(4) Plant layout

Plant layout is decided with considerations for effective flow of raw materials and products and also which are expected to be feasible in the future. Its three main paticular futures are summerlized in the followings.

1) Coal transport conveyor belt was planned so as to shorten the coal transportation distance. As the result of this, the coal transport conveyor to the charging coal bin can be taken from the coke side.

2) In order to reduce the investiment in facilities as much as possible, new technics are not included into this plan in both stage I and II. However, a provision of space has been considered for future establishment of coke dry quenching equipment or coal briquetting equipment to the coke plants and desulphurization equipment to the by-product plant.

3) Coke transport conveyor to the blast furnace has been planned and laid out so that the facility cost of the stage I is minimized and the transport distance is shortest. The layout diagram is shown in *Fig. 13-5-3.*

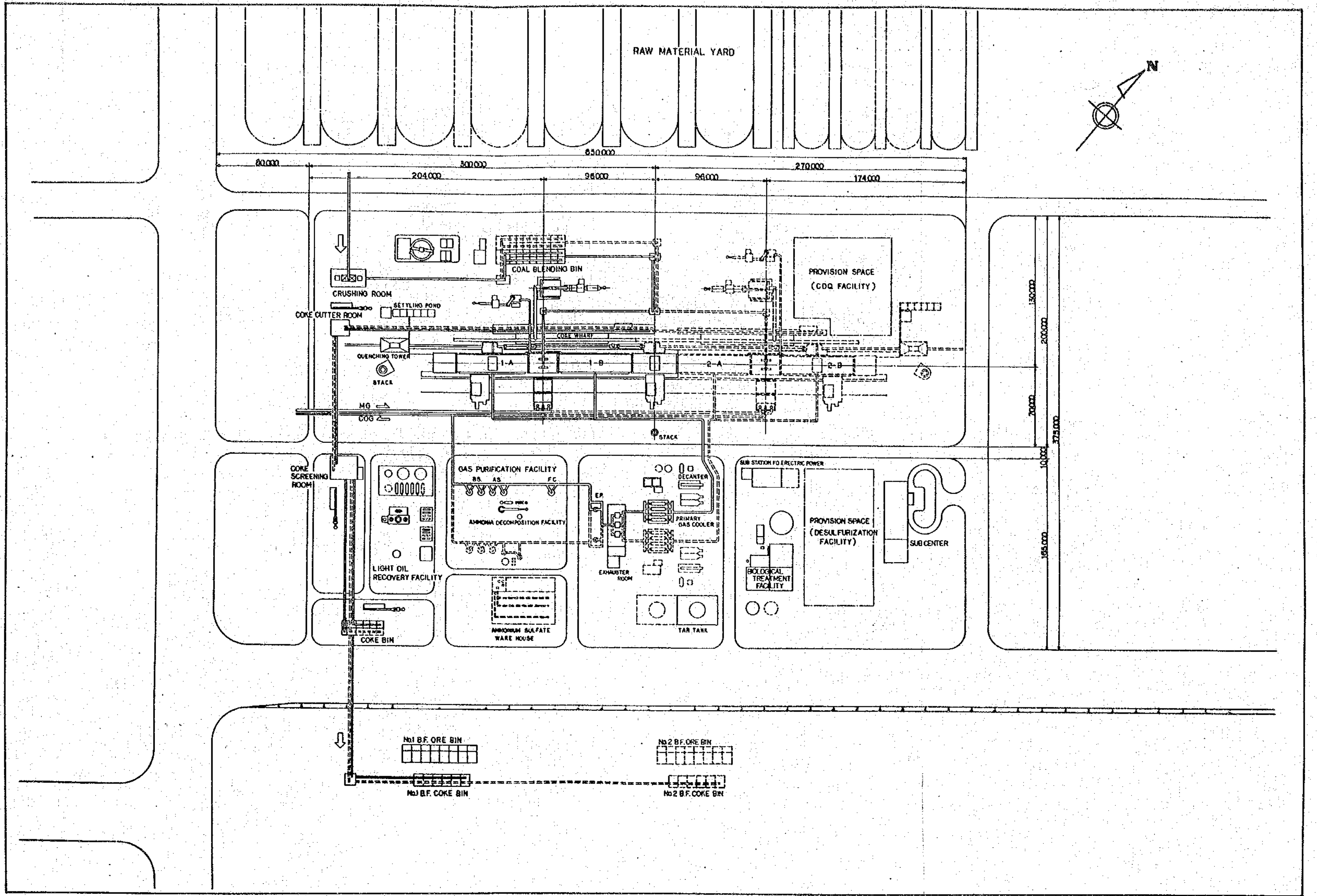


Fig. 13-5-3 Coke ovens and by-product layout

(5) Relation to stage II facility

1) Coal receiving conveyor shall be planned so that it is possible to transport coal in stage II from the coal yard to coal blending bin.

2) No. 2 coke oven (stage II) is laid out in alignment of No. 1 coke oven so that mutual use of prepared devices such as coal charging cars and pusher machine can be made, and also the stack of B Battery, No. 1 coke ovens, is mutually used with A Battery, No. 2 coke ovens.

3) Water treating equipment for dust collector of charging car is planned so as to be capable of treating discharged water in the second stage.

4) Coke wharf which receives coke stored in the yard when the operation of the coke oven is stopped for a long period of time is built at stage I. This wharf is a temporarily built facility and will be taken out in stage II. A permanent facility to serve as a receiving wharf will be built in stage II.

5) Coke transport conveyor is in one line for each stage. However, breeze coke transport conveyor shall be built in one line in stage I so as to have capability for stage II.

6) Gas exhauster room and electrical room for by-product facilities will be designed to accommodate the equipment of the stage II.

7) Light oil collecting facilities, except heat exchanger and part of light oil tank, shall be planned so as to have capabilities for stage II.

8) Waste water discharged from the by-product facilities is treated by the biological treatment facility. All facilities except the waste water storage tank shall be planned so as to have capability for stage II.

(6) Operation conditions

Utility unit, consumption, quantity of products and by-products under normal operation levels of coke ovens and by-product facility are shown in *Table 13-5-7*.

Table 13-5-7 Utility requirements

Utility	Utility		Quantity of products and by-products/Y
	Unit/t. coke	Consumption/Y	
Coke oven gas	19.0 Nm^3	13.0×10^6 Nm^3	379.4×10^6 Nm^3
Mixed gas	851.6 Nm^3	747.2×10^6 Nm^3	
Electric power	47.9 KWH	42.0×10^6 KWH	
Steam	93.4 kg	81,900 t	39,400 t
Fresh water	1.02 m^3	894.3×10^3 m^3	
Sea water	19.3 m^3	16.9×10^6 m^3	
Potable water	0.07 m^3	58.4×10^3 m^3	
Washing oil	1.20 kg	1.1×10^3	
Phosphor	0.02 kg	18 t	
Lime	0.06 kg	55 t	
Lump coke	—	—	746,000 t
Breeze coke	—	—	131,000 t
Tar	—	—	41,500 t
Light oil	—	—	10,700 t

13-5-4 Technical explanation

(1) Equipment operation outline at the coke ovens and by-product plant

From the raw material handling facility, coal is transported to the coke plant separately by the brand of coal. Coal is crushed according to the brand of coal, and blended and controlled by the bin blending method to get the required coke quality. Since coal characteristics fluctuate even in the case of the same coal brand, it is necessary to have an accurate and quick understanding of the coal characteristics to perform proper blending at all times.

The coke oven is a complicated brick structure with silica bricks in the main, and is normally heated to 1280°—1300°C. In regard to oven temperature, control of the average oven temperature is as important as maintaining the end flue temperature and temperature deviation between flue at prescribed levels.

These are critically related to the coke oven operation efficiency. Note that bricks are subject to the maximum permissible temperature. Any abnormally high temperature causes damage to coke oven, so flue temperature control should be made with at most care.

Coke whose carbonization is completed, is quenched at the quenching tower, and it undergoes sizing and screening at the coke handling equipment to be carried to the blast furnace coke bin.

In this process, good coke screen control is a determining factor of the coke yield fluctuation and blast furnace operation results. It is a very critical control element.

Coke oven gas, tar and other by-products generated during carbonization are brought to the by-product plant, where they are treated for COG cooling and recovery and elimination of various components. And COG becomes a purified gas that can be used for fuel at the steel works in this plan, and for removal of ammonia in COG is employed the ammonia decomposition facility, whose advantages include inexpensive equipment cost, and ease of operation and of equipment control.

(2) Basis for determining of major facilities specifications

1) Coke oven

Specifications of oven dimensions and number of ovens are decided by general considerations for loads of coke oven operation, economy of workers and construction costs. Hereby in case that an oven height of the coke oven is a parameter, specifications of the coke oven and comparision of advantages and disadvantages are shown in the *Table 13-5-8*.

Table 13-5-8 Coke oven specifications and comparison of advantages and disadvantages

Subject \ Oven Ht.	5 m oven	6 m oven	6.5 m oven
Necessary coke quantity (Q)	2,405 t/d (877,000 t/d)		
Coal charge density (ρ)	0.7 t/m³		
Total coke yield (Y)	0.74		
Oven average operation rate (R)	145%		
Effective inner volume of chamber (V)	29.6 m³/chamber	36.0 m³/chamber	39.1 m³/chamber
Ovens to be installed (N)	110	* 90	82
Average number of pushing	158chambers/d	129 chambers/d	118 chambers/d
Operation load	Too small	Suitable	Small load
Workers economy	Bad	Good	Good
Construction costs	Large	Small	Medium
General judgment	×	○	△

As seen in the above table, specifications of the coke oven with the scale of production are most advantageous by using 6^m high ovens numbering 90, it was decided.

* Chamber number calculation

$$N = \frac{Q}{V.\rho.Y.R} = \frac{2405}{36.0\times0.7\times0.74\times1.45} \fallingdotseq 90 \quad \text{(oven)}$$

2) Chemical by-product plant

The peak rate is considered to determine the capacity of the by-product equipment, and reasons for determining that equipment capacity are as follows.

Coke oven coal charging quantity: $3{,}250^{t/d}$ $(1{,}186{,}000^{t/y})$

Gas generation unit: $320^{Nm^3/coal\ t}$

Generated gas peak rate: 1,2

Coke oven operation rate: 145%

$$\text{By-product plant capacity} = \frac{3{,}250 \times 320}{24} \times 1.2 \fallingdotseq 52{,}000^{Nm^3/hr}$$

3) Biological treatment facilities

The biological treatment facilities have the capability for stage II. The basis of the determination of the facilities capability are as follows.

Coke oven charging quantity: $6{,}515^{t/d}$ (including stage II)

Ammonia liquor yield: 13% (against coal)

Generated chemical by-product ammonia liquor: 30% of ammonia generated quantity

Capacity of biological treatement equipment: $(6515 \times 0.13) \times 1.3 = 1100^{m^3/d}$

Ammonia dilation rate is another condition for determination of this facility and is decided to be 4.

(3) Wast gas treatment of ammonia decomposition facility

Wast gas of the ammonia decomposition facility is led into the stack and dispersed into air, which is mutually used with No. 1B, 2A oven battery and nearest to the facility. During the time when desulfurization equipment is not installed, waste gas from the ammonia decomposition facility contains great deal of SOx, because a part of H_2S in the COG is absorbed by ammonia scrubber and it is burned in the ammonia decomposition facility. For this reason, it will be necessary to use acid proof lining to the stack of No. 1B, 2A oven battery.

(4) Plan for starting up coke oven

1A and 1B coke ovens should be started up 30 and 15 days respectively prior to the blast furnace and supply coke for the blast furnace hot run and COG for use in trial operation of each factory inside the steelworks. However, operation starting time of the 1B Battery which produces coke has been delayed 15 days in order to eliminate overstocking of coke. After the operation starts, it is necessary to perform a wall joints repair due to heating-up process, make adjustment of temperature distribution for coke-battery and perform treatment of initial trouble for each equipment, as well as train the operators. The operation rate is planned to be gradually increased as shown in *Fig. 13-5-4* to maintain a balance with the operation starting of the blast furnace.

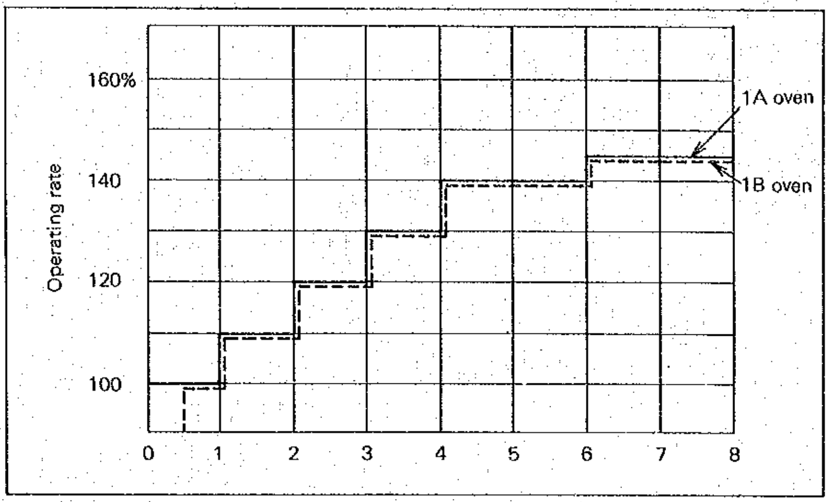
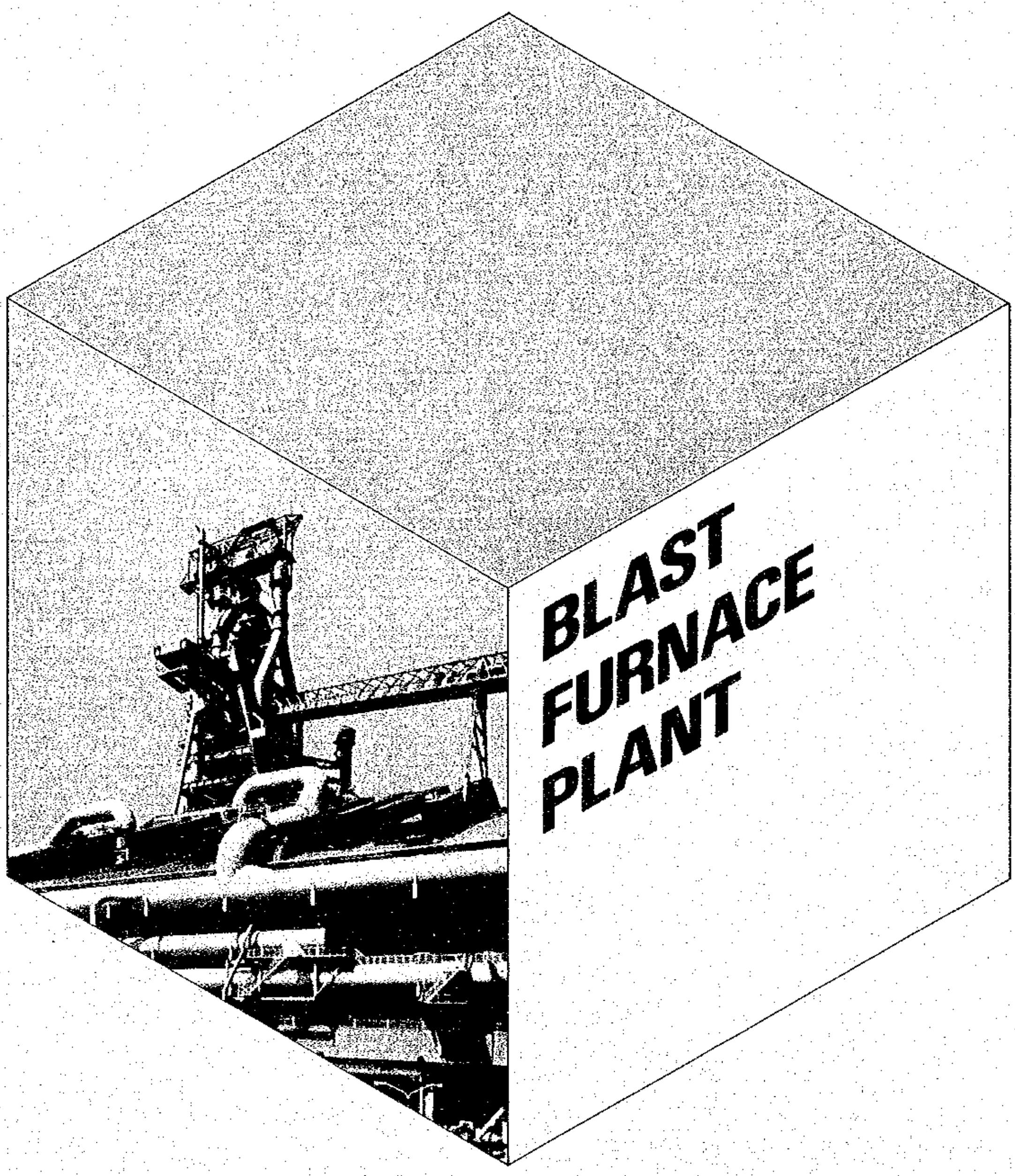


Fig. 13-5-4 Coke oven start-up plan

(5) Coal pre-treatment technics

Briquetted blend coking process has been closed up recently as a coal pre-treatment technic that aims at increasing strength whcih is one of the most important factors in coke quality. This is very effective and new technology under the severe material situations that high quality hard coking coal is in a trend of diminishing. However, this is not included into the plan in order to minimize the investiment cost of facilities. When this technology is adopped in the future, it is possible to utilize the provision space of the coke dry quenching equipment (CDQ) for the establishment of the briquetted blend coking process.

CHAPTER 13-6



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13-6 Blast furnace plant

13-6-1 General

The blast furnace plant in stege I is built to have an inner volume of 2600^{m^3} and produces $1,434,000^t$ of pig iron per year. In stage II, an additional blast furnace with the same volume as stage I will be built and provide a combined production capacity of $2,876,000^t$ of pig iron per year. The blast furnaces' stable production on a continuing basis is extremly important in maintaining overall production levels of the steel plant as a whole. This calls for a number of well trained personnel in operation and work and the equipment of high reliability. Especially as this is the first blast furnace with such a great volume of 2600^{m^3} in the Philippines, the plans for this plant must include selection of the good equipment that gives easy operation and high reliability.

In selecting the planned values, such as the pig iron productivity and other operating conditions have been consulted for reference to the values of Japan and other countries, so that the planned produciton can be accompllished with certainty. The equipment specifications will be such as to minimize the equipment cost in keeping with these operating conditions.

13-6-2 Preconditions

(1) Material preconditions

In order that the operation of the blast furnace is stable, the quality of raw materials and fuels must be stable. Planning has been made with the following conditions and estimates concerning raw materials and fuels.

1) Sinter

① Sinter in its entirety will be supplied from the P.S.C. in stage I and stage II.

② The sinter-and-pellet ratio is 80% and the sinter ratio will be at about 60%.

③ The quality of sinter supplied to the blast furnace is assumed to be of the same quality in Japan. Whether the sinter is directly conveyed from the sinter plant to the blast furnace or conveyed from a sinter yard will have a large effect on operatione of the blast furnace. So it is desirable that a plan of the direct conveying system be studied from the viewpoint of the effects of sinter on the productivity and operation methods of PSC and the quality of transported sinter to the KSC. In this report, the operating conditions of the blast furnace are planned with the quality of sinter assuming the most of sinter will be conveyed directly from sinter plant and in part also conveyed from the sinter yard.

④ The quality of sinter supplied is supposed to *Table 13-6-1.*

Table 13-6-1 Sinter conditions (On ore bin)

T. Fe	CaO/SiO	SI	Fine Ratio	Grain Size	Remarks
> 53%	1.5 ~ 1.6	> 82%	Approx. 8%	5 ~ 40 mm	

2) Coke

The quality of coke which is transported from the coke plant is shown in *Table 13-6-2.*

Table 13-6-2 Coke conditions

Ash	T.S	Drum Index	Grain Size	Fine Ratio	Remarks
12%	< 0.7%	DI^{150}_{50} > 82%	25 ~ 80 mm	15%	

3) Other Material Conditions

Other material conditions are shown in the following

Table 13-6-3 Other material conditions

	Tumbler Index	Swelling Index	Grain Size	Remarks
Sized Ore Pellet	— –1 mm < 5%	— < 14%	8 ~ 25 mm Approx. 10~15 mm	Non-viscosity and non-descrepitation ore

(2) Operation Conditions

1) Production Plan

The production of the blast furnace is shown in *Table 13-6-4*

Table 13-6-4 Blast furnace production

Material	Period	Unit	Production
Pig Iron	Stage I Stage II	1,000 t/y 1,000 t/y	1,434 2,876

The production of slag is shown as being planned in *Table 13-6-5 Slag production*

Table 13-6-5 Slag production

Material	Period	Unit	Production
Slag	Stage I Stage II	1,000 t/y 1,000 t/y	430 863

2) Conditions of raw materials and fuels

The units of consumption of the raw materials and fuels are as shown in *Table 13-6-6*. In order to secure the stability of operation, sinter-and-pellet ratio is about 80%. Because of the P.S.C.'s supply conditions, the sinter ratio will be about 60%, and so the pellet ratio will be set at about 20%.

Table 13-6-6 Condition of raw materials and fuel

Raw materials and fuels	Unit of consumption	Remarks
Sinter	953 kg/t-pig	58.9%
Pellet	342 kg/t-pig	21.1%
Sized ore	325 kg/t-pig	20.0%
Manganese ore	9 kg/t-pig	
Limestone	40 kg/t-pig	
Coke	520 kg/t-pig	
Heavy oil	40 kg/t-pig	

3) Operating Conditions

According to the foregoing way of thinking, the operating condition is determined as follows, and it will serve as a pre-requisite of the equipment plan.

Table 13-6-7 Operating conditions

Item	Planned values
Pig iron production – Normal day ave.	3,930 t/d
Normal day max.	4,136 t/d
Operation mode	24 hr, 3 ~ 8 hr shifts
Operating rate	95%
Productivity	1.5 t/d/m³
Fuel ratio	560 kg/t-pig
Coke ratio	520 kg/t-pig
Oil ratio	40 kg/t-pig
Ore ratio	1,620 kg/t-pig
Sinter-and-pellet ratio	80%
Slag volume	300 kg/t-pig
Coke ash	12%
Blast temperature	1,050 °C
Top pressure	1.5 kg/cm² G
Blast volume	4,050 Nm³/min.
Blast pressure	2.5 kg/cm² G
Gas generation	341,000 Nm³/hr
Flue dust (Dry)	20 kg/t-pig
Flue dust (Wet)	12 kg/t-pig
Charging sequence	O-O-C-C
Charging frequency	126 times per day
Charging quantity	
Coke	17.1 t/ch
Ore	54.8 t/ch
Tapping frequency	10 ~ 12 times per day

13-6-3

13-6-3 Equipment plan

(1) Equipment specifications

The major divisions of blast furnace plant are in the following 6 categories.

1) Raw materials transporting facilities, which blend the raw materials and transport them
2) Blast furnace equipment, which produces pig iron, slag and blast furnace gas through reaction of iron ore, fuels and hot blast.
3) Cast house equipment, which handles pig iron and slag
4) Hot stove equipment, which heats the blast
5) Gas cleaning equipment, which removes dust from the blast furnace gas
6) Pig casting machine, which manufactures cast pig iron from hot pig iron when the B.O.B. is shut down

Main equipment specifications of these equipment are shown in *Table 13-6-8.*
In facilities outside the area but related to the blast furnace plant, power plant and raw material preperation plants will have to be provided for in the overall operation.

1) Blower euqipment, which provide a blast for the hot stove
2) A gas holder, which stores BFG.
3) Feeding conveyor, which carries raw materials to the bins

Table 13-6-8 Equipment specifications

Item	Stage I		Stage II	
	Quantity	Main specifications	Quantity	Main specifications
1 Raw materials transporting facilities				
(1) Raw materials bin	1 unit	Sinter bin: 270 m^3 x 5 Pellet bin: 270 m^3 x 2 Reserve bin: 270 m^3 x 1 Ore bin: 90 m^3 x 5 Miscelaneous material bin: 90 m^3 x 2 Reserve bin: 90 m^3 x 1 Coke bin: 400 m^3 x 6	1 unit	Same as left
(2) Screen	11 sets	Sinter screen: 200 t/hr x 5 Coke screen: 90 t/hr x 6	11 sets	Same as left
(3) Feeder	10 sets	Ore feeder: 180 t/hr x 6 Pellet feeder: 150 t/hr x 2 Miscelaneous material feeder: 150 t/hr x 2	10 sets	Same as left
(4) Conveyor	1 unit	For ore: 700 t/hr x 1 system For coke: 410 t/hr x 1 For fine sinter: 100 t/hr x 1 For coke breeze: 45 t/hr x 1	1 unit	Same as left
(5) Charging conveyor	1 unit	Capacity: Ore: 1,500 t/hr Coke: 500 t/hr Belt width: 1,400 mm Belt speed: 120 m/mm	1 unit	
2 Blast furnace equipment				
(1) Top charging gear	1 unit	Top charging method: 2 bells and valve seal system Large bell dia.: 6,300φ Small bell dia.: 2,150φ	1 unit	Same as left
Pressure equalizing		Device Large bell hopper: Waste gas equalizing Small bell hopper: 1st equalizing: BFG 2nd equalizing: N_2 Other devices Movable armour		

Item	Stage I		Stage II	
	Quantity	Main specifications	Quantity	Main specifications
		Hydraulic equipment Centralized lubricating equipment Sounding device Top gas sampler Top igniter High top pressure equipment		
(2) Blast furnace proper	1 unit	Furnace supporting system: Free-standing type Inner volume: 2,600 m^3 Hearth diameter: 11,200 mm No. of tap holes: 2 No. of cinder notches: 2 No. of tuyeres: 30 Furnace body cooling system: Industrial water circuit system	1 unit	Same as left
(3) Accessory equipment	1 set	Fuel injector Heavy oil injected: 40 kg/pig No. of tuyeres: All tuyers (30)	1 set	Same as left
3 Cast house equipment				
(1) Cast floor	1 set	2 casting areas About 2,800 m^2	1 set	Same as left
(2) Main iron trough	2 sets	Replaceable type	2 sets	Same as left
(3) Iron runner	2 sets	Fixed runner and tilting spout	1 set	Same as left
(4) Slag runner	2 sets	Fixed runner 3 slag pits	1 set	Same as left
(5) Clay gun	2 sets	Full hydraulic type 0.25 m^3/stroke (Effective)	2 sets	Same as left
(6) Tap hole opener	2 sets	Pneumatic remote control type		
(7) Cinder notch stopper	2 sets	Pneumatic remote control type		
(8) Cast house crane	2 sets	60 t		
(9) Cast house dust collecting equipment	1 unit	Dry type 10,000 m^3/min.		
(10) Clay preparing equipment	1 set	Mixer capacity: 2 t/hr	1 set	Mixer will be increased in stage II

Item	Stage I		Stage II	
	Quantity	Main specifications	Quantity	Main specifications
4 Hot stove equipment	1 unit	Hot stove type: Cowper: 3 units Dome temperature: Max. 1,250°C Exhaust gas temperature: Max. 350°C Stove operation Blast: 45 min. Combustion: 80 min. Changeover: 10 min. Fuel: BFG Heating surface: 52,500 m^2/stove Stove diameter: 9,500 mmφ Stove height: 45,000 mm Volume of BFG for combustion: 64,000 Nm^3/hr Volume of air for combustion: 51,000 Nm^3/hr Burner fan: 3 units	3 units	Same as left
5 Gas cleaning equipment	1 unit	Gas cleaning method: Dust catcher → Primary venturi scrubber → Secondary venturi scrubber Treating gas volume: 341,000 Nm^3/hr Degree of gas cleaning: 10 mg/Nm^3 (Below)	1 unit	Same as left
6 Casting machine	1 unit	Stationary fixed roller Max. 35,000 t/month	1 unit	Same as left
7 Building				
(1) Cast house building	1 set	About 2,800 m^2	1 set	Same as left
(2) Integrated control room	1 set	350 m^2 3 stories	1 set	Same as left
(3) Blast furnace sub-center	1 set	910 m^2 2 stories	–	An addition over the Stage 1, 270 m^3 2 story building

The blast furnace cross sectional drawing is shown below.

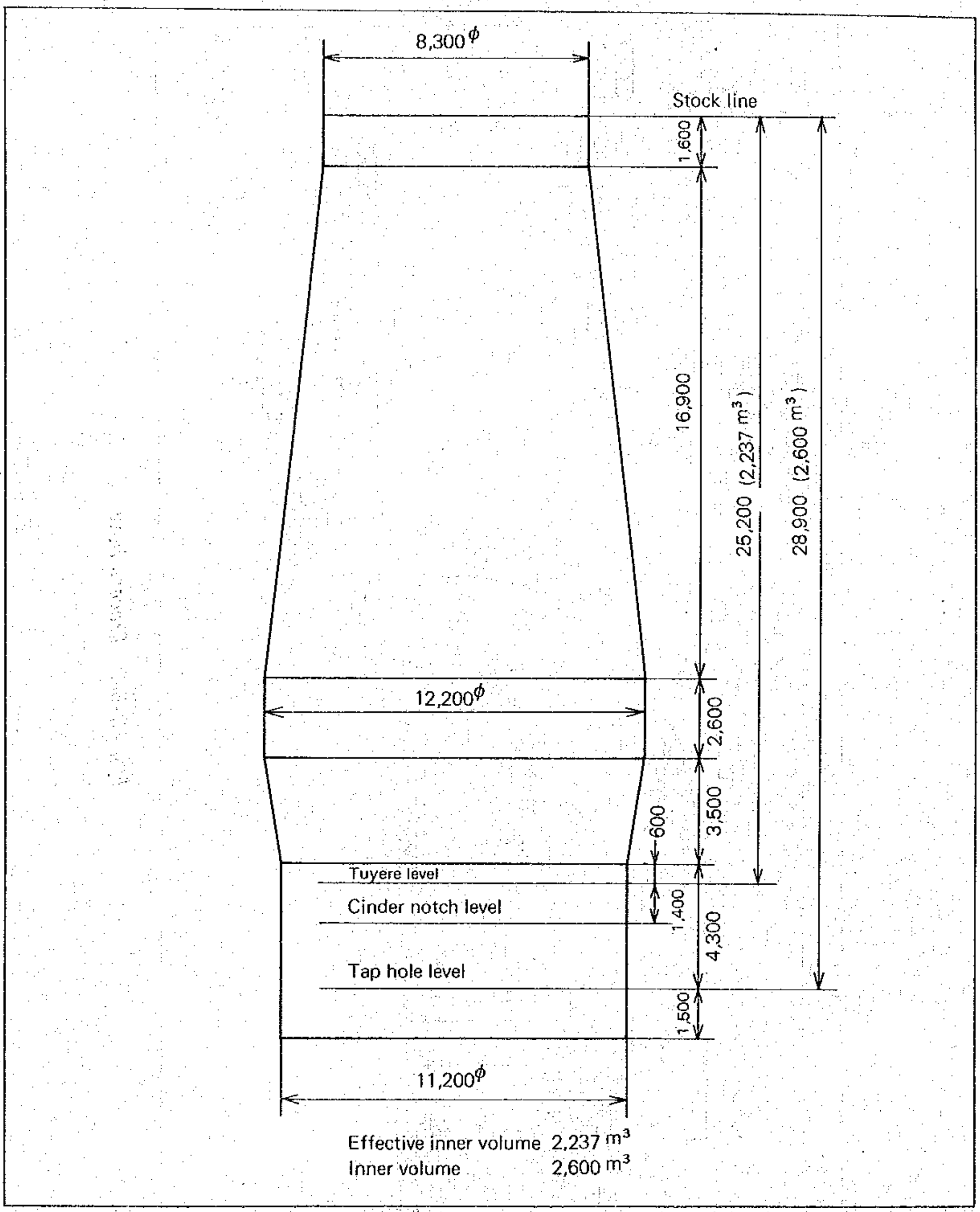

Fig. 13-6-1 Blast furnace sectional area

(2) Process flow

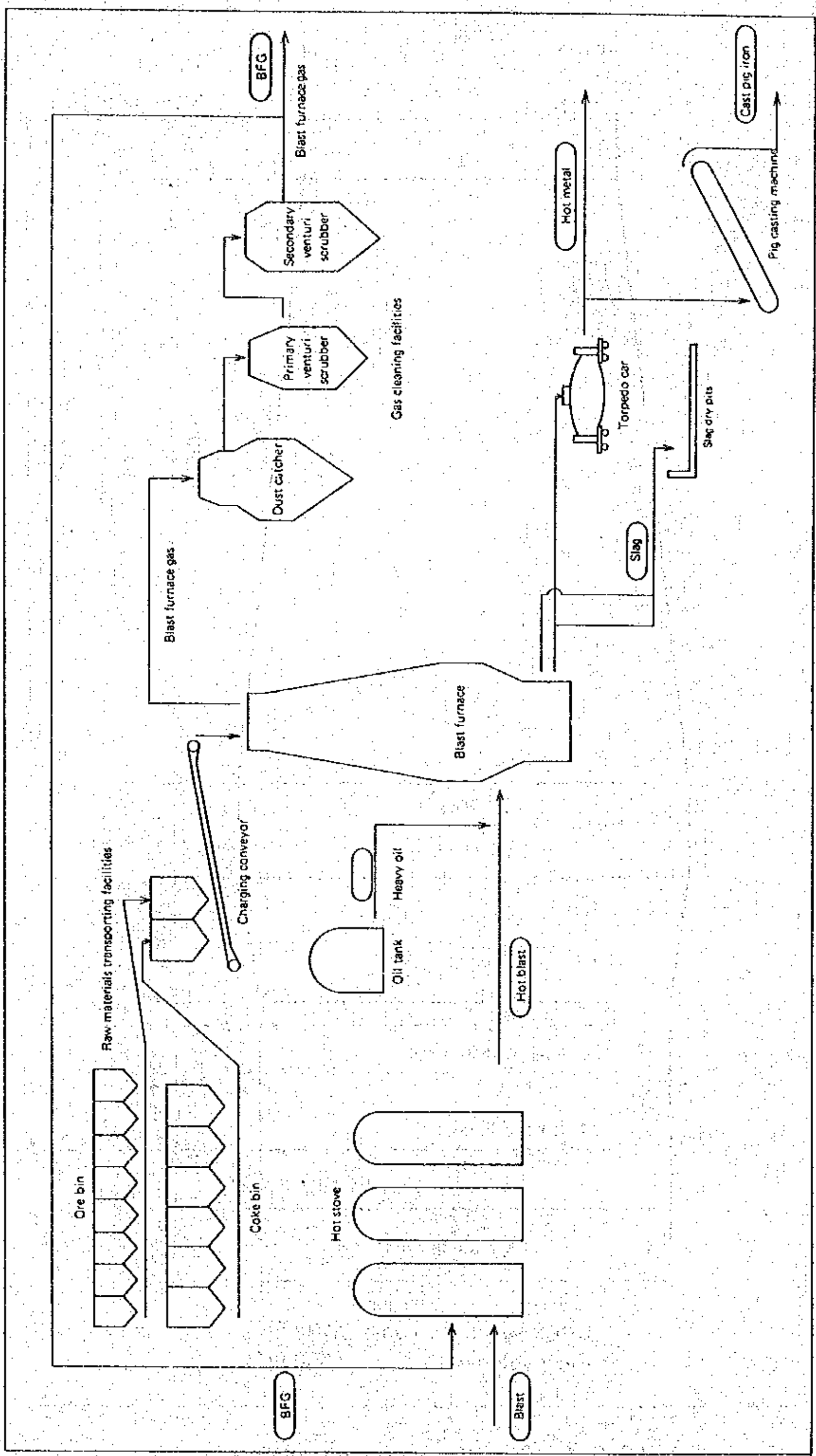

Fig. 13-6-2 Process flow

(3) Material balance

The figures for a material balance in both stage I and stage II are shown in *Fig. 13-6-3* below. The figures in brackets indicate combined figures of stage I and II.

Unit: 1,000 t/y
( ): Stage II

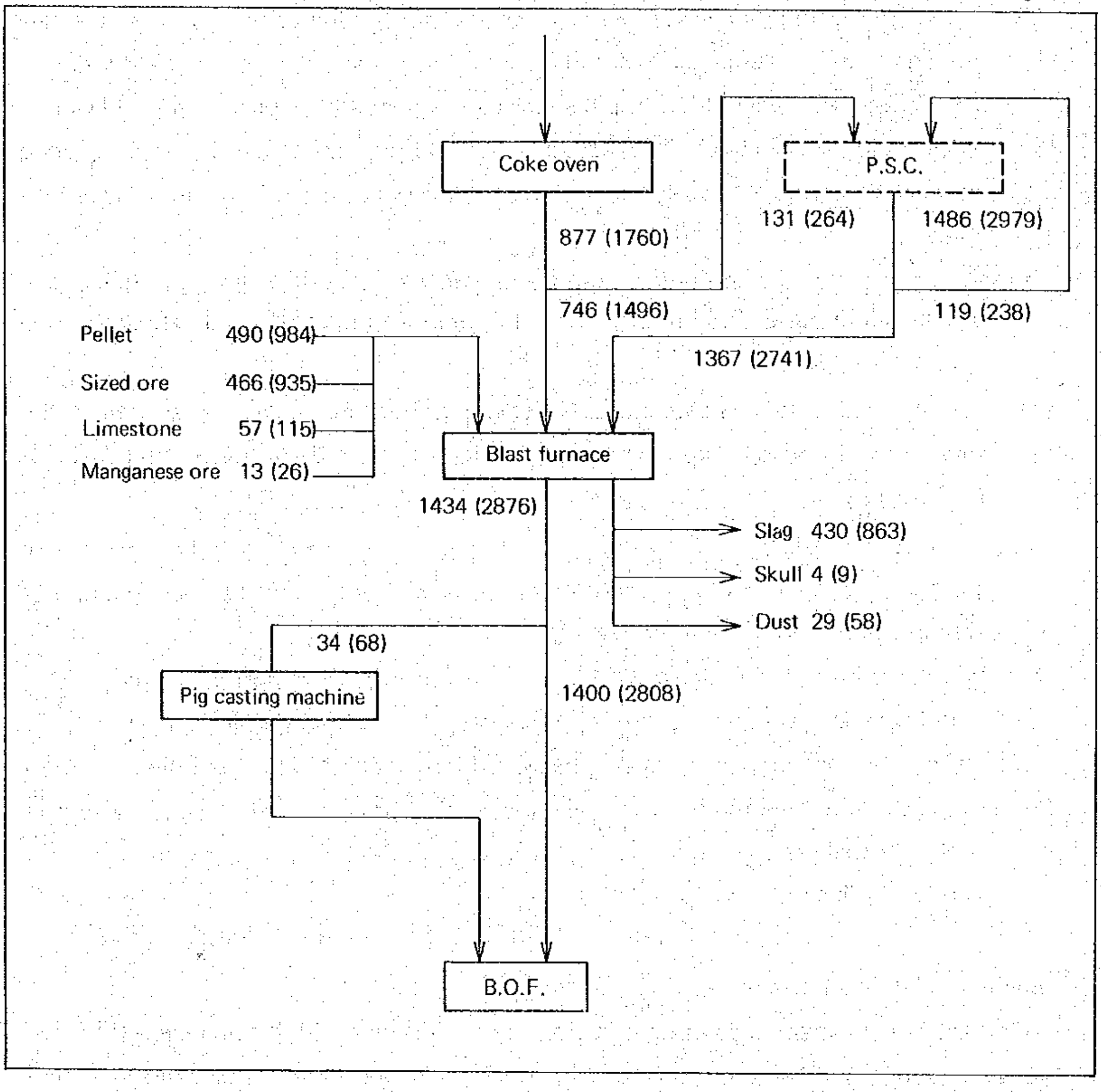

Fig. 13-6-3 Material balance

(4) Layout

The layout of the facilities has been decided so that a flow of commodities in the whole of the steel works can be conducted smoothly and also so that the site for 2~4 blast furnaces which are to be built in the future can be insured.

1) The layout of 1 and 2 blast furnace is planned similarly and the distance between them has been determined 220^{m} in the consideration of the layout of each facility.
2) As for the feeding conveyor lines to the stockhouse, due to the layout of the raw materials handling and coke plant, the ore conveyor line is designed in a form so that the conveyor is seperated at the center point between the stockhouse for blast furnace 1 and the stockhouse for blast furnace 2, and the coke conveyor line is designed so that the coke conveyor for blast furnace 2 passes over the coke bin for blast furnace 1.
3) The hot metal transportation equipment consists of 320^{t} capacity torpedo car. The layout of the rails is planned so that the shortest route between the blast furnace and B.O.F. is used.
4) A slag dry pit system is adopted for the slag treatment and the equipment except the raw material transporting facilities are arranged at the side of the counter slag dry pit.
5) The raw materials transporting facilities are installed in a direction of the raw material yard and coke plant, 300^{m} from the blast furnace in order that the slanted angle of the charging conveyor can be ensured.
6) In order to ensure a site for constructing a blast furnace in the future, the pig casting equipment is installed 600^{m} from the blast furnace. Other equipment is laid out beside the blast furnace. Its layout has been done in consideration that the construct-on costs are minimized, daily operations can be made reasonably well and simultaneously relining work can be easily done as well as initial construction.
   The layout is shown in *Fig. 13-6-4*

(5) Relation to the facilities at stage II

The blast furnace plant is basically planned so that facilities with the same specification for both stage I and II are independently laid out. Therefore, the main facilities in stage I have no relation to those for stage II but the following facilities are planned partly in consideration of stage II.

1) Sub-center
   At the time of stage II, additional building for insufficient building space will have to be added to those built in stage I.

2) Pig casting equipment

Pig casting machine is not installed stage II in consideration of the scheduled shut down periods of the blast furnace and the BOF.

3) Clay preparing equipment

The clay preparing equipment is commonly used at stage I and II. At the time of stage II only the mixer is established. Other incidental facilities are planned at stage I so as to be commonly used throughout stage I and II.

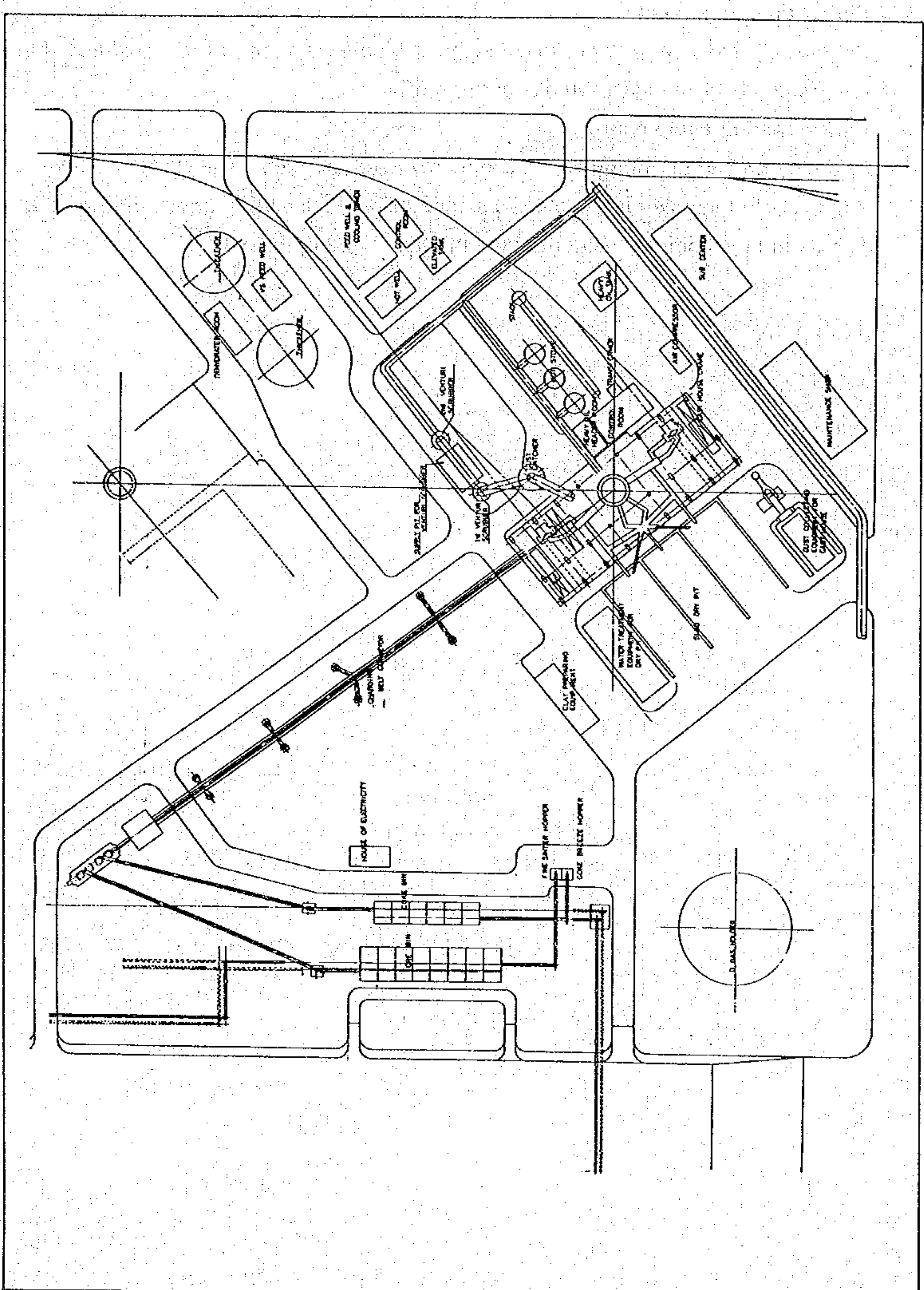

Fig. 13-6-4 BF layout

(6) Production

In order to assure the production of pig iron 1,434,000[t] per year in stage I, raw materials needed, utility and by-products are noted in the following tables.

1) Raw materials to be used

Table 13-6-9 Quantity of raw materials

Raw material	Unit of consumption kg/t-pig	Yearly consumption (1,000 t/y)	Remarks
Sinter	953	$1,367 \times 10^3$	
Pellet	342	490×10^3	
Sized ore	325	466×10^3	
Manganese ore	9	13×10^3	
Limestone	40	57×10^3	
Coke	520	746×10^3	

2) Quantity of utility

The table below will give a yearly estimate of the quantity of utility related material necessary.

Table 13-6-10 Quantity of utility

Item	Unit of consumption	Yearly volume	Remarks
Blast volume	1,360 Nm^3/t-pig	$1,951 \times 10^6$ Nm^3/y	
Heavy oil	40 kg/t-pig	57.4×10^3 t/y	
BFG	660 Nm^3/t-pig	946.6×10^6 Nm^3/y	
COG	2 Nm^3/t-pig	2.9×10^6 Nm^3/y	
Steam	15 kg/t-pig	21.5×10^3 t/y	
Electric power	20 KWH/t-pig	28.7×10^6 KWH/y	
Industrial water	4.1 m^3/t-pig	5.9×10^6 t/y	Make-up water
Potable water	0.015 Nm^3/t-pig	21.5×10^3 t/y	
Oxygen	3 Nm^3/t-pig	4.3×10^6 Nm^3/y	
Nitrogen	23 Nm^3/t-pig	33×10^6 Nm^3/y	

3) Quantity of by-product

The table below gives the quantity of by-products produced on a yearly basis

Table 13-6-11 Quantity of by-product

Material	Unit of consumption	Yearly production	Remarks
BFG	1,980 Nm^3/t-pig	2,839 x 10^6 Nm^3/y	
Slag	300 kg/t-pig	430 x 10^3 t/y	
Skull	3 kg/t-pig	4.3 x 10^3 t/y	
Dust	20 kg/t-pig	28.7 x 10^3 t/y	

4) Quantity of fine generated

Table 13-6-12 Quantity of fine generated

Item	Yearly volume generated	Remarks
Fine sinter	119 x 10^3 t/y	
Coke breeze	131 x 10^3 t/y	Including coke plant production

(7) Technical explanation

1) For the blast furnace plant equipment operation, it is essential to keep the temperature and gas distributions inside the furnace proper in good condition and maintain a smooth descent of charging materials. Consequently, meticulous care must be exercised in controlling the operating conditions that greatly affect the condition inside the furnace, for example , coke ratio, fuel, heavy oil volume, and blast temperature.

Much as the blast furnace proper is protected by the cooling system, damage to the cooling system will be directly connected to damage of the furnace proper, and a cooling down inside the furnace will occur if water leaks into the furnace. Therefore, checking and maintenance of the cooling equipment should be performed with extra care. It is planned that the furnace cooling system will be of the cooling plate type and has the following features that should prove to be profitable.

Special features of the cooling plate system

① By the use of cooling plates, both cooling and supportive effects of wall will withstand the erosion to the furnace wall.
② Maintenance is easy, if damaged, replacing the plates is possible and the protection of wall by injection of castables is possible.
③ The water system for cooling is simple and maintenance is easy.
④ Structure of cooling plate is simple and installation cost is cheap.

Attention must be paid to controlling the work for tapping and flushing for several reasons: to supply a constant amount of hot metal to the B.O.F. or casting machine in a periodic time; and to insure no excess hot metal and slag remians inside the furnace.

Stable function without disturbing the blast furnace operation is required for the raw materials transporing facilities, hot stoves, gas cleaning equipment, while ease of working is particularly required for the cast house equipment. The gas cleaning equipment serves a role of supplying clean fuel to the hot stove.

The slag dry pit system was chosen for slag treatment equipment in the stage I. The system to be applied in the stage II should be studied, giving thought to the uses of processed slag and its demand.

It is necessary to also have the capability of collecting and having information on the status of each equipment, cast floor works schedule, raw material quality and quality of blast furnace products. An integrated control room is necessary for making the above possible and instructions to appropriate sections need also be output there.

2) Blowing in and relining

After operating for one campaign (about 6 years), the blast furnace undergoes relining of its refractories. This opportunity is also used to repair various equipment. A major repair is required for hot stoves and cast house after 3-campaign operations. As for the blast furnace blown-in, it will normally take about 6 months before normal productivity is reached. The fuel ratio is higher during that peiod.

Month	1	2	3	4	5	6	7
Normal day maximum production ton/day	2,245	2,840	3,405	3,750	3,980	4,090	4,136
Fuel ratio kg/t-pig	700	655	615	585	570	565	560

Since the quantity of hot metal to be received by the B.O.F. will not reach this magnitude in the first year or so, cast pig iron is produced by the casting machine during that period of time.

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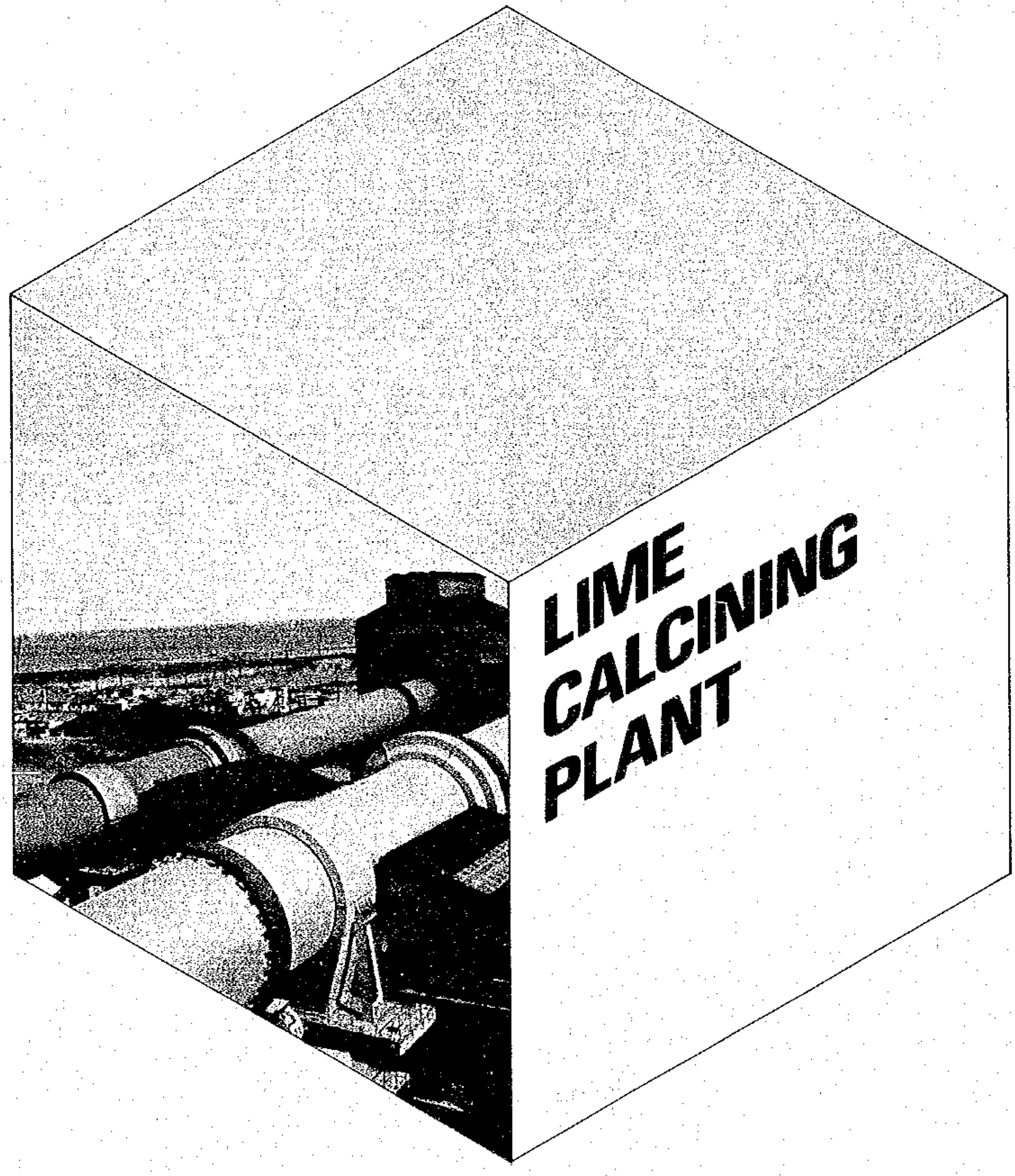

13-7 Lime calcining plant

13-7-1 General

One lime calcining kiln with a nominal capacity of $350^{t/d}$ will be installed to calcine 940,140$^{t/y}$ of necessary burnt lime for the production of 1,569,000$^{t/y}$ of molten steel at BOF plant.

The rotary calcining kiln is used to obtain the high-grade and soft calcined burnt lime necessary for BOF process. The grate travelling type preheater and cooler will be also installed as the auxiliary equipment.

A plan has been made so that another kiln adjacent to the planned kiln can be installed in order to make the lime calcining capacity increased to correspond to the capacity of the BOF plant when expanded in the future. Raw limestone goes through grinding and washing to provide for proper material conditions before being charged into the kiln. The burnt lime product is fed from a storage bunker with a capacity of 2,700^{t} directly to the flux transport equipment of the BOF plant.

COG is used as fuel for calcining. Waste gas is heat-exchanged in the preheater and exhausted into the atomosphere via a dust collector.

Lime dust from the calcining and transport processes is collected completely in each process.

13-7-2 Preconditions

(1) Production plan

*Table 13-7-1*shows the production plan of the lime calcining plant according to the production plan of the BOF plant.

Table 13-7-1 The production of lime calcining kiln

B.O.F plant production (Molten steel basis)	1,569,000 $^{t/y}$
(As cast basis)	1,500,000 $^{t/y}$
Unit consumption of burnt lime	60 $^{kg/t}$ (Molten steel basis)
Amount of required burnt lime	94,140 $^{t/y}$
Lime calcining plant production	94,140 $^{t/y}$

(2) Process yields

Table 13-7-2 shows the process yields of the line calcining plant.

Table 13-7-2 Lime yield at each process

Process	Yield
1) Crushing yield of raw limestone $\frac{\text{Limestone to be washed after crushing}}{\text{Limestone received}} \times 100$	90.0%
2) Washing yield of raw limestone $\frac{\text{Limestone to be charged into calcining kiln}}{\text{Washed limestone}} \times 100$	97.7%
3) Calcining yield $\frac{\text{Burnt lime from the kiln}}{\text{Charged limestone}} \times 100$	50.0%
4) Screening yield of burnt lime $\frac{\text{Burnt lime producted}}{\text{Burnt lime from the kiln}} \times 100$	97.5%

(3) Operating conditions

Table 13-7-3 shows the basic operating conditions.

Table 13-7-3 Operating conditions of the lime calcining plant

		Planned value
1) Operating time	1-1) Annual operating days 1-2) Monthly operating days	329^{d} Average 27^{d}
2) Kiln shutdown*	(Scheduled shutdown days per year)	36^{d} Average time of shutdown: Every 2 months, 6 days for each shutdown Maximum time of shutdown: Every 2 months, 8 days for one shutdown
3) Operating ratio	(Operating d/calendar d x 100)	90.0 %
4) Production	4-1) Annual production 4-2) Average monthly production 4-3) Daily production Average daily production Monthly production when the kiln is shutdown	$94{,}140^{t}$ $7{,}845^{t}$ $7{,}845^{t}/27^{d} = 290^{t/d}$ $7{,}845^{t}/(30-8)^{d} = 355^{t/d}$
5) Calcining capacity	5-1) Average calcining capacity 5-2) Maximum calcining capacity 5-3) Minimum calcining capacity	$350^{t/d}$ $450^{t/d}$ $150^{t/d}$

* Scheduled kiln shutdown
The lining bricks of rotary kiln must be relined in company with their wear and tear. The relining work is performed with a schedule of approximately once two months for the length of 8 ~ 10 m each in the longitudinal direction one after the other. Overall and simultaneous maintenance works also are carried out for mechanical and electrical equipment as well with this Kiln shutdown.

13-7-3 Equipment plan

(1) Equipment specifications

Table 13-7-4 shows the specifications for the lime calcining plant.

The general functions and plans of each equipment are described as follows:

1) Raw limestone receiving and storage facilities

Normally the raw limestone is dumped from a truck into a hopper (capacity 35^{m^3}) with a receiving tray. The capacities of grinding and washing equipment are $150\sim200^{t/hr}$. The storage bin has a capacity of $1{,}050^{t}$ and is designed to store the raw limestone of 1.5 days use. Only day-time workers shall be applied for the raw limestone receiving work.

2) Charging equipment

The raw limestone discharged from the storage bin is transported by a conveyor belt, hoisted to charging bins by a bucket elevator and charged into the preheater.

In order to maximize the heat efficiency of the preheater, the charging equipment is so designed that it classifies the raw limestone into two groups of sizes and it lays them in two layers on the grate of the preheater. Those related to the charging equipment are designed at the capacity of approximately $60^{t/hr}$.

3) Preheater

The charged raw limestone is heated up to approximately 800°C in the grate travelling type preheater.

The raw limestone fallen through the grate during the travelling is caught by a chain conveyor and collected by a bucket elevator. The collecting capacity of fallen limestone is set at $20^{t/hr}$.

The preheater capacity is designed at $950^{t/d}$ so as to match the calcining capacity of max. $450^{t/d}$.

4) Kiln

The kiln is designed with the average capacity of $350^{t/d}$.

Taking into consideration the fact that the required amount of burut lime fluctuates according to the daily operational conditions of the B.O.F. plant, the kiln capacity is set so that the kiln be able to maintain stable product quality even if it operates in the low and high load conditions i.e., 150 and $450^{t/d}$.

The furnace type is a rotary kiln and the furnace rotation velocity can be selected within the range of 0.5 and 2.0^{rpm}.

As the measure of the trouble caused by a power failure, the kiln is provided with an emergency engine powered by gasoline.

Coke oven gas is used as the kiln fuel.

5) Cooler

The temperature of burnt lime just after being burnt is approximately 1150°C and a cooler is installed to cool down the burnt lime to approximately 50°C.

The cooler is of a grate travelling type like the preheater. The cooling fan capacity is specified at approximately $800^{m^3/min}$.

The air used for cooling the burnt lime is reused for the secondary air of the kiln.

The cooler capacity is specified at $450^{t/d}$ at maximum and $350^{t/d}$ at average.

6) Waste gas treating equipment:

The waste gas generated in the kiln is put through the preheater and then discharged into the atomosphere via a dust collector where the inlet temperature of the waste gas is approximately 350°C.

The blower capacity is approximately $3{,}000^{Nm^3/min}$. The dust collector has two-stage dust catchers; cyclone dust separater for stage I and venture scrubber for stage II and each dust collector has a capacity of $3{,}000^{Nm^3/min}$.

7) Transport and storage equipment of the product:

Burnt lime is transported by a belt conveyor with a capacity of $50^{t/h}$.

Burnt lime is classified by a screen into a lump product and a fine product and each stored in a bunker.

The bunker which supplies the burnt lime to the B.O.F. plant has a storage capacity of $2{,}700^{t}$ (9 days use) and the fine burnt lime bunker has a storage capacity of 75^{t}.

Fine burnt lime is used for sinter material, desulfurazing agent for molten iron and for producing fertitizers, etc.

Table 13-7-4 Equipment specifications of lime calcining plant

Classification		Equipment	Specifications: Stage I	Specifications: Stage II
1		Receiving equipment of raw limestone		
	01	Truck charging hopper	35 m^3 x 1 unit	
	02	Shovel bulldozer	2 ^{t} x 1 unit	
	03	Crusher	200 $^{t/hr}$ x 1 unit	
	04	Washer	200 $^{t/hr}$ x 1 unit	
	05	Screen	200 $^{t/hr}$ x 1 unit	
	06	Belt conveyor	200$^{t/hr}$ x 1 set	
	07	Bucket elevator	150 $^{t/hr}$ x 1 unit	
	08	Auxiliary equipment	Classifier 50 $^{t/hr}$ x 1 set	
	09	Limestone storage silo	Storage capacity: 750 m^3 (1,050 ^{t})	750 m^3 (1,050 ^{t})
	10	Fine limestone bin	Storage capacity: 110 m^3 (150 ^{t})	110 m^3 (150 ^{t})
2		Charging equipment of raw limestone		
	01	Belt conveyor	60 $^{t/hr}$ x 2 units	60 $^{t/hr}$ x 2 units
	02	Bucket elevator	60 $^{t/hr}$ x 1 unit	60 $^{t/hr}$ x 1 unit
	03	Screen	60 $^{t/hr}$ x 1 unit	60 $^{t/hr}$ x 1 unit
	04	Material charging equipment	60 $^{t/hr}$ x 1 set	60 $^{t/hr}$ x 1 set
3		Preheater		
	01	Preheater proper	950$^{t/d}$ x 1 unit (Grate travelling type)	950 $^{t/d}$ x 1 unit
	02	Chain conveyor	20 $^{t/hr}$ x 1 set	20 $^{t/hr}$ x 1 set
	03	Bucket elevator	20 $^{t/hr}$ x 1 unit	20 $^{t/hr}$ x 1 unit
	04	Auxiliary equipment	Beam cooling fan x 2 sets	Beam cooling fan x 2 sets
4		Kiln		
	01	Kiln proper	150 ~ 450 $^{t/d}$ x 1 unit Type: Rotary kiln Kiln profile: Approx. 3.2 ^{m} dia. x 60 ^{m} long	150 ~ 450 $^{t/d}$ x 1 unit

Classification	Equipment	Specifications	
		Stage I	Stage II
02	Tilting device	1 set (0.5 ~ 2.0 r.p.m)	1 set
03	Auxiliary equipment	1 set 1) Gasoline engine Emergency kiln rotating device 1 set 2) Kiln hood equipment 1 set 3) Air seal device 1 set 4) Kiln head cooling fan 1 set	1 set
04	Combustion equipment	1 set Fuel: COG Burner equipment 1 set Primary air fan 1 set	1 set
5	Cooler		
01	Cooler proper	Max. 450 t/d x 1 unit (Grate travelling type)	Max. 450 t/d x 1 unit
02	Cooling fan	Approx. 800 m^3/min. x 2 units (Type: Bag filter)	Approx. 800 m^3/min. x 2 units
6	Waste-gas-treating equipment		
01	Dust catcher	Approx. 3,000 Nm^3/min. x 1 unit (Multi-cyclone type)	Approx. 3,000 Nm^3/min. x 1 unit
02	Blower	Approx. 3,000 Nm^3/min. x 1 unit (At 550 min. H_2O)	Approx. 3,000 Nm^3/min. x 1 unit
03	Wet dust catcher	Approx. 3,000 Nm^3/min. x 1 unit (Ventury type)	Approx. 3,000 Nm^3/min. x 1 unit
7	Transport and storage equipment of product		
01	Belt conveyor	50 t/hr x 1 set 25 t/hr x 1 set	50 t/hr x 1 set 25 t/hr x 1 set
02	Screen	50 t/hr x 1 unit Dust catching: Bag filter type Fan capacity: 1,050m^3/min.	50 t/hr x 1 unit

Classification		Equipment	Specifications	
			Stage I	Stage II
	03	Lump product bunker	Storage capacity: 2,700 t	Storage capacity: 2,700 t
	04	Fine product bunker	Storage capacity: 75 t	Storage capacity: 75 t
8		Auxiliary equipment		
	01	Air compressor and piping Miscellaneous piping	1 set Compressor x 2 units COG, miscellaneous piping	1 set
	02	Emergency limestone yard	Required area: Approx. 3,000 m^2	
9		Electrical equipment		
	01	Power supply equipment	1 set	1 set
	02	Lighting	1 set	1 set
	03	Communication equipment	1 set (4 stations for interphone)	1 set
	04	Power supply and cable	1 set	
10		Instrumentation	1 set Controllers for the transport and charging of raw materials Controllers for preheater, calcining kiln and cooler Controllers for burnt lime product transport	1 set
11		Civil	1 set	1 set
12		Buildings	1 set Main control room and product bunker	1 set Main control room and product bunker
13		Water supply	1 set Drainage and piping facility	1 set Drainage and piping facility

(2) Process flow:

*Fig. 13-7-1*shows the production process flow of the lime calcining plant.

(3) Raw material and product balance:

Fig. 13-7-2 shows the material balance between raw material and product.

(4) Layout:

The lime calcining plant shall be allocated to the southeast of the B.O.F. plant so that the lime calcining plant can be connected easily to the fluxes transportation line of the B.O.F. plant.

Fig. 13-8-3 shows the plant layout.

(5) Relationship with stage II equipment.

One lime calcining furnace with a capacity of $350^{t/d}$ is so designed as to match the operation of one B.O.F. onverter.

This means that in stage II, the same type of one calcining furnace has to be provided when two B.O.F. start operations.

However, as the ore accepting facilities and the burnt lime transportation facilities to the B.O.F. are sufficinet, their exapansions are not necessary.

(6) Consumption units.

Table 13-7-5 shows the production and consumption units.

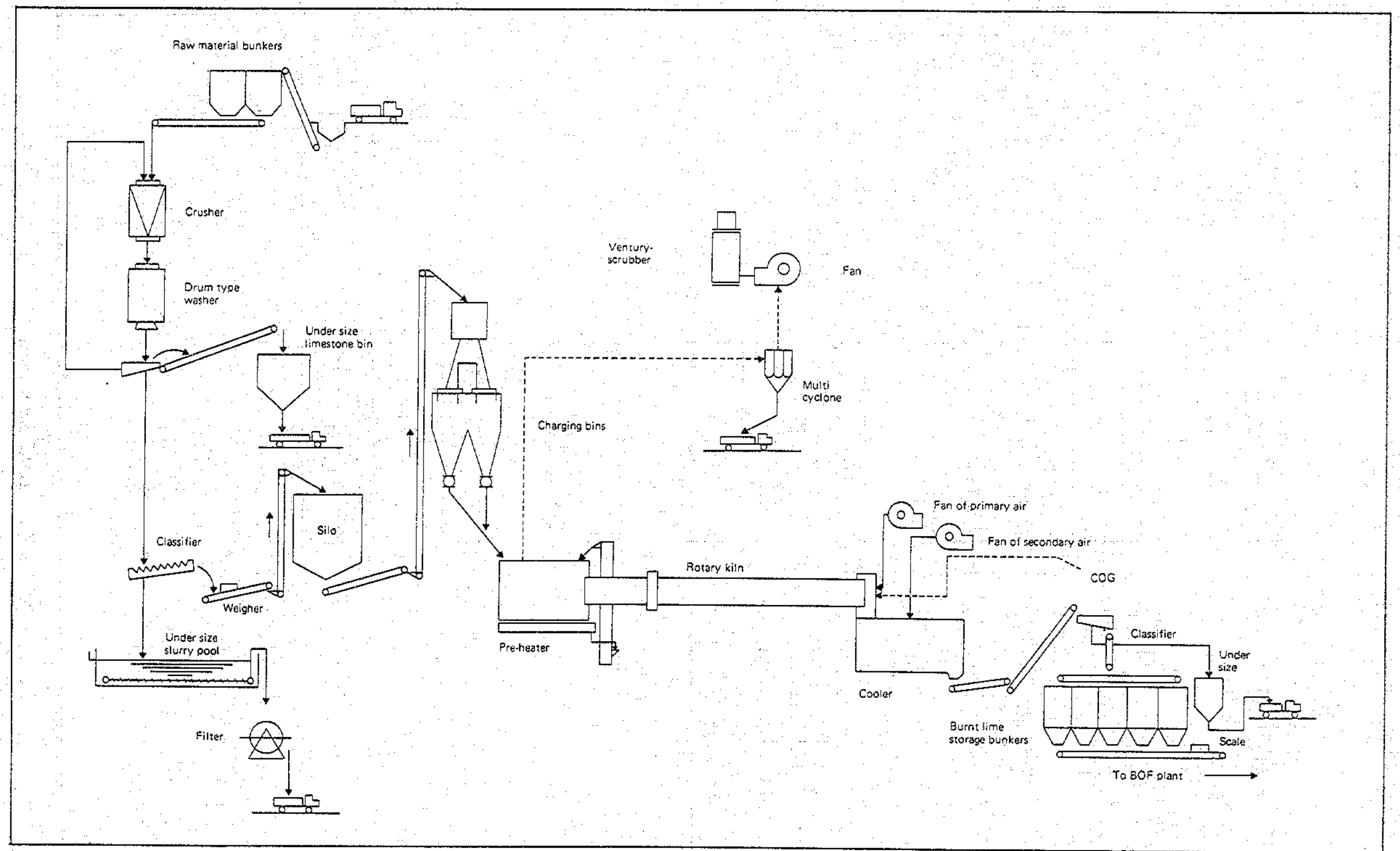

Fig. 13-7-1 Manufacturing process flow of the calcining plant

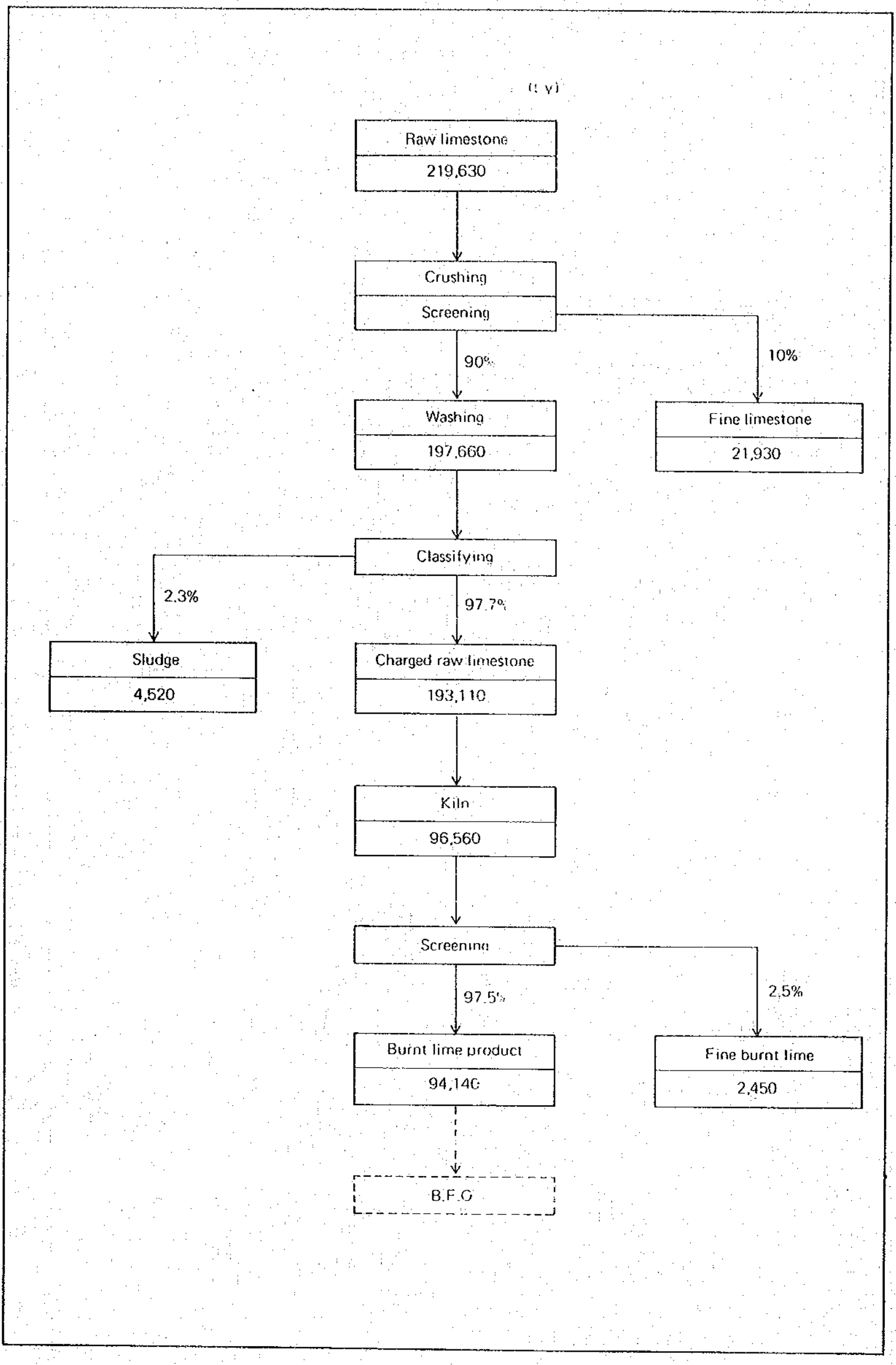

Fig. 13-7-2 Materials balance

Table 13-7-5 Production and consumption of the lime calcining plant

Item			Unit	Annual consumption or generation	
				Stage I	Stage II
Product	0	Burnt lime		94,140 t/y	188,830 t/y
Raw material	1	Raw limestone	2,333 kg/t	219,630	440,540
	2	Fine limestone	* 233 kg/t	21,930	44,000
By-product	3	Fine burnt lime	* 26 kg/t	2,450	4,910
	4	Sludge	* 48 kg/t	4,520	9,060
Utilities	5	COG	322.2 Nm^3/t	30.3 x 10^6 Nm^3	60.8 x 10^6 Nm^3
	6	Electric power	55 kWh/t	5.18 x 10^6 kWh	10.4 x 10^6 kWh
	7	Industrial water	3.2 m^3/t	0.30 x 10^6 m^3	0.60 x 10^6 m^3
	8	Potable water			
Materials	9	Brick	0.7 kg/t	66 t/y	132 t/y
	10	Brick waste	* 0.3 kg/t	28 t/y	57 t/y

* By-product

13-7-4 Technical explanation

Since burnt lime is a main material to make basic slag for desulfuration and dephosphorization, the most important factors for burnt lime is sulfer content and the degree of calcining. The sulfer content in burnt lime is affected by the sulfer content of calcining fuel. As for the degree of calcining, the lower the calcining temperature becomes, the softer (easier slag formation) the burnt lime becomes. Compared with the shaft kiln, the rotary kiln provides rather soft-calcined and stable burnt lime which suits for steelmaking.

The items stipluated below will be required as the characteristics of the quality of burnt lime to be used at the B.O.F. plant.

(1) Chemical analysis

CaO	$> 88\%$
CO_2	$< 3\%$
MgO	$< 5\%$
SiO_2	$< 2\%$
Al_2O_3 / Fe_2O_3	$< 2\%$
S	$< 0.04\%$
P	$< 0.03\%$
Others	$< 1\%$

(2) Reactivity test values

Reactivity in 30 seconds — 40°C and over (High reactive lime as defined in ASTM Specification C-11-71 Section 9.)

(3) Burnt lime size

5—30 mm

Upper limit of the fines mixing rate: 5%

(4) N.B.

Burnt lime to be used at the B.O.F. plant must not be "slaked."

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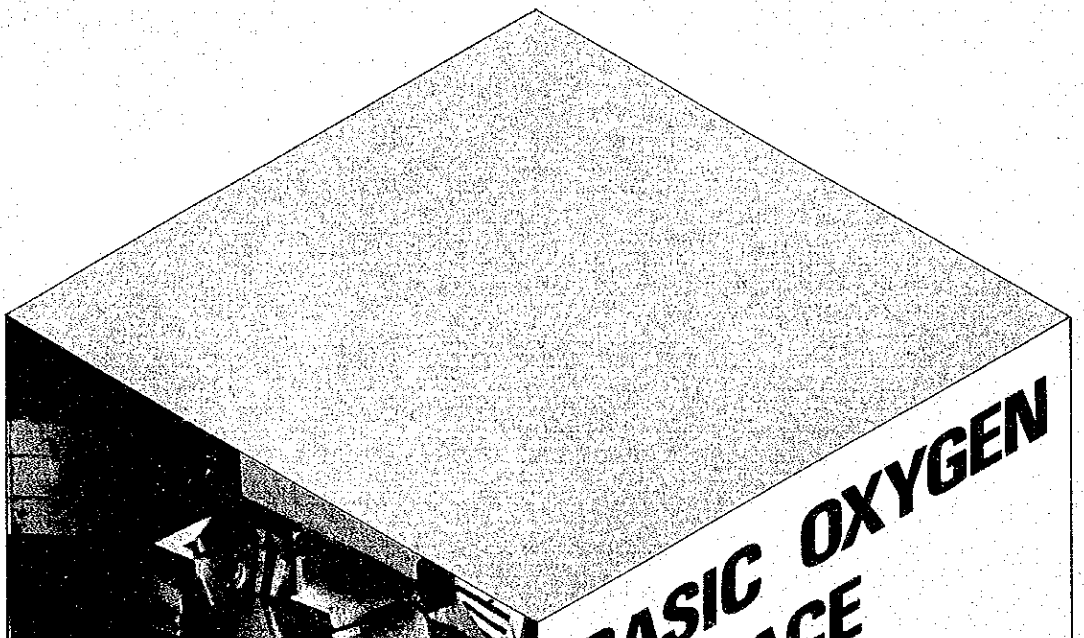

13-8 Basic oxygen furnace plant

13-8-1 General

In the basic oxygen furnace (BOF) plant, two basic oxygen furnaces of nominal capacity of $160^{t/heat}$ (average $155^{t/heat}$) shall be installed to attain the annual molten steel production of $1,569^{thous.t/y}$. The operating mode of the plant shall be one furnace (in operation) out of two (installed). The plant layout shall allow installation of another one furnace in the future so that the plant finally be able to apply the operating mode of "two out of three".

As to the converter waste gas treating method, noncombustive gas-recovery method shall be adopted for energy saving. The oxygen flow rate is planned to average $36,500^{Nm^3/hr}$, and the average tap-to-tap time is planned to be 36 minutes. Hot metal shall be carried into the B.O.F. plant by torpedo cars and transferred into a charging ladle in the plant. Part of the hot metal shall be desulfurized in the torpedo car desulfurization equipment installed between the blast furnace and the B.O.F. plant, then carried into the B.O.F. plant.

Scrap generated in each plant is stored, selected and prepared, in the scrap yard, and carried into the B.O.F. plant by dump trucks, then loaded into a charging chute by a lifting magnet according to a production plan.

Fluxes shall be stored in the underground bunkers installed outside the plant, and lifted to the level over the converters via conveyer belts. Ferro-alloy shall be hoisted to the hopper on the top-rear of the furnaces by the telpher for storage.

The hoisting of fluxes to the high-level hoppers and charging into the furnaces, and ferro-alloy addition into the teeming ladle are planned to be remote-controlled.

Converter slag shall be carried by the slag pot-cars via railroads to the B.O.F. slag processing yard. The ingot making equipment shall be installed for backup of the continuous casters at the startup period, emergency of the continuous casters, and ingot making of unacceptable molten steel for continuous casting. Teeming car method shall be adopted for ingot making. After completion of teeming, the cars shall be moved into another building for mould stripping and ingot processing.

Besides the above ingot making equipment, a molten steel returning traverser shall be installed between the teeming and material handling bays as a backup system for continuous casters. As to the operation, after the molten steel to be returned to a furnace is re-ladled into a hot metal ladle in the teeming bay, the ladle is transferred to the material handling bay and then the molten steel is charged into the furnace together with additional hot metal.

13-8-2 Preconditions

(1) Conditions of the usptream

Table 13-8-1 outlines the target compositions and temperature of the hot metal from the blast furnaces, which is the main material of the B.O.F. plant.

Table 13-8-1 Chemical composition and temperature of hot metal

	Si	Mn	P	S	Temp.
Target	0.5 ~ 0.9%	0.5 ~ 1.0	< 0.14	< 0.050	1,400 ~ 1,450 °C
Expected average value	0.7	0.6	0.12	0.045	–

(2) Preconditions of operation

Production plan and main materials blending ratio and yields are shown in *Table 13-8-2* and *Table 13-8-3* as preconditions.

1) Production plan

Table 13-8-2 Production plan

		Production quantity 1,000 t/y	
		As cast basis	Molten steel basis
1. Slab			
Plate		100.0	104.2
Cold rolled	Galvanized plate	250.0	260.4
	Tin plate	200.0	208.3
	Sheet and coil	230.0	239.6
Hot rolled		270.0	281.2
Pipe		150.0	156.2
(Slab subtotal)		1,200.0	1,250.0
2. Bloom			
(Bloom subtotal)		300.0	319.0
As cast slab and bloom total		1,500.0	1,569.0

2) Main materials blending ratio and yields

Table 13-8-3 Main materials blending ratio and yields

			%
1) Main material blending ratio		Hot metal + Cold pig iron Ratio	83.0 + 2.0
		Scrap Ratio	15.0
2) Yield		Molten steel yield (to main materials)	93.0
	Ingot	Sound ingot yield (to molten steel)	98.0
	Slab	Slab as cast yield (to molten steel)	96.0
	〃	Conditioning yield (to slab as cast)	98.5
	〃	Slab slitting yield	99.24
	Bloom	Bloom as cast yield (to molten steel)	94.0

3) Operating conditions

Basic items for operating conditions are shown in *Table 13-8-4.*

Table 13-8-4 Operating conditions of the B.O.F. plant

		Planned value
1) Operating time	1-1) Annual operating days	341 d
	1-2) Monthly operating days	28 d
	1-3) Periodical shutdown maintenance	2 d/month (12 hr x 4/month)
2) Operating rate	(Total steelmaking time/Operable time)	74 %
3) Steel tapped per heat	(tons)	Average 155 t MAX 160 t
4) Steel tapped (tons)	Annual tannage	1,569,000 t
	Monthly tannage	130,800 t
	Daily tannage	4,670 t
5) Steel tapped (heats)	Annual heats	10,123 heat
	Monthly heats	844 heat
	Daily heats	30 heat
6) Daily steel tapped by destinations (tons and heats)	Slab continuously cast	3,730 t (24 heat)
	Bloom continuously cast	940 t (6 heat)
7) Steelmaking time	(Tap to Tap)	Average 36 min/heat
	Breakdown Charging	5 min.
	Blowing	16 min.
	Killing	7 min.
	Tapping	5 min.
	Slagging-off	3 min.

13-8-3 Equipment plan

(1) Equipment specifications

Table 13-8-5 outlines equipment specifications of the B.O.F. plant. Function and conception of plan of each equipment are outlined below.

1) Torpedo desulphurization equipment

As outlined in *Table 13-8-1*, the average sulphur percent of hot metal is as high as

0.045%, and it is difficult to attain stable product quality and casting operation, when the sulpher content is left as it is. The torpedo car desulphurization equipment that treats a large volume of hot metal is planned to cope with this problem.

2) Hot metal handling equipment

Tropedo cars with capacity of 320^t shall be used to carry hot metal from the blast furnace plant to the B.O.F. plant. Since a tropedo car has an average capacity of 2 heats or more of a furnace and temperature drop of hot metal inside the torpedo car is very small, no mixing furnace shall be installed, which reduces the investment cost. Hot metal is poured from the torpedo car to a hot metal ladle in the hot metal receiving pit. Since the hot metal ladle is placed on the weighing car (240^t), the discharging weight shall be indicated continuously, enabling accurate discharge of the required weight of hot metal.

The dust produced then is collected by a hood and removed by a bag filter (9,000 m^3/min).

Maximum molten iron volume	:	170^t
Molten iron ladle weight	:	60^t
Margin	:	10^t
Total	:	240^t

3) Scrap handling equipment

Three scrap pits shall be installed at the end of the south-west side of the material handling bay to receive scrap from the scrap yard. Assuming that the minimum hot metal ratio as 75%, the capacity of a scrap charging box is fixed as 45^t, and two weighing machines (90^t) shall be installed between the scrap pits. Two 15^t lifting magnet cranes shall be used to load scrap into the charging box.

4) Converter equipment

A furnace of nominal capacity of $160^{t/heat}$, inner volume of 155^{m^3} (specific volume 0.97), height-to-diameter ratio (H/D) of 1.30, and the basic dimensions of H = $9{,}000^{mm}$ and D = $7{,}000^{mm}$ shall be used.

The tilting device shall be driven by DC motors, and rotating speed can be arbitrarily selected between 0.1 and 1 rpm by notch control.

5) Oxygen blowing equipment

To attain 36-minutes tap-to-tap time, the oxygen blowing equipment shall be designed as the average blowing time is 16-minutes and oxygen flow rate of a lance is 36,500$^{Nm^3/hr}$. The capacity of an oxygen supply pipe and pressure and flow rate control shall be at maximum 40,000$^{Nm^3/hr}$. Lance quick change system by remote control is also planned.

6) Sublance equipment

Blowing control has a great influence on the efficiency, yield, quality, and cost of converter operation. The simultaneous hitting ratio by the static control is as low as 30~40%, which can be increased to 70% or higher by introducing a sublance system. By the sublance method, sublance measurement is made 2 minutes before the blow end, in which the temperature and carbon content of the molten steel shall be mesasured and samples shall be taken to judge the blow-off time and coolant weight.

7) Waste gas processing equipment

As an postive energy saving measure, waste gas processing equipment of noncombustive recovery type shall be installed for two converters. The waste gas volume is planned at approximately 100,000$^{Nm^3/hr}$, which is calculated from the maximum oxygen flow rate and charged iron ore weight.

The dust content in the waste gas after dust collection shall be 0.1$^{g/Nm^3}$ or less. Waste gas shall be burned and discharged from one 75-m-high tri-pod stack during nonrecovery operation. Gas shall be recovered by switching the three-way valves to the recovery side and sending the gas into the LDG holder.

8) Fluxes handling equipment

Fluxes except burnt lime shall be received by trucks in the underground bunker, which shall be made up of a total of 8 bunkers of 5 brands. The fleuxes shall be transferred into the high-level bunkers via the conveyer belts, which shall be joined by the burnt lime conveyer.

High-level 8 bunkers of 6 brands for each furnace are installed above the two furnaces. The flux charging equipment is planned to be able to charge fluxes during blowing operation for manufacturing high-quality steel.

9) Ferro-alloy handling equipment

Ferro-alloys shall be loaded into buckets in the material warehouse, and carried into the BOF plant by trucks. Buckets shall be hoisted, carried and charged by a 5^t telpher to the ferro-alloy bunkers. After the brand and quantity of ferro-alloy are determined according to the steel grade and the blow-off conditions for each heat, the ferro-alloys are charged into the weighing hopper for weighing.

Ferro-alloys shall be charged into a teeming ladle via a charging chute during the tapping operation.

10) Ingot making equipment

The top pouring on teeming cars (two 250^t teeming cars for 1 heat) shall be taken as the ingot making method, and a teeming platform for 2 heats (for 4 teeming cars) shall be installed in the teeming bay. Mold operation (stripping, cooling, conditioning, and setting), and ingot operation shall be made in the adjacent mold and ingot treatment yard, which separates the mold operation from ingot teeming operation. The stripped ingots shall be carried out by ingot cars to the storage yard for shipment.

To enable to continue steel melting operation even when one of the three continuous casters breaks down, the capacity of the ingot making equipment is set to handle $6^{heats/d}$.

11) Molten steel transportation equipment

The molten steel tapped from a converter shall be charged into a teeming ladle, a capacity of 160^t, and carried to the teeming bay by molten steel ladle cars, a capacity of 240^t. The teeming ladle is hoisted by a 240^t molten steel ladle crane, and carried into three continuous casters (in case of emergency, part of the molten steel is also carried to the ingot teeming yard).

Capacities of molten steel ladle car, molten steel ladle crane, and molten steel returning traverser.

Maximum molten steel volume	:	160^t
Casting ladle weight	:	70^t
Margin	:	10^t
Total	:	240^t

Table 13-8-5 Equipment specifications of B.O.F. plant

Division	Item	Specifications	
		Stage I	Stage II
1	Torpedo car desulphurization equipment		
01	Torpedo car desulphurization equipment	CaC_2, lance blowing Processing capacity: 2.5 $^{mil.\ t/Y}$ x 1	
02	Torpedo car deslagging equipment	Sealed type x 1	
03	Dust collector	Bag filter type 3,000 $^{Nm^3/min.}$ x 1	
2	Hot metal handling equipment		
01	Hot metal charging ladle	170^{t} x 3	170^{t} x 2
02	Hot metal weighing car	Electrically self-travelling type 240^{t} x 2	
03	Hot metal ladle deslagging machine	Cylinder type x 1	
04	Hot metal ladle transfer and molten steel returning car	Electrically self-travelling type 240^{t} x 1	
3	Scrap handling equipment		
01	Scrap chute	45^{t} x 3	45^{t} x 1
02	Scrap weighing machine	90^{t} x 2	90^{t} x 2
03	Scrap pit	800 m^2	
04	Scrap yard facilities		
	1) Scrap storage	150^{m} x 230^{m} (35,000 m^2)	1 set
	2) Scrap gas-cutting device	Oxy-acetylene cutting method x 2	
	3) Crawler crane	25^{t} x 2	

Division	Item	Specifications: Stage I	Specifications: Stage II
04	4) Pylon	3-column winch type x 1	
	5) Cutter of coolant	$3^{t/hr}$ x 2 (2-ton jib crane x 1)	
	6) Coolant box	3^{t} x 15	
4	Furnace equipment		
01	Furnace proper	Nominal capacity: $160^{t/heat}$ x 2 (Average: $155^{t/heat}$) Inner volume: 275 m^3 approx. Inner volume (after bricklaying): 155 m^3 approx. Furnace height: $9,000^{mm}$ approx. Furnace diameter: $7,000^{mm}$ approx.	1
02	Furnace tilting device	2 Single-side-drive, 4-motor, Shaft-mounted type Tilting speed: 0.1 – 1.0^{rpm}	1
5	Oxygen blowing system		
01	Lance and its accessories	For 2 converters Oxygen blowing capacity: Average 36,500 Nm^3/hr Lance diameter: 250^{mm} dia. approx. Flexible hose for oxygen (Made of copper): 1 unit Flexible hose for cooling water (Made of natural rubber): 1 unit	For 1 converter
02	Lance lifting device	Quick change type x 4	x 2
03	Oxygen blowing pressure control device	2 systems Piping capacity: 40,000 Nm^3/hr	1 system

Division	Item	Specifications	
		Stage I	Stage II
04	Lance cooling water equipment	1 Cooling method: Cooling tower Water volume: 200 t/hr	1
6	Sublance equipment	With probe mounting/demounting device 2	1
7	Waste gas treating equipment		
01	Converter waste gas treating equipment	2 Type: Non combustion type Capacity: Waste gas volume: 100,000 Nm^3/hr Dust density: 0.1 g/Nm^3 Blower: 100,000 Nm^3/hr x 2	1
02	Stack	Tri-pod type 75 m high x 1	
03	Cooling water equipment	Closed and circulating type 1	1
04	Dust collector for furnace mouth, hot metal receiving pit, and deslagging equipment	1 Type: Bag filter Capacity: 9,000 m^3/min. approx.	1 Type: Bag filter Capacity: 5,000 m^3/min. approx.
8	Flux transport and charging equipment		
01	Underground bunker equipment	1 5 brands, 8 bunkers	
02	Transport equipment	1 Conveyer belt transport method	Partial extension of high-level equipment
03	High-level bunker	2 6 brands, 9 bunkers	1

Division		Item	Specification	
			Stage I	Stage II
	04	Flux weighing and charging equipment	2 (Chargeable during blowing)	1
9		Ferro-alloy transport and charging equipment		
	01	Ferro-alloy transport equipment	5T monorail hoist method x 1	
	02	Ferro-alloy high-level bunker	2 5 brands, 5 bunkers	1
	03	Special-alloy high-level bunker	2 2 brands, 2 bunkers	1
	04	Ferro-alloy charging equipment	2	1
10		Converter brick lining equipment		
	01	Relining tower	1	
	02	Lining breaker	Unishovel type x 1	
	03	Brick receiving ladle	$45^{t} \times 2$	
	04	Brick cutter	Electrical brick cutter x 1	
11		Auxiliary equipment		
	01	Elevator	For goods x 1 For passengers x 1	
	02	Shovel bulldozer	$2^{t} \times 2$	$2^{t} \times 2$
	03	Forklift	$2^{t} \times 2$	$2^{t} \times 2$
	04	Miscellaneous piping	1 O_2 piping N_2 piping Air piping COG piping Ar piping Miscellaneous water piping	1

Division	Item	Specifications	
		Stage I	Stage II
05	Air conditionner	1	1
06	Sump pump and piping	1	1
07	Temperature measuring equipment	5 Hot metal ladle, in front and back of furnaces	2 In front and back of converter
08	Infra plant communications equipment	3 systems (1) ITV camera x 1, Monitor x 8 (2) 8 interphone stations (3) 2 paging systems (10 stations each)	Extended
12	Molten steel transport equipment		
01	Molten steel ladle	160^t x 15	160^t x 8
02	Molten steel ladle car	Electrically self-travelling. 240^t x 2	240^t x 1
03	Molten steel ladle tilting device	Winch-wire tilting method 240^t x 2	
04	Ladle nozzle setting and detouching device	Hydraulic (70 kg/cm^2) x 2	
05	Sliding nozzle operating device	Hydraulic x 3	
06	Ladle repair facilities	1 Repairing platform: 5 stands	1
07	Ladle drying facilities	4 Upright drying, COG burner 8 hours for 800°C	4
13	Ingot making facilities	(See transport equipment column for transport equipment)	
01	Teeming platform	For 2 heats	

Division	Item	Specifications: Stage I	Specifications: Stage II
02	Sliding nozzle operating device	Hydraulic x 1	
03	Mold cooling yard	500 m^2	
04	Stripping and mould setting platform	For 2 heats	
05	Accessories	Mold repair tools x 1 set	
14	Slag disposal equipment	(See transport equipment column for transport equipment)	
01	Slag treatment facilities	1 Slag yard area: 4,500 m^2 approx. Shovel bulldozer: 2^t x 3 Shovel car: 1.5^t x 2 Cold slag charging equipment: 1 set Accessories: 1 set	1
15	Crane equipment		
01	Hot metal charging crane	$240^t / 40^t$ x 1	$240^t / 40^t$ x 1
02	Scrap charging crane	$90^t / 75^t$ x 1	
03	Scrap loading crane	15^t x 2 With lifting magnet crane	15^t x 1
04	Converter service crane	30^t x 1 Radio-operated crane	
05	Molten steel ladle service crane	$60^t / 20^t$ x 1	
06	Molten steel crane	$240^t / 40^t$ x 2	
07	Stripper crane	35^t x 1	
08	Wall crane	5^t x 1	5^t x 1
09	Crane repair hoist	7^t x 3 and 5^t x 3	7^t x 1 and 5^t x 1

Division	Item	Specifications	
		Stage I	Stage II
16	Electrical equipment		
	Power supply equipment and materials for electrical work	1	1
	Plant lighting and work materials	1	1
	Trolley line and materials for power work	1	1
17	Instrumentation		
	Control equipment for oxygen blowing and converter waste gas treating	1	1
	Control equipment for molten steel temperature measuring	1	1
	Control equipment for hot metal and scrap weighing	1	1
	Control equipment for fluxes and ferro-alloys charging	1	1
	Others		
18	Civil	1	1
19	Buildings	1	1
20	Water works	1 Plant drainage and piping facilities	1 Plant drainage and piping facilities

(2) Process flow

Fig. 13-8-1 outlines the production process flow from the B.O.F. plant to the continuous casting plant.

(3) Raw materials-product balance

Fig. 13-8-2 shows the raw materials-product balance in each plant of B.O.F. and continuous casting plants.

(4) Equipment layout

Fig. 13-8-3 shows the layout of the B.O.F. CC , and lime calcining plants.

The plant layout as shown in *Fig. 13-8-3* is so planned that the furnaces are placed on the center part of the B.O.F. plant, which prevents interference between the charging operations of raw materials such as hot metal and scrap and handling operations of molten materials such as steel and slag.

The ladle preparation bay shall be installed between the converter plant and the continuous casting plant to prevent interference with each other.

Scrap loading into the charging box shall be made in the material handling bay, and 2-stages run way girders shall be installed to run the scrap charging crane and loading cranes.

The plant layout is designed to be compact, considering easy construction and operation in case of "2 out of 3" furnace operation in the future.

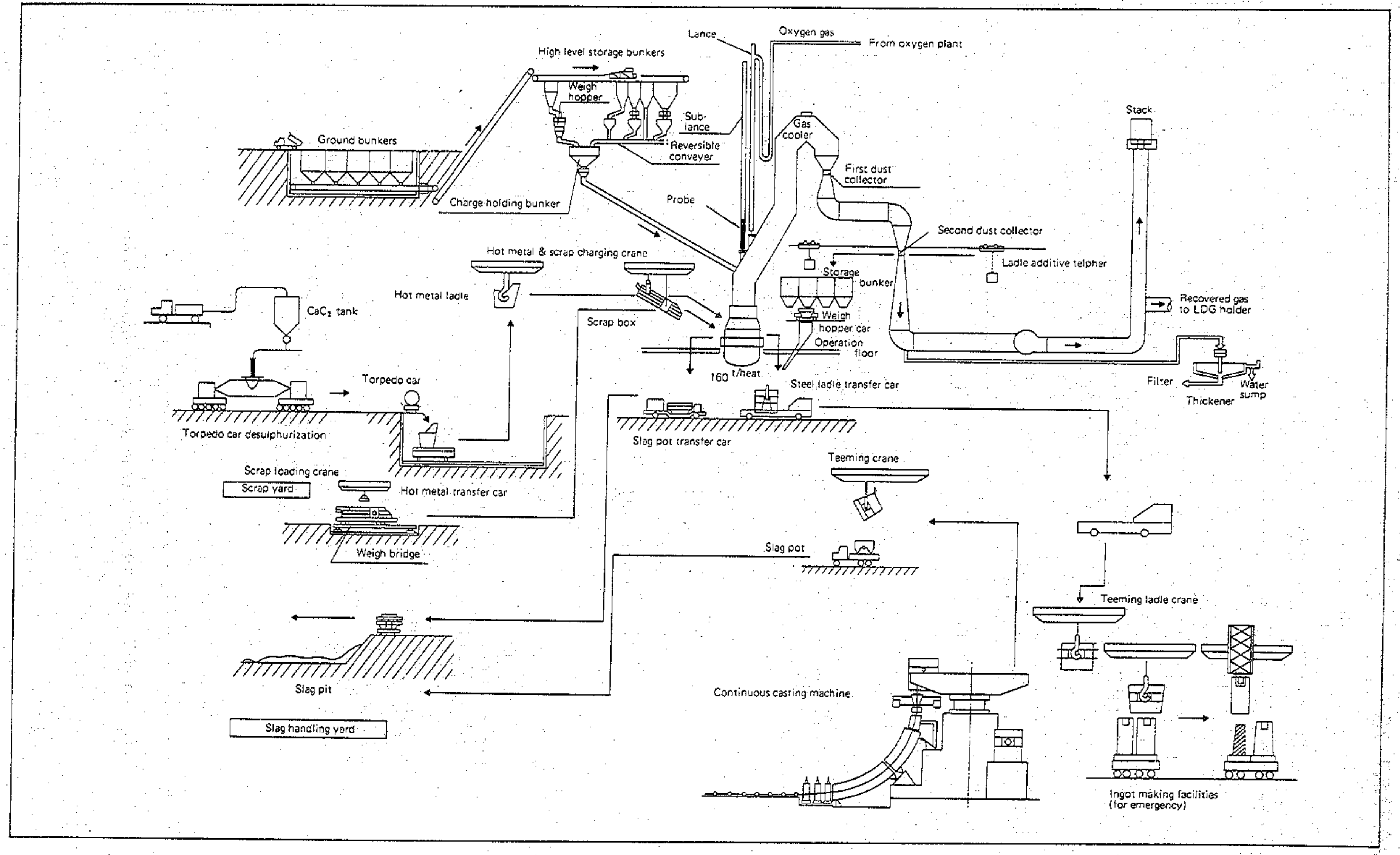

Fig. 13-8-1 Process flow of steel making