/D)	2,500		3,028.^{5}		3,172.^{5}		3172.^{5} 3201.^{8} 3300.^{8}		2250 x 1.467 x 140 x 0.95 = 439.000 T/Y
1.5 Furnace availability (%)	94.4		95		95		95		Total hot metal product = 1,801.496 T/Y .
1.6 Annual production (THM/Y)	862,000 (861,556)		1,050,100		1,100,000		1,801,496		
1.7 Production plan (THM/Y)			1,050,000		2,200,000		1,800,000		
1.8 Crude steel (Ton/Y)			(1,000,000)		(1,150,000)		(1,772,000--1,800,000)		
	Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	Unit Consumption (Kg/THM)	Annual Q'ty (1000T/Y)	
3.0 Miscellaneous material									
3.1 Mud			1.^{4}	1.^{5}	1.^{4}	3.^{0}	1.^{4}	2.^{5}	
3.2 Sand			1.^{4}	1.^{5}	1.^{4}	3.^{0}	1.^{4}	2.^{5}	
3.3 Steel bar			1.^{4}	1.^{5}	1.^{4}	3.^{0}	1.^{4}	2.^{5}	
3.4 Mixture			1.^{4}	1.^{5}	1.^{4}	3.^{0}	1.^{4}	2.^{5}	
3.5 Refractory			2.^{8}	3.^{0}	2.^{8}	6.^{0}	2.^{8}	5.^{0}	
4.0 Waste material									
4.1 Dust (Dry)	33	28.5	20	21	20	44	20	36	
4.2 Sludge (Wet)			13	13.^{7}	13	28.^{6}	13	23.^{4}	
4.3 Waste refractory			2.^{8}	3.^{0}	2.^{8}	6.^{0}	2.^{8}	5.^{0}	
4.4 Skull	(11.1)	(95.6)	5.^{5}	5.^{8}	5.^{5}	12.^{0}	5.^{5}	9.^{9}	
4.5 Slag yield	749	645.5	470	493.^{5}	460	1012	<453>	815.^{6}	
4.6 Air cooled BF slag			0	0	0	0	0	0	
4.7 Granulated slag			470	493.^{5}	460	1012	<453>	815.^{5}	
5.0 Hot metal production	1000	862	1000	1050	1000	2200	1000	1800	
5.1 Hot metal to SMS	(856)	(738)	920.^{4}	966.^{4}	945.^{45}	2080	<951.^{8}>	1713.^{3}	
5.2 Cold pig production	(110)	(95)	59.^{6}	62.^{6}	34.^{6}	78.^{1}	<29.^{4}>	52.^{9}	
5.3 Cold pig to SMS	(1)	(1)	22.^{2}	23.^{3}	22.^{8}	50.^{1}	<23.^{3}>	41.^{9}	
5.4 Cold pig for others	(109)	(94)	37.^{4}	39.^{3}	11.^{8}	26.^{0}	<6.^{1}>	11.^{0}	
5.5 Metal loss	(34)	(29)	20	21	20	44	<18.^{8}>	33.^{8}	



Notes:
Hot metal : Cold pig = 83 : 2
Crude steel = Good ingot + Good cast bloom and billet
Crude steel : Hot metal = 1 : 989.7 = 1.0104 : 1.0000

Fig. 7.4.4 Material flow and balance sheet - Crude steel 1.0 MT/Y

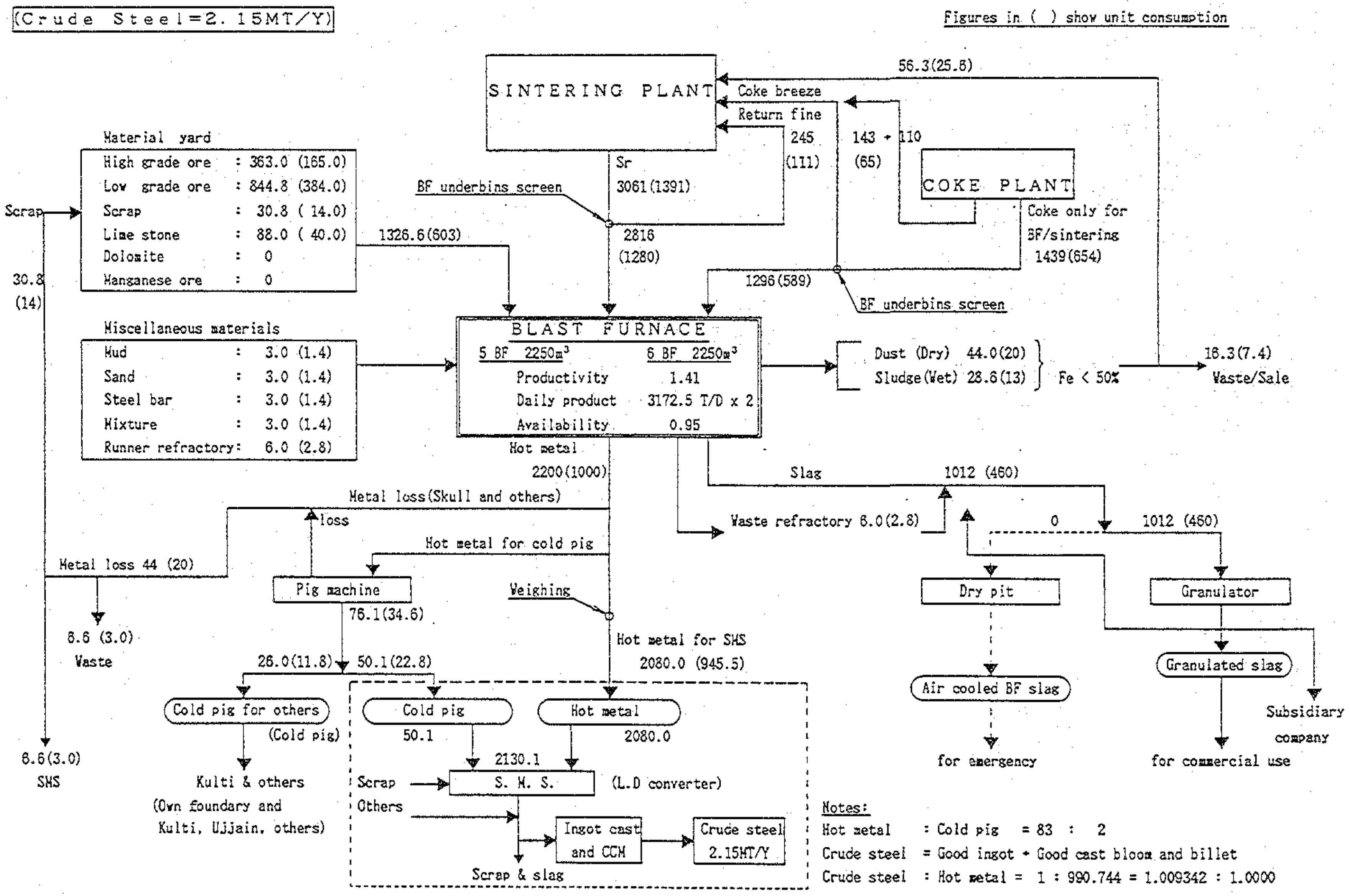


Fig. 7.4.5 Material flow and balance sheet - Crude steel 2.15 MT/Y

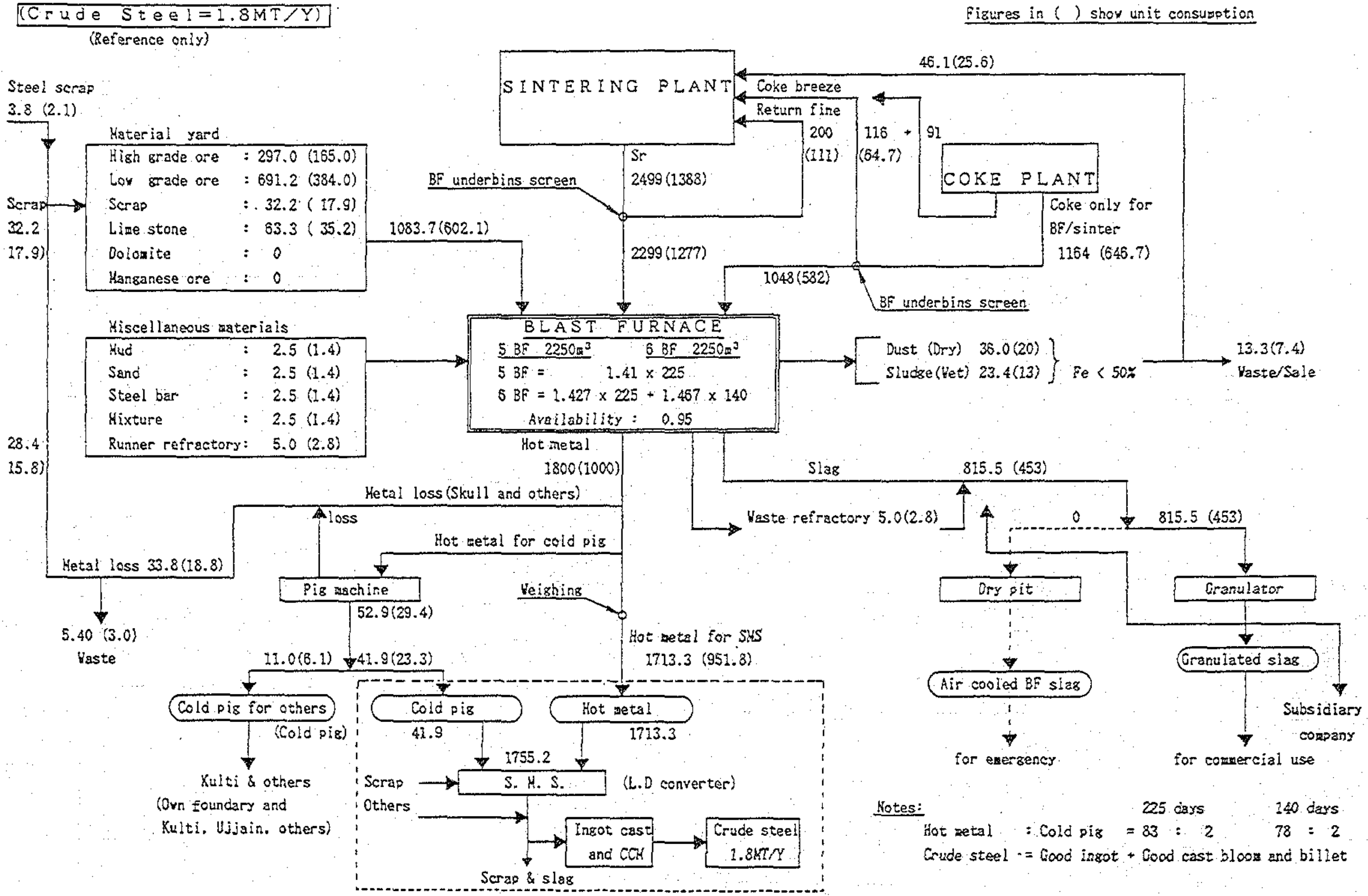


Fig. 7.4.6 Material flow and balance sheet - Crude steel 1.8 MT/Y
(BF revamping year of 5BF 140days revamp)

7-4-8. Energy and utility

Premises of matters related to energy and utility for the 1st step (No.5 BF) and the 2nd step (No.5 BF + No.6 BF) are discussed below and unit consumption of energy is given in Table 7.4.7.

(1) Blowers for blast furnaces are to give blast pressure and volume of air blast corresponding to high pressure operation and coke rate of the furnaces. Their capacity should be large enough to satisfy hot stove filling at change over. In the 1st step the blowers number 2 with 1 in use, and in the 2nd step one more blower is installed to make the total number 3, of which 2 are in operation.

(2) Blast furnace gas presently used is of 900 kcal/Nm^3, but in this plan coke rate decreases and generation and consumption of blast furnace gas are converted by assuming the calorific value of 800 kcal/Nm^3.

(3) Though coke oven gas is not sufficiently available in the 1st step, it is available in the 2nd step in amount sufficient to ensure high hot blast temperature.

(4) Fuel injection plant is not provided. Oxygen enriched blast is not used in normal year. Purchased high pressure oxygen (150 kg/cm^2) is used to open iron notch.

(5) Steam is added to the blast air at an average of 20 g/Nm^3 (30 kg/THM) to increase moisture in the blast.

(6) Industrial water is used for cooling of blast furnace facilities, slag granulation, gas cleaning and dust collection and recycled. The figure shows the amount of required make-up water corresponding to such recirculation.

(7) Compressed air and nitrogen gas are to be made available.

(8) Required electric power supply should be assured. Power consumption given in Table 7.4.7 is for blast furnace facilities and water treatment and does not include power for the blast furnace blowers.

(9) Energy saving facilities or power generating facilities at ironmaking area are to be installed after they are found economically viable. And they are not included in the present power balance.

Table 7.4.7 Unit Consumption of Energy and Utility

			1st. step	2nd. step
(1)	Cold blast	(Nm^3/THM)	1500	1400
(2)	B gas (Blast furnace gas)		B gas volume is shown as conversion at 800Kcal/Nm3	
	- B gas yield	(Nm^3/THM)	2100	1950
	- Consumption at hot stove	(Nm^3/THM)	720	700
(3)	C gas (Coke oven gas)			
	- for hot stove	(Nm^3/THM)	7	38
	- for casthouse	(Nm^3/THM)	3	3
(4)	Oil, Tar, Pulverized coal, CaO injection		0	0
(5)	Steam			
	- for blast humidity control	(Kg/THM)	30	28
	- for others	(Kg/THM)	16	16
(6)	Compressed air -7Kg/cm^2G	(Nm^3/THM)	20	20
(7)	Nitrogen gas	(Nm^3/THM)	5	5
(8)	Oxygen for tap hole openning - purchased	(Nm^3/THM)	15	15
(9)	Industrial water - make up	(T/THM)	3.0	2.8
(10)	Electric power			
	- for blast furnace	(KWH/THM)	22	21
	- for water treating system	(KWH/THM)	17	16

7-4-9. Facilities included in estimates

Details of facilities included in the estimates and facilities plan and specification are given in Table 7.4.8.

(1) Scope of estimates

Following facilities and projects related to the construction of No.5 BF and No.6 BF

1) Blast furnace, equipment & refractories and blast furnace water treatment system including pump station.
2) Environmental (pollution control) equipment
3) Electric and instrument equipment
4) Buildings, houses and equipment
5) Foundation work (Those for facilities, buildings, etc.)
6) Vehicles
7) Spares (for two years)

(2) Items related to blast furnace facilities, but estimated in common with other departments or for the Works

1) Weighing for hot metal sent to Steelmaking Shop
   Each hot metal ladle is weighed by crane scale for calculation, which makes it possible to perform production control of hot metal by blast furnace and by tapping.
2) De-slagging facilities (To be installed after mixers at steelmaking plant)
3) Blast furnace blowers, air compressors, blast furnace gas holder, etc.
4) Of the vehicles: hot metal ladle cars and ladles, locomotives, trucks, reilway cars (wagons), crane cars, shovel loader for dust cleaning, etc.

(3) Though not included in the estimates, those facilities, for which space is set aside in the layout so that they can be built in future and which are to be installed as their installation is justified by necessity in production or energy-saving effect.

1) Fuel injection plant
2) CaO injection plant
3) TRT (Top gas energy recovery furnace)
4) De-silicon, de-sulphur and de-slag plants

(4) Existing No.1 through No.4 BFs
(Not included in the estimates)

1) In this feasibility study, expenses for relining of existing blast furnaces prior to 1993 are excluded from the estimates. It is presumed that IISCO has made budgets for relining of those furnaces by 1992.

2) Under the basic plan (No.5 BF + No.6 BF), no relining after 1993 is planned for any of existing BFs, No.1, No.2, No.3, and No.4.

3) It is considered that expences for safety measures at blown out of existing BFs are kept within the limit of ordinary maintenance expenses.

(5) Relining project of No.5 & No.6 BFs
cost of relinings is by special provision for blast furnace repair considering belows.

1) Relining of each BFs, No.5 and No.6, is done every 7-8 years.

2) The repair is mainly brick relining and the minimum extent of repair which can be performed only at the time of furnace relining.

Table 7.4.8 Blast furnace equipment specifications

sheet 1 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
1. Raw materials transporting facilities				
(1) Raw materials bin	1 unit	Sinter bin : $160m^3$ x 8	1 unit	Same as left
		Ore bin : $100m^3$ x 4		ditto
		Miscellaneous material bin : $40m^3$ x 5		ditto
		Coke bin : $600m^3$ x 2 + 1	(2)	Coke bine : $600m^3$ x 2
		Fine sinter bin : $130m^3$ x 1		Same as left
		Coke breeze bin : $100m^3$ x 1		ditto
(2) Screen	11 sets	Sinter screen : 165T/h x 8	10 sets	Sinter screen : 165T/h x 8
		Coke screen : 200T/h x 2 + 1		Coke screen : 200T/h x 2
(3) Feeder	8 sets	Ore feeder : 450T/h x 4	8 sets	Same as left
		Limestone feeder : 60T/h x 4		
(4) Weighing	10 sets	Coke weigh hopper : $35m^3$ x 2	10 sets	Same as left
		Material weigh hopper: (2 to $7m^3$) x 8		
(5) Reserving hopper	2 sets	Reserving hopper : $25m^3$ x 2	2 sets	Same as left

(Continued)

sheet 2 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
(6) Conveyor	1 unit	For Ore : 1000T/h For Coke : 500T/h For Fine sinter : 100T/h For Coke breeze : 40T/h	1 unit	Same as left
(7) Charging conveyor	1 unit	Type : Gallery type Capacity : 1000T/h Belt width : 1200mm Belt speed : 100m/min	1 unit	Same as left
(8) Stockhouse dust collecting equipment	1 unit	Dry type : 7000m^3/min x 1	1 unit	Same as left
2. Top charging system				
(1) Top charging gear	1 unit	Top charging method : Bell-less top Bunker : 35m^3 x 2 Top pressure : 1.5 kg/cm^2	1 unit	Same as left
(2) Others		Hydraulic equipment Centralized lubricating equipment 4-sounding device Top igniter Dust collector : Dry type 500m^3/min x 1		

(Continued)

sheet 3 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
		High top pressure control equipment (Bleeder valves, equalizer & relief valves)		
3. Blast furnace	1 unit		1 unit	Same as left
(1) Furnace shell	1 set	Furnace supporting system : Free-stand type Inner volume : 2250m^3 Working volume : 1930m^3 Hearth diameter : 10,400mm No. of tap holes : 2 No. of cinder notch : 1 No. of tuyeres : 27		
(2) Furnace structure	1 set	4 column structure and platforms		
(3) Cooling devices	1 set	Cooling plates, staves and shower		
(4) Refractories	1 set	Al2O3/SiO2, SiC, carbon etc.		

(Continued)

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
4. Cast house equipment	1 unit		1 unit	Same as left
(1) Cast floor	1 set	2 casting areas : about 2600m^2		
(2) Main iron trough	2 sets	Fixed trough		
(3) Iron runner	2 sets	Runner and tilting spout		
(4) Slag runner	3 sets	Runner slag granulation system and to slag pit		
(5) Slag treatment equipment	1 unit	1 slag granulation system : 1500T/D = (100%) 1 slag pit (Dry pit) for emergency	1 unit	Same as left
(6) Clay gun	2 sets	Full hydraulic type 0.25 m^3/stroke (Effective)	1 unit	Same as left
(7) Tap hole opener	2 sets	Pneumatic remote control type	2 sets	Same as left
(8) Cinder notch stopper	1 set	Pneumatic remote control type	1 set	Same as left
(9) Cast house crane	2 sets	20t x 18m span	2 sets	Same as left
(10) Main iron trough cover crane	2 sets	Post type jib crane : 10t (Air type)	2 sets	Same as left
(11) Dust collecting equipment	1 unit	For runner : Dry type : 7500 m^3/min x 1 For cast house: Dry type : 10000 m^3/min x 1	1 unit	Same as left
(12) Pig casting machine	2 units	Stationary fixed roller type: max 600T/D each (Repair and reuse of existing equipment)	----	None

(Continued)

sheet 5 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
5. Hot stove equipment	1 unit		1 unit	Same as left
(1) Hot stove	3 sets	Hot stove type : Cowper 3 units Blast temperature : 1100°C Blast pressure : Max. 3.2 Kg/cm^2 Blast volume 3350 m^3/min Heating surface : 41,500 m^2/stove Fuel : Mixed gas (BFG & COG) Combustion gas : 52,500Nm^3/h stove Combustion air : 45,000Nm^3/h Hot stove valve cooling		
(2) Combustion air fan	3 sets			
(3) Valves	1 unit	Stove valves : 3 sets Backdraft valve : 1 set Snort valve : 1 set		
(4) Duct	1 unit	Ducts, bustle main, bustle pipe etc.		
(5) Refractories	1 unit	Refractories for stoves, ducts, etc.		
(6) Coke oven gas booster	2 sets			

(Continued)

sheet 6 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
6. Gas cleaning equipment	1 unit	Gas cleaning method : Dust catcher ----> Wet type scrubber (with top pressure control) ----> mist separator Treating gas volume :Max 280,000 Nm^3/h Degree of gas cleaning : $10mg/Nm^3$ (Below)	1 unit	Same as left
7. Water treating system				
(1) Blast furnace cooling water	1 unit	Amount of feed water : Approx. 9,000m^3/h including cooling tower, pump, strainer and piping and elevated water tank $(1000 + 350 = 1350m^3)$	1 unit	Same as left
(2) Gas cleaning waste water	1 unit	Amount of feed water : Approx. 900m^3/h including thickener (25mϕ), dehydrater, cooling tower, pump, strainer and piping	1 unit	Same as left
(3) Slag pit water	1 unit	Amount of feed water : Approx. 300m^3/h including pump, strainer and piping	1 unit	Same as left
(4) Slag granulation water	1 unit	Amount of feed water : Max. 42m^3/min including granulator, filter, cooling tower, pump and piping	1 unit	Same as left

(Continued)

BLAST FURNACE
EQUIPMENT SPECIFICATIONS

sheet 7 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
8. Service piping	1 unit	- Water, compressed air, steam, nitrogen gas, oxygen gas and coke oven gas for casthouse etc. - Oxygen enrichment (for production increase).	1 unit	Same as left
9. Instrument	1 unit	- Infrared camera, above burden probe, shaft differential pressure, CO2 detector, gas analizer (profile meter, shaft horizontal penetrate probe) - Weighing with auto calibrator and moisture control. - Gas cleaning pressure control. - Blast humidity control. - Field instrument including thermocouple, orifice, pressure gauge etc. - CRT, shared display, data logging, control equipment and computer.	1 unit	Same as left
10. Electric equipment	1 unit	- Substation, battery back up. - Switch gears, panel, motor, limit switches. - PLC and automation equipment and control. - Elevator, air conditioning, lighting. - Inter-communication system, ITV. - Metal detector, sounding etc.	1 unit	Same as left

(Continued) sheet 8 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
11. Building	1 unit			
(1) Stockhouse dome	1	575m^2	1	Same as left
(2) Driving house	1	120m^2	1	ditto
(3) Casthouse	1	2600m^2	1	ditto
(4) Keepers room	1	8m x 10m	1	ditto
(5) Control room	1	570m^2 x 3 storied (including electric room)	1	ditto
(6) Electric room	3	for stockhouse, slag and pump rooms	3	ditto
(7) Elevator tower	1	3m x 3m x 63mH	1	ditto
(8) Dehydrater house	1	150m^2		
(9) Iron making office	1	800m^2 x 3 storied	-	Nil
(10) Clay preparation house	1	150m^2	-	Nil
(11) Runner repair house	1	300m^2	-	Nil
(12) Store house	1	200m^2	-	Nil
(13) Expansion of ladle refractory repair house	-	Nil	1	Expansion 300m^2
12. Equipment for buildings	1	Mechanical and electrical equipment for buildings are included in respective equipment items	1	Same as left

(Continued)

sheet 9 of 9

Item	Step I (BF No. 5)		Step II (BF No. 6)	
	Quantity	Main specifications	Quantity	Main specifications
12. Civil	1 unit	- Foundation of BF, HS and other equipment - Foundation of buildings - Stockhouse bunker - Dry pit and fence - Water ponds - Railway, road, drainages	1 unit	Same as left
13. Vehicle and others				
(1) Scope of BF	1 unit	- Power shovel and bulldozer for dry pit (repair) - Fork-lifts for storehouse	1 unit	Same as left Quantity of fork-lifts are different
(2) Scope of common	1 unit	- Hot metal ladles, ladle cars, diesel loco, shovel loader/truck/wagon for slag, dust and others, truck, truck crane for maintenance, etc.	1 unit	Same as left (Quantity of vehicles are different)
(3) Scope of SMS	1 unit	- Hot metal weighing, slag dig-out machine	1 unit	Same as left
14. Spare parts	1 unit	For 2 years	1 unit	Same as left

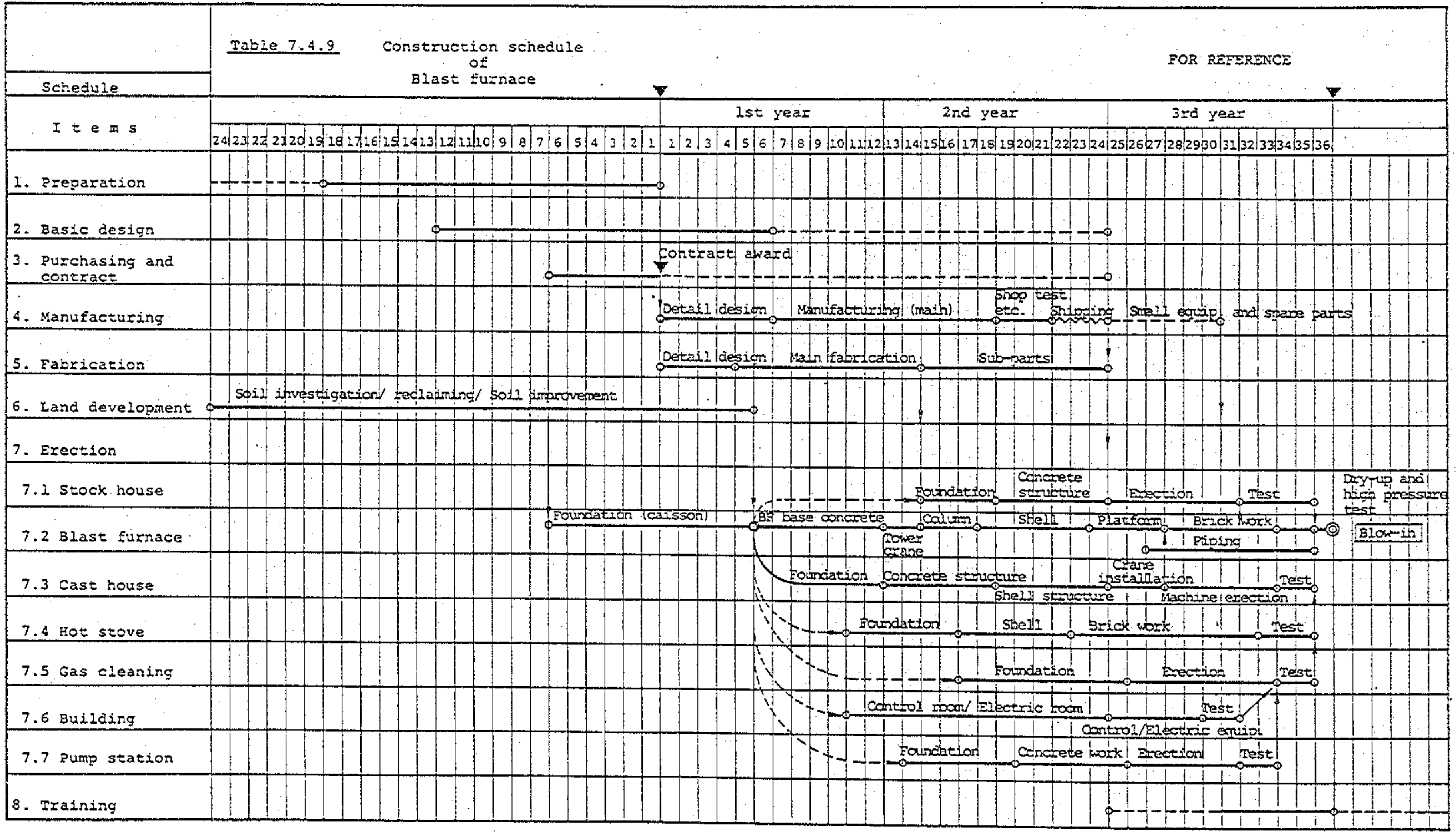
7-4-10. Construction schedule (Refer to Table 7.4.9)

The period of construction of a blast furnace is approx. three years after decision of implementation of basic plan. Total period will be about five years being added to two years for such preparation terms as study of alternative plans, decision of implementation, plan of project, soil investigation and soil improvement.

To realize BF blowin within three years, careful plan, modernized method of construction, minute schedule control and functional active organization of project team are required.

Furthermore, training and familiarization of modernized BF equipment and operation shall be fully executed before blowin to achieve the planned production in a short period of starting up.

Table 7.4.9 Construction schedule of Blast furnace



7-5. Steelmaking (Basic oxygen furnaces)

7-5-1. Necessity and basic idea of new steelmaking shop

Present steelmaking shop is critically deteriorated in its various facilities and in planning a long-range plan for future it is essential to build a new steelmaking shop based of basic oxygen furnaces as discussed in the introduction in Chapter 1 for reasons summarized below.

(1) Duplex process based on the combination of bessemer converters and open hearth furnaces itself is out-of-date and besides, improvement and maintenance of facilities of both the converters and furnaces since their start-up were inadequate. Therefore they cannot be used for long in future.

(2) With the present facilities which are low in production efficiency and much deteriorated, it is difficult to achieve the current goal of annual production of one million tonnes of sound steel.

(3) Yield of steel to hot metal is low, unit consumption of energy is high, and labour productivity is very poor. As a result, production cost is high and competitiveness is lost.

(4) The facilities such as weighing equipment, measuring and instrument equipment are inadequate and very little mechanized and automated.

(5) Working environment is very bad and hardly any pollution control measures are taken for the regional community.

In planning the new steelmaking shop, study was made by taking into consideration the present condition of BURNPUR Works and in line with the basic policy of this feasibility study that the present condition is not to be reviewed from the soft aspect but remedied from the hard aspect of introduction of basic oxygen process. The basic matters are:

(1) Based on two conditions of quality of hot metal as main raw material and quality of products expected from product mix, operation condition of BOFs and their specifications were decided. It was also contemplated that process flow from receiving hot metal to delivery of molten steel to ingot and continuous casting should be as simple as possible.

(2) In addition to the basic oxygen furnaces proper, such facilities as OG facilities (non-combustion system of BOF waste gas with recovery), sublance facilities as automatic, dynamic blowing control system, and automatic relining tower for BOFs are included as facilities which must be installed in the shop as a modern steelmaking shop.

(3) In view of energy condition in India and with a view of cutting steelmaking cost, it was planned to recover waste gas for effective utilization in the Works.

(4) In consideration of its consumption and quality problem, it was planned that burnt lime, main flux material for BOFs, be produced by large capacity shaft kilns newly constructed and delivered directly to BOFs and existing shaft kilns be discarded.

(5) It was planned to install environmental facilities which would be able to meet future environment standards so as to ensure perfect pollution control measures for both air and water.

In accordance with production plan of the entire project, the new steelmaking shop will have two BOFs with one being in operation in the 1st step of one million-tonne production and one more BOF of same size will be installed in the 2nd step of 2.15 million-tonne production.

7-5-2. Premise for planning facilities

(1) Hot metal

Target composition and temperature of hot metal before charging into BOFs are as shown in Table 7.5.1.

Table 7.5.1 Chemical composition and temperature of Hot Metal

	C	Si	Mn	P	S	Temp
Target	3.8 ~ 4.2%	1.1 ~ 1.6	0.6 ~ 1.0	<0.28	<0.07	1,230 ~ 1,280°C
Expected average	4.0	1.3	0.8	0.25	0.05	1,250

(2) Product mix in crude steel

Production plan in terms of sound ingot or sound cast is given in Table 7.5.2.

Table 7.5.2 Preduct mix in crude steel (sound ingot and steel cast)

			Crude steel production 10^3 T/Y	
Casting method	Cast size	Final product	Step I 1,000	Step II 2,150
1) Ingot casting	5T	Sheet	148	---
		Bar, Rod, Shape & Billet	367	295
2) No.1 Billet-CC	100□mm	Bar, Rod & Shape	200	250
3) Bloom-CC	300 x 400 mm	Heavy structural	285	335
4) No.2 Billet-CC	150□mm	Bar, Rod & Shape	---	615
5) No.3 Billet-CC	180□mm	Bar, Rod & Shape	---	655
Continuous casting ratio			48.5%	86.3%

(3) Raw materials blending ratio and yield

Main raw materials blending ratio and yield are shown in Table 7.5.3. For main material blending, hot metal ratio is determined to ensure optimum operation of BOFs. Cold pig is used as buffer to absorb dispersion in hot metal quality and in opertion of BF - BOFs. As regards scrap, return balance point in the 1st step is 13.5% and that in the 2nd step 7.3%, and scrap shortage will be covered by purchased scrap and home scrap.

Table 7.5.3 Main materials blending ratio and yields

1) Main material blending ratio	a) Hot metal ratio	83 %
	b) Cold pig iron ratio	2
	c) Scrap ratio	15
2) Yield	a) Molten steel yield (to charged main material)	89
	b) Sound ingot yield (to molten steel)	97
	c) No.1 Billet-CC as cast yield	96
	d) Bloom-CC as cast yield	96
	e) No.2 Billet-CC as cast yield	96.5
	f) No.3 Billet-cc as cast yield	96.5

(4) Operation condition

Considering fluctuation in Si content in hot metal, it was assumed that 20% of heats would be refined by double slag method with intermediate slag off. Average charge to tap time and working ratio was assumed to be as shown in Table 7.5.4 and Table 7.5.5.

Basic items of operation condition are shown in Table 7.5.6.

Table 7.5.4 Estimated charge to tap time

	Single slag	Double slag
Charging	4 minutes	4 minutes
Blowing	18	18
Re-blowing	6	6
Intermediate slag off	--	10
Blow-off adjustment	6	6
Tapping	5	5
Final slag off	2	2
Average charge to tap time	41	51

Total average charge to tap time 41 x 0.8 + 51 x 0.2 = 43 minutes

Table 7.5.5 Estimated working ratio

Hindrance ratio	Break-down of equipment	5 %
	Waiting for hot metal	6 %
	Break-down of subsequent process	6 %
	Matching between BOF & CC	6 %
	Others	3 %
Working ratio		74 %

Table 7.5.6 Operating conditions of the B.O.F. plant

		Step 1	Step 2
1) Operating time	a) Anuual operating days	348D	
	b) Monthly operating days	29D	
	c) Periodical shutdown for maintenance	8.5h x 4 times/M	
2) Working ratio		74 %	
3) Steel tapped per heat		129.3T	
4) Steel tapped (tons)	a) Annual tonnage	1,036,000T	2,230,000T
	b) Monthly tonnage	86,300T	185,800T
	c) Daily tonnage	2,980T	6,400T
5) Steel tapped (heats)	a) Annual heat	8,012 heats	17,247 heats
	b) Monthly heat	667 heats	1,437 heats
	c) Daily heat	23 heats	50 heats
6) Daily steel tapped by destination	a) Ingot casting	1,560T (12 heats)	900T (7 heats)
	b) Continuous casting	1,420T (11 heats)	5,500T (43 heats)
7) Charge to tap time	Average	43 mins	
	Single slag (80% of heats)	41 mins	
	Double slag (20% of heats)	51 mins	

7-5-3. Outline of facilities and their specifications

(1) Process flow

In order to achieve sound steel production of 1 million T/Y in the 1st step and 2.15 million T/Y in the 2nd step, at the steelmaking shop two 130 T/heat BOFs are to be installed in the 1st step, of which one is always in operation, and another BOF added in the 2nd step to make the total to 3 BOFs, of which two units are always in operation. Molten steel refined in BOFs is teemed into ingots and continuously cast into blooms and billets. Production process flow of the steelmaking shop is given in Fig. 7.5.1.

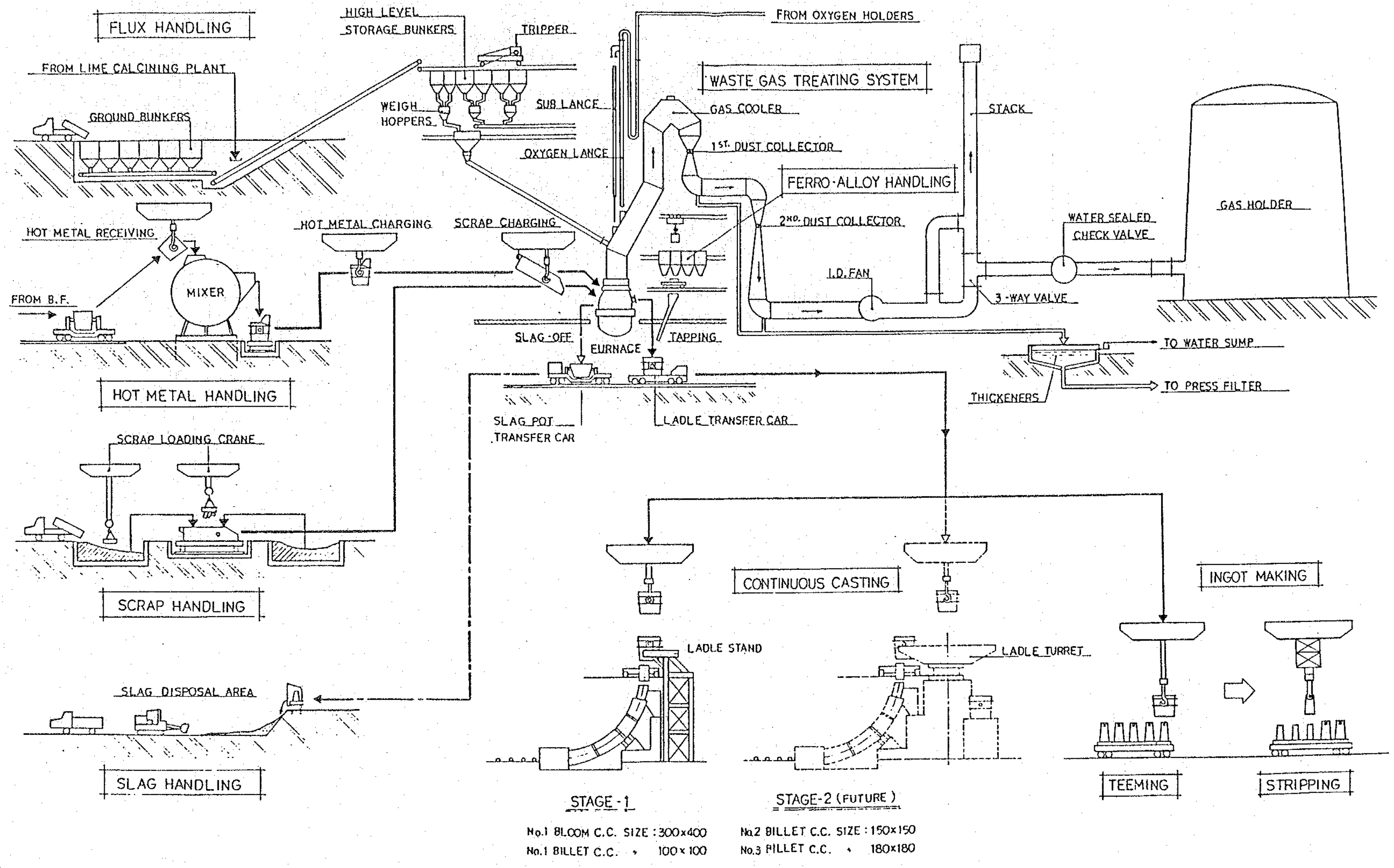


Fig. 7.5.1 Process flow of steelmaking

(2) Layout of facilities

As shown in the overall layout in Chapter 7-1, the steel-making shop is located almost at the centre of the newly installed groups of facilities at BURNPUR Works. The layout is compact and so arranged that metal material flow runs direct and shortest route to new merchant mills from new BFs passing BOFs and ingot/continuous casting all positioned close each other. The layout of Steel-making shop is shown in Fig. 7.5.2.

BOF building is laid out in a straight line. With BOFs in the centre, hot metal and scrap handling facilities are located on the both wings. Two dead mixers sit in series with BOFs and there are two railway tracks in front of the mixers to receive hot metal. For scrap, there are indoor scrap pits and scrap, after loaded on scrap chute on weighing cars, is transported by crane directly to BOFs.

Molten steel and slag from BOFs move at a right angle to the metal material flow. Molten steel is received in ladles on ladle transfer cars and taken to casting bay and delivered to the subsequent process. BOF slag is received in slag pots on slag pot transfer cars under the furnaces and transported to the direction opposite that of molten steel.

On the southwest of BOF building are installed accessory facilities. Namely next to the BOF building, there are BOF waste gas treatment facilities, water treatment facilities, electric room, ventilation and dust collecting facilities, gas holders and others.

Further outside, there is lime calcining plant, burnt lime produced by which is sent by conveyor directly to BOF hoppers.

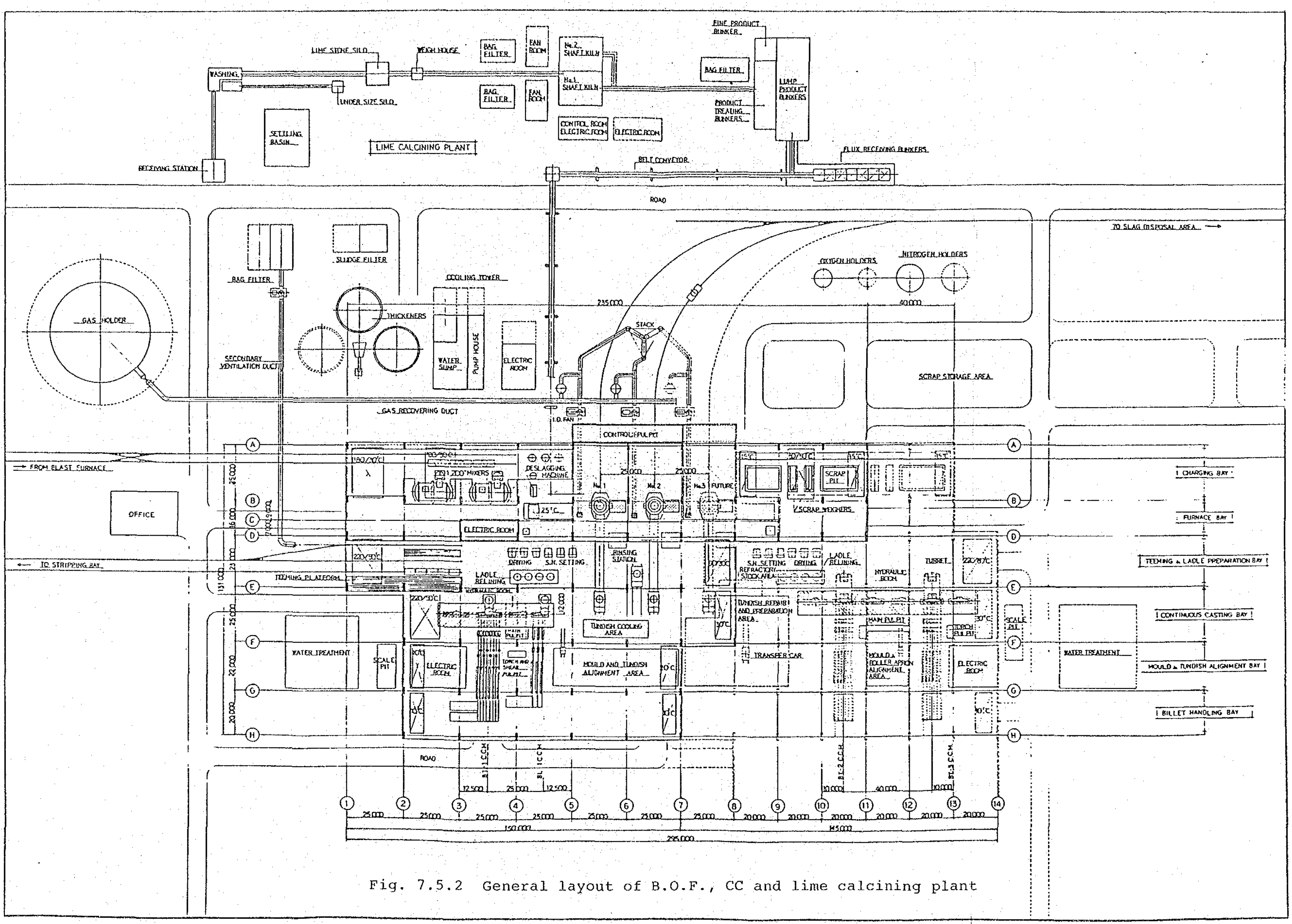


Fig. 7.5.2 General layout of B.O.F., CC and lime calcining plant

In Fig. 7.5.2, the parts indicated by solid line show the facilities which are to be constructed in the 1st step and those indicated by broken line show the facilities to be added in the 2nd step.

(3) Main specifications of facilities

Table 7.5.7 shows specifications of facilities in BOF shop. Function of each facilities and the idea of plan are outlined below.

1) Hot metal handling equipment

Hot metal transfer from BF shop to BOF shop is planned to be done by existing 75-T hot metal ladles and dead mixer is used. Two units of 1200T mixer are installed. Hot metal transferred from BFs is charged into the mixer by ladle crane and discharged into charging ladles according to BOF blowing schedule. Charging ladles are put on weighing machine and the amount of hot metal is continuously measured. Dust occurring at the time is collected by hood and sent to and removed by bag filters.

2) Scrap handling equipment

Scrap is stockpiled near the steelmaking shop and transported by dump trucks or wagons to scrap charging bay and received in two large pits. Scrap is charged into scrap chutes placed on weigher by two 15T lifting magnet cranes. Scrap is charged into BOFs by scrap charging crane.

3) Furnace equipment

BOF has rated capacity 130T/heat and inner volume (lined) 123 m^3 (specific volume 0.95). Its height is 9,000 mm and diameter 6,600 mm, the H/D ratio being 1.36. Tilting device is driven by 4 DC motors and tilting speed can be selected freely between

0.1-1.0 r.p.m. by notch control. Provision is made for installation of bottom blowing equipment to enable top and bottom combination blowing in the future.

For actual installation of the equipment, it is required to decide the type of bottom blowing and equip necessary facilities including instrumentation as well as auxiliary equipments such as gas supply, storage and transportation. Their installation cost is not included in the feasibility study.

With a view of reducing relining time of BOFs and ensuring safety, relining tower will be adopted.

4) Oxygen blowing equipment

As Si and P contents of hot metal are high, it was planned to adopt double slag method for 20% of total heats. Blowing time is 18 minutes for both single slag and double slag, and oxygen flow rate is 28,000 Nm^3/h, for which capacity of oxygen supply piping is 30,000 Nm^3/h max.

Oxygen lance lifting and lowering equipment is of cartridge type with guide post and the lances can be changed quickly.

5) Sublance equipment

End point control of BOF has a big effect on production efficiency, yield, quality and cost. Simultaneous hit rate by static control is 40% at most, but with introduction of sublance and dynamic control, the hit rate can be raised to 70% or more. The method of dynamic control with the sublance in conjunction with computer models measures a steel carbon and temperature 2 minutes before the end of blow and also taking a steel sample by lowering the sublance into the bath during blowing and controls end point.

6) Waste gas treating equipment

In order to implement energy saving and environmental pollution control actively, the OG system (non-combustion type with gas recovery) is adopted. The quantity of waste gas is calculated based on the maximum volume of oxygen blown and gas generated from iron ore charged and is planned to be about 78,000 Nm^3/h. Primary and secondary dust collecters are installed for dust collection and dust contained in waste gas is reduced to 0.1 g/Nm^3 or less. Waste gas not recovered is flared and emitted from a 75 m high tripod stack. By switching three way valve to recovery position, gas recovered is sent to gas holder and used for many purposes as general fuel and boiler fuel.

7) Flux handling equipment

Burnt lime produced by lime calcining plant near BOF shop is supplied from storage bunkers direct onto flux conveyor and other flux materials are transported by trucks to underground bunkers. Flux materials delivered from the underground bunkers are transported by conveyor to high level storage bunkers and stored. There are 9 high level bunkers for 6 brands to each BOF. Their delivery to BOFs is weighed via vibrating feeder and after temporarily stored in charge holding hoppers, charged into BOFs.

8) Ferro-alloy handling equipment

Ferro-alloys are loaded on container boxes at storeroom and transported by trucks to Steelmaking shop. The container is lifted by mono-rail hoist and carries ferro-alloys to storage bunkers. There are 5 bunkers for 5 brands to each BOF. Ferro-alloys are delivered from the bunkers by vibrating feeder and weighed by weigh hopper car and during tapping of steel, added to ladles through adding chute.

(4) Technical explanation

1) Capacity of BOF

Capacity of BOFs required to produce 2.23 million T/Y of molten steel is 130 T/heat BOF x 2. This capacity was calculated from the following basis. Namely, average charge to tap time is 43 minutes and working days are 348 days a year. Working ratio during the working days is assumed to be 74% in consideration of operational matching with 4 continuous casting machines in the subsequent process and also idle time resulting from delay in hot metal supply and failure of equipment. The calculation is as follows:

$$\frac{1}{2} \times \frac{\dfrac{2{,}230{,}000 \text{ T/Y}}{348 \text{ D/Y} \times 1{,}440 \text{ min/D} \times 0.74}}{43 \text{ min}} = 129.3 \text{ T/heat}$$

$$\doteqdot 130 \text{ T/heat}$$

2) Sublance equipment

Sublance equipment consists of sublance proper, sublance guide, guide rotating device, winch, measuring and instrument equipment. Fig. 7.5.3 shows outline of sublance equipment.

Sublance is lowered into the BOF bath during blowing and probe attached to the tip of sublance performs a steel carbon and temperature measurement and takes a steel sample. The probe is removed to recover the sample and a new one is automatically attached. In general, the measurement by sublance is performed 2 minutes before the end of blow and the blowing is controlled based on the measurement to hit the target steel composition and temperature. Fig. 7.5.4 shows basic concept of dynamic control.

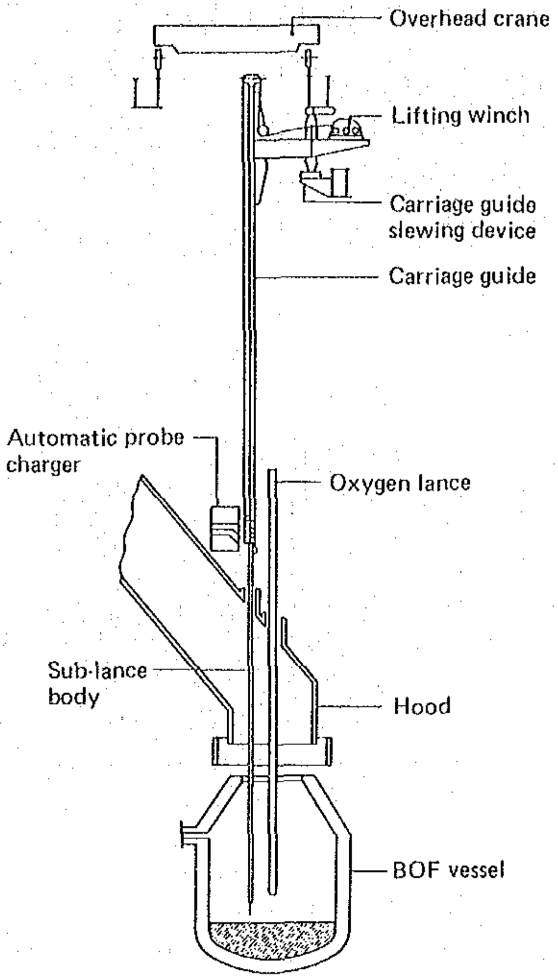


Fig. 7.5.3 Schematic diagram of sub-lance equipment

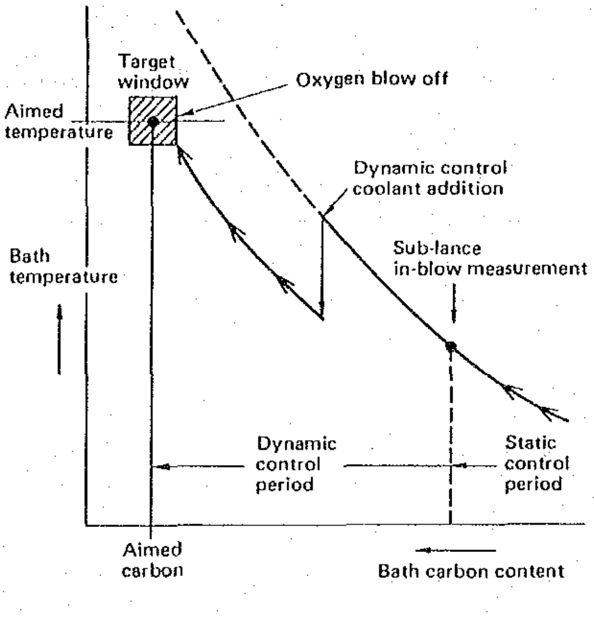


Fig. 7.5.4 Basic concept of BOF dynamic control (Blow-end control)

3) Waste gas treating equipment

For effective utilization of by-product energy, it is planned to install OG system which recovers non combustion waste gas from BOFs. Fig. 7.5.5 shows the flow of waste gas recovery system.

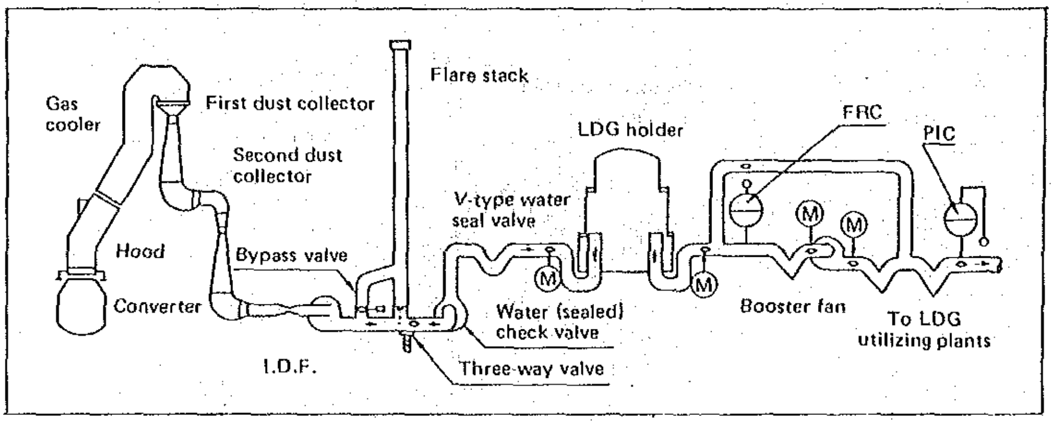


Fig. 7.5.5 LDG recovery system flow

Particulars of recovered waste gas are as follows:

CO	64% or more
SO_2	0.5 ppm or less
H_2S	0.1 ppm or less
Dust density	0.1 g/Nm^3 or less

The quantity of gas recovered varies according to operating condition, gas recovery condition, capacity of gas holder, and others, but in fact recovery in the quantity of 70-100 m^3/T is reported.

Table 7.5.7 Equipment specifications of B.O.F. plant

Division	Item	Specifications	
		Step 1	Step 2
1.	Hot metal handling equipment		
01	Mixer	Inactive mixer: 1,200T x 2	
02	Hot metal weighing machine	Weigh bridge type: 180T x 2	
03	Hot metal charging ladle	130T x 3	130T x 2
04	Deslagging machine	Cylinder type: 1	
05	Slag pot	Steel casting: 20T x 3	20T x 1
06	Hot metal ladle dryer	Top burning type with cover: 1	1
2.	Scrap handling equipment		
01	Scrap charging chute	30T x 3	30T x 1
02	Scrap weighing machine	Weigh bridge type: 80T x 2	80T x 2
03	Coolant & coke charging chute	3T x 2	
3.	Furnace equipment		
01	Furnace proper	Nominal capacity: 130T x 2	130T x 1
		Furnace height: 9,000mm	
		Furnace Diameter: 6,600mm	
		Inner volume: 246m^3	
		Inner volume (after lining): 123m^3	
02	Furnace tilting device	2	1
		Single side 4 motor	
		Shaft-mounted type	
		Tilting speed: 0.1 ~ 1.0 rpm	

(continued)

Division	Item	Specifications	
		Step 1	Step 2
4.	Oxygen blowing equipment		
01	Oxygen holder	Spherical type: 400m^3 x 1	400m^3 x 1
02	Piping & control system	2 systems	1 system
		Piping capacity: 30,000Nm^3/h	
03	Lance	8 for 2 furnaces	4 for one furnace
		Oxygen blowing capacity: 28,000Nm^3/h	
		Lance diameter: 250mm	
		Lance length: 21,000mm	
04	Flexible hose	4 for oxygen (Rubber)	2 for oxygen
		8 for cooling water (Rubber)	4 for cooling water
05	Lance lifting device	Side shift quick change type: 4	2
06	Lance cooling water piping	2 systems	1 system
		Water volume: 200m^3/h/furnace	
5.	Sub lance equipment	2	1
		Fixed type with automatic probe charger	
6.	Waste gas treating equipment		
01	Waste gas treating system	2	1
		Non combustion type with gas recovering system (OG)	
		Waste gas volume: 78,000Nm^3/h	
		Dust density: 0.1g/Nm^3	

(continued)

Division	Item	Specifications	
		Step 1	Step 2
	I.D. Fan capacity: $78,000Nm^3/h$ x 1750mmHg x 1300kw		
	Tri-pod type stack, height 75m		
02	Gas holder	Dry type: $20,000m^3$ x 1	
03	Nitrogen holder	Spherical type: $600m^3$ x 1	$600m^3$ x 1
04	Water treating system	2	1
		Closed & circulating system	
05	Sludge handling equipment	2	1
		Sludge thickener & filter	
06	Secondary ventilation system	2	1
		Bag filter capacity: $10,000m^3/min$	
		Around furnace & mixer	
7.	Flux handling equipment		
01	Under ground bunkers	1	
		7 bunkers for 5 brands	
02	Transport equipment	1	Expansion of belt conveyer
		Belt conveyer transport method	
03	High level storage bunkers	2	1
		9 bunkers for 6 brands	
04	Weighing & charging equipment	2 sets	1
8.	Ferro-alloy handling equipment		
01	Ferro-alloy transport equipment	Mono rail hoist: 5T x 1	
		Container box: 10	5

(continued)

Division	Item	Specification	
		Step 1	Step 2
02	Ferro-alloy storage bunkers	2	1
		5 bunkers for 5 brands	
03	Weighing & charging equipment	2 sets	1
9.	Furnace brick lining equipment		
01	Relining tower	1	
		Tower, woking deck, hoist & roller table	
02	Lining breaker	Unishovel type: 1	
03	Worn brick receiving ladle	2	
04	Gunning machine	1	
10.	Auxiliary equipment		
01	Elevater	Goods elevater: 1	
		Passenger elevater: 1	
02	Shovel bulldozer	Capacity: 2T x 2	2T x 2
03	Forklift truck	Capacity: 2T x 2	2T x 2
04	Air conditioner	1 set	1
05	Temperature measuring equipment	5	
		1 for hot metal	
		2 for furnace front	1
		2 for furnace back	1
06	Communication system	3 systems	Extended
		1) I.T.V. Camera: 4, Monitor: 8	Camera: 2, Monitor: 4
		2) Interphone station: 8	4
		3) Paging system: 20 stations	10

(continued)

Division	Item	Specification	
		Step 1	Step 2
07	Miscellaneous piping	1 set	Extended
		1) O_2 piping	
		2) N_2 piping	
		3) COG piping	
		4) Air piping	
		5) Miscellaneous water piping	
08	Air chuter	3 stations	1 station
11.	Molten steel handling equipment		
01	Ladle transfer car	200T x 2	200T x 1
		Electrically self travelling	
12.	Slag handling equipment		
01	Slag pot	Steel cast pot: 35T x 8	35T x 4
02	Slag pot transfer car	35T x 8	35T x 4
03	Shovel bulldozer	2T x 2	2T x 2
04	Shovel car	2T x 2	2T x 2
13.	Crane equipment		
01	Hot metal charging crane	180T/30T x 2	
02	Scrap charging crane	60T/50T x 1	
03	Scrap loading crane	15T x 2	15T x 1
04	Furnace bay service crane	25T x 1	
05	Crane repair hoist	7T x 2, 5T x 1	7T x 1
06	Crawler crane	25T x 2	25T x 1

(continued)

Division		Item	Specification	
			Step 1	Step 2
14.		Auxiliary electrical equipment		
	01	Power supply system & materials for electrical work	1	1
	02	Plant lighting & work materials	1	1
	03	Trolly line & materials for power supply work	1	1
	04	Others	1	1
15.		Instrumentation		
	01	Control system for oxygen blowing	1	1
	02	Control system for waste gas treating equipment	1	1
	03	Control system for temperature measuring equipment	1	1
	04	Others	1	1
16.		Computer		
	01	BOF process computer system	1 system	Additional
17.		Water works		
	01	Pure water supply system	Capacity: $10m^3/h \times 1$	1
18.		Civil works		
	01	Foundation of building	1	1
	02	Foundation of equipment	1	1

(continued)

Division	Item	Specification	
		Step 1	Step 2
19.	Buildings		
01	Main building	1	1
02	Auxiliary buildings & structures	1	1

7-5-4. Operation

(1) Material flow

Material flow in the final 2.15 million-tonne/year step is shown in Fig. 7.5.6. High Si, high P hot metal being used, steel yield by BOFs is 89% and rather low from the world standard, but integrated yield from hot metal to sound steel increases remarkably from 76% of the present steelmaking shop to 86%.

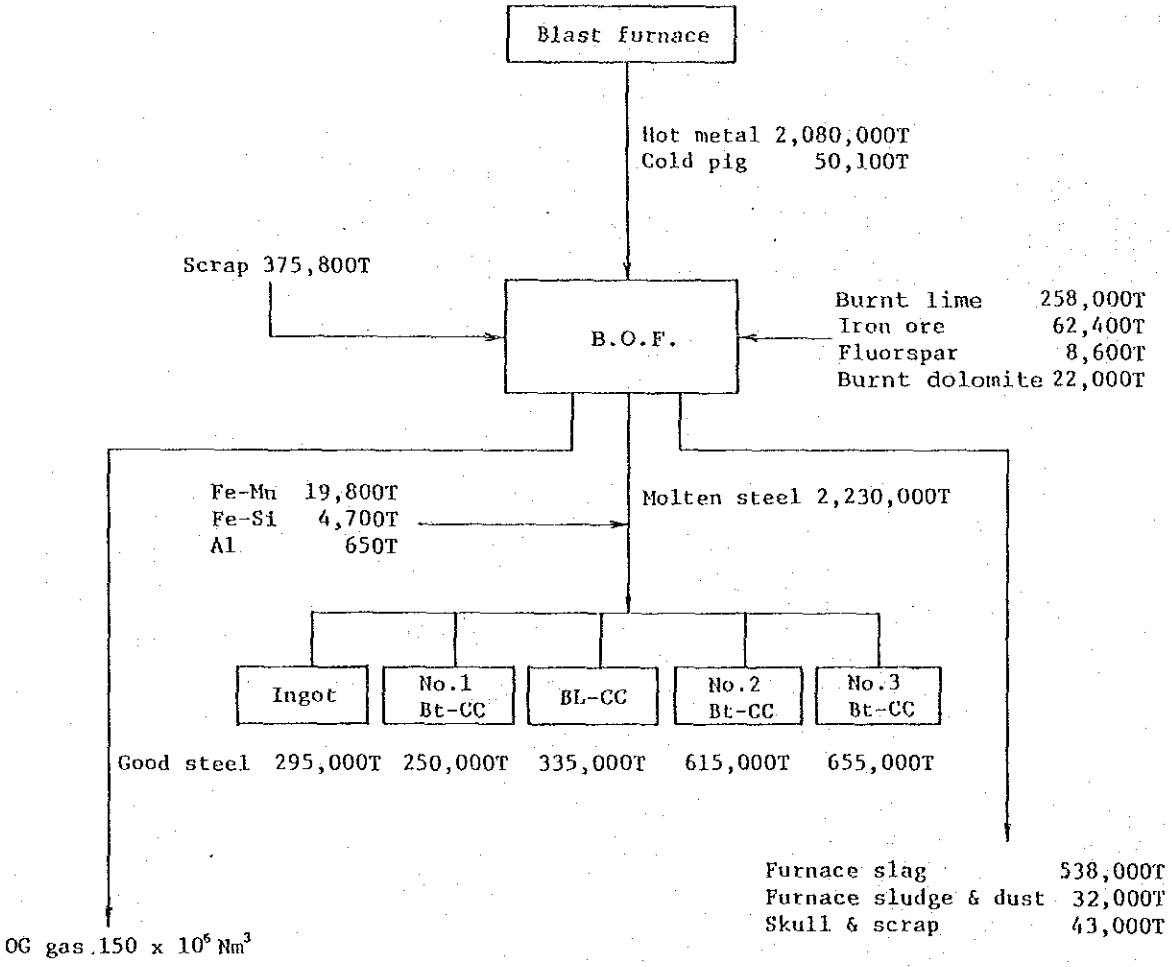


Fig. 7.5.6 Material flow of B.O.F. shop at step 2

(2) Operation of BOFs

Operation level of BOFs is set fairly high, with charge to tap time of ordinary heat being 41 minutes. In order to improve successful hit rate at the end of blow, sublance system is employed, but in view of high Si and high p contents of hot metal, much efforts need to be made to improve the hit rate.

Steelmaking time in terms of average tap-to-tap as used in India is 55 minutes in ordinary heat, but it should be noted that the figures is a result of calculation in consideration of distrubing factors for delivery of heats in appropriate timing to 4 units of continuous casting machines in the 2.15 million-tonne step.

In actual operation, however, steelmaking shop personnel must be able to tap BOFs in 41 minutes of charge-to-tap time, if necessary, for ensuring required production by coping with troubles in continuous casting and others. Different from ingot casting process, high level of operation control and technique is essential to match timing of tapping BOFs with timing of casting of 4 units of continuous casting machines.

Continuous casting ratio is set 86%, but if it fails to obtain ability to produce steel in 41 minutes of charge-to-tap time through familiarization with operation of continuous casting in the 1st step, the number of heats which go to ingot casting process increases, which not only disturbs steelmaking operation markedly but results in increased production cost.

Table 7.5.8 shows production and unit consumption of BOF steelmaking shop.

Table 7.5.8 Production and consumption of B.O.F. plant (per ton of good steel)

Item			Unit consumption or Production		Annual consumption and production		Remarks
					Step 1	Step 2	
Product		Good steel			1,000,000 T	2,150,000 T	
		Molten steel			1,036,300 T	2,230,000 T	
Raw materials	1	Hot metal	966.4	967.4 kg/T	966,400 T	2,080,000 T	83 %
	2	Cold pig iron	23.3	23.3 kg/T	23,300 T	50,100 T	2 %
	3	Scrap	174.7	174.8 kg/T	174,700 T	375,800 T	15 %
	4	Burnt lime	120 kg/T		120,000 T	258,000 T	
	5	Iron ore	32	29 kg/T	32,000 T	62,400 T	
	6	Fluorspar	4 kg/T		4,000 T	8,600 T	
	7	Burnt dolomite	10 kg/T		10,000 T	22,000 T	
	8	Ferro manganese	8.8	9.2 kg/T	8,800 T	19,800 T	
	9	Ferro silicon	1.5	2.2 kg/T	1,500 T	4,700 T	
	10	Aluminum	0.17	0.30kg/T	170 T	650 T	
	11	Coke (breeze & lump)	0.7 kg/T		700 T	1,500 T	
By products	12	Furnace slag	250 kg/T		250,000 T	538,000 T	
	13	Furnace sludge & dust	15 kg/T		15,000 T	32,000 T	
	14	Ladle slag	20 kg/T		20,000 T	43,000 T	
	15	Skull & scrap	20 kg/T		20,000 T	43,000 T	
	16	OG gas	70 Nm^3 /T		70 x 10^6 Nm^3	150 x 10^6 Nm^3	2,300 kcal/Nm^3
Utilities	17	Oxygen	66 Nm^3 /T		66 x 10^6 Nm^3	142 x 10^6 Nm^3	Blowing 64 Nm^3 /T
	18	Nitrogen	9 Nm^3 /T		9 x 10^6 Nm^3	19 x 10^6 Nm^3	

(continued)

Item			Unit consumption or Production	Annual consumption and production		Remarks
				Step 1	Step 2	
	19	COG	5 Nm^3/T	5 x 10^6 Nm^3	11 x 10^6 Nm^3	
	20	Electric power	30 Kwh/T	30 x 10^6 Kwh	65 x 10^6 Kwh	
	21	Industrial water	0.3 m^3/T	300,000 m^3	645,000 m^3	
	22	Soft water	0.06 m^3/T	60,000 m^3	129,000 m^3	
	23	Compressed air	5 Nm^3/T	5 x 10^6 Kwh	11 x 10^6 Nm^3	
Refractories	24	Mixer brick	0.52 kg/T	520 T	1,100 T	
	25	Furnace brick	12.3 kg/T	12,300 T	26,400 T	Gunning 2 kg/T
	26	Charging ladle brick	0.45 kg/T	450 T	970 T	
	27	Brick waste	3 kg/T	3,000 T	6,500 T	

7-5-5. Lime calcining plant

(1) Facilities

Assuming burnt lime used in BOFs to be 120 kg per ton of sound steel, the lime calcining plant is to produce 258,000 tonnes of burnt lime required for production of 2.15 million tonnes of crude steel a year.

Based on MECON's information that there is a generally accepted conclusion in India that because of characteristics of Indian domestic limestone, shaft type kilns are superior to rotary kilns, it was planned to install one unit of large Becken Bach furnace with nominal capacity of 400 T/D in the 1st step and another in the 2nd step for 2-unit operation.

Raw limestone is to be washed at mines, and after received at the plant, washed simply and charged into shaft kilns. Burnt lime calcined in the furnace is crushed and sized. Those in sizes of 3-40 mm are temporarily stocked in product bunkers and as rquired, fed direct on flux conveyor to BOFs. Fine burnt lime under 3 mm is formed into briquettes and used in BOFs. Fine burnt lime which occurs during calcining in shaft kilns is recovered and used as material for sintering. Table 7.5.9 shows specifications of the lime calcining plant. As shown in Fig. 7.5.2, the plant is laid out adjacent to the new steelmaking shop.

(2) Operation

Raw limestone is received in size of 40-80 mm, and lump burnt lime used in BOFs is in size of 3-40 mm. Fig.7.5.7 shows material balance from raw limestone to product. Coke oven gas is used as fuel for calcining of limestone and it is desirable to remove sulphur from coke oven gas used. If sulphur is not removed, S content in fine burnt lime occurring in kilns is high, but the fines can be home consumed as it is as part of sintering materials.

Table 7.5.10 shows production and unit consumption of lime calcining plant.

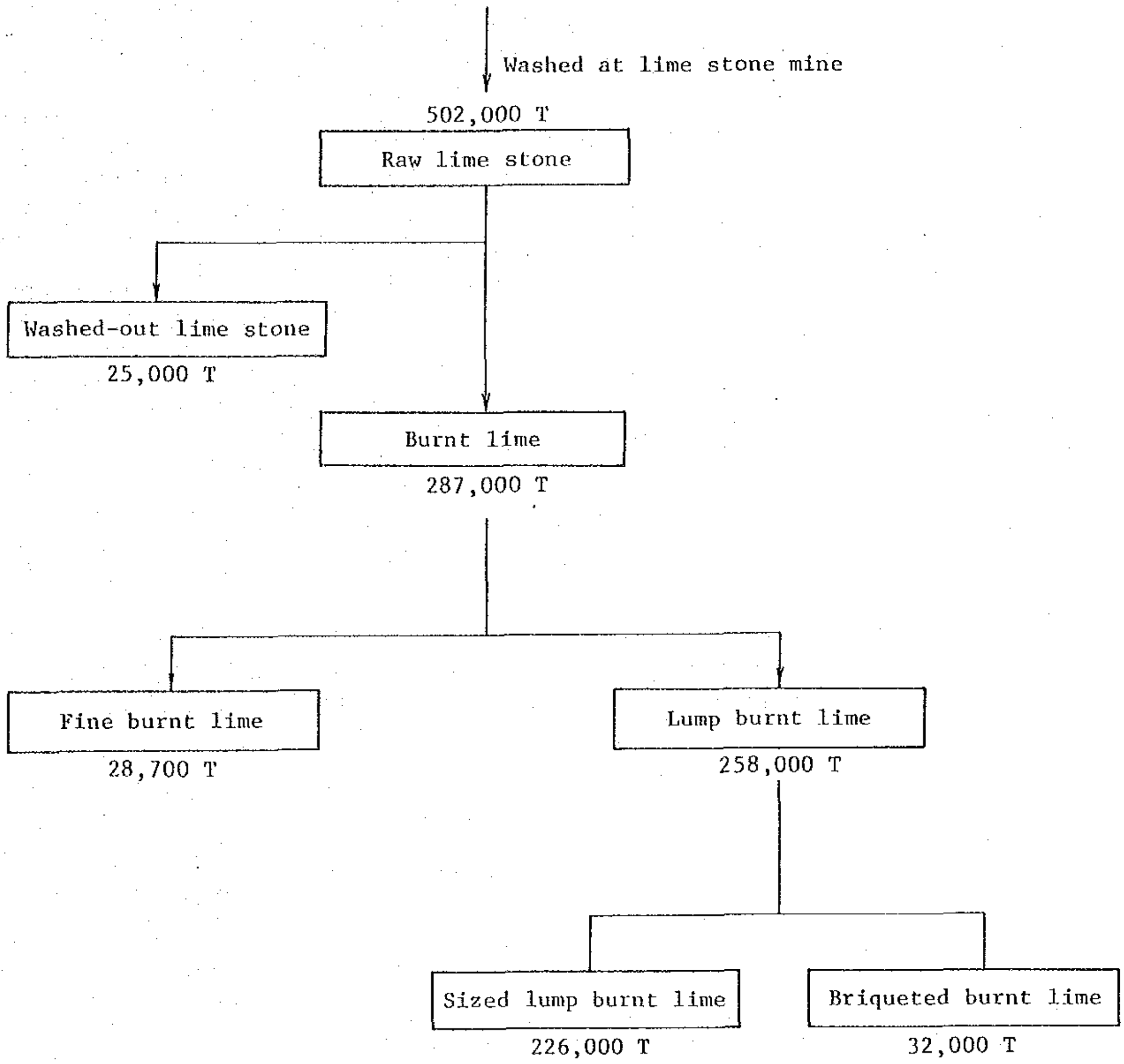


Fig. 7.5.7 Material balance (Lime)

Table 7.5.9 Equipment specification of lime calcining plant

Division	Item	Specifications	
		Step 1	Step 2
1.	Receiving equipment of raw limestone		
01	Belt conveyer	200T/h x 1 approx.	
02	Limestone storage silo	1,000m³ x 1	
03	Fine limestone bin	100m³ x 1	
04	Vibrating screen	180T/h x 1 Wet type	
05	Washing equipment	1	
2.	Charging equipment		
01	Limestone silo	1,000m³ x 1	
02	Belt conveyer	150T/h x 1	
03	Weigher	1	
04	Inclined belt conveyer	150T/h x 1	
05	Material charging equipment	1	1
3.	Kiln equipment		
01	Kiln proper	400T/D x 1 Becken Bach kiln	400T/D x 1
		Kiln profile: Diameter 7.5m approx.	
		Height 55m approx.	
02	Driving air blower	145m³/min x 1, 4,000mm Ag. approx.	145m³/min x 1
03	Inner cylinder cooling fan	170m³/min x 2, 800mm Ag. approx.	170m³/min x 1
4.	Waste gas treating equipment		
01	Blower	1,300m³/min, -1,500mm Ag.	1,300m³/min x 1
02	Dust catcher	1,300m³/min	1,300m³/min x 1

(continued)

Division	Item	Specifications	
		Step 1	Step 2
5.	Transport and storage equipment		
01	Belt conveyer	60T/h x 1	
		30T/h x 1	
02	Screen	60T/h x 1	
		30T/h x 1	
		10T/h x 1	
03	Single roll crusher	30T/h x 1	
04	Briquet press machine	5T/h x 1	
05	Lump product bunker	2,000T approx.	
06	Fine product bunker*	100T approx.	
07	Briquet surge tank	80T approx.	
6.	Auxiliary equipment		
01	Air compressor and piping	1	
02	Miscellaneous piping	1	
7.	Electrical equipment		
01	Power supply system	1	1
02	Lighting	1	1
03	Communication system	1	1
8.	Instrumentation	1	1
9.	Civil works	1	1

(continued)

Division	Item	Specifications	
		Step 1	Step 2
10.	Buildings		
01	Main control room	1	
02	Product bunkers	1	
03	Product treating house	1	
04	Electrical room	2	1
05	Fan room	1	1
06	Weigher house	1	
11.	Water works		
01	Drainage and water supply piping	1	

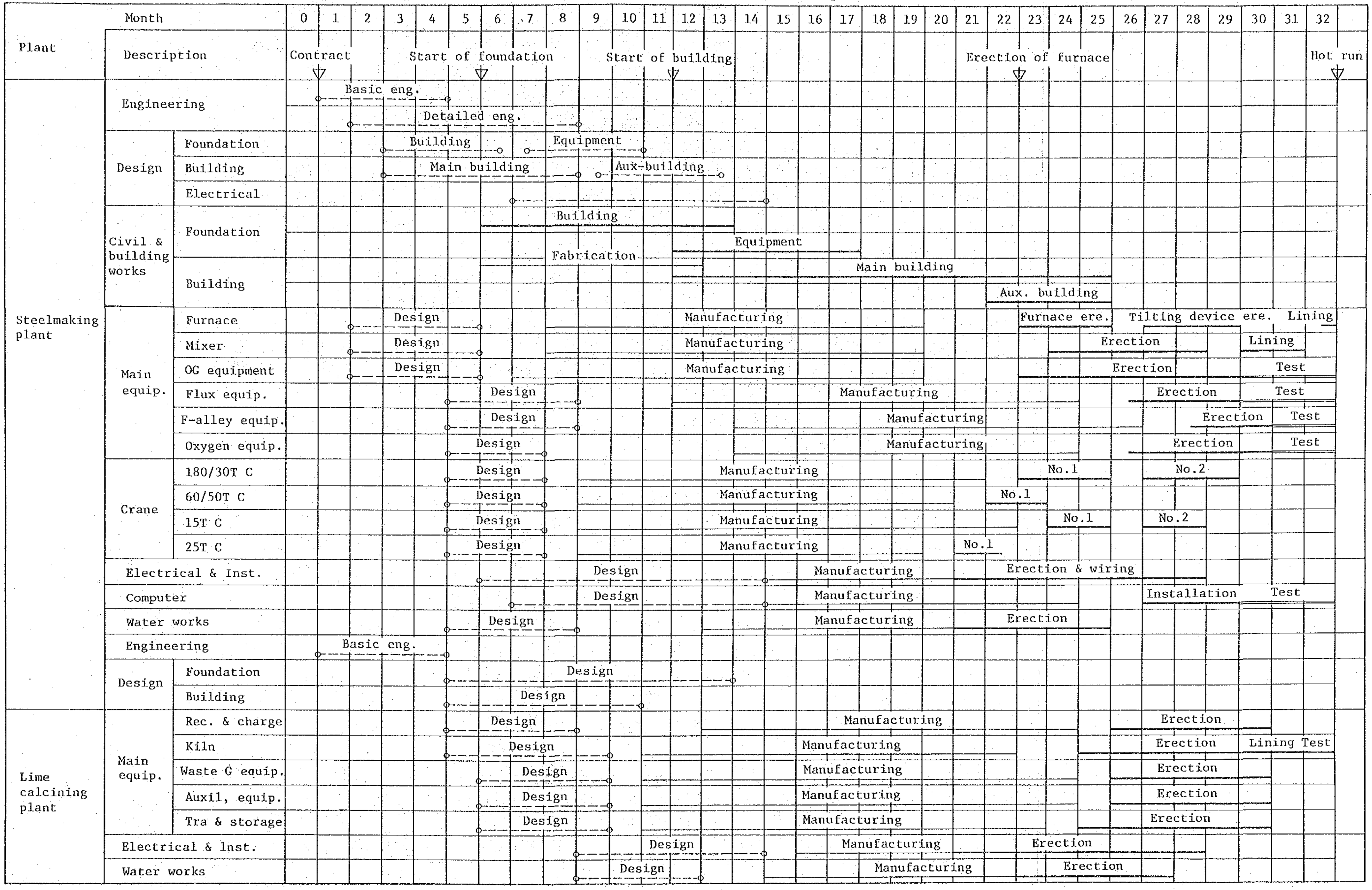
Table 7.5.10 Production and consumption of lime calcining plant (per ton of burnt lime)

Item			Unit consumption or Production	Annual consumption and production		Remarks
				Step 1	Step 2	
Product		Burnt lime		133,000 T	287,000 T	
		Sized burnt lime		120,000 T	258,000 T	3 ~ 40 mm
Raw material	1	Raw lime stone	1,750 kg/T	233,000 T	502,000 T	40 ~ 80 mm
By-product	2	Wash-out lime stone	87 kg/T	11,600 T	25,000 T	
	3	Fine burnt lime	100 kg/T	13,300 T	28,700 T	
Utilities	4	COG	226 Nm^3/T	30 x 10^6 Nm^3	65 x 10^6 Nm^3	
	5	Electric power	65 Kwh/T	8.6 x 10^6 Kwh	18.7x 10^6 Kwh	
	6	Industrial water	0.8 m^3/T	106,000 m^3	230,000 m^3	
	7	Nitrogen	0.02 Nm^3/T	2,700Nm^3	5,700Nm^3	
	8	Compressed air	0.5 Nm^3/T	200,000Nm^3	430,000Nm^3	
Refractories	9	Brick	0.3 kg/T	40 T	86 T	
	10	Brick waste	0.1 kg/T	13 T	29 T	

7-5-6. Construction schedule

As mentioned in the schedule to implement the project, the 1st step, one million-tonne production scale, is to be established in 1993, but it is desirable to replace existing steelmaking shop with new one as early as possible. Therefore as soon as land preparation and other conditions are all set, the construction of the new shop will be undertaken to have it in operating condition before the Works throughout obtains the 1 million-tonne scale and existing bessemer converter-open hearth furnace (duplex process) steelmaking shop is to be closed. Table 7.5.11 shows construction schedule of BOF steelmaking shop and lime calcining plant for reference. It is scheduled that hot run begins in 32 months of signing construction agreement. The first half of this schedule, namely period for engineering and designing and period for supply of equipment, may vary depending on conditions of actual agreement, and the table shows one standard example of schedule.

Table 7.5.11 Construction schedule of steelmaking plant & lime calcining plant (for reference only)



7-6. Continuous casting and ingot casting

7-6-1. Outline

The modernization of the Works is to be carried out in two steps, and the Works will have crude steel production scale of one million tonnes a year in the 1st step and 2.15 million tonnes in the 2nd step.

Consequently one each of continuous bloom caster and billet caster will be installed in the 1st step, where production of cast bloom and billet totals 485,000 tonnes/year and continuous casting (CC) ratio is 48.5%.

In the 2nd step two more billet casters are installed and the total production of cast bloom and billet will be 1,855,000 tonnes a year and CC ratio rises to 86.2%.

Incidentally, the facilities installed in the 1st step and those in the 2nd step are completely independent each other and the expansion project in the 2nd step does not hinder operation of the facilities already installed in the 1st step.

7-6-2. Premiss of study

(1) Production

Production of crude steel by casting process in the 1st and 2nd steps is shown in Table 7.6.1. Production by Bloom -1 caster and Billet -1 caster in the 2nd step is higher than that in the 1st step and this is because the production is expected to increase as operation skill is improved.

Table 7.6.1 Production of crude steel

Unit : T/Y

Process		Step 1	Step 2
Caster	Bloom-1	285,000	335,000
	Billet-1	200,000	250,000
	Billet-2	---	615,000
	Billet-3	---	655,000
	CC Total	485,000	1,855,000
	(CC ratio)	(48.5%)	(86.2%)
Ingot casting		515,000	295,000
Total		1,000,000	2,150,000

(2) Description of cast bloom and billet

Table 7.6.2 shows measurements and unit weight of cast bloom and billet.

Table 7.6.2 Measurements and unit weight

Caster	Nominal cross sectional dimensions (mm)	Length (mm)	Unit weight (T/m)	Weight of a bloom or billet (T)
Bloom-1	300 x 400	5,000 max.	0.936	4.68 max.
Billet-1	100 SQ	4,000 max.	0.078	0.312 max.
Billet-2	150 SQ	12,000 max.	0.176	2.112 max.
Billet-3	180 SQ	12,000 max.	0.253	3.036 max.

(3) Operation condition

Table 7.6.3 shows operation condition of the continuous casters.

Table 7.6.3 Operating conditions

Item		Days
Operating days	Annual operating days	348
	Monthly operating days	29
	Scheduled maintenance days/month	1.4
Average liquid steel in ladle		129.3 T/heat
Average tap to tap time		50 min.

Process		No. of heats to be cast (heats/D)	
		Step 1	Step 2
Caster	Bloom-1	6.6	7.7
	Billet-1	4.6	5.8
	Billet-2	--	14.1
	Billet-3	--	15.1
Ingot casting		11.8	6.8
Total		23.0	49.5

(4) Productivity

Casting time ratio of bloom and billet is as shown in Table 7.6.4. The figures are normal and do not pose any problems.

Table 7.6.4 Casting time ratio of each caster

(2.15 million stage)

Caster	Production (T/Y)	Heats/Y	Heats/M	Casting time (hrs)	*Casting time ratio (%)
Bloom-1	335,000	2699	225	262	36
Billet-1	250,000	2015	168	204	28
Billet-2	615,000	4928	411	425	58
Billet-3	655,000	5248	437	386	53

$$\text{*Casting time ratio} = \frac{\text{Casting time}}{\text{Calendar time}} \times 100\ (\%)$$

(5) Casting yield

Table 7.6.5 shows the casting yield by process.

Table 7.6.5 Casting yield

Process		Casting yield (%)	Loss (%)			
			Scale	Skull	Crop	Butt
Caster	Bloom-1	96 (Good blooms/Liquid steel)	0.8	1.5	1.7	--
	Billet-1	96 (Good billets/Liquid steel)	0.8	1.5	1.7	--
	Billet-2	96.5 (Ditto)	0.8	1.5	1.2	--
	Billet-3	96.5 (Ditto)	0.8	1.5	1.2	--
Intgot casting		97.0 (Good ingots/Liquid steel)	--	1.0	--	2.0

(6) Operational data

Unit consumption of casters is shown in Table 7.6.6.

Table 7.6.6 Unit consumption for casters

Item		Step 1		Step 2	
		Bloom-1	Billet-1	Billet-2	Billet-3
1. Refractories					
- Ladle					
Ladle brick (High grade fire clay)	kg/T	5.8	5.8	5.8	5.8
Sliding nozzle (High alumina)	kg/T	0.3	0.6 (Double Nozzle)	0.2	0.2
- Tundish					
High grade fire clay brick	kg/T	4.0	6.0	5.0	5.0
Castable (High alumina)	kg/T	2.5	4.5	3.1	3.1
Nozzle (Zircon)	kg/T	0.12	0.09	0.05	0.05
2. Utilities					
Electric power	Kwh/T	10.0	10.0	10.0	10.0
Compressed air	Nm^3/T	7.0	7.0	8.0	8.0
Water	m^3/T	0.4	0.4	0.4	0.4
C.O.G.	Nm^3/T	4.5	4.5	4.0	4.0
Oxygon gas	Nm^3/T	1.6	0.1	1.0	1.0
L.P.G.	Nm^3/T	0.5	----	0.3	0.3
Nitrogen gas	Nm^3/T	0.4	0.4	0.4	0.4