of natural gas. Heat of the reformer is supplied by two burner systems. The main burner supplies heat required for reforming reaction, and part of the top gas is mixed with natural gas and burnt by preheated hot air. The auxiliary burner serves to make up for heat loss through reformer shell and only natural gas is used as fuel.

(3) Heat recovery

To recover heat of waste gas of the reformer, a heat exchanger of shell and tube type is installed, and the heat is used to preheat combustion air as well as gas before reforming, thereby reducing unit consumption of fuel and facilitating reforming reaction.

6-3-4. Specifications of main facilities

Table 7-6-14 List of Major Equipment & Their Specifications

No.	Equipment or System	Q'ty	Description
1.	Direct reduction furnace	2	Shaft furnace equipped with charge hopper, slide gates, burden feeders and discharge feeder
2.	Reformer	2	200 mm dia. tubes with catalyst
3.	Top gas scrubber	2	Venturi and packed tower type
4.	Cooling gas scrubber	2	- ditto -
5.	Reformed gas cooler	2	Packed tower type
6.	Seal gas cooler	2	- ditto -
7.	Recuperator	4	Shell & tube type heat exchanger
8.	Stack	2	Height: Approx. 40m
9.	Process gas compressor	6	Positive displacement type rotary lobe compressor
10.	Cooling gas compressor	2	- ditto -

No.	Equipment or System	Q'ty	Description
11.	Main air blower	2	Centrifugal type air blower
12.	Auxiliary air blower	2	- ditto -
13.	Seal gas compressor	2	Screw type compressor
14.	Mist eliminator	2 sets	For process gas, cooling gas & seal gas
15.	Piping system	2 sets	Including valves and fittings
16.	Dust collection system	4 sets	Composed of cyclone, venturi scrubber, fans and dust storage bin
17.	Compressed air system	1 set	Composed of plant air receiving tank, instrument air dryer and instrument air receiving tank
18.	Briquetting system	1 set	Capacity: 15 t/h
19.	Water system	2 sets	Composed of clarifier, cooling tower and pumps
20.	Electrical and instrumentation	2 sets	Max. capacity: 23.6 MVA
21.	Product storage bin	3	Capacity: 4,500 m^3x3 equipped with feeder
22.	Oxide day bin	6	Capacity: 550 m^3x6 equipped with feeder
23.	Material handling system	2 sets	Composed of screens, belt scales and belt conveyors

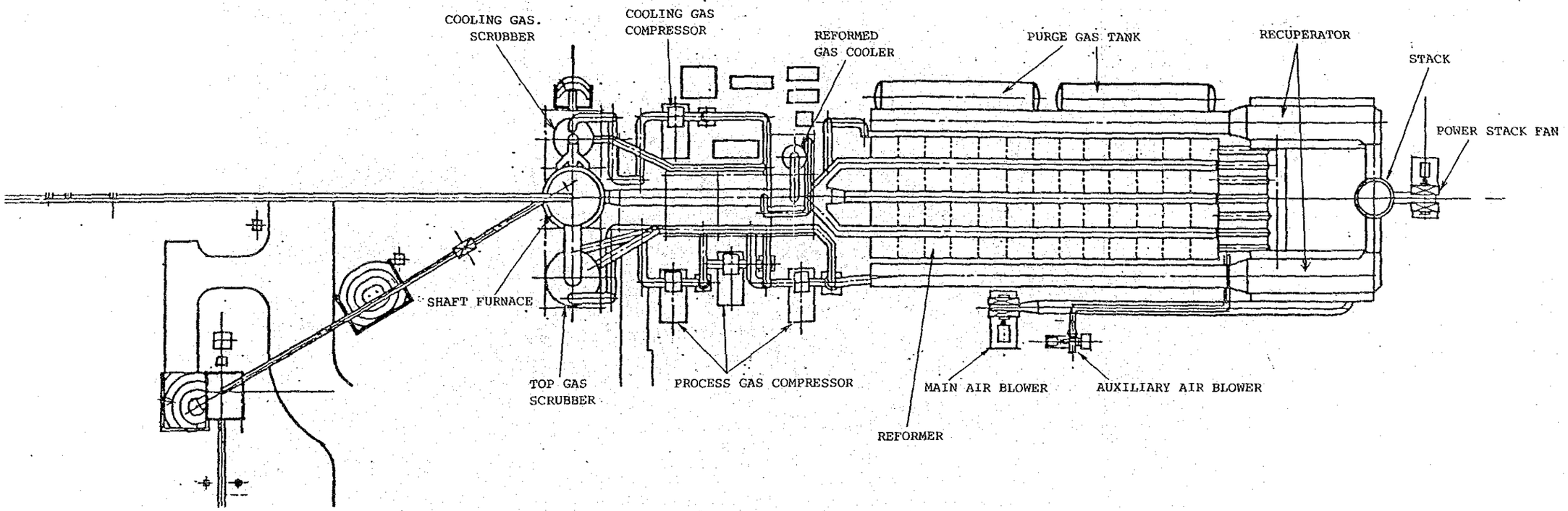


Fig. 7-6-18 Plane Figure of D.R.

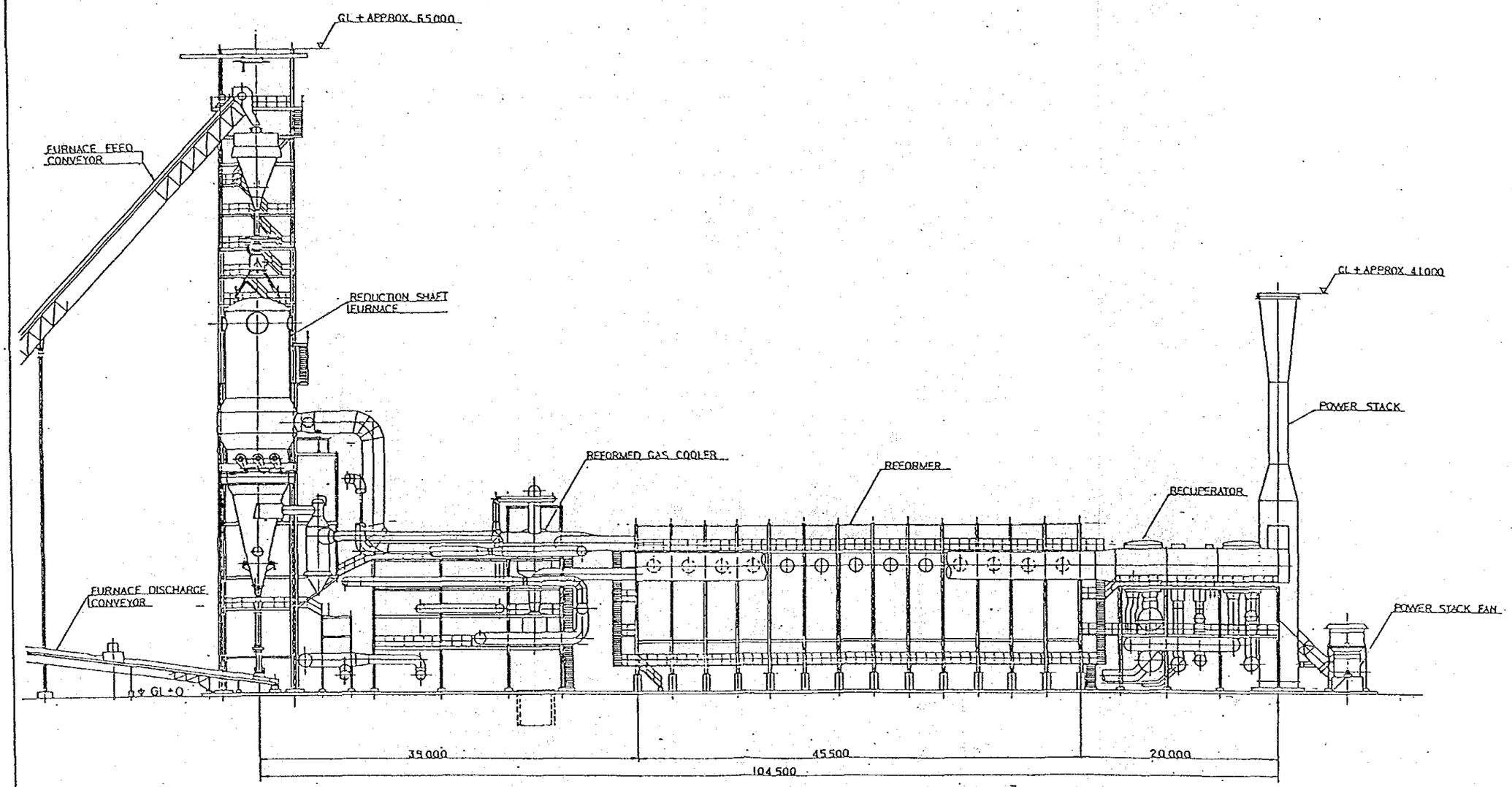


Fig. 7-6-19 Front View of D.R.

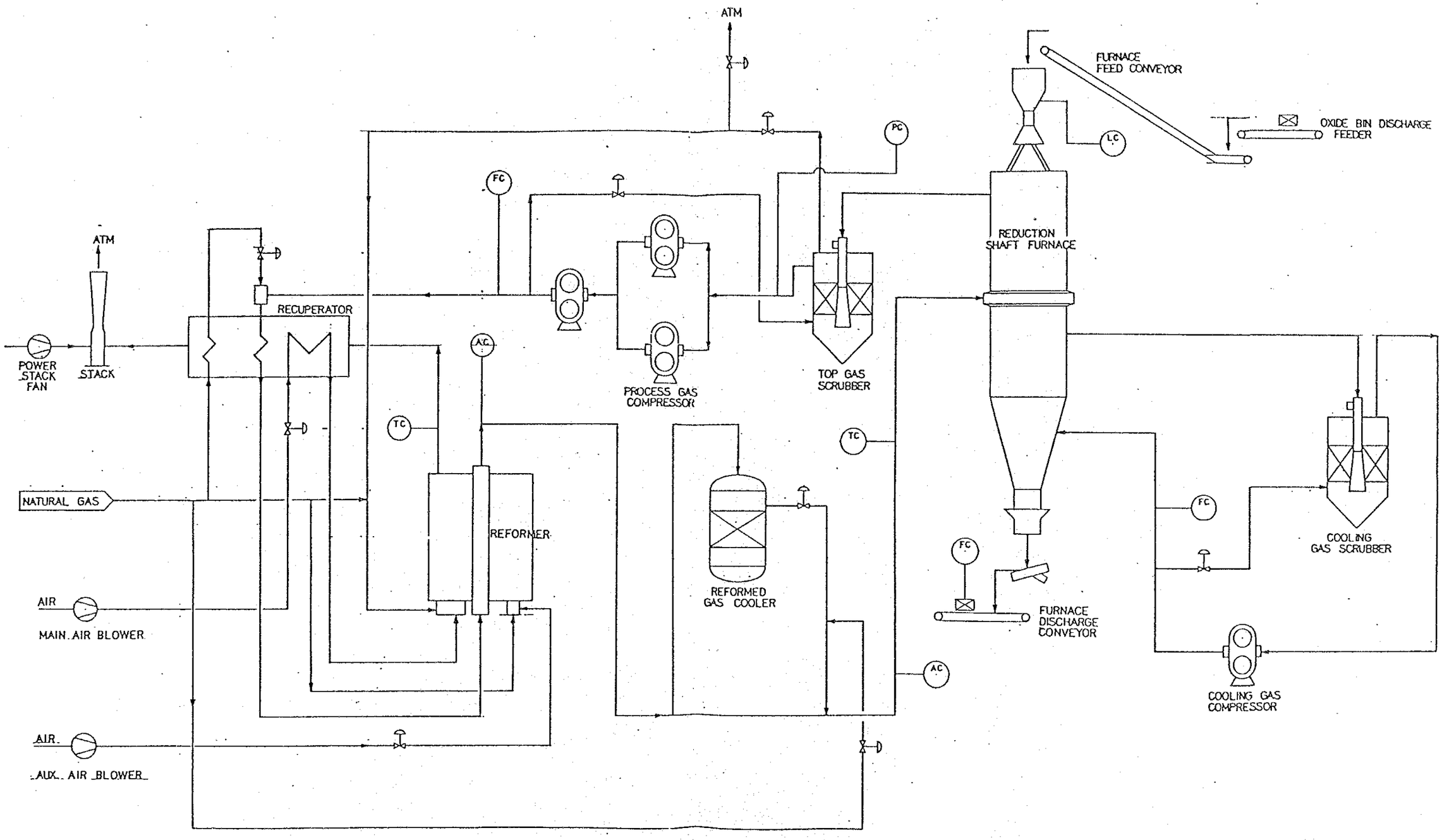


Fig. 7-6-20 Process Flow Schematic

6-4. Lime calcining plant

6-4-1. General

Burnt lime (CaO) is used for refining molten steel (EAF & LF), and it is produced by calcining limestone. Facilities listed under "calcining plant" are

1) facilities for receiving limestone (called raw limestone) and charging it into calcining plant
2) equipment for washing and classifying raw limestone and raw limestone hopper
3) facilities for storing and delivering burnt lime and utilities such as power, water and fuel to be necessary for operation of this plant and including operation control systems.

Burnt lime in size of 3 mm and above is supplied for refining and transported by belt conveyor from calcining plant to EAF and LF.

(1) Production capacity and number of units

Unit consumption of burnt lime at EAF and LF:
42 kg/t liquid steel

Annual crude steel production:
1,604,000 t liquid steel

Annual requirements of burnt lime:
42 kg/t x 1,604,000 t = 67,368 t = 67,400 t/y

Annual working days of calcining kiln:
350 days (as periodical repair is 15 d/y)

Yield (Burnt lime for EAF÷Burnt lime production):
92%

Allowance 15%

Consequently, planned daily production:

[(67,400 t/y ÷ 0.92) ÷ 350 d/y] x 1.15 = 240.7 t/d

To minimize the decrement of burnt lime production during shut down for kiln repair, two shaft kilns are desirable.

Daily production per unit: 240 t/d ÷ 2 = 120 t/d

(2) Component of raw limestone

1) Chemical composition

Loss of ignition	44%
CaO	55% min.
MgO	0.50% max.
Fe_2O_3	0.01% max.
Al_2O_3	0.50% max.
SO_3	0.04% max.
P_2O_5	0.08% max.

2) Size and others

Compressive strength	1,200 kg/cm^2 min. (1 cm^3 sample)
Size	20-40 mm
20-30 mm	55% max.
30-40 mm	45% min.
Adhering clay	2% max.

(3) Quality of burnt lime

1) Chemical composition:

P	0.060% max.
S	0.030% max.
Residual CO_2	3.5% max.

2) Size: Effective size 3 mm min.

3) Reactivity >150 ml -4N HCl
(25 g sample, 10 min.)

(4) Yield in production process and raw limestone quantity required

1) Yield

Burnt lime/Raw limestone (washed)	53.0%
Burnt lime for EAF/Burnt lime	92.0%
Fines/Burnt lime	8.0%

2) Quantity required of raw limestone:

(67,400 t/y ÷ 0.92) ÷ 0.53 = 138,228 t/y

138,228 t/y ÷ 350 d/y = 394.9 t/d

(5) Operation condition

Continuous operation for 350 d/y
Receiving and washing raw limestone by 2 shifts.(morning shift to afternoon shift)
Working rate: 0.66 [(8 h/shift x 2) ÷ 24 h/d]

6-4-2. Selection of the process

Though rotary kiln process also is used to produce burnt lime, shaft kiln process was selected for the following reasons.

1) Operating cost is low; fuel consumption is about 60% of that of rotary kiln process.
2) Area occupied per unit of production is compact.
3) Repair time is short and relining less frequent.
   Rotary kiln requires relining usually every 4 - 6 months, which calls for stocking burnt lime in the quantity equal to one week's consumption during the period. Burnt lime quantity required for stocking:
   240 t x 7 days = 1,680 t
   Therefore, burnt lime storage bins have to be big.
   Shaft kiln is shut down usually once a year for about 15 days for repair.

6-4-3. Plant description

Shaft kiln is installed on the north side of EAF building.

Sized raw limestone is transported to the open raw limestone yard for storage.

Raw limestone is carried by shovel loader to the receiving hopper and washed and classified. Limestone in size 20 mm or more is stocked at the raw limestone hopper. Raw limestone discharged from the hopper is weighed to specified quantity and charged into shaft kiln.

Burnt lime is discharged from the bottom of the shaft kiln and measured and classified by 3 mm screen.

Large size is sent to product bins and smaller size to designated bins.

Burnt lime in the product bins is discharged and loaded directly on exclusive dump truck or transported by conveyor to EAF plant. Signal for discharge to EAF is input with operation panel of DRI/burnt lime delivery system installed at EAF plant. The shaft kiln is to be equipped with dust collector for fine dust generated.

One central operating room is provided for 2 units of shaft kiln.

Fine powder of washed and screened limestone and undersized burnt lime are sent to disposal yard by exclusive dump truck. Undersized burnt lime may be used partly for water treatment and soil improvement.

From the storage hopper, burnt lime is transported by conveyor to EAF plant, and there are DRI bin and burnt lime bin in front of each EAF.

For charging burnt lime into clamshell bucket for EAF, burnt lime hopper is installed right above the buggy for the clamshell bucket in EAF plant building.

6-4-4. List of major equipment

Table 7-6-15 List of Major Equipment of Calcining Plant

Name	Q'ty	Specification
1 Limestone washing and screening	1	Conveyor(s) 70 t/h
2 Limestone charging	2	70 t/h
3 Calcining furnace	2	4.4 m dia. 120 t/d
4 Calcining furnace auxiliary	1	
5 Waste gas treatment	2	330 m^3/min.
6 Burnt lime hopper	1	250 t
7 Burnt lime handling	1	Conveyor(s)

Table 7-6-15 List of Major Equipment (Cont'd)

8	Shovel loader for limestone	2	3 m^3
9	Diesel engine generator	1	35 kVA
10	Lubrication system	1	
11	Supervisor for construction and commissioning		Included
12	Utility facilities	1	Wire, pipe, etc. included
13	Buildings	2	Calcining pulpit and IDF motor room

6-4-5. Utilities

1) Electricity

	Equipment Capacity	
3.3 kV high voltage		
Blower for calcining furnace	260 kW x 2	(200 kWx2)
415 V low voltage		
Raw stone line	40 kW	(20 kW)
Product line	50 kW	(25 kW)
Total	610 kW	(445 kW)

Figures in parentheses show actually consumed power.

445 kW x 350 days x 24 hrs = 3,738 MWh/y

2) Water

Cooling water for equipment:

40 lit/min. x 1,440 min/d x 2 x 350 days

= 40,320 t/y Recycled

However, assuming water evaporating loss to be 3%, water supply is 40,320 t/y x 3% = 1,210 t/y.

Washing water for equipment:

60 lit/t of raw stone unrecycled

Unrecycled water is untreated water (raw water usable)

[(60 ℓ/t x 240 t/d) ÷ 0.53] x 0.66* x 350 d/y

= 6,300 t/y.

* working rate (See page 321)

3) Fuel

Thermal value required to calcine raw lime stone:

930 kcal/kg

Burnt lime quantity for EAF and LF:

67,400 t/y ÷ 0.92 = 73,260 t/y (See page 319)

Annual thermal value required for calcining:

930 kcal/kg x 73,260 t/y = 68,100 x 10^6 kcal/y

In case of natural gas, calorific value:

9,165 kcal/N.m^3

Consequently, annual gas volume to be required:

(68,100 x 10^6 kcal/y) ÷ 9,165 kcal/N.m^3

= 7.4 x 10^6 N.m^3/y

4) Nitrogen For meter purging 25 A x 1

6-4-6. Drawings

1) Fig. 7-6-21 Planned Drawing of EAF Plant
2) Fig. 7-6-22 Process Flow Diagram

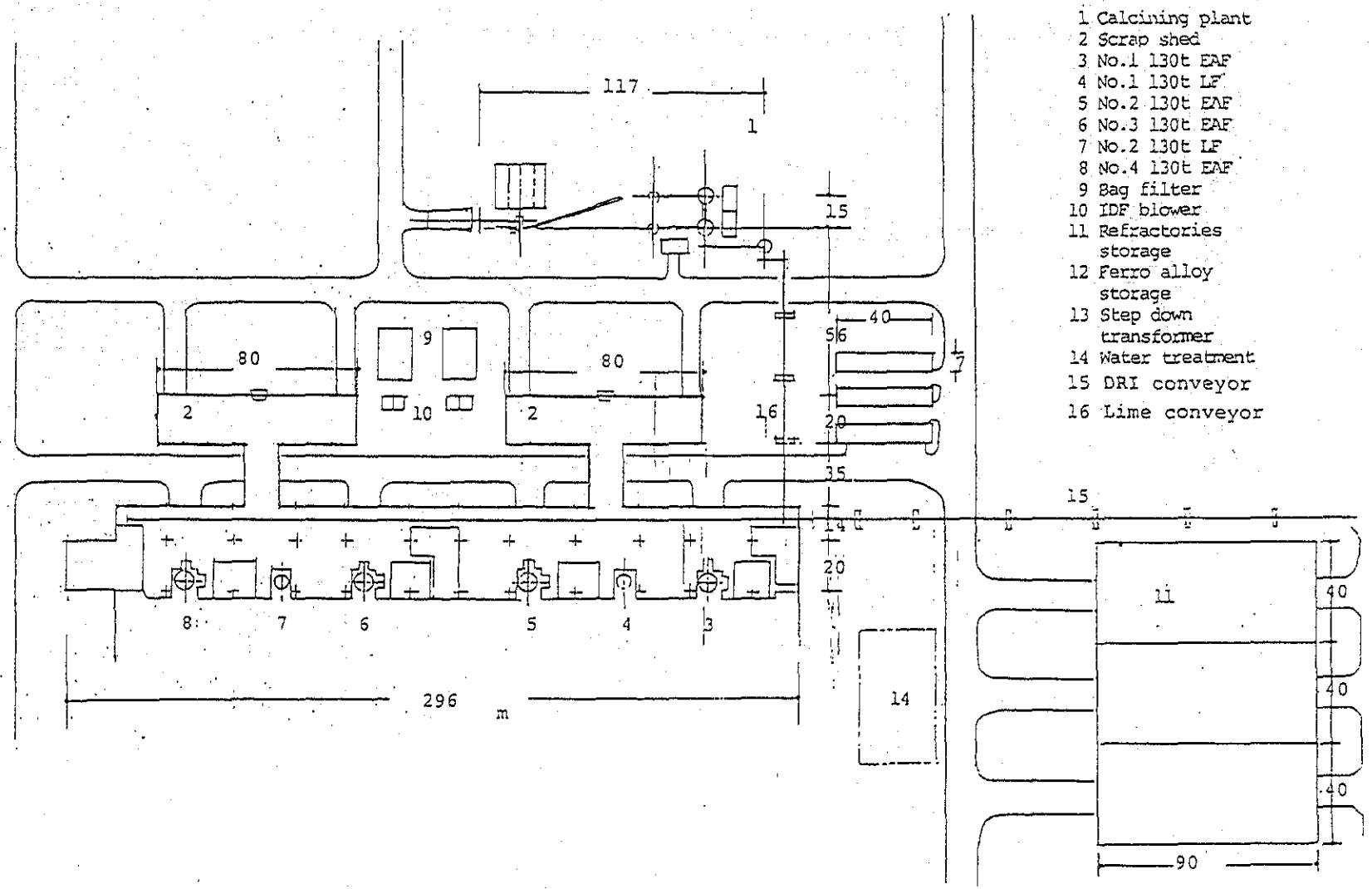


Fig. 7-6-21 The Schematic Arrangement of Steelmaking Shop.

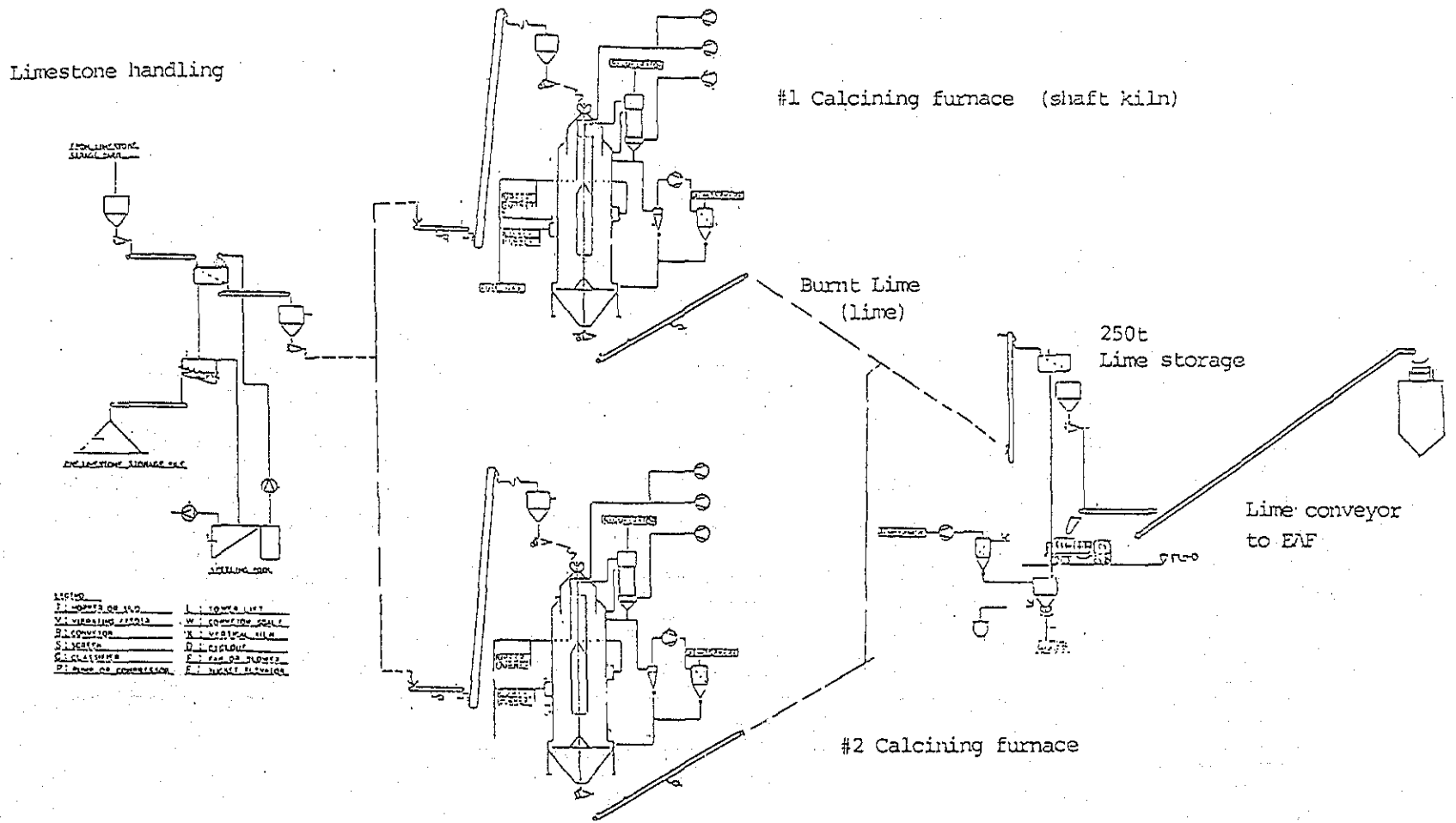


Fig. 7-6-22 The Process Flow Chart of Calcining Plant

6-5. Electric arc furnace (EAF)

6-5-1. General

The EAF plant is the steelmaking facilities to melt and refine the annual requirements of molten steel of 1,604,000 tons. Capacity and the number of EAF to be installed are decided by determining annual operating days of the EAF on the basis of operating rate of CC facilities to cast the molten steel.

The main equipment are two 130 ton EAFs and one 130 ton-LF forming one unit in compatible with one unit of CC facilities. The two units of those equipment are installed.

Iron raw materials charged into EAF are DRI and scrap. There are installed the facilities to charge those materials into the furnace.

Quantities of fume and dust generated from EAF are to be collected by dust collector.

The facilities listed under "EAF plant" include mainly EAF, LF, DRI/burnt lime conveying facilities, scrap facilities, ferro-alloy warehouse, low voltage power source for EAF, and step-down transformer (25 kV/ 3.3 kV) and materials warehouse in steelmaking shop area, but does not include water treatment facilities, molten steel receiving ladle and subsequent facilities and sub-centers in steelmaking shop area.

6-5-2. Design conditions

1) Tap to tap

As the molten steel is produced by two EAFs and refined by one LF and sent to CC, tap to tap time of EAF is to be 120 minutes to meet 60 minutes pitch delivery of molten steel to CC.

(EAF)

Scrap charging	5 minutes
Start of scrap melting to start of DRI charging	15 "
DRI charging	75 "
Temperature adjustment	5 "
Tapping	5 "
Repair including electrode connection	15 "
Total tap to tap	120 minutes

(LF treatment)

Slag off	10 minutes
Ferro-alloy addition and temperature adjustment	30 "
Total	40 minutes

2) Annual production

(1) Annual operation time:

[EAF] (4-group, 3 shift continuous operation)

Calendar day/y	365 days	8,760 hrs
Scheduled shut-down time:		
Minor repairs	-35 days	-840 hrs
Major repairs	-5 days	-120 hrs
Sub-total	325 days	7,800 hrs
Unscheduled shut-down time:		
5% (325 days x 0.05)	-16 days	-384 hrs
Total (operation time for EAF):	309 days	7,416 hrs

[C.C.]

Operation cycle time:

As casting time is 65 min./heat and basical operation pattern is seven sequence casting.

Casting time 65 min/heat x 7 c-c = 455 min/cycle		
Dummy bar setting and others		60 min/cycle
Sub-total		515 min/cycle

Number of 7 c-c: (7,416 hrs/y x 60 min/hrs) ÷ 515 min/cycle = 864 cycle/y

Dummy bar setting time: (864 cycle/y x 60 min/cycle) = 36 days

	-36 days	-864 hrs
Sub-total	273 days	6,552 hrs

Unscheduled shut-down time:

5.5% (273 days/y x 0.055)	-15 days	-360 hrs

Grand total (operation time for sequence c-c):

258 days	6,192 hrs

(2) Number of heats required:

(6,192 hrs/y x 60 min/hr) ÷ *120 min./heat = 3,096 heats/y

* Tap to tap time.

3) Capacity of EAF

Capacity of EAF: (1,604,000 t/y ÷ 3,096 heats/y) ÷ 4 EAFs = 129.5 t/heat EAF = 130 t/heat EAF

Therefore, combination of EAF and LF is as follows:

[(130 t EAF x 2) + (130 t LF x 1)] unit x 2 lines

4) Yield Based on Midrex process, DRI 75% and scrap 25%

DRI	750 kg x 91.4% T.Fe x 97% =	665 kg
Scrap	240 kg x 90.0% T.Fe x 97% =	210 kg
Mill scale	10 kg x 40.0% T.Fe x 97% =	4 kg
Total	1,000 kg	879 kg

1,000/879 = 1,138 kg/liq. t

Yield of liquid steel = liq. t÷(DRI+scrap+mill scale)
= 87.9% = 88%

where chemical composition of DRI (%) is

T.Fe	M.Fe	D.M.	FeO	C	P	S	SiO_2	Al_2O_3	CaO
91.4	85.0	93.0	8.3	1.5	0.02	0.01	1.5	0.5	1.4

MgO	Other
1.1	0.7

Gangue = 5.2%

5) Continuous feeding speed of DRI

DRI quantity per a heat: (130 t/heat ÷ 0.88) x 0.75
= 111 t/heat

DRI feeding time: 75 min. (See page 328)

Continuous feeding speed = 111 t/heat ÷ 75 min./heat
= 1.48 t/min. = 88.8 t/hr

As allowance in design base is 7%

88.8 t/hr x 1.07 = 95 t/hr, max. assumed.

6) Selection of EAF transformer capacity

Critical DRI continuous feeding speed: 28-30 kg/min.Mw

Continuous feeding speed: 1,480 kg/min.

Input power level: 1,480 kg/min ÷ 28 kg/min.Mw=52.8 Mw
1,480 kg/min ÷ 30 kg/min.Mw=49.3 Mw

If power factor at short arc is 70.7%, transformer capacity is calculated as follows:

52.8 Mw ÷ 0.707 = 74.7 MVA

49.3 Mw ÷ 0.707 = 69.7 MVA

Therefore, transformer capacity is made 75 MVA.

7) Base consumption unit of raw materials and auxiliary raw materials and annual consumption

Heat/day/furnace T-T 120 minutes 12 heats

Liquid steel production 1,604,000 t/y

	Consumption Unit, kg/t	Consump./y
Main raw materials:		
DRI	853.5	1,369,000 t
T.Fe 91.4% Fe equiv.	(780)	(1,251,120 t)
Scrap	273.1	438,100 t
Mill scale	11.4	18,300 t
Aux. raw materials:		
Burnt lime	42	67,400 t
Fluorspar	3.0	4,810 t
Fe-Mn	6.0	9,620 t
Si-Mn	4.0	6,420 t
Fe-Si	4.0	6,420 t
Coke	25	40,100 t
Carbon powder	15	24,060 t
Materials:		
Electrodes	6	9,620 t
Furnace wall brick	1.5	2,410 t
Furnace bottom refractory	0.2	320 t
Gunning material	25	40,100 t

8) Utilities

	Consumption Unit	Consumption/y
Electricity for melting	820 kwh/t	1,315,300 Mwh
Electricity for others	48 kwh/t	77,000 Mwh
Oxygen	4 m^3/t	6,420,000 m^3
Argon for LF		222,400 m^3
Nitrogen for LF		24,700 m^3

Note: Calculation on Ar and Nz

Assuming the following production condition, consumptions are calculated

(1) High carbon steel (C>0.25%): 20%

Steel production quantity = 1,604,000 t/y x 0.20
= 320,800 t/y

(2) Low carbon steel (C≤0.25%): 80%

Steel production quantity = 1,604,000 t/y x 0.80
= 1,283,200 t/y

1) In case of (1)

Blowing volume of Ar and N_2 per heat

Ar: (1,000 ℓ/min. x 10 min/heat)÷130 t/heat=77 ℓ/t

N_2: (500 ℓ/min. x 20 min/heat)÷130 t/heat=77 ℓ/t

Requirements: Ar=(320,800 t/y x 77 ℓ/t)÷1000 ℓ/m^3
=24,702 m^3/y

N_2=(320,800 t/y x 77 ℓ/t)÷1000 ℓ/m^3
=24,702 m^3/y

2) In case of (2)

Blowing volume of Ar per heat

Ar: [(1,000 ℓ/min. x 10 min/heat) +
(500 ℓ/min. x 20 min/heat)] ÷ 130 t/heat
= 154 ℓ/t

Requirements: (Ar = 1,283,200 t/y x 154 ℓ/min.)÷
1,000 ℓ/m^3 = 197,613 m^3/y

Total of Ar 24,702 m^3/y + 197,613 m^3/y = 222,315 m^3/y

Compressed air 56,160,000 m^3

Make up water 140 m^3/min.x3%x325 days=1,966 t/y
=2,000 t/y

9) Wastes

EAF dust	1%	16,040 t	unrecovered
Slag	135 kg/t	216,540 t	
Waste brick	0.2 kg/t	320 t	

10) Specifications of ferro-alloys and aux. raw materials

	Size, Grade	Bulk Density	Chemical Component
Burnt lime	10-40mm	1.0	CaO 90-94%, SiO_2 3-4% Ig. loss 2-3%
Fluorspar	10-80mm	1.5	CaF_2 75-83%
Coke	5-25mm	0.5	
Carbon powder	5-10mm	0.5	C 98%
Fe-Mn	20-60mm	3.5	Mn 73-78%, C 7.3%, Si 1.2% P 0.40%, S 0.04%
Si-Mn	20-60mm	3.3	Si 15%, Mn 62-65%, P 0.40% S 0.04%
Fe-Si	20-60mm	1.5	Si 75-80%, C 0.2%, P 0.05% S 0.02%
Scrap	1.5 m max.		Rubber & nonferrous removed
Oxygen	99.6% min.		
Nitrogen	99.6% min.		
Argon	99.8% min.		

6-5-3. Selection of the melting facilities

Not only to improve productivity of EAF but also to use as a buffer between EAF and CC, LF was adopted.

The combination of EAF and LF has been widely adopted not only by steel mills producing special steels but also by steel mills producing ordinary steels. In order to improve casting yield, sequence casting is imperative and the EAF-LF combination is very useful as a buffer to achieve sequence casting smoothly. In addition, demand for quality is growing in rolled steels of ordinary steel, and for the new steel works to have international competitiveness, adoption of this process should have the advantage of improving quality of liquid steel for years to come. If LF is not adopted, it becomes necessary to increase the number of EAF and it will result in increased investment.

6-5-4. Plant description

The EAF plant facilities include, in addition to EAF and LF in steelmaking shop building, continuous charging facilities for DRI and burnt lime, facilities to add ferro-alloys, dust collector for EAF, indoor scrap yard, step-

down transformer for steelmaking area, open-air conveyor lines for DRI and burnt lime, material warehouse and ferro-alloy warehouse in steelmaking area.

1) Transport and furnace charging of DRI and burnt lime

DRI from the discharge hopper in DR plant is transported via several steps of open-air conveyors to EAF building at the height of FL + 16 m. The discharge hopper for EAF is connected to belt weighing feeders and controlled from the control panel for transport of DRI/burnt lime in central operating room in EAF plant. Burnt lime joins at midway in the conveyor line. DRI and burnt lime are discharged separately and stocked in specified hoppers in front of each EAF.

The open-air conveyors are attached with inspection passage.

Charging of DRI and burnt lime from their respective hoppers in front of EAF is controlled by the discharge panel installed in each EAF operating room. DRI charge is assumed to be continuous charge usually of 75% mixing. The capacity of DRI hopper in front of each EAF holds DRI equal to two heats.

2) Transport and furnace charging of ferro-alloys

At the ferro-alloy warehouse separated from EAF building, ferro-alloys are put into bottom-opening containers, which are carried by 2-ton forklift to EAF building. Two 5-ton hoist cranes in the EAF building are used to lift up the container and fill the ferro-alloy hoppers installed in front of each EAF separately with different ferro-alloys. The residual quantity of ferro-alloy in the hoppers is visually learned.

Ferro-alloys are discharged from the hopper by means of magnetic discharge feeder and weighed on scale car and transported by conveyor and added into EAF, a ladle at

the time of tapping and LF. For correspondence to prepare for change of operation method, relay chute is included, which permits ferro-alloys put in and left in a ladle.

Setting and control of discharge of ferro-alloys by kind is conducted at the ferro-alloy operation panel at the side of EAF.

3) Transport and charging of scrap

Scrap is used in the mixing ratio of 25%.

Purchased scrap is piled at an open-air yard, separated by kind.

Scrap, length of which exceeds 1.5 m, must be cut by gas outdoors and Cu alloy scrap and that containing Cu have to be removed.

It is necessary to cut in half in advance any cylinder or cylindrical articles closed on both ends. Oils and fats, rubber tires, nonferrous castings and the like are to be treated and removed in advance.

Scrap in lots which underwent pretreatment or do not require pretreatment is transported by truck lot by lot to indoor scrap yard.

Unloading or transport of scrap delivered in the steel-making shops requires crawler crane fitted with lifting magnet. Ladle skull, residual metal, tundish skull are cut by gas and reused as much as possible. Flowed metal in flat form is cut by gas to specified size.

EAF dust cannot be recycled.

Mill scale is dried under the sun and dried lots are one by one transferred to the indoor scrap yard. Fine DRI occurring in DR plant is briquetted and treated as one of scrap. The indoor scrap yard is equipped with two overhead travelling cranes with lifting magnet per yard to handle scrap. There will be two indoor scrap yards.

The indoor scrap yard is divided by simple wood partition in 7-10 m intervals for control of scrap by kind.

The crane with lifting magnet takes up scrap of designated kind according to the internally illuminated mixing instruction and fills charging buckets with scrap as instructed.

Scrap is classified into No.1 heavy melting, No.2 bundle, DRI, pellet, DRI briquet, turnings, skull & butt, etc.

For charging scrap into EAF, clamshell type charging bucket which opens widely at the bottom is used. (50 m^3 x 4 units)

Specified quantity of scrap for EAF is put into the clamshell bucket by lifting magnets or bag charging. The weight of the scrap is indicated inside and outside the place and also printed out.

The clamshell bucket rests on a buggy and the rails for the buggy are connected to an electronic load cell. There will be two clamshell bucket buggies each yard, totalling 4 buggies in two yards. The buggy is self-driven and runs about 60 m in the indoor scrap yard and EAF building. Its operation is respectively conducted from the operating panel installed at melting shop and scrap yard cabin.

Charging burnt lime into the clamshell bucket is done with the burnt lime hopper installed right above the center of the clamshell bucket buggy. It is important to put burnt lime dispersedly for preventing the electrode breakage.

4) EAF

Using main raw materials of DRI 75% and scrap 25% (of which 1% is mill scale), liquid steel is produced by EAF.

Four units of EAF with nominal capacity of 130 t/heat are installed, the inside diameter of furnace steel shell being 6.7 m.

Power is received by furnace transformer of 75 MVA, 25 kV. The transformer belongs to the grade of ultra high power for steel melting. The furnace roof and the major part of side-wall are constructed with water cooled panel and diameter of three-phase electrodes is 608 mm (24"). The furnace is so designed that DRI, burnt lime and ferro-alloys are added into the center position of the 3 electrodes. Following melt-down of scrap, DRI is added continuously into the furnace and the top of the bath rises gradually. After completion of continuous DRI addition, the liquid steel is adjusted to prescribed temperature and tapped. Tapping hole is of usual open tap hole type, enabling adoption of eccentric bottom tapping in future. A quantity of slag generated as a result of continuous addition of DRI is tapped into slag pot which is transported by self-loading slag dump truck. As auxiliary facilities of EAF, there are furnace repair stand, furnace roof assembly stand, hot gunning fetting machine, oxygen blowing lance pipe and hose, lance pipe holder, heat shield panel, working tools, sampling spoons, monitor panel, operating panel, and pyrometer.

5) LF

Liquid steel tapped from EAF is adjusted with the LF as to chemical composition, temperature and condition of deoxidation. Ferro-alloys and burnt lime are added into the LF as required for refining through respective adding equipment.

The LF serves also as a buffer to permit operation of sequence casting in conformity of operation of the CC. The LF also permits use of EAF as melting only and im-

proves productivity of the entire steelmaking shop. It is given adequate refining capability for high quality steel as demanded in future.

Transport of liquid steel to LF is done by ladle transfer car.

Just before ladle refining, the ladle is tilted with exclusive stand having hydraulic system to remove slag on the steel surface. For this slag removal, simple manipulator is installed.

Slag is poured into a slag pot which is transferred by casting crane to the space where exclusive transfer car can pick it up by itself.

The LF is equipped with the pipe for N_2 or Ar blowing pipes to stir liquid steel in the ladle. At the bottom of the ladle, porous plug is installed, through which gas is blown. Usually argon is used, but for some kind of steel, it is substituted by N_2.

6) Direct suction dust collector for EAF

Quantities of fume and dust generated by EAF are led into the direct suction dust collector and dust is finally collected by bag filters.

In the furnace roof, the fourth hole is opened for direct suction in addition to the three electrode holes and around the electrode holes, piping for air curtain is installed to prevent gas emission from the furnace.

Furnace gas from the fourth hole passes water-cooled elbow, horizontal duct, combustion chamber, underground duct, cooling tower and outdoor duct for cooling and is brought to exhaust fan. Dust collected by bag filters is periodically shaken down and sent to dust hoppers by screw conveyor. Below the dust hopper

is a pug mill to agglomerate the dust for facile handling and preventing secondary pollution.

Fugitive fume which escapes from the electrode hole or during scrap charge or steel tapping is collected by canopy hood right above each EAF temporarily and fed into the direct suction system by shifting damper.

7) Process computer

Input demand control is installed in central substation (primary) to control the plural number of ultra-high-power EAF. Facilities to prevent flicker and improve power factor are also installed in the central sub-station because of necessity to control load in rolling mill.

At the side of EAF, automatic input controller is installed to each EAF, which set in advance secondary voltage, secondary current, input power and pattern of continuous charging of DRI and monitors them. This can print out and tabulate operation record.

For the LF, process computer covering metallurgical guide control such as ferro-alloy addition calculation is installed. This is connected also with output of furnace analysis and performs tabulation of operation record similarly.

8) Analysis facilities for molten steel

These facilities are placed in the analysis center that is set up in steelmaking shop area.

They include facilities to analyze molten steel by emission spectrochemical analysis in vacuum and communicate the quantity of each element to the EAF office within five minutes and facilities to prepare samples.

The analysis facilities also have function to complement and calculate automatically the effect of other elements which coexist (kind and content). Pneumatic carrier tube for sending samples from EAF plant to analysis room is installed.

Facilities to communicate the results of analysis to EAF, LF and CCM are installed.

Simultaneous measuring apparatus for oxygen and nitrogen are installed. Analyzing equipment for iron oxide and slag are installed separately.

9) Electric and instrumentation facilities

Close to EAF plant, one unit of 10 MVA transformer for step-down from 25 kV to 3.3 kV is installed.

Direct-coupled with 25 kV line are

EAF transformer 75 MVA x 4 units and
LF transformer 18 MVA x 2 units.

Direct-coupled with 3.3 kV high voltage line are

blower motor for EAF dust collector	1,000 kW x 4,
blower motor for lime shaft kiln	250 kW x 2 and
motor in steelmaking shop water treatment plant	5,000 kW x 1.

Utilizing four transformer rooms for four 130-ton EAF, low voltage power receiving facilities for EAF plant are installed. Low voltage power transformers (3.3 kV to 415 V) in EAF plant are three 2,000 kVA units and two 600 kVA units.

The power is supplied mainly to building lighting, cranes, CCM, calcining kiln and others in general.

10) Material warehouse

Three one-story warehouses with area 40 m x 90 m are to be built, which can store furnace refractories (for roof, wall and hearth), casting refractories, electrodes and hot gunning materials in the quantity equal to three-month consumption.

11) Ferro-alloy warehouse

Three ferro-alloy warehouses, 7 m x 40 m, are built. With 3 warehouses holding a total of about 4,200 tons, they represent consumption in about 2.2 months.

12) Cranes

The number of cranes is as follows:

Crane with lifting magnet for iron raw materials (X-Y) 15 t	4 units
EAF charging crane 80/20 t	2 units
Service hoist in EAF bldg. (B-C) 5 t	2 units
Suspension crane in EAF annex bldg (A-B) 3 t	2 units

6-5-5. List of major equipment

Table 7-6-16 List of major equipment of EAF

Name	Quantity	Specification
1. Raw material handling	1	Indoor scrap bay x 2 50t weighing scale x 4 Scrap cabin x 2 Scrap bucket transfer carx4
2. DRI/Lime transportation	1	300t/h conveyor, 900mm width Tripper x 2 60m³ DRI bin x 8 20m³ lime bin x 4 20m³ lime bin x 4 20m³ cokes bin x 2
3. DRI/Lime conti-feed system	4	Belt scale and feeder x 4 100t/h conveyor x 4 Bucket conveyor x 4 Charging chute x 4
4. Ferro alloy handling	4	15m³ ferroalloy bin x 16 15m³ lime bin x 4 15m³ fluospar bin x 2
5. Electric arc furnace	4	130t, 75MVA, 6.7m 120% 2hrs UHP grade Water cooled panel and roof 24 inches electrode
6. Ladle refining furnace	2	130t, 18MVA Ladle car(s)
7. Waste gas cleaning		8,500 m³/min, 650mmAq. 3.3kV, 1,000kW x 4 Bag filter, glass fibre
8. Mobile	9	40t self-loading dump truck x 3 2t fork lift truck x 4 2t shovel fork truck x 2
9. Inter communication		Inter phone Air chuter for steel sample
10. Air conditioning	10	For each pulpit
11. Pipe and piping		

Name	Quantity	Specification
12. Electric equipment		Step down transformer 10MVA x 1, 25kV/3.3kV Intake transformer 3.3kV/415V 2MVA x 3, 600kVA x 2, Carvert tunnel wire and wiring
13. Process computer	2	Input power control for 4 EAF Metallurgical guide control for 2 LF
14. Scrap treatment	1	
15. Supervisor for construction and commissioning included		
16. Building		
Ferro alloy storage	3	740 m² 7mx40mx3
Refractories storage	3	10,800 m² 40mx90mx3
Scrap shed (indoor scrap bay)	2	3,200 m² 20mx80mx2 CH=FL+10,000mm
Scrap cabin (pulpit)	2	48 m² 4mx6mx2
Scrap car aisle	2	1,050 m² 15mx35m
Raw material bay (EAF aux. bay)	1	3,864 m² 14mx276m CH=FL+20,000mm 2nd floor=FL+ 7,500mm 3,864m² 3rd floor=FL+14,000mm 3,864m²
Furnace bay	1	5,920 m² 20mx296m CH+FL+23,000mm 2nd floor=FL+7,500mm 4,700m²
IDF motor room	4	80m² 4mx5mx4
Total		25,702 m² C.H=Crane rail height

6-5-6. Drawings

1) Fig. 7-6-23 The Schematic Arrangement of Steelmaking Shop
2) Fig. 7-6-24 The Schematic Arrangement of Steelmaking Shop (section)
3) Fig. 7-6-25 The Layout Arrangement of Furnace Bay
4) Fig. 7-6-26 The Process Flow Chart of DR1/Lime/Ferro Alloy Transportation

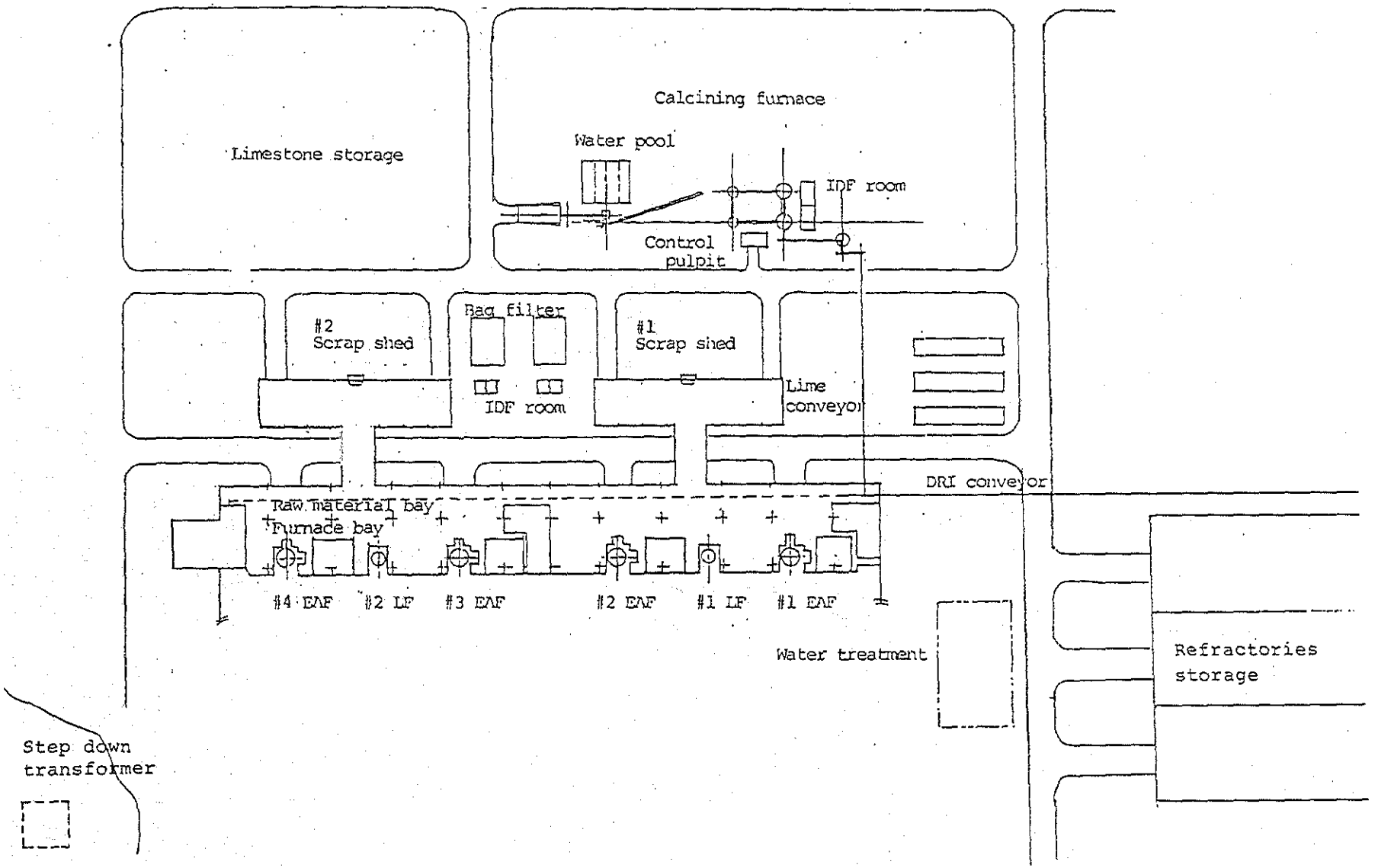


Fig. 7-6-23 The Schematic Arrangement of Steelmaking Shop

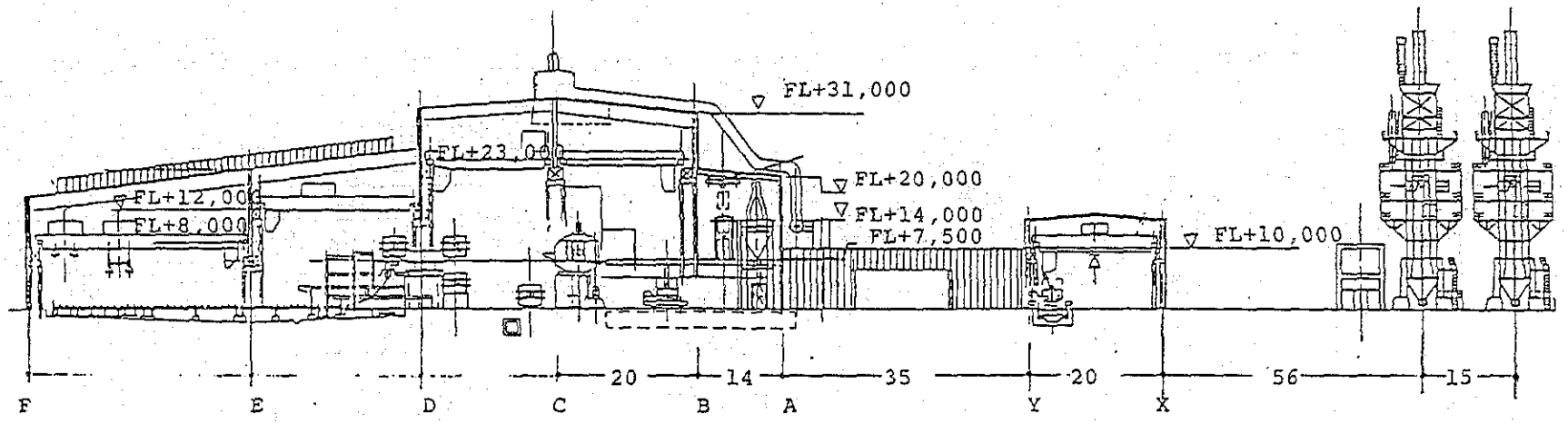


Fig. 7-6-24 The Schematic Arrangement of Steelmaking Shop (section)

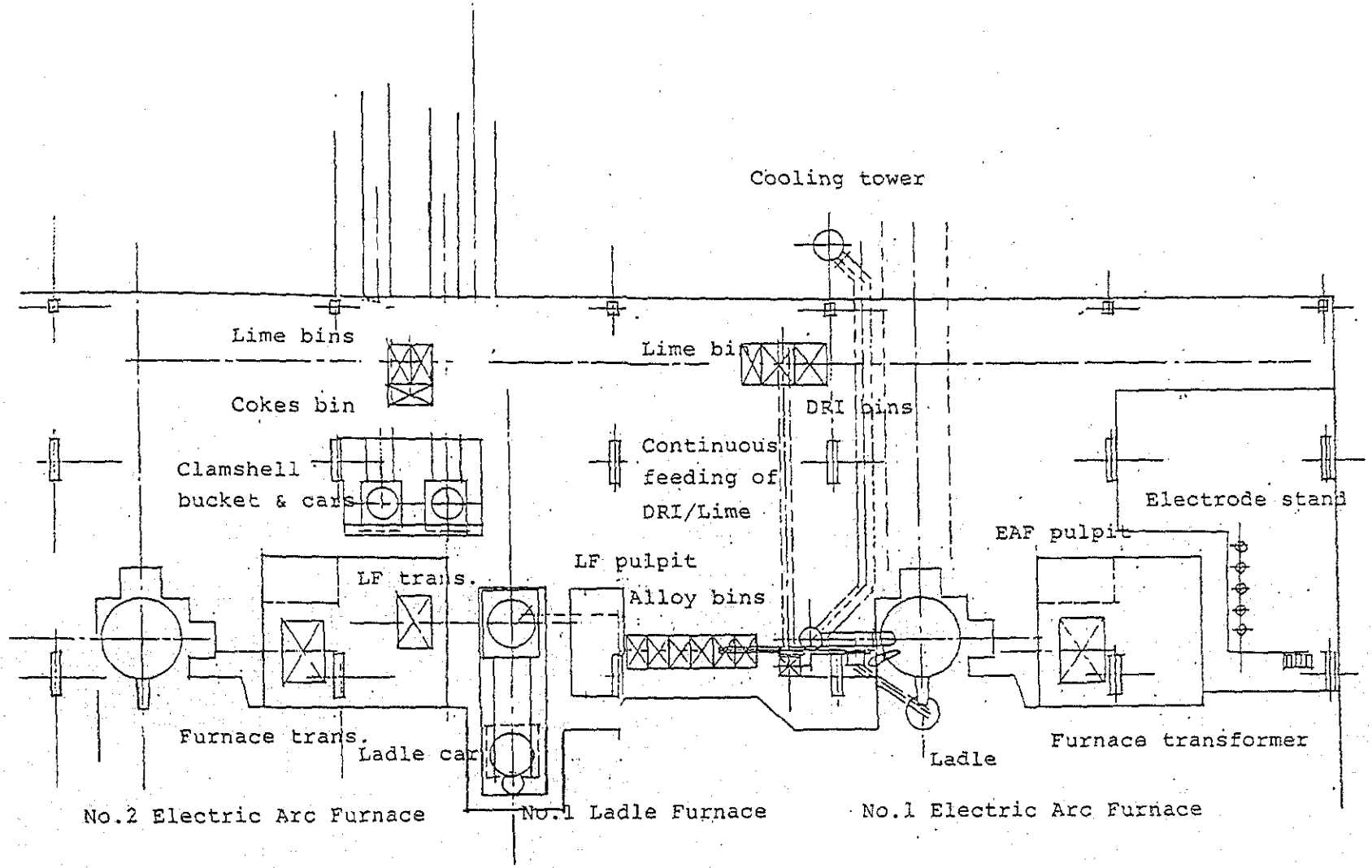


Fig. 7-6-25 The Layout Arrangement of Furnace Bay

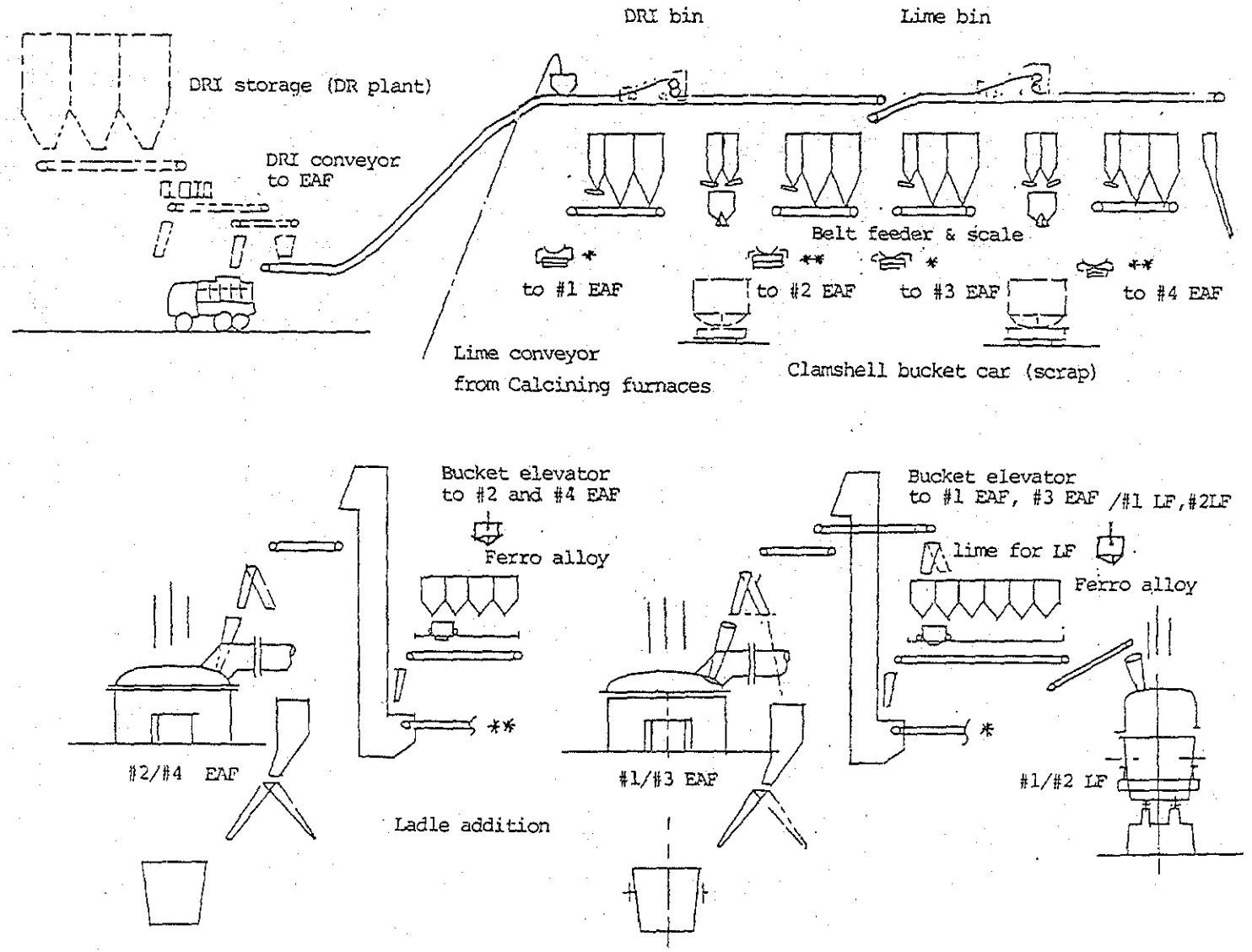


Fig. 7-6-26 The Process Flow Chart of DRI/Lime/Ferro Alloy Transportation

6-6. Billet continuous casting machine (CCM)

6-6-1. Basic idea

The billet CCM produces 774,000 t/y of billets per unit and with 2 such units, annual production of billets will be 1,548,000 tons.

Liquid steel from the two EAFs is processed in one LF and supplied to a billet CCM every 60 minutes or so.

Billet CCM is equipped with one ladle turret and two tundish cars, enabling sequence casting. Two 6-strand CCMs are of the same specification and cast billets, 150 mm square and 12 m long, max. Cast billets are, while hot, transferred by special truck to rolling mill (RM) with a view of saving of energy by so-called hot charge.

A space is prepared for future expansion in parallel with SMP.

6-6-2. Premises for facilities plan

(1) Billet production

In order to produce 1.5 million tons/year of rolled steels, it is necessary to have 1,540,000 tons/year of billets considering yield in rolling process.

(2) Size of billet

Size of billets is shown in Table 7-6-17.

Table 7-6-17 Size of Billets

CCM	Nominal Cross-section (mm)	Billet Length (mm)	Unit Weight (t/m)	Weight of Billet (t)
Billet-1 Billet-2	150 x 150	1,200 max.	0.176	2.112 max.

(3) Operation conditions

Table 7-6-18 shows the basic operation conditions. The annual operating rate is assumed to be 80.5%.

Table 7-6-18 Operation Conditions

Item		Numericals
Working days: (days)		
Annual working days		294
Annual scheduled maintenance days		40
Annual unscheduled maintenance days:		
EAF		16
CCM		15
Average liquid steel in ladle (t/heat)		130
Average tap to tap time (min.)		60
Average casting time (min./heat)		59
Dummy bar preparation time (min.)		50
Sequence casting index per dummy bar (heats/D.B. insert)		7
Number of heats cast		
	Billet-1 (heats/day)	21
	Billet-2 (heats/day)	21
	Total	42

(4) Productivity

Productivity of the billet CCMs is shown in Table 7-6-19. The rate of casting time is 69%, which is standard for this type of CC machine.

Table 7-6-19 Productivity

CCM	Production (t/y)	Number of Heats/Y. heats/y)	Number of Heats/Mon. (heats/m)	Casting Time/Mon. (hrs/m)	Casting Time Rate* (%)
Billet-1	774,000	6,170	514	506	69
Billet-2	774,000	6,170	514	506	69

Note: Casting time rate = Net casting time/calendar hours x 100(%)

(5) Yield in the process

Yield in the process is shown in Table 7-6-20.

Table 7-6-20 Yield in the Process

CCM	Casting Yield (%) (Sound billet/ Liquid steel in ladle)	Loss (%)		
		Scale	Skull	Crop
Billet-1	96.5	0.8	1.5	1.2
Billet-2	96.5	0.8	1.5	1.2

6-6-3. Technical explanation

The CCM is of most popular curved mold type, which is easy for maintenance as the construction is simple. As the same specification is applied to both billet-1 and billet-2, spares can be used in common and their stock reduced.

Billets are of single size, 150 mm square. As this can save idle time due to size change, the production can be increased. Making sequence castig index 7 enables production of 774,000 t/y per machine.

The machine radius should be decided by taking into consideration unbending strain and the radius of this machine is 7 m so that it can fully meet the requirements in casting steel of higher grade in future.

Liquid steel is supplied from EAF every 60 minutes or so, and the number of strands is made 6 to confirm the pitch. Each billet CCM is equipped with a ladle turret and two tundish cars, and if production of each kind of steel is fully available, extended sequence casting can be performed.

Automation is adopted for casting start and mold level control system to ensure stable operation and billet quality. Mini-computer is introduced as process computer to perform secondary cooling control, data logging and report preparation.

When contemplating production of high grade steel in future, application of submerged nozzle should be easy as the size of mold is as big as 150 mm. Incidentally it is needless to say that additional installation of automatic level control system with sliding gate and electromagnetic stirrer, etc. is necessary.

6-6-4. Main specification of CC facilities

Main specifications of billet CCM are shown in Table 7-6-21 below.

Table 7-6-21 Main Specifications of Billet CCM

Item	Description
1. Number of CCM	2
2. Type of machine	Curved mold
3. Size of mold	150 mm x 150 mm
4. Number of strands	6
5. Machine radius	7 m (One point straightening)
6. Casting speed	2.2 m/min.
7. Metallurgical length	17 m
8. Heat size	130 t
9. Casting time	59 min./heat
10. Ladle change method	Ladle turret
11. Tundish capacity	14 t
12. Tundish car	2 cars/machine
13. Cutting equipment	Torch cutter
14. Automation & computerization	Automatic casting start Automatic level control Spray control Data logging

Table 7-6-22 shows list of major facilities.

Table 7-6-22 List of Major Equipment

No.	Description	Q'ty	Remarks
1.	Crane		
1.1	Scrap crane	4	15 t with lifting magnets
1.2	Charging crane	2	80 t/20 t
1.3	Suspension crane	2	3 t
1.4	Hoist	2	5 t
1.5	Ladle crane	2	220 t/50 t
1.6	Tundish crane	1	30 t/5 t
1.7	Billet transfer crane	2	30 t with C hook
1.8	Jib crane (installation and repair)	2	2 t
2.	Billet CCM -1 & -2		
2.1	Steel structure	2	
2.2	Ladle turret	2	1 rpm
2.3	Tundish	4	Capacity 14 t
2.4	Tundish cover	4	Special iron casting
2.5	Tundish car	4	Self driven
2.6	Tundish preheater	4	
2.7	Slag pot	4	
2.8	Mold	12	150 mm sq.x700 lit.
2.9	Rape seed oil supplier	2	
2.10	Pendant box	12	
2.11	Oscillator	12	50 - 200 cpm
2.12	Segment (1)	12	
2.13	Segment (2)	12	
2.14	Segment support	12	
2.15	Segment changing winch	2	
2.16	Pinch roll	12	
2.17	Torch cutter	12	
2.18	Torch approach roller table	12	
2.19	Torch roller table	12	
2.20	Torch run-out table	12	
2.21	Crop transfer equipment	2	
2.22	Transfer roller table	12	
2.23	Chain transfer	2	
2.24	End stop	12	
2.25	Dummy bar	12	
2.26	Dummy bar receiver	12	
2.27	Exhaust chamber	2	
2.28	Hydraulic unit	2	
2.29	Lubrication system	2	
2.30	Spare parts		
2.30.1	Tundish	10	
2.30.2	Tundish cover	10	
2.30.3	Mold	20	
2.30.4	Dummy bar head	12	
2.30.5	Dummy bar link	2	
2.30.6	Others	1 set	

Table 7-6-22 List of Major Equipment (Cont'd)

No.	Description	Q'ty	Remarks
3.	Tundish yard		
3.1	Tundish tilting device	2	
3.2	Tundish skull punch	2	Hydraulic
3.3	Tundish drying equipment	2	
3.4	Tundish repair platform	2 sets	
4.	Mold & roller apron yard		
4.1	Mold tilting stand	6	
4.2	Mold stand	30	
4.3	Mold assembly stand	2	
5.	Ladle & aux. equipment		
5.1	Ladle	12	130 t
5.2	Ladle tilting device	2	
5.3	Ladle drying facilities	2	
5.4	Ladle preheating equipment	2	
5.5	Sliding nozzle	12 sets	
5.6	Sliding nozzle hydraulic equipment	4	
5.7	Slag pan	16	
6.	Transporting facilities		
6.1	Billet transporting truck	7	50 t
6.2	Forklift	3	2 t
7.	Water treatment facilities	1	Direct water: 9,400 m^3/h Indirect water: 500 m^3/h
8.	Diesel pump for emergency water	1	4,200 m^3/h
9.	Building		
	Ladle building	1	25 m x 280 m
	CC building	1	25 m x 188 m
	Billet delivery building	1	35 m x 188 m
10.	Sub-center	1	

6-6-5. Layout

Layout is shown in Fig. 7-6-27. The billet CCMs are to be set one each at the east and west parts of the CC plant, and tundish yard and mold yard are annexed to each billet CCM.

In principle, cast billets are transferred by exclusive truck while hot to RMs. For emergency, temporary billet yard is prepared in the billet delivery building.

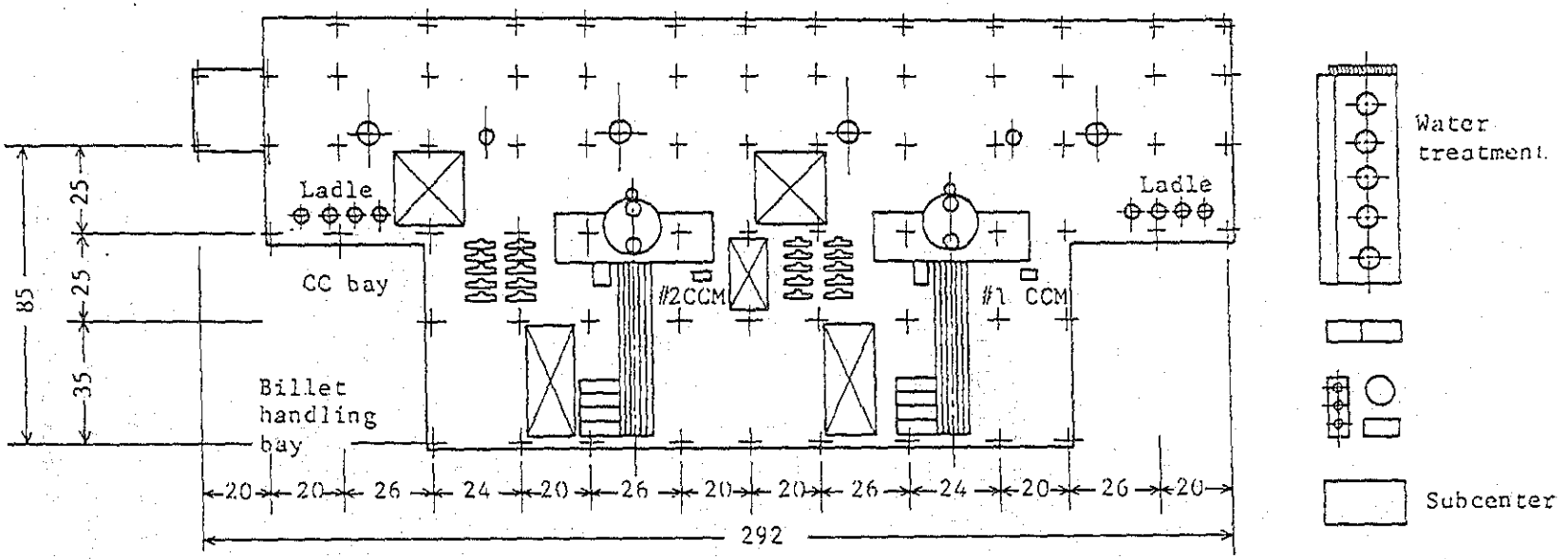
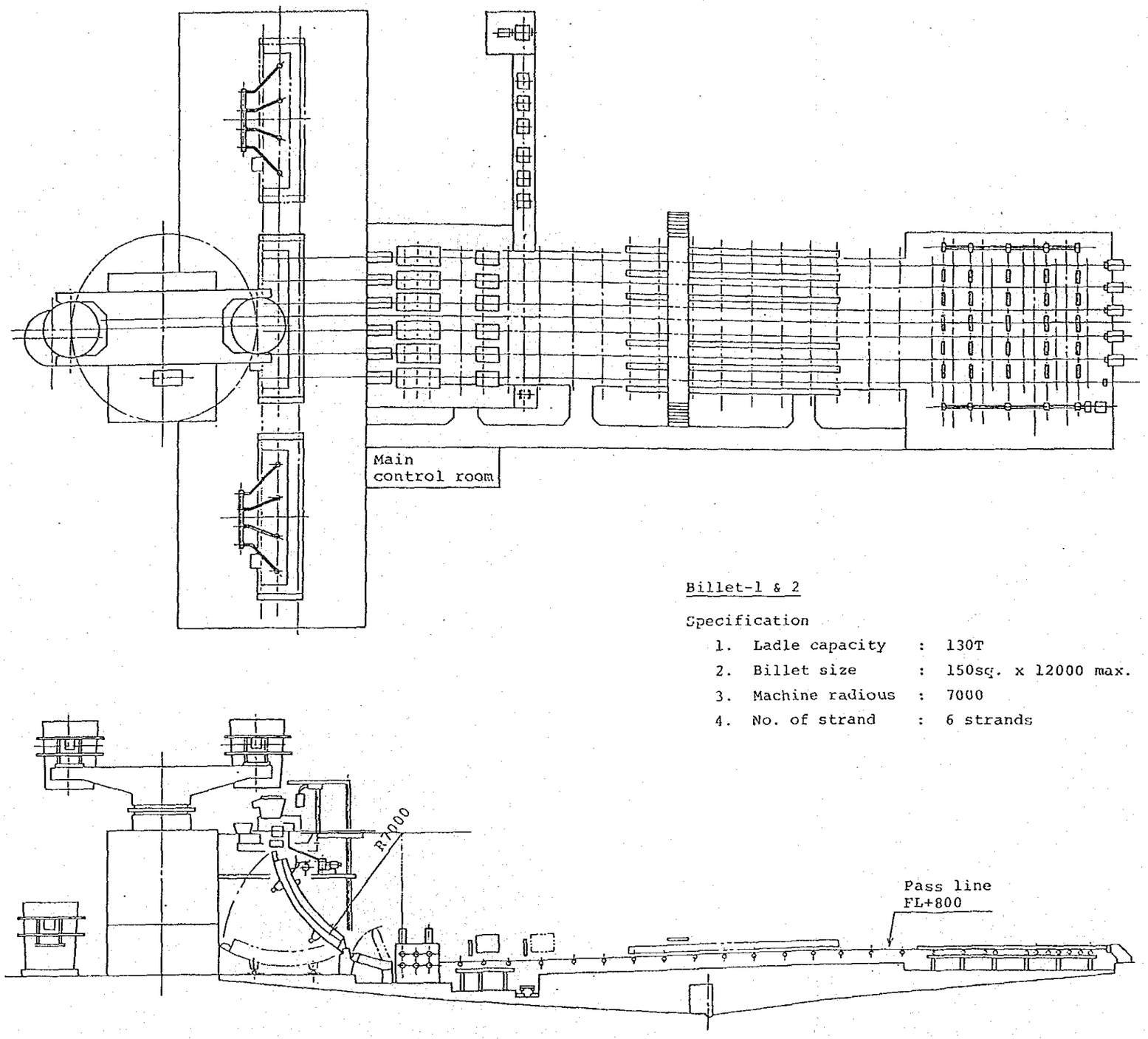


Fig. 7-6-27 Layout of CCM Shop



Billet-1 & 2

Specification

1. Ladle capacity : 130T
2. Billet size : 150sq. x 12000 max.
3. Machine radious : 7000
4. No. of strand : 6 strands

Fig. 7-6-28 Schematic Drawing of Billet CCM

6-7. Medium section mill

6-7-1. General

Productivity of a medium section mill is generally lower than that of a wire rod or bar mill. This results mainly from difficulty of high speed rolling and the low productivity in the finishing line subsequent to rolling line. The type of section mill varies greatly depending on type of products, size range and production amount.

There seems to be approximately fifteen manufacturers of hot rolled sections at present in Indonesia. Also, it seems that the only exclusive section mill of comparatively high production capacity is in P.T. Krakatau Steel and other manufacturers than the above appear to be producing small-sized angles or channels in bar mills or in section mills in minor scale.

Production of large-sized sections including H-beams inevitably requires a big scale of rolling facilities and bloom continuous casting machine for supply of large-sized rolling materials. In view of the characteristics of the new steel works, it is considered reasonable to produce a variety of sections of medium sizes other than H steels. Therefore, a mill which can produce efficiently many types of medium-sized sections of plain carbon steels is planned. As already mentioned, in the production of medium sections, the mill capacity is often limited by the capacity of finishing line and finishing capacity may be low if the line is not continuous. Consequently, it is contemplated to have a full-continuous mill including the finishing line, not to mention the rolling line. To produce medium-sized sections, 2-high horizontal rolling stands are arranged in tandem and the finishing line which directly follows the rolling line leads to labor saving and improvement of productivity.

Besides angles of main products, production of channels, I beams, tees and flat bars is planned so as to meet demand of current markets.

The facilities are designed on the basis of production of angles.

(1) Scope of the plan

This section mill is to have functions of product storage and shipment in addition to the rolling. It also has independent roll shop equipment and water treatment equipment.

(2) Product mix

Major types of products in this plan are to be as follows:

Steel grade:

Structural steels for general use (JIS SS xx)

Size (mm):	Angles	∠ 50 to 120
	Channels	[75 to 125
	I beams	I 75 to 125
	Tees	T100 to 125
	Flat bars	FB70 to 125

Product mix is increased so as to meet changing demand. It is possible to roll round bars over 50 mm dia. if necessary, but dimensional accuracy is not so good due to the twist between consecutive horizontal stands. Billet size being 150 mm sq., sections of bigger sizes than the above can be rolled, but such expansion of the product size will increase roll changing and adjusting time and lower production capacity of the entire mill consequently.

(3) Billets

Basically, billets, 150 mm sq. and 8 m long and weighing 1,400 kg a piece, are employed. For producing angles of all sizes, 8 m billets are used, but for channels and I beams, unit weight of billets is adjusted so that the overall length of products as-rolled is within the maximum effective length of cooling bed, and the length of the smallest billets will be 4 m.

(4) Production capacity

In the section mill in horizontal stand tandem arrangement, the maximum finishing speed is generally limitted to approximately 10 m/sec. for ensuring appropriate dimensional accuracy of rolled products. Because the production capacity of this mill is determined not by rolling capacity but by finishing capacity, the productivity of finishing line is improved by means of the continuous arrangement of finishing equipment, adoption of straightening of long products and automatic piling. Also, irregular length products are salvaged on-line instead of off-line.

As the frequency of roll and groove changing is high due to the wide range of product sizes, the hydraulic stand clamping and sliding system is adopted to reduce roll and groove changing time.

(5) Energy saving

To reduce fuel consumption, proper combustion control and hot billet charging are applied.

(6) Labor saving

The operation is mechanized as much as possible to save labor force and improve labor productivity thereby. The continuous arrangement of finishing line and introduction of automatic equipment aim at labor saving, and production control and operation systems will contribute to the same purpose.

(7) Environmental control

As measures against atomospheric and water pollution in the new steel works for the second generation, proper combustion control is applied in the reheating furnace to eliminate emission of black smoke and direct cooling water for rolls and products is treated in the recirculating system to remove scale and oil.

(8) Product shipment

At Cilegon site, the products are almost regularly shipped out by rail, truck and ship, whereas, in Arun site they are transported mainly by sea to other islands. At Arun site, therefore, shipment of the products from section mill is done intermittently and concentratedly, so the product storage yard is extended by 50 m to increase storage capacity and one more crane is added.

6-7-2. Premises of facilities plan
(Calculation of production capacity)

Assuming that the mill can attain the performance of similar type of medium section mills in Japan, operation condition of the mill is decided and its production capacity calculated. The mill is to produce mainly angles and the percentage of sections other than angles is low, and the

average size is assumed as equal angles of 75 mm leg.

Table 7-6-23 Operation Conditions of Section Mill

Total working time	(A)	8,760 hrs/y	4-team, 3-shift continuous operation
Scheduled down time	(B)	620 hrs/y	Annual repair: once/year Monthly repair: once/month
Total operation time	(C)	8,140 hrs/y	(C) = (A) - (B)
Roll rotating time	(D)	5,560 hrs/y	(D)/(C) = 0.68
Average productivity	(E)	45 t/hr	Aver. size: 75 mm leg equal angle
Annual production capacity	(F)	250,000 t/y	(D) x (E)

6-7-3. Technical explanation

(1) General

1) Layout

The medium section mill comprises rolling line consisting of horizontal stands arranged in tandem which is followed by a continuous finishing line including straightening, shearing, automatic piling, bundling and weighing. Products of irregular lengths are finished on-line and not off-line.

Products are shipped basically as rolled condition, but sometimes conditioning (shape correction or defect removal) of the products may be necessary and a space is provided in the product yard.

2) Billet yard

For energy saving, in principle, hot cast billets are charged into the reheating furnace. Billets transferred by truck are unloaded and loaded on the receiving tables by two units of cranes. Some amounts of cold billets are always kept in the billet yard, and when productivity of the section mill exceeds the hot billets supplying, the cold billets are used to fill the gap. There is a receiving table each for cold billets and hot billets.

3) Reheating furnace

Billet reheating furnace is of walking-hearth-type and its capacity is set 70 t/h considering the productivity of medium size angles. Short billets in length less than 8 m are used for a part of channels and I beams, but such short billets are rather few so the overall heating efficiency is not so lowered.

The recuperator is installed to recover waste heat and also proper furnace temperature control and hot billets charging are applied to save unit consumption of fuel.

In principle, billets are charged into the reheating furnace in single row, but they can be charged in two rows for some sizes of channels.

4) Rolling equipment

This is a mill of horizontal rolling stands arranged in tandem. The stands are hydraulically clamped enabling roll and groove changing in a short time. Rolling speed of the finishing stand is approximately 10 m/sec. max. At the delivery side of the roughing train is installed a crop shear that crops the front and tail

ends to prevent cobbles. When angles are produced, a rolled product is divided by the dividing shear installed at the delivery side of the finishing train into some pieces of a certain length which gives the highest yield within the effective length of the cooling bed. In the rolling of sections other than angles, however, rolled products are not divided for the reason that the division causes deformed cut ends probably resulting in troubles in the subsequent finishing line and consequently in decrease of finishing productivity.

5) Finishing equipment

The cooling bed is of rake type and permits products with better straightness. Products cooled on the bed are straightened by the in-line straightner in long lengths. Compared with straightening after cutting to ordered lengths, the above straightening manner enables high productivity as well as better product yield.

Water cooling zone prior to the straightner is to prevent return to unstraightened condition. After the straightening in long lengths, the products are cut by cold shear into ordered lengths, and this cold shear is of universal type and is available for all sections such as angles, channels, and tees. Cut-off-length products, after on-line inspection, are automatically counted, piled, bundled and weighed.

Either irregular length products or products partly having some defects are transferred to the salvaging line for discarding defective parts or cutting to maximum lengths available.

All the above finishing facilities are continuously arranged for ensuring labor saving and easing of bottleneck in the finishing line.

6) Electrical equipment

Every main motor is D.C driven individually, i.e., in one roll stand - one motor manner, and power is supplied to a DC motor by an independent variable voltage DC source. Thyristor Leonard system is compact and advantageous in maintenance.

7) Systems

There are provided six systems including billet charging, combustion, mill operation, roll preparation, production result and shipping. Those systems are all independent each other and a general system controlling the operation of mill as a whole is not included in the plan.

Those systems are effective for stable operation, improvement of roll rotating time, and labor saving.

8) Roll shop equipment

The section mill requires a considerable number of rolls because of many types of products and limited application range of every groove. Grooves are machined with profiled cutting tools.

(2) Measures for the future

As the tasks for the future, increase of production capacity and diversification of new type products are expected. To increase mill production capacity, it is important just the same to improve productivity of the finishing line, but as the product yard has enough space, it is easy to accommodate additional finishing equipment.

6-7-4. Specifications of major equipment

Major equipment of the medium section mill and their specifications are as shown in Table 7-6-24.

6-7-5. Layout

Layout of the section mill in Cilegon and Arun sites is as shown in Fig. 7-6-29 and Fig. 7-6-30, respectively.

Basically there is not much difference between the two sites, except for that the product yard in Arun site is 50 m longer and that railways is available for shipping products in Cilegon site.

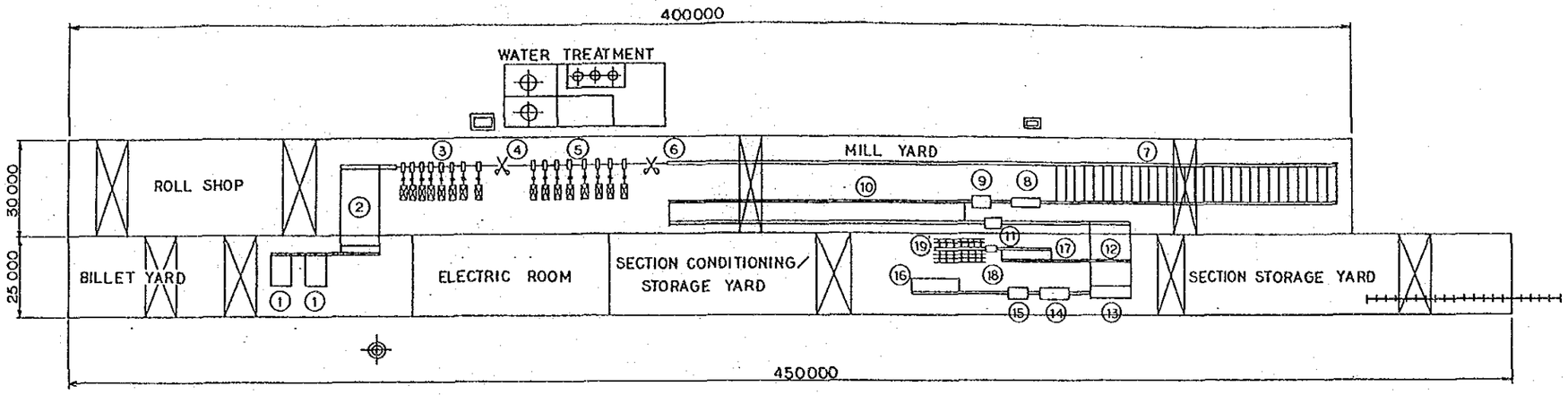
Table 7-6-24 Major Equipment List of Section Mill

Name of Equipment	Q'ty	Specification
Billet Receiving Equipment	1 set	Consisting of - Billet receiving table: Two (2) - Furnace approach roller table
Reheating Furnace	1	. Three-zone, walking hearth type . Heating capacity: 70 t/hr . Fuel : Natural gas Including - Combustion and combustion control equipment - Exhaust gas suction equipment such as flue and stack
Billet Charging/Discharging Equipment	1 set	
Roughing Mill Train	8 stands	. Two-high horizontal, closed top stand tandem arrangement, each of individually driven type . Stand clamping/shifting : Hydraulically operated Including - Driving equipment such as reduction gear, pinion stand and mill spindle
Finishing Mill Train	8 stands	- Same as roughing stand - . Maximum finishing speed : Approx. 10 m/sec.
Mill Guide & Guiding Device	1 set	
Roll	1 set	. New roll diameter : 550 mm for No.1 to No.4 stand 480 mm for No.5 to No.8 stand 430 mm for No.9 to No.16 stand

Name of Equipment	Q'ty	Specification
Shear	2	Consisting of - Crop/cobble shear behind roughing train - Dividing shear behind finishing train
Cooling Bed	1	. Walking-beam type Including - Run-in roller table - Section aligning device - Run-out roller table
In-line Straightening Machine	1	. Canti-lever, roller straightening type . No. of roller : Five top rollers (Driven) Four bottom rollers (Free) Including - Water cooling zone
Long Product Transfer Table	1	
Cold Shear	1	. Down cut, universal type . Shearing capacity: 350 t Including - Front/rear roller table - Cold shear gauge
Section Finishing Equipment		
° Regular length section handling equipment	1 set	Consisting of - Cut-off-length product transfer table - Piling machine - Binding machine - Weighing machine - Bundle collecting table

Name of Equipment	Q'ty	Specification
° Irregular length section salvaging equipment	1 set	Consisting of - Discharging roller table - Irregular length section transfer table - Cold shear for salvaging - Irregular length section collecting pocket
Lubrication & Hydraulic System	1 set	Consisting of - Oil lubrication system - Grease lubrication system - Oil hydraulic system
Mill Auxiliary Equipment	1 set	Including - Scrap removal system - Fire protection system - Air conditioning & ventilation system
Roll Shop Equipment	1 set	Including - Numerically controlled roll turning lathe - Roll grinding machine
Water Treatment System		
° Indirect cooling water recirculating system	1 set	Consisting of - Cooling water basin - Cooling tower - Supply pump - Diesel pump for emergency - Chemical dosing unit
° Direct cooling water recirculating system	1 set	Consisting of - Scale pit - Settling basin - Cooling water basin - Super filter - Cooling tower - Oil belt skimmer - Supply/washing pump - Chemical dosing unit

Name of Equipment	Q'ty	Specification
Overhead Travelling Crane	1 set	. 10 units for Arun Site . 9 units for Cilegon Site
Electrical Equipment		
° Electric power source and distribution	1 set	25 kV system, 6.6 kV system
° DC main mill motor and control	1 set	. DC main motor: Eighteen (18) . Total power : 9,400 kW
° Auxiliary motor and control	1 set	
° Computer system	1 set	Consisting of respectively independent system as follows: - Billet charging system - Combustion system - Mill operation system - Roll preparation system - Production result system - Shipping system
° Communication system	1 set	
° Lighting system	1 set	
Other Ancillary Equipment	1 set	

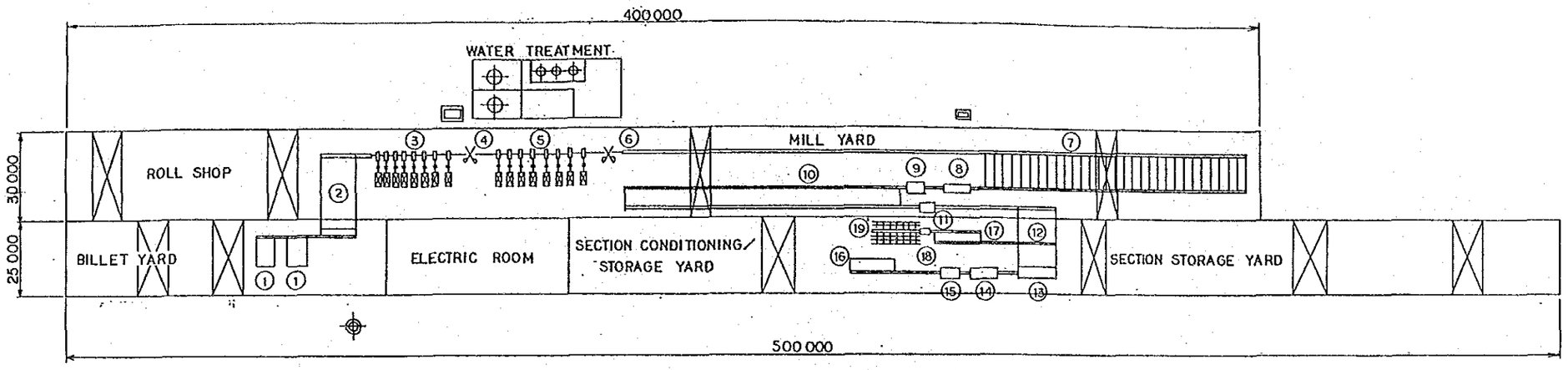


GENERAL SPECIFICATION

- TYPE OF MILL : HORIZONTAL STAND TANDEM ARRANGEMENT
- NO OF STRAND : 1 (ONE)
- PRODUCTION CAPACITY : 250,000 T/Y
- BILLET : CONTINUOUSLY CAST BILLETS
  150 mmsq. x 8,000 mm MAX. (APPROX. 1,400 kg/PIECE MAX.)
- TYPE OF PRODUCTS
  - STEEL GRADE : STRUCTURAL STEELS FOR GENERAL USE
  - SIZE : ANGLES 50 x 50 TO 120 x 125 mm
    CHANNELS 75 x 40 TO 125 x 65 mm
    I-BEAMS 75 x 75 TO 125 x 75 mm
    OTHERS(FLAT BARS, T-BARS)
- MAXIMUN FINISHING SPEED : APPROX. 10 m/SEC

NO.	NAME OF MAJOR EQUIPMENT	NO.	NAME OF MAJOR EQUIPMENT
(1)	BILLET RECEIVING TABLE	(11)	COLD SHEAR
(2)	REHEATING FURNACE	(12)	CUT-OFF-LENGTH PRODUCT TRANSFER TABLE
(3)	ROUGHING TRAIN (8 STANDS)	(13)	PILING MACHINE
(4)	CROP & COBBLE SHEAR	(14)	BINDING MACHINE
(5)	FINISHING TRAIN (8 STANDS)	(15)	WEIGHING MACHINE
(6)	DIVIDING SHEAR	(16)	BUNDLE COLLECTING TABLE
(7)	COOLING BED	(17)	IRREGULAR LENGTH SECTION TRANSFER TABLE
(8)	WATER COOLING ZONE	(18)	COLD SHEAR FOR SALVAGING
(9)	IN-LINE STRAIGHTENING MACHINE	(19)	IRREGULAR LENGTH SECTION COLLECTING POCKET
(10)	LONG PRODUCT TRANSFER TABLE		

Fig. 7-6-29 General Layout of Section Mill for Cilegon Site



GENERAL SPECIFICATION

- TYPE OF MILL : HORIZONTAL STAND TANDEM ARRANGEMENT
- NO OF STRAND : 1 (ONE)
- PRODUCTION CAPACITY : 250,000 T/Y
- BILLET ; CONTINUOUSLY CAST BILLETS
  150mm sq. x 8,000mm. MAX. (APPROX. 1,400 kg/PIECE MAX.)
- TYPE OF PRODUCT
  - STEEL GRADE : STRUCTURAL STEELS FOR GENERAL USE
  - SIZE : ANGLES 50 x 50 TO 120 x 125mm
    CHANNELS 75 x 40 TO 125 x 65mm
    I-BEAMS 75 x 75 TO 125 x 75mm
    OTHERS(FLAT BARS, T-BARS)
- MAXIMUN FINISHING SPEED : APPROX. 10 m/SEC

NO.	NAME OF MAJOR EQUIPMENT	NO.	NAME OF MAJOR EQUIPMENT
(1)	BILLET RECEIVING TABLE	(11)	COLD SHEAR
(2)	REHEATING FURNACE	(12)	CUT-OFF-LENGTH PRODUCT TRANSFER TABLE
(3)	ROUGHING TRAIN (8 STANDS)	(13)	PILING MACHINE
(4)	CROP & COBBLE SHEAR	(14)	BINDING MACHINE
(5)	FINISHING TRAIN (8 STANDS)	(15)	WEIGHING MACHINE
(6)	DIVIDING SHEAR	(16)	BUNDLE COLLECTING TABLE
(7)	COOLING BED	(17)	IRREGULAR LENGTH SECTION TRANSFER TABLE
(8)	WATER COOLING ZONE	(18)	COLD SHEAR FOR SALVAGING
(9)	IN-LINE STRAIGHTENING MACHINE	(19)	IRREGULAR LENGTH SECTION COLLECTING POCKET
(10)	LONG PRODUCT TRANSFER TABLE		

Fig. 7-6-30 General Layout of Section Mill for Arun Site

6-8. Bar mill

6-8-1. General

Of non-flat products, round bars are in high demand and there are about 30 bar mills including re-rolling mills in Indonesia. Production capacity of those mills is comparatively low and P.T. Krakatau Steel bar mill of annual production capacity of 150,000 tons is the biggest among them. They are either semi-continuous type or continuous type employing repeater rolling of low rolling speed. There is no full-continuous tandem mill of high speed rolling.

As regards bar size, small-sized bars of 25 mm dia. and under account for the major part of the total production, but demand for larger-sized bars, up to 50 mm dia., is expected to increase in the future. As the bar mill for the second generation, a bar mill to mass-produce medium and small sized bars from 10 to 50 mm dia. is planned for the new steel works. Namely this mill is full-continuous tandem mill with horizontal stands and vertical stands alternately arranged. In addition, the mill adopts split rolling and high speed rolling to improve productivity of smaller sizes, and the mill as a whole has annual capacity of 650,000 tons.

This plan envisages production of rebars mainly, but irrespective of originally planned product mix, the mill will have such equipment as required for production of high grade steel bars in the future.

(1) Scope of the plan

This mill not only produces bars but also makes delivery of the products. The products are directly shipped from the mill. It also has independent roll shop equipment and water treatment equipment.

(2) Product mix

Major types of products in this plan are as follows:

Steel grade:

Steel bars for concrete reinforcement (JIS SRxx, SDxx)

Structural steels for general use (JIS SSxx)

Size:	Plain bars (mm)	10 to 50 dia.
	Deformed bars	D10 to D51 dia.

The mill produces mainly plain carbon steel bars of medium and small sizes and the above is reasonable as the product mix for the time being. As regards size, the mill produces mainly bars of 25 (D25) mm dia. and under and deformed bars will account for 50% or more. Base length of product is 12 m.

In principle, neither billet conditioning nor product conditioning is processed and the products are shipped in as-rolled condition.

(3) Billets

For improvement of yield, increasing unit weight of the billets is effective, and the billets for rolling all sizes are 150 mm sq. and 12 m long (weighing 2,100 kg/billet).

Reduction ratio is about 11.5 for the maximum bar size of 50 mm dia., and cast structure of billets is fully destroyed and the rolled products feature fibrous structure and there is no problem in quality.

(4) Rolling capacity

For increasing production capacity of the mill under the condition that the size range is wide and smaller sizes account for high percentage, improvement of productivity of small sizes and reduction of rolling down time (unscheduled down time, preparation time) are most effective.

As the conventional rolling method has a certain limit for improvement of productivity of smaller sizes, the mill applies split rolling to 10 to 16 mm dia. and employs high speed rolling of 25 m/sec. max. Those drastically improve the productivity of smaller sizes which has been extremely low.

To increase roll rotating time, the mill is so designed as to reduce preparation time for roll and groove changing and also down time due to cobbles.

(5) Energy saving

Reduction of fuel consumption is planned by proper combustion control and hot billet charging.

By adopting split rolling, unit consumption of power in rolling the sizes 10 to 16 mm dia. can be expected to decrease by about 20% as compared with the conventional method.

(6) Labor saving

Mechanization is contemplated wherever possible for the purpose of improving labor productivity. On-line irregular length product finishing equipment, systems for production control and operation, and application of various automated equipment fall under the category.

(7) Environmental control

In order to prevent atomospheric and water pollution, proper combustion control is applied in the reheating furnace to eliminate black smoke and direct cooling water is treated in recirculating system to remove scale and oil and then part is discharged.

(8) Product shipping

At Cilegon site, the products are almost regularly sent out by rail, truck and ship, but at Arun site, they are shipped out mainly by sea and shipping of the products from the bar mill takes place intermittently and concentratedly. Consequently, the product yard at Arun site is extended by 50 m and one more crane is installed.

6-8-2. Premises for facilities plan
(Calculation of production capacity)

Assuming that the performance of Japan's similar bar mills can be attained at this mill, operating conditions are decided accordingly and the production capacity is calculated. The average size is assumed to be 16 mm dia., and the productivity in this case is determined by finishing speed.

Table 7-6-25 Operating Conditions of Bar Mill

Total working time (A)	8,760 hrs/y	4-team, 3-shift continuous work
Scheduled down time (B)	620 hrs/y	Annual repair: once/year Monthly repair: once/month
Total operation time (C)	8,140 hrs/y	(C) = (A) - (B)
Roll rotating time (D)	6,500 hrs/y	(D)/(C) = 0.80
Average productivity (E)	100 t/hr	Aver.size 16 mm dia.
Annual production capacity (F)	650,000 t/y	(D) x (E)

6-8-3. Technical explanation

(1) Outline of facilities

1) Layout

The bar mill is a full-continuous mill consisting of horizontal and vertical stands arranged alternately and the irregular length product finishing line follows continuously on line.

As the mill has function of shipping products as well, its product yard has storage capacity of about 10,000 tons.

The bar storage yard is spacious enough to accommodate additional recutting machine and bending table.

2) Billet yard

For energy saving, in principle, hot billets from CCM plant are transferred directly to the reheating furnace and charged while hot. Considering truck-transportation of billets and the frequency of billet unloading, two cranes are provided.

The billet yard always keeps cold stock, and when CCM is out of operation or when productivity of the bar mill exceeds the supply capacity of hot billets, the gap is filled by the cold billets stock. There are two billet receiving tables, one for cold billets and the latter for hot billets.

3) Reheating furnace

Billet reheating furnace is of walking-hearth type and its maximum heating capacity is 130 t/h to ensure the average rolling productivity of 100 t/h.

As long billets are side-discharged, there is no problem of temperature drop at the tail end of the billet. Proper furnace temperature control reduces scale loss, improving yield, and at the same time, together with recovery of waste heat by recuperator, decreases fuel consumption. Hot billet charging contributes to reduce fuel consumption further.

4) Rolling equipment

Stands of the rolling mill are arranged in tandem, and roughing, intermediate and finishing trains are in alternate horizontal and vertical stand line-up and have single strand pass except when split rolling goes on. Though the facilities may seem too much for production of plain carbon steels mainly, they result from consideration of future production of high grade steels. The alternate horizontal and vertical stand line-up permits twist-free rolling resulting in cobble reduction and good surface quality as well as superior dimensional accuracy of finished products.

Roll stands are hydraulically clamped and pass line is kept constant and groove changing can be completed in a short time. Rolls are exchanged by stand changing method to reduce roll changing time.

For rolling small-sized bars, 10 to 16 or D10 to D16 mm dia., split rolling process is employed, and this results in

a) less capital investment due to decrease in the number of stands required (2 stands saved)
b) improvement in productivity
c) reduction of power consumption.

In particular, when percentage of smaller sizes in the total production increases, this proves effective to keep the high production capacity of the mill. Split rolling is performed by the splitting unit installed in line between stand No. 17 and stand No. 18, which splits a rolling stock into two pieces up and down, and stands No. 18 and No. 19 have two strand passes. Schematic drawing is as given in Fig. 7-6-31.

The crop and cobble shear installed behind the roughing train is applied to prevention of cobble by croping both ends of rolling stocks and for cutting off cobble when occurred. The dividing shear installed behind the finishing train divides rolled products into the optimum cut-lengths giving the highest yield within the effective length of the cooling bed.

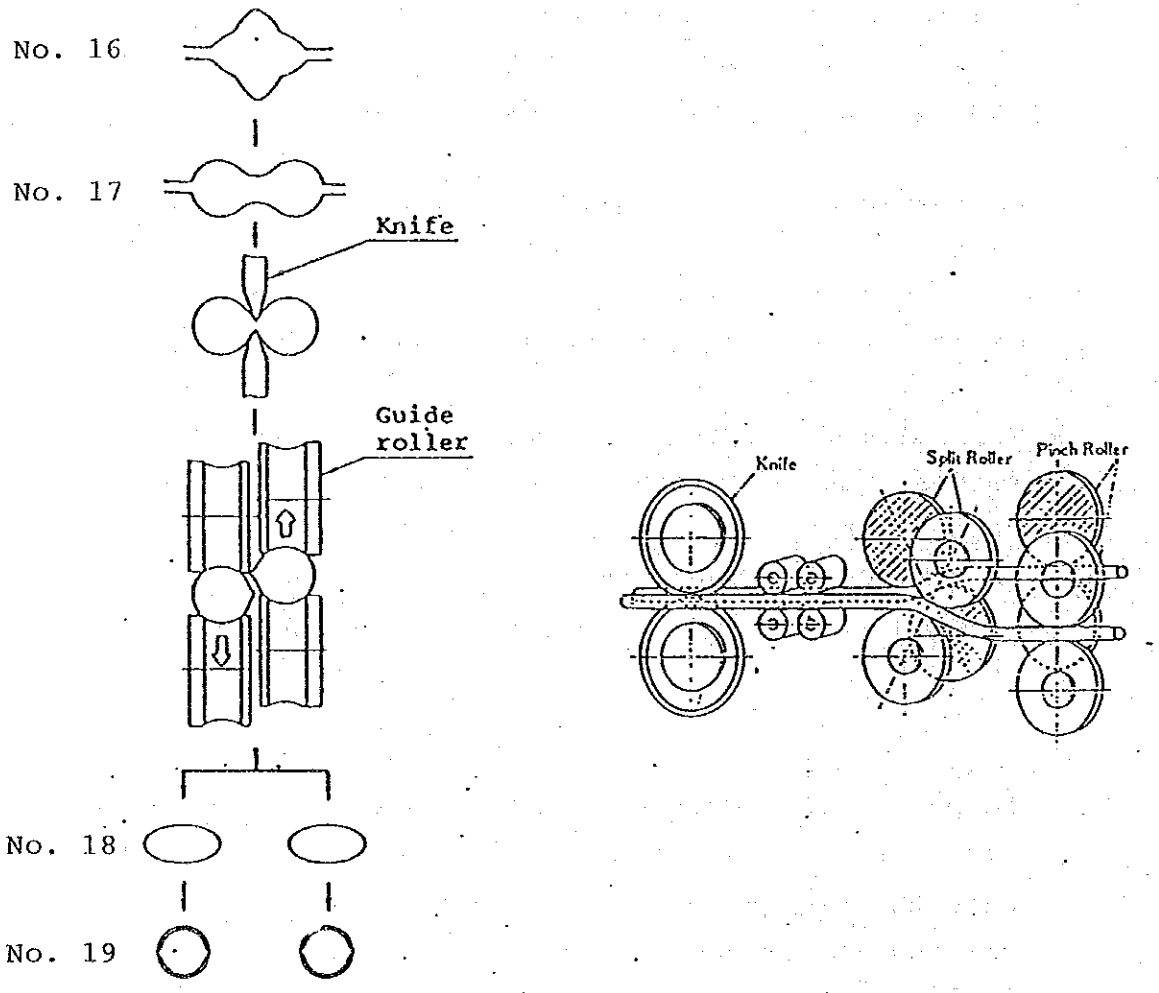


Fig. 7-6-31 Schematic Diagram of Splitting Rolling

5) Finishing facilities

Rolled products of over 16 mm dia. are delivered onto the cooling bed by the run-in roller table and 10 to 16 mm dia. bars by the high speed run-in trough.

The cooling bed is of rake type and equipped with the bar aligning device to improve product yield.

Products are cut by down-cut type cold shear into ordered lengths and automatically bundled and weighed. In the cold shear, plain blades are used for smaller sizes and grooved blades for larger sizes, to maintain satisfactory end shape.

Cut-off-length products by the cold shear are inspected for straightness and surface defects on-line. Defective and irregular length products are transferred to irregular length product finishing line, where defective parts are discarded or irregular length products are cut to the maximum length available to improve the yield.

6) Electrical equipment

Main motors are all D.C. motors and of individual drive type, i.e. one stand being driven by one motor. Its direct current variable voltage power sources are of static Leonard system (thyristor Leonard) and feature good response and are compact and easy to maintain.

7) System

Six systems including billet charging, combustion, mill operation, roll preparation, production result and shipment are employed. By those systems, advantage such as effective utilization of past operation data, stable

operation, improvement of roll rotating time and labor saving can be expected.

However, the above six systems are all independent each other and a general system integrating those systems to cover the entire operation of the mill is not contemplated in this plan.

8) Roll shop equipment

The forming machine for transversal ribs of finishing grooves of deformed bars is characteristic of the roll shop in the bar mill. Both the transversal rib cutting machine and the electro discharging machine are provided for such requirement.

(2) Measures for future production of high grade steels

The bar mill planned has the facilities which can meet requirements for production of high grade steel products in future. Namely, the reheating furnace employed is of walking-hearth type, which facilitates decarbonization control and reduces scratches on billets.

The mill is of alternate horizontal and vertical stands arrangement, which allows twist-free rolling and consequently enables good surface quality and high dimensional accuracy.

The cooling bed is of rake type, ensuring production of products with superior straightness.

As the stands are driven individually, their response against impact drop is high, which permits precise speed control.

As described above, the mill can produce bars with less dimensional variation along overall length with good roundness and with less surface defects.

However, for production of high grade steels in future, it is imperative to install billet inspection and conditioning facilities, and product inspection and conditioning facilities, which are not included in this plan. The both require a considerable site area, however, only a space is provided for the future expansion above close to the bar mill area.

6-8-4 Specifications of major equipment

Major equipment of the bar mill and their specifications are as shown in Table 7-6-26.

6-8-5. Layout

Layouts of the bar mill plant at Cilegon site and Arun site are as shown in Fig. 7-6-32 and Fig. 7-6-33, respectively.

There is no basic difference between the sites, except that the product yard at Arun is 50 m longer and that railway transportation is available for shipping products at Cilegon site.

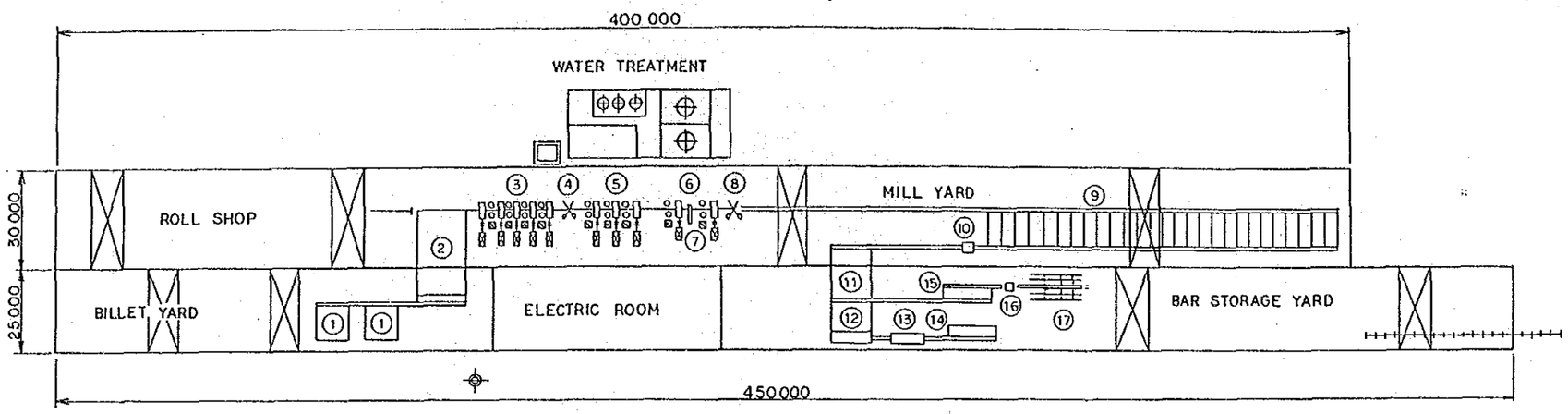
Table 7-6-26 Major Equipment List of Bar Mill

Name of Equipment	Q'ty	Specification
Billet Receiving Equipment	1 set	Consisting of - Billet receiving table: Two (2) - Furnace approach roller table
Reheating Furnace	1	. Three zone, walking hearth type . Heating capacity: 130 t/hr . Fuel : Natural gas Including - Combustion and combustion control equipment - Exhaust gas suction equipment such as flue and stack
Billet Charging/Discharging Equipment	1 set	
Roughing Mill Train	9 stands	. Horizontal-vertical alternate tandem arrangement . Each of individually driven type . Stand clamping/shifting : Hydraulically operated . Two-high horizontal stand : Five (5) . Two-high vertical stand : Four (4) Including - Driving equipment such as reduction gear, pinion stand and mill spindle
Intermediate Mill Train	6 stands	- Same as roughing stand - . Two-high horizontal stand : Three (3) . Two-high vertical stand : Three (3) Including - Driving equipment

Name of Equipment	Q'ty	Specification
Finishing Mill Train	4 stands	- Same as roughing stand - . Two-high horizontal stand : Two (2) . Two-high vertical stand : Two (2) . Splitting unit: One (1) . Maximum finishing speed : Approx. 25 m/sec. Including - Driving equipment
Mill Guide & Guiding Device	1 set	
Roll	1 set	. New roll diameter : 570 mm for No.1 and No.2 stand 530 mm for No.3 to No.6 stand 480 mm for No.7 to No.9 stand 430 mm for No.10 to No.15 stand 380 mm for No.16 to No.19 stand
Shear	2	Consisting of - Crop/cobble shear behind roughing train - Dividing shear behind finishing train
Cooling Bed	1	. Walking-beam type Including - Run-in roller table - High speed run-in trough - Bar aligning device - Run-out roller table
Cold Shear	1	. Motor driven, down-cut type Including - Cold shear gauge - Cold shear rear roller table

Name of Equipment	Q'ty	Specification
Bar Finishing Equipment		
° Regular length bar handling equipment	1 set	Consisting of - Product transfer table - Binding machine - Weighing machine - Delivery roller table - Bundle collecting table
° Irregular length bar salvaging equipment	1 set	Consisting - Discharging roller table - Irregular length bar transfer table - Cold shear for salvaging - Irregular length bar collecting pocket
Lubrication & Hydraulic System	1 set	Consisting of - Oil lubrication system - Grease lubrication system - Oil hydraulic system
Mill Auxiliary Equipment	1 set	Including - Scrap removal system - Fire protection system - Air conditioning & ventilation system
Roll Shop Equipment	1 set	Including - Numerically controlled roll turning lathe - Transversal rib cutting machine - Electro discharging machine
Water Treatment System		
° Indirect cooling water recirculating system	1 set	Consisting of - Cooling water basin - Cooling tower - Supply pump - Diesel pump for emergency - Chemical dosing unit

Name of Equipment	Q'ty	Specification
° Direct cooling water recirculating system	1 set	Consisting of - Scale pit - Settling basin - Cooling water basin - Super filter - Cooling tower - Oil belt skimmer - Supply/washing pump - Chemical dosing unit
Overhead Travelling Crane	1 set	. 9 units for Arun Site . 8 units for Cilegon Site
Electrical Equipment		
° Electric power source and distribution	1 set	25 kV system, 6.6 kV system
° DC main mill motor and control	1 set	. DC main motor: Nineteen (19) . Total power : 12,550 kW
° Auxiliary motor and control	1 set	
° Computer system	1 set	Consisting of respectively independent system as follows: - Billet charging system - Combustion system - Mill operation system - Roll preparation system - Production result system - Shipping system
° Communication system	1 set	
° Lighting system	1 set	
Other Ancillary Equipment	1 set	

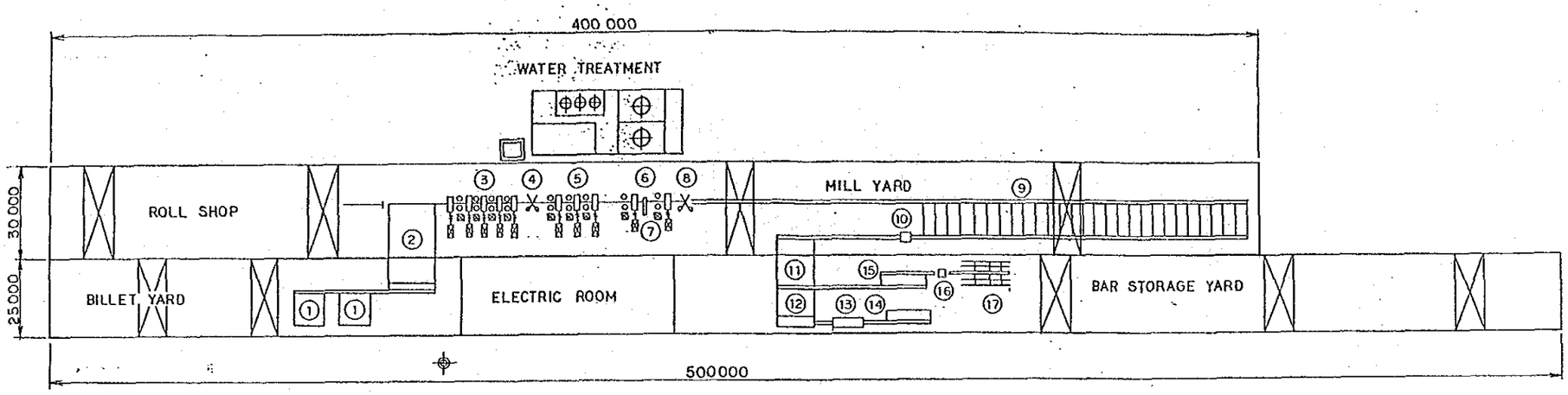


GENERAL SPECIFICATION

- TYPE OF MILL : HORIZONTAL-VERTICAL STAND ALTERNATIVE TANDEM ARRANGEMENT
- NO. OF STRAND : 1 (ONE), EXCEPT SPLIT ROLLING
- PRODUCTION CAPACITY : 650,000 T/Y
- BILLET : CONTINUOUSLY CAST BILLETS
  150mmsq. x 12,000mm (APPROX. 2,100 kg/PIECE)
- TYPE OF PRODUCTS
  - STEEL GRADE : STEEL BARS FOR CONCRETE REINFORCEMENT
    STRUCTURAL STEELS FOR GENERAL USE
  - SIZE : PLAIN & DEFORMED BARS 10 TO 50mm DIA.
- SPLIT ROLLING : FOR 10 TO 16mm DIA. BARS
  (2 STRAND ROLLING)
- MAXIMUM FINISHING SPEED : APPROX. 25 m/SEC
  (AT 10mm DIA. BARS)

NO.	NAME OF MAJOR EQUIPMENT	NO.	NAME OF MAJOR EQUIPMENT
①	BILLET RECEIVING TABLE	⑩	COLD SHEAR
②	REHEATING FURNACE	⑪	PRODUCT TRANSFER TABLE
③	ROUGHING TRAIN (9 STANDS)	⑫	BINDING MACHINE
④	CROP & COBBLE SHEAR	⑬	WEIGHING MACHINE
⑤	INTERMEDIATE TRAIN (6 STANDS)	⑭	BUNDLE COLLECTING TABLE
⑥	FINISHING TRAIN (4 STANDS)	⑮	IRREGULAR LENGTH BAR TRANSFER TABLE
⑦	SPLITTING UNIT	⑯	COLD SHEAR FOR SALVAGING
⑧	DIVIDING SHEAR	⑰	IRREGULAR LENGTH BAR COLLECTING POCKET
⑨	COOLING BED		

FIG. 7-6-32 GENERAL LAYOUT OF BAR MILL FOR CILEGON SITE



GENERAL SPECIFICATION

- TYPE OF MILL : HORIZONTAL-VERTICAL STAND ALTERNATIVE TANDEM ARRANGEMENT
- NO. OF STRAND : 1 (ONE), EXCEPT SPLIT ROLLING
- PRODUCTION CAPACITY : 650,000 T/Y
- BILLET : CONTINUOUSLY CAST BILLETS
  150mmsq. x 12,000mm (APPROX. 2,100 kg/PIECE)
- TYPE OF PRODUCTS
  - STEEL GRADE : STEEL BARS FOR CONCRETE REINFORCEMENT
    STRUCTURAL STEELS FOR GENERAL USE
  - SIZE : PLAIN & DEFORMED BARS 10 TO 50mm DIA.
- SPLIT ROLLING : FOR 10 TO 16mm DIA. BARS
  (2 STRAND ROLLING)
- MAXIMUM FINISHING SPEED : APPROX. 25 m/SEC
  (AT 10mm DIA. BARS)

NO.	NAME OF MAJOR EQUIPMENT	NO.	NAME OF MAJOR EQUIPMENT
(1)	BILLET RECEIVING TABLE	(10)	COLD SHEAR
(2)	REHEATING FURNACE	(11)	PRODUCT TRANSFER TABLE
(3)	ROUGHING TRAIN (9 STANDS)	(12)	BINDING MACHINE
(4)	CROP & COBBLE SHEAR	(13)	WEIGHING MACHINE
(5)	INTERMEDIATE TRAIN (6 STANDS)	(14)	BUNDLE COLLECTING TABLE
(6)	FINISHING TRAIN (4 STANDS)	(15)	IRREGULAR LENGTH BAR TRANSFER TABLE
(7)	SPLITTING UNIT	(16)	COLD SHEAR FOR SALVAGING
(8)	DIVIDING-SHEAR	(17)	IRREGULAR LENGTH BAR COLLECTING POCKET
(9)	COOLING BED		

FIG. 7-6-33 GENERAL LAYOUT OF BAR MILL FOR ARUN SITE

6-9. Wire rod mill

6-9-1. General

In recent years, as a small sized wire rod mill of mass-production type, a high speed rolling mill with block mill in the finishing train becomes most popular, and the finishing speed was originally 50-60 m/sec., but it has been increased and it is expected the speed of 100 m/sec. level will be general soon. At present, of the four wire rod mills in operation in Indonesia, the mill provided with the block mill is only one and its finishing speed is 60 m/sec. at the maximum. Wire rod manufacturers in Indonesia supply both low carbon and high carbon wire rods, but the production ratio of the latter remains low, and it is expected there will be necessity to increase production of high carbon wire rods in future. Unit weight of coil also is 1 ton at the maximum and it is predictable that increase of the unit weight will be requested by secondary processors in future. As a wire rod mill for the second generation, this plan envisages a high speed mill with the finishing speed of 100 m/sec. and capable of supplying 2-ton coils.

Wire rods of 5.5 mm dia. represent major parts of total production in general wire rod mills and the production capacity is usually determined by finishing rolling speed.

In this plan, two-strand rolling mill is designed to produce mainly both low carbon and high carbon wire rods in the size range of 5.5 to 16.0 mm dia. with the annual production capacity of 600,000 tons.

Now that direct heat treatment of wire rods which contributes to process omission in secondary working of wire rods is in general application, this mill too provide on-line controlled cooling equipment (forced air cooling) to increase value added.

(1) Scope of the plan

This wire rod mill has functions as product storage and shipment in addition to the production of wire rods. It has also independent roll shop equipment and water treatment equipment.

(2) Product mix

Major types of products in this plan are as follows:

Steel grade:	Low carbon wire rods (JIS SWRMxx)
	High carbon wire rods (JIS (SWRHxx)
Size:	5.5 to 16.0 mm dia.

This size range can correspond to the increasing market demand, but regarding steel grade it is predictable wire rods for cold heading and forging and for core wire of welding electrode will be required in the future. However, the wire rod mill planned here will meet the requirement for rolling of such products.

(3) Billets

Unit weight of billets is as big as 150 mm sq. x 12 m long, weighing 2,100 kg/piece, for improving product yield, and at the same time, bigger coil weight helps improve productivity and yield at wire rod secondary processing.

(4) Rolling capacity (maximum finishing speed)

Productivity increases in proportion to the increase of rolling speed and in future the operation with the speed of 100 m/sec. seems to be popular, so the maximum finishing speed is also designed to be 100 m/sec. in this mill.

The equipment of the mill is taken into consideration so that it can reduce down time due to cobble, roll adjusting time and groove and roll changing time, thereby increasing roll operating time.

(5) Energy saving

Reduction of fuel consumption at the reheating furnace is planned by proper combustion control, waste heat recovery by recuperator, and hot billet charging.

(6) Labor saving

Mechanization is applied wherever possible to improve labor productivity. This mill is full continuous from billet charging to product finishing. In addition, the mill involves production control and operation systems, but the systems are independent each other and the total system integrating all the systems is excluded in this plan.

(7) Environmental control

As a wire rod mill for the second generation, the mill is operated carefully to prevent atmospheric and water pollution. At the reheating furnace, proper combustion control prevents emission of black smoke, and direct cooling water for cooling rolls and products is treated in the recirculating system to remove scale and oil.

(8) Product shipping

At Cilegon site, mostly regular shipping of products is carried out by rail, truck and ship, whereas, at Arun site, products are shipped mainly by sea to other islands. As a result, at Arun site, shipping of products from the wire rod mill has to be made intermittently and concentratedly, and the product yard is

extended by 50 m to increase storage capacity and one more crane is installed.

6-9-2. Premises for facilities plan (calculation of production capacity)

On the assumption that the mill can be operated to attain the present performance of similar type of wire rod mills in Japan, operating conditions for the mill are decided and its production capacity is calculated on under 2-line rolling. As 5.5-mm diameter wire rods accounts for the major part of production at the wire rod mill, 5.5-mm diameter rod is assumed as the representing size.

Table 7-6-27 Operating Conditions of Wire Rod Mill

Total working time	(A)	8,760 hrs/y	4 team, 3-shift continuous operation
Scheduled down time	(B)	620 hrs/y	Annual repair: once/year Monthly repair: once/month
Total operation time	(C)	8,140 hrs/y	(C) = (A) - (B)
Roll rotating time	(D)	6,350 hrs/y	(D)/(C) = 0.78
Average productivity	(E)	94.5 t/h	
Annual production capacity	(F)	600,000 t/y	(D) x (E) 2-line rolling

6-9-3. Technical explanation

(1) Outline of facilities

1) Layout

The wire rod mill has two rolling lines of full-continuous tandem arrangement and is a high speed mill with a block mill in the each finishing train. As the product is shipped out directly from the mill, the mill has an extensive product yard with storage capacity of about 9,000 tons.

2) Billet yard

For saving energy, hot billets from CCM are transferred direct to this mill and hot-charged into the reheating furnace. The billets are brought here by truck and two cranes are operated to handle the billets. At the billet yard, there is always kept stock of cold billets, and if productivity of the wire rod mill exceeds supply capacity of hot billets from CCM plant, the cold billets are used. Two billet receiving tables are provided, one each for cold and hot billets.

3) Reheating furnace

Reheating furnace is of walking-hearth type and has the maximum heating capacity of 130 t/h to ensure average rolling capacity of 100 t/h. As long billets are side-discharged, there is no problem of temperature drop at the tail end of billets during discharging. Proper furnace temperature control reduces scale loss and improves yield. Together with recovery of waste heat by recuperator, it lowers fuel consumption. In addition, hot billet charging reduces fuel consumption further.

4) Rolling equipment

Roughing train and the No.1 intermediate train consist of horizontal stands in tandem of two strand passes, whereas the No.2 intermediate train and finishing train comprise two lines of one strand pass each. Each of No.2 intermediate trains is in horizontal and vertical alternate stand arrangement and each finishing train consists of a block mill of 10 stands. Both permit twist-free rolling. Because the four stands ahead of the block mill are in the vertical-horizontal alternate arrangement, the rolling stock with high roundness can be fed to the block mill ensuring improvement of dimensional accuracy and lower frequency of cobbles.

The roughing train and intermediate train are both of fixed pass line during rolling and rolls and grooves are exchanged hydraulically in short time.

Except the block mill, roll changing method is of stand changing type to shorten roll changing time. Less-abrasive tungsten carbide ring rolls are applied to every 10 stands comprising the block mill and such light ring rolls allow manual roll changing operation. Those ring rolls and guides can be hydraulically set in short time.

While all stands in the roughing train and intermediate train are driven by individual motors, one stand by one motor, the ten stands of the block mill are driven by one motor in common. D.C. motors have been applied to block mill driving, but recently thyristor motors which facilitate maintenance job are getting common and are employed for block mills in this wire rod mill also.

5) Finishing equipment

Upon leaving the finishing mill, the wire rods pass through cooling water zones installed between the block mill and the laying head and are further cooled by forced air on the coil conveyor. The coil conveyor consists of five zones with one blower for each zone.

Depending on steel grades and customers' specifications, the cooling rate in the cooling water zones and on the conveyor is controlled to produce wire rods with satisfactory drawability and with less surface scale, which can contribute toward saving process in secondary working.

For this controlled cooling, a system is employed to determine cooling condition (water flow rate, air flow rate, conveyor speed) depending on steel grade and wire rod size.

At the tail end of the coil conveyor, the wire rods are formed and transferred to the hook conveyor via the downender. On the hook conveyor line, defective parts on both ends are trimmed and then the coils are inspected for defects, bound, weighed and unloaded off the hooks. As any troubles at binding stage directly lead to production reduction, a stand-by unit is installed.

6) Electrical equipment

All main motors of the roughing and intermediate trains are of D.C. type and stands of those trains are driven by individual motors with power from individual D.C. sources. This permits quick recovery and control of speed against impact drop and tension-free rolling in the No.2 intermediate train to avoid dimensional variations through-out the length. Direct current

variable voltage power sources are thyristor Leonard type and have better response and easier maintenance than the mercury-arc rectifier. A thyristor motor (A.C.) drives the block mill as mentioned already.

7) System

Seven systems of billet charging, combustion, mill operation, roll preparation, production result, shipping and controlled cooling are provided. Though those systems are independent respectively, they are effective for ease of operation, improvement of quality and roll rotating time.

8) Roll shop equipment

Characteristic of roll shop in the wire rod mill is groove forming of tungsten carbide rolls. This requires the electrolytic polishing machine for ring rolls and the dressing machine for grinding diamond wheels.

(2) Measures for future production of high grade steels

The wire rod mill planned here is provided with such equipment that can meet requirements for future production of high grade steels. Namely, the reheating furnace is of walking-hearth type, which permits easier decarbonization control and less scratches.

The No.2 intermediate and finishing trains allow tension-free rolling resulting in good surface quality and dimensional accuracy.

However, as the requirement for surface and internal quality is very strict for high grade steel, it is imperative to install billet inspection and condition-

ing facilities and a space is provided close to the rod mill area.

6-9-4. Specifications of major equipment

Major equipment of the wire rod mill and their specification are shown in Table 7-6-28.

6-9-5. Layout

As layout of the wire rod mill, those at Cilegon and Arun sites are as shown in Fig. 7-6-34 and Fig. 7-6-35, respectively.

There is no basic difference in the layout between the sites, except for that the product yard at Arun site is 50 m longer than Cilegon site and that railway transportation is available for shipping products at Cilegon site.

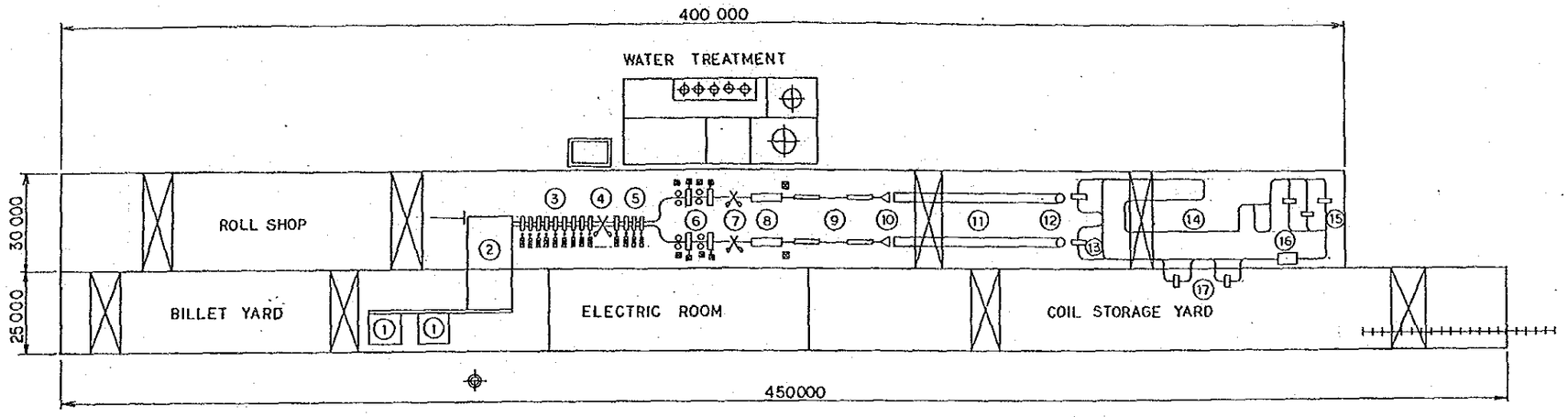
Table. 7-6-28 Major Equipment List of Wire Rod Mill

Name of Equipment	Q'ty	Specification
Billet Receiving Equipment	1 set	Consisting of - Billet receiving table: Two (2) - Furnace approach roller table
Reheating Furnace	1	. Three-zone, walking hearth type . Heating capacity: 130 t/hr . Fuel : Natural gas Including - Combustion equipment - Combustion control equipment - Exhaust gas suction equipment such as flue and stack
Billet Charging/Discharging Equipment	1 set	
Roughing Mill Train	9 stands	. Two-high horizontal closed top and individually driven type . No. of strand: Two (2) . Stand clamping/shifting : Hydraulically operated Including - Driving equipment such as reduction gear, pinion stand and mill spindle
No.1 Intermediate Mill Train	4 stands	- Same as roughing stand -
No.2 Intermediate Mill Train	4/line x 2 (8 stands)	. Two-line, one strand rolling . Horizontal-vertical stand alternate tandem arrangement . Each of individually driven type . Stand clamping/shifting : Hydraulically operated . Two-high horizontal stand : Four (4) . Two-high vertical stand : Four (4) Including - Driving equipment

Name of Equipment	Q'ty	Specification
Finishing Mill Train (Block Mill)	1/line x 2	. Ten stand twist free type, commonly driven by one motor . Roll: Tungsten carbide ring type . Main motor: Thyristor motor . Roll clamping/guide settling : Hydraulically operated . Maximum finishing speed : 100 m/sec. (Design) Including - Driving unit
Mill Guide & Guiding Device	1 set	Including - Looper - Pinch roller
Shear	4	Consisting of - Crop/cobble shear behind roughing train : Two (2) - Crop/shopping shear ahead of block mill : Two (2)
Roll for Roughing and Intermediate Train	1 set	. New roll diameter : 570 mm for No.1 and No.2 stand 530 mm for No.3 to No.6 stand 480 mm for No.7 to No.9 stand 460 mm for No.10 to No.13 stand 300 mm for No.14 to No.17 stand
Water Cooling Zone	1 set/line x 2	Pressurized water nozzle spray type
Laying Head	1/line x 2	Laying speed: Max. 100 m/sec. Coil dimension : 1350 mm (Outer dia.) 950 mm (Inner dia.)

Name of Equipment	Q'ty	Specification
Coil Cooling Conveyor	1/line x 2	. Chain conveyor type . No. of cooling zone: Five (5) . Air blower for forced air cooling : Centrifugal type, Five (5)
Coil Forming Chamber	1/line x 2	Including - Reforming tub - Separating device
Coil Collecting & Transfer Unit	1/line x 2	Including - Coil collecting device - Coil transfer car
Coil Handling Equipment	1 set	Consisting of - Hook conveyor - Coil compacting/binding machine : Two (2) for working, one (1) for standby - Weighing machine - Coil unloader
Lubrication & Hydraulic System	1 set	Consisting of - Oil lubrication system - Grease lubrication system - Oil mist lubrication system - Oil hydraulic system
Mill Auxiliary Equipment	1 set	Including - Scrap removal system - Fire protection system - Air conditioning & ventilation system
Roll Shop Equipment	1 set	Including - Numerically controlled roll turning lathe - Electrolytic polishing machine for tungsten carbide roll - Dressing machine for grinding diamond wheel

Name of Equipment	Q'ty	Specification
Water Treatment System		
° Indirect cooling water recirculating system	1 set	Consisting of - Cooling water basin - Cooling tower - Supply pump - Diesel pump for emergency - Chemical dosing unit
° Direct cooling water recirculating system	1 set	Consisting of - Scale pit - Settling basin - Cooling water basin - Super filter - Cooling tower - Oil belt skimmer - Supply/washing pump - Chemical dosing unit
Overhead Travelling Crane	1 set	. 9 units for Arun Site . 8 units for Cilegon Site.
Electrical Equipment		
° Electric power source and distribution	1 set	25 kV system, 6.6 kV system
° Main mill motor and control	1 set	. DC main motor: Nineteen (19) . AC main motor: Two (2) . Total power : 15,900 kW
° Auxiliary motor and control	1 set	
° Computer system	1 set	Consisting of respectively independent system as follows: - Billet charging system - Combustion system - Mill operation system - Controlled cooling system - Roll preparation system - Production result system - Shipping system
° Communication system	1 set	
° Lighting system	1 set	
Other Ancillary Equipment	1 set	

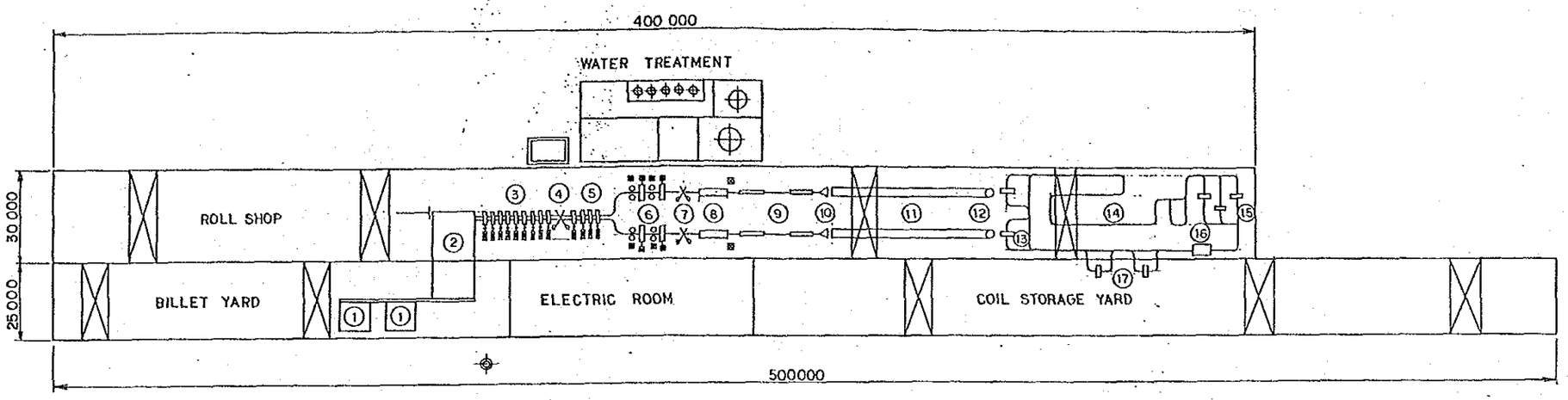


GENERAL SPECIFICATION

- TYPE OF MILL : FULL CONTINUOUS TYPE
- NO OF STRAND : 2 (TWO) FOR ROUGHING AND NO.1 INTERMEDIATE TRAIN
  1 (ONE) FOR NO.2 INTERMEDIATE AND FINISHING TRAIN
- PRODUCTION CAPACITY : 600,000 T/Y
- BILLET : CONTINUOUSLY CAST BILLETS
  150mm sq. x 12.000 mm (APPROX. 2,100 kg/PIECE)
- TYPE OF PRODUCTS
  - STEEL GRADE : LOW CARBON STEEL WIRE RODS
    HIGH CARBON STEEL WIRE RODS
  - SIZE : 5.5 TO 16.0 mm DIA.
- MAXIMUM FINISHING SPEED : APPROX. 100 m/SEC
  (AT 5.5 mm DIA. WIRE RODS)

NO.	NAME OF MAJOR EQUIPMENT	NO.	NAME OF MAJOR EQUIPMENT
①	BILLET RECEIVING TABLE	⑩	LAYING HEAD
②	REHEATING FURNACE	⑪	COIL COOLING CONVEYOR
③	ROUGHING TRAIN (9 STANDS)	⑫	REFORMING TUB
④	CROP & COBBLE SHEAR	⑬	DOWN – ENDER
⑤	NO.1 INTERMEDIATE TRAIN (4 STANDS)	⑭	HOOK CONVEYOR
⑥	NO.2 INTERMEDIATE TRAIN (4 STANDS/LINE)	⑮	COMPACTING / BINDING MACHINE
⑦	CROP & CHOPPING SHEAR	⑯	WEIGHING MACHINE
⑧	FINISHING TRAIN (10 STAND BLOCK MILL)	⑰	COIL UNLOADER
⑨	WATER COOLING ZONE		

FIG. 7-6-34 GENERAL LAYOUT OF WIRE ROD MILL FOR CILEGON SITE



GENERAL SPECIFICATION

- TYPE OF MILL : FULL CONTINUOUS TYPE
- NO OF STRAND : 2(TWO) FOR ROUGHING AND NO.1 INTERMEDIATE TRAIN
  1(ONE) FOR NO.2 INTERMEDIATE AND FINISHING TRAIN
- PRODUCTION CAPACITY : 600,000 T/Y
- BILLET : CONTINUOUSLY CAST BILLETS
  150mmsq.x12.000mm (APPROX. 2,100 KG/PIECE)
- TYPE OF PRODUCT
  - STEEL GRADE : LOW CARBON STEEL WIRE RODS
    HIGH CARBON STEEL WIRE RODS
  - SIZE : 5.5 TO 16.0 mm DIA.
- MAXIMUM FINISHING SPEED : APPROX. 100 M/SEC
  (AT 5.5 mm DIA. WIRE RODS)

NO.	NAME OF MAJOR EQUIPMENT	NO.	NAME OF MAJOR EQUIPMENT
①	BILLET RECEIVING TABLE	⑩	LAYING HEAD
②	REHEATING FURNACE	⑪	COIL COOLING CONVEYOR
③	ROUGHING TRAIN (9 STANDS)	⑫	REFORMING TUB
④	CROP & COBBLE SHEAR	⑬	DOWN-ENDER
⑤	NO.1 INTERMEDIATE TRAIN (4 STANDS)	⑭	HOOK CONVEYOR
⑥	NO.2 INTERMEDIATE TRAIN (4 STANDS/LINE)	⑮	COMPACTING / BINDING MACHINE.
⑦	CROP & CHOPPING SHEAR	⑯	WEIGHING MACHINE
⑧	FINISHING TRAIN (10 STAND BLOCK MILL.)	⑰	COIL UNLOADER
⑨	WATER COOLING ZONE		

FIG. 7-6-35 GENERAL LAYOUT OF WIRE ROD MILL FOR ARUN SITE

6-10. Utilities

6-10-1. Power plant

(1) Basic idea

As EAFs are used in steelmaking process, a vast amount of electricity is consumed and availability of power is important. Power consumption averages as high as about 222,000 kW and is indeed very big for both Cilegon and Arun areas. As already mentioned in Chap. VI 4-2, fuel supply condition varies slightly between Cilegon area and Arun area. As the fuel condition is changeable in the both areas, reheat cycle boiler and turbine system which can use two or three kinds of fuel is adopted as the basic plan for the power plant of the new steel works. Power plant based on coal-firing is not only expensive itself but necessitates a considerable change in the layout of the steel works including port plan, transport plan and yard plan. Therefore in this study, oil-firing power plant is considered.

As discussed in Chap. VI 4-2, the capacity of the power plant is to be 400,000 kW. Steam turbine requires a large amount of cooling water and the power plant will be built close to the seashore. Heavy oil as fuel is transported by sea. Power receiving station is set up in the compound of the steel works to receive power from P.L.N..

(2) Premises for facilities plan

1) Capacity of the facilities

As discussed in Chap. VI 4-2, except part of peak power demand, average power consumed in the works is supplied from its captive power plant. The power requirements is 300,000 kW, but the power plant is to have installed

capacity of 400,000 kW including a spare unit to cover shortage at the time of periodical inspection of boiler and turbine.

2) Fuel

Fuel used is to be heavy oil equivalent to C heavy oil in JIS and of low sulfur.

Table 7-6-29 Conditions of Fuel Oil

Item	Content
Higher heat value	10,200 kcal/kg
Density	1.0 kg/ℓ, max. (at 15 degree centigrade)
Viscosity	15 - 75 cst.
Sulfur content	0.3% wt. max.
Standard	Equivalent to C heavy oil in JIS

3) Cooling water (sea water)

As no detailed data are available, the temperature is assumed to be 30 ^{o}C. Water quality is assumed to be equal to that in Cilegon.

4) Atmospheric condition

Temperature is assumed to be 26 ^{o}C at annual average.

5) Periodical inspection

Each unit of boiler and turbine is to undergo periodical inspection for duration of about 3 weeks/year.

6) Power consumption of the steel works

Expected fluctuation of power consumption in the steel works is shown in Fig. 7-6-36.

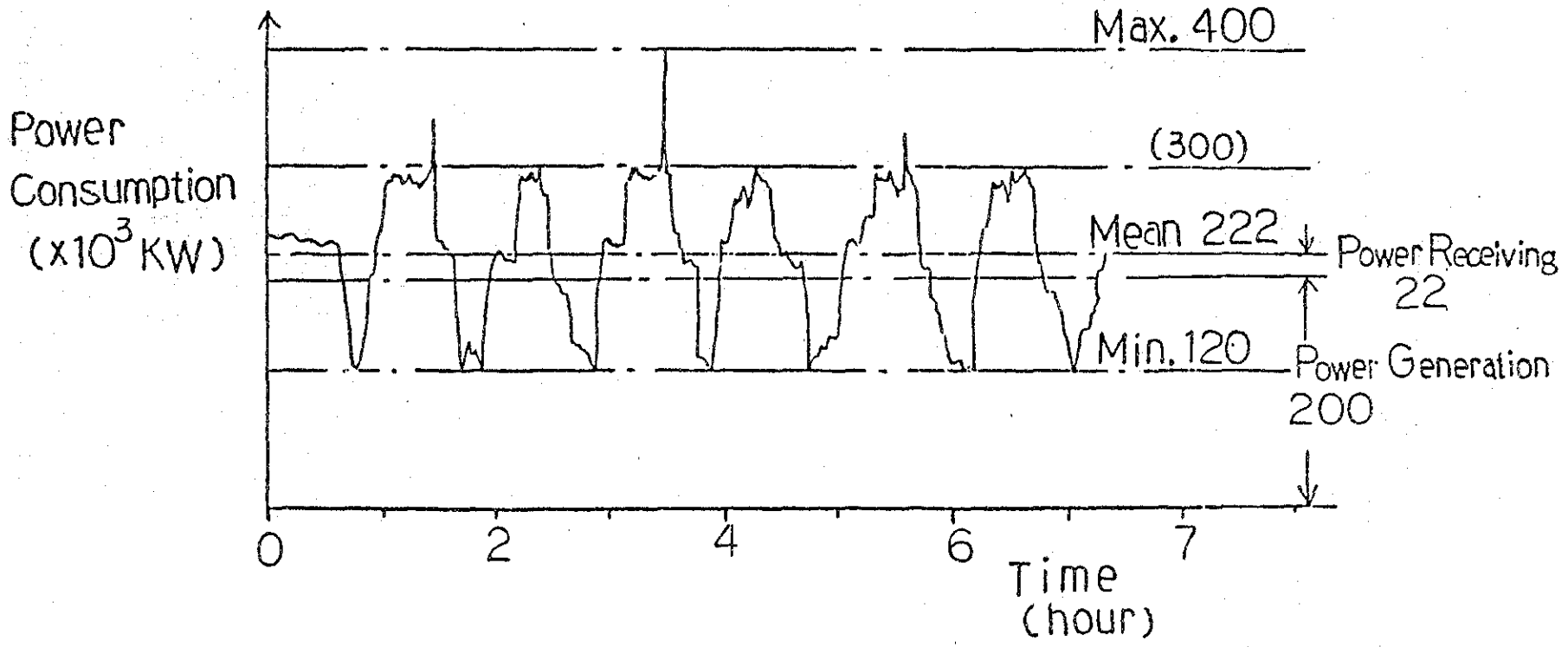


Fig. 7-6-36 Power Consumption Estimation

7) Consumption of hydrogen

Hydrogen used for cooling the generators is purchased bottled in cylinder.

(3) Technical explanation

Fuel oil is unloaded at oil unloading berth and sent to a oil storage tank and then to boilers. The fuel oil is burnt in the boiler and converted to high pressure steam. The steam is converted in the steam turbine to power and the power is converted into electricity in the generator.

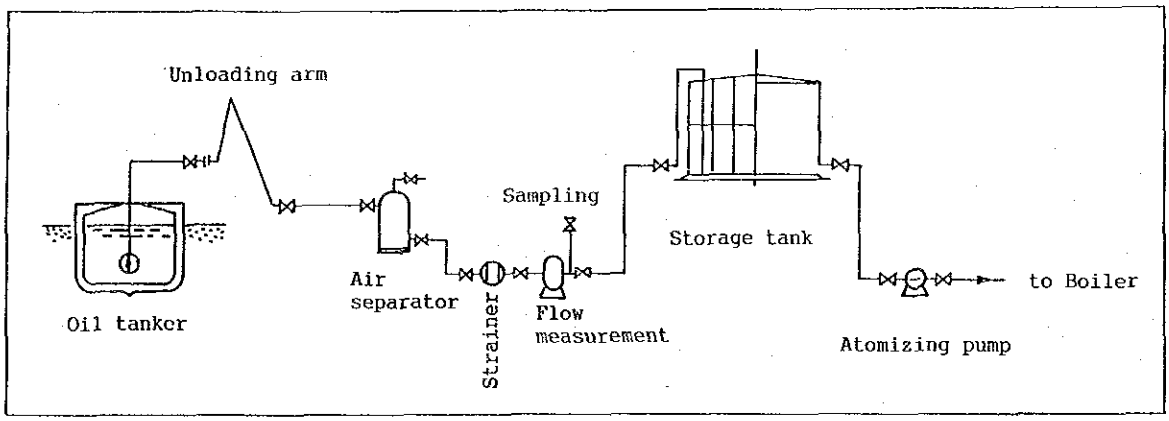


Fig. 7-6-37 Schematic Flow Diagram of Heavy Oil, Receiving to Boiler

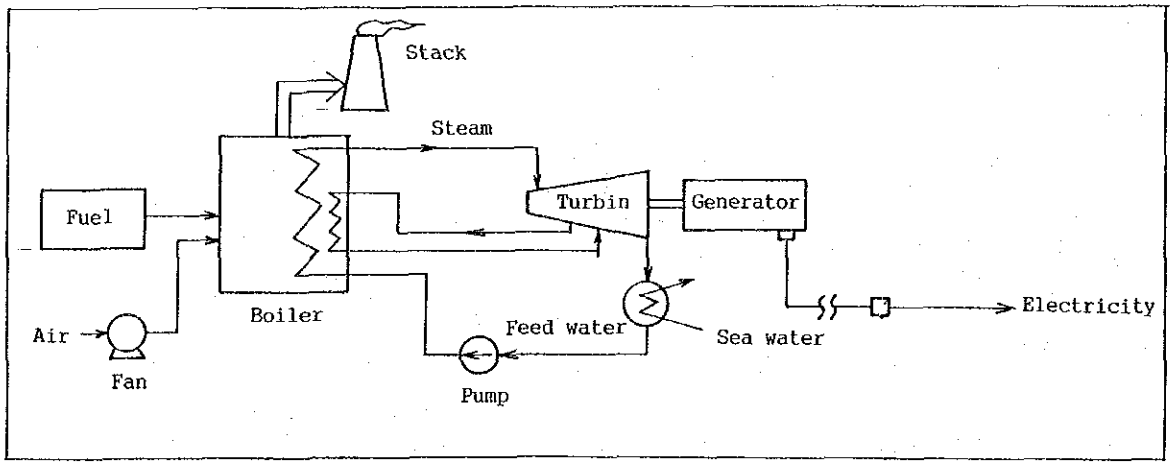


Fig. 7-6-38 Conceptional Diagram of Power Plant

Fluctuation of power demand of EAFs is very fast as given in Chap. VI 4-2 and estimated to be at a rate of 100,000 kW in five minutes. The response of the power plant, even of oil-firing type, is estimated to take more than ten minutes to change its output by 50%. The coal-firing plant takes about 30 minutes for such change. In any case, it is very difficult for the power plant to follow up the fluctuation of power demand of EAF and it is necessary to operate by connecting the power line of the works with a large capacity outside power source to reduce frequency fluctuation of the power.

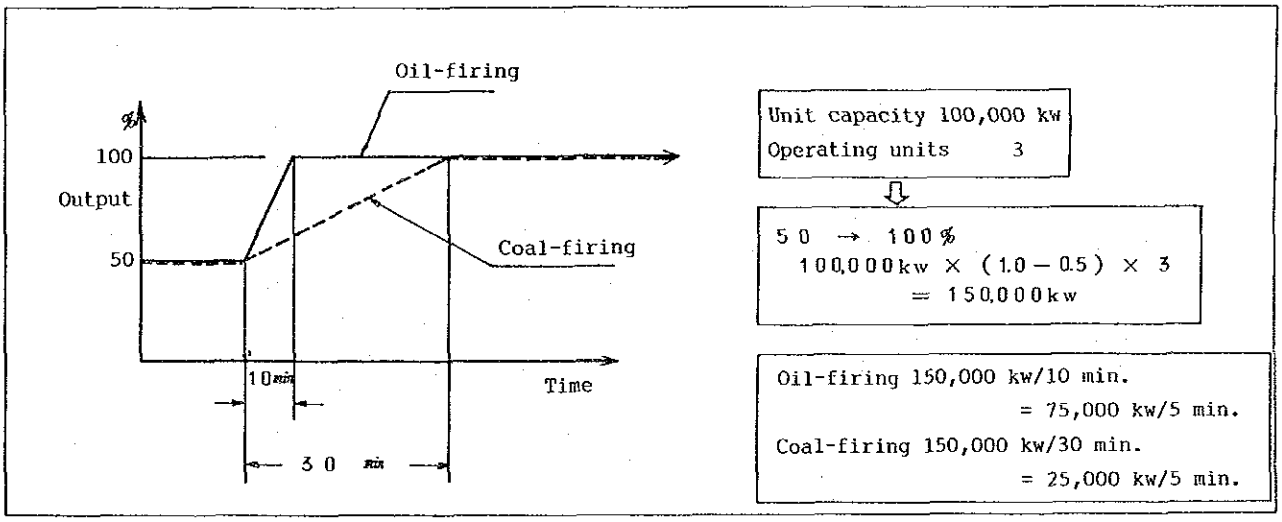


Fig. 7-6-39 Comparison of Output Changing Speed between Oil-firing Plant and Coal-firing Plant

Thermal efficiency of boiler, with higher heat value fuel, reaches 90% at maximum continuous rating. Heat rate of the turbine at the maximum output is 2,000 kcal/kWh. Combined heat rate of boiler and turbine is 2,222 kcal/kWh, but as the actual average operating point is partial load, the actual heat rate is about 2,343 kcal/kWh. The heat rate of power plant is as shown in Fig. 7-6-40.

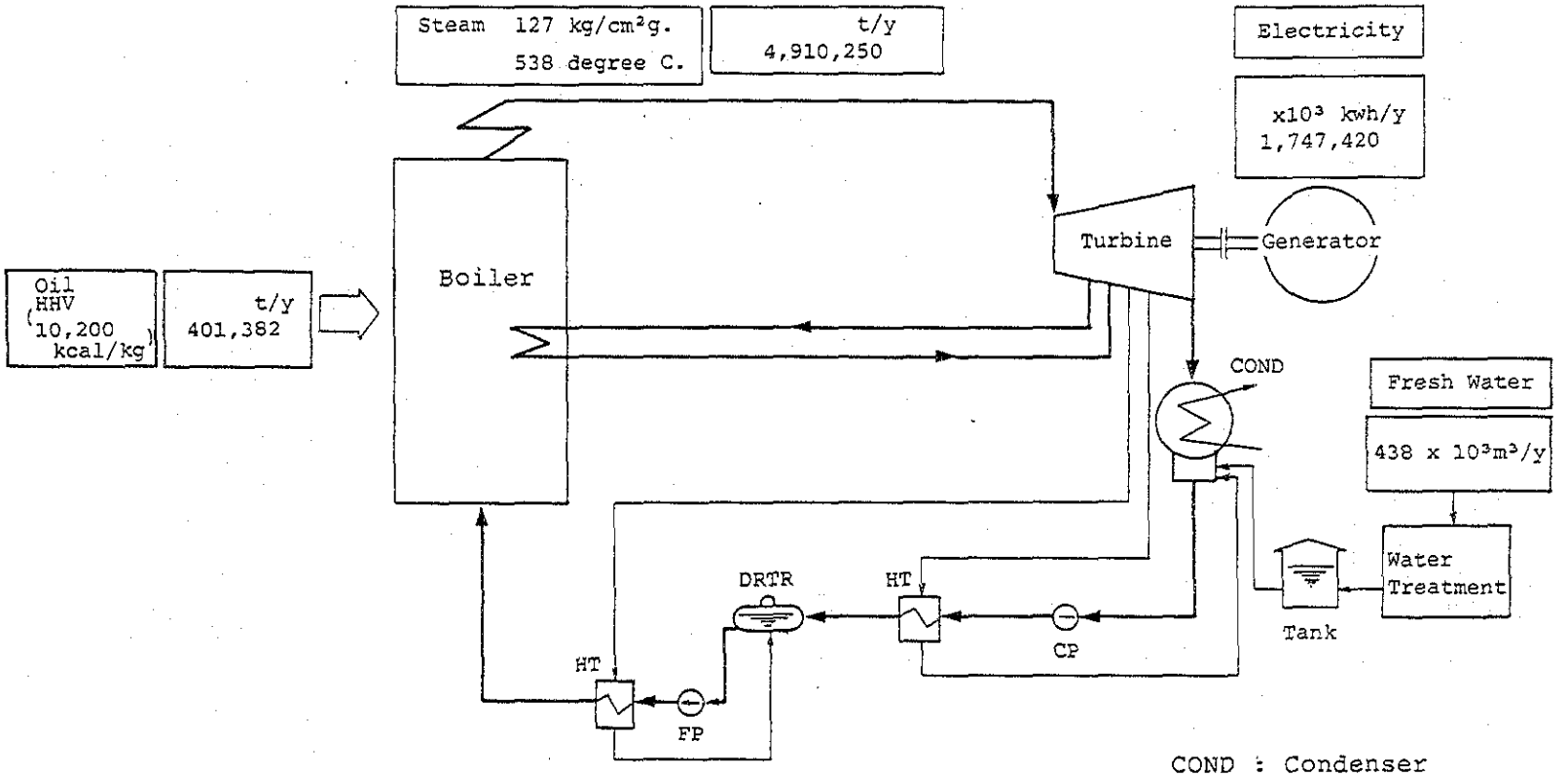


Fig. 7-6-40 Heat Rate of Power Plant

Electricity purchased from P.L.N. is determined by how output of the captive power plant is controlled. But in fact it is difficult to make the output of captive power plant follow up the fluctuation of power demand of EAFs, and it is expected that, on an average, power equal to about 10% of power demand of the steel works will be purchased from P.L.N.

(4) Specifications of major equipment

Major equipment and their specifications are shown in Table 7-6-30.

(5) Layout

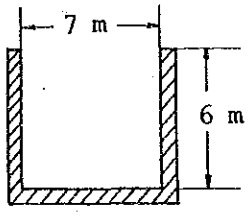
Layout of power plant is shown in Fig. 7-6-41.
The sub-center is in the power plant building.
In order to permit conversion to coal firing in future, a space is ensured for coal mill and electrostatic precipitator of waste gas line. Its location is shown by hatching in Fig. 7-6-41.

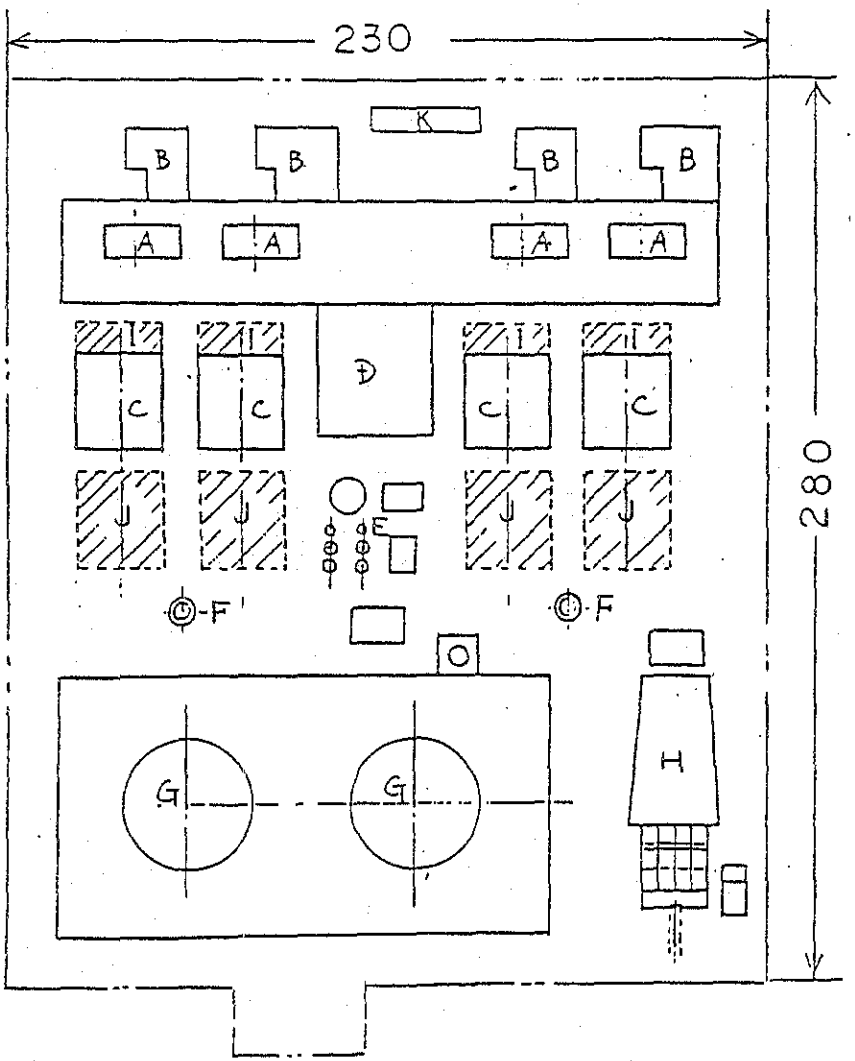
Table 7-6-30 Specification of Power Plant

Equipment	Quantity	Specification
Steam Generator (Boiler)	4 units	Type : Natural Circulation Boiler Evaporation : 300 t/h Steam Pressure : 156 kg/cm²g (design) 134 kg/cm²g (outlet) Steam Temp. : 541°C Draft System : Balanced Draft Fuel : Oil Main Equipment : Steam Drum, Furnace, Superheater, Reheater, Economizer & Air Heater
Steam Turbine	4 units	Type : Two Cylinders, Double Flow Exhaust, Reheat, Condensing Turbine Rating : 100,000 kw Speed : 3,000 rpm Steam Condition : 127 kg/cm²g (throttle) 538°C (throttle) 30 kg/cm² (reheat) 538°C (reheat) Condenser Vaccum : 722 mmHg See Water Temp. : 30°C
Generator	4 units	Type : Totally Enclosed, Self-ventilated, Sationary Amature, Cylindrical Field Hydrogen-cooled Capacity : 117,647 KVA Voltage : 12.5 KV Power Factor : 0.85 No. of Phase : 3 Frequency : 50 Hz Speed : 3,000 rpm
Transformer	4 units	Main Transformer Capacity : 117,647 KVA Voltage : 12.5 KV/150 KV Unit Transformer
Electrical Equipment	1 set	Switchgear, Battery and Charging Set

Equipment	Quantity	Specification
Instrumentation	4 units	Automatic Boiler Control System, Turbine Supervisory System, Burner Control System
Power Demand Monitor	1 set	Data Processing of Power Demand in E.A.F.
Water Treatment System (Fresh water)	1 set	Demineralized system: 2 trains of 2 beds 3 towers with polisher 50 t/h
Demineralizd-Water Tank	2 units	Capacity 200 m^3
Oil Tank	2 units	Capacity 20,000 kℓ
Sea Water Pump	4 units	Capacity 15,000 t/h
Sea Water Intake	1 set	Cilegon Piping { diameter 2,100 mm length 400 m line 5 Open Channel (*) length 1,100 m Arun Piping { diameter 2,100 mm length 500 m line 5 Open Channel (*) length 530 m
Sea Water Discharge	1 set	Cilegon Piping { diameter 2,100 mm length 200 m line 5 Open Channel (*) length 550 m Arun Piping { diameter 2,100 mm length 500 m line 5 Open Channel (*) length 500 m

(*) Sectional View of Open Channel





A. Turbine
B. Transformer
C. Boiler
D. Control & Electric Room
E. Water Treatment
F. Stack
G. Oil Storage Tank
H. Sea Water Pump Station
I. Coal Mill (Coal Firing)
J. Electrostatic Precipitator (Coal Firing)
K. Gas Insulated Switch Gear

Fig. 7-6-41 Layout of Power Plant

6-10-2. Power receiving and distributing equipment

(1) Basic idea

Because of big load fluctuation of EAFs and its fast speed, it is difficult for a captive private power plant alone to provide stable power supply to the steel works. Therefore it is necessary to connect the power line of outside power sources such as P.L.N. and the power line of the private power plant to the bus from which the power is fed to the plant. As measure to cope with the problem of flicker in power system serving EAFs, static var compensator is installed. For coping with harmonic wave, filter is installed.

(2) Premises for facilities plan

1) Power source

It is assumed that there are big and stable outside power sources, from which back up power is received. Condition of such outside power is that it is 150 kV and frequency is 50 Hz.

2) Scope

Equipment following the power receiving switch installed in the compound of the power plant are included in the study.

3) Voltage of power supplied to the plant

150 kV, 25 kV and 6.6 kV

4) Power balance in the steel works

As shown in Fig. 7-6-42.

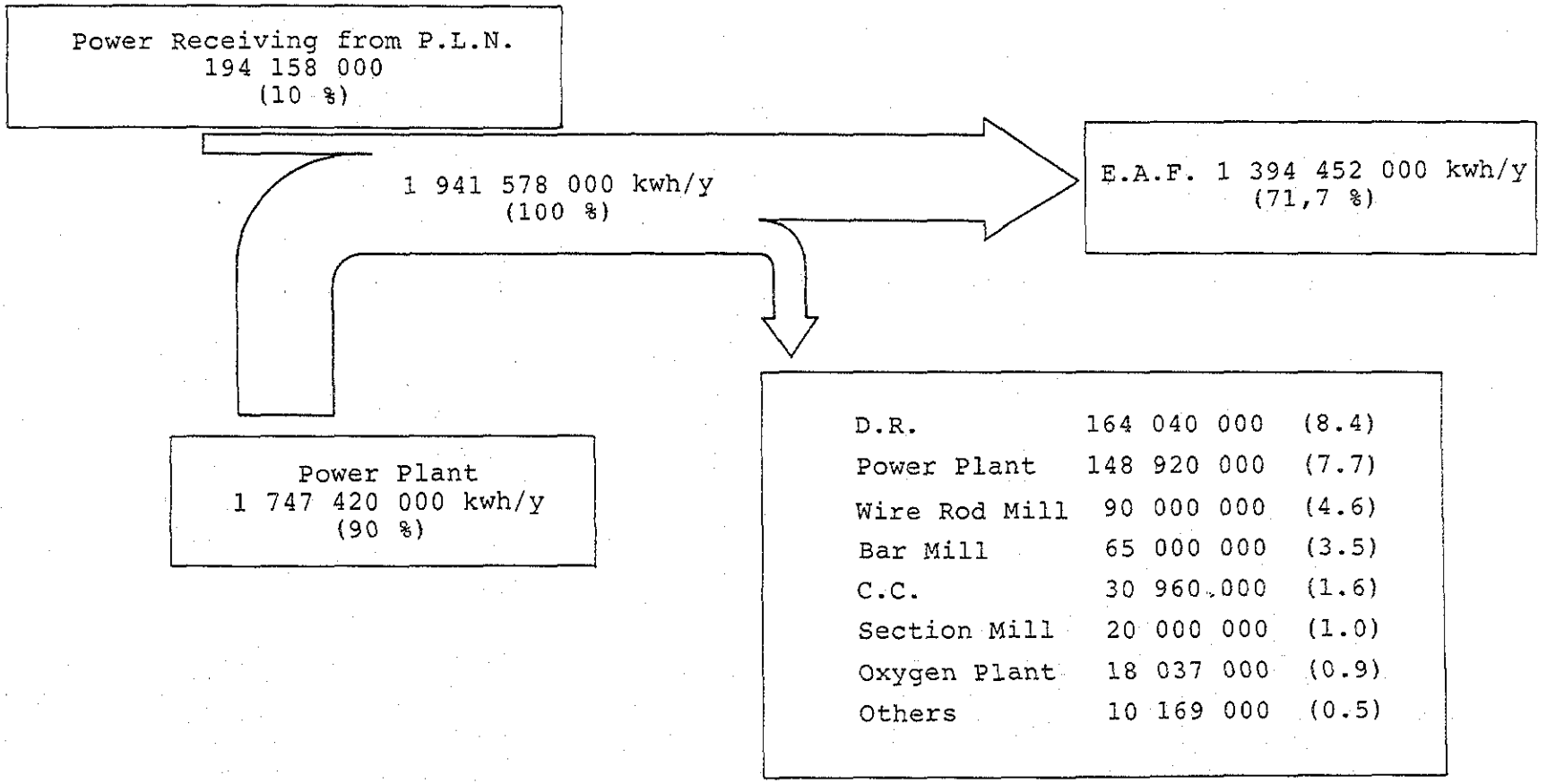


Fig. 7-6-42 Electricity Balance

(3) Technical explanation

The power line of outside power source such as P.L.N. is connected with the 150 kV bus which is connected to the power plant. The 150 kV bus is to be double. More than 70% of the total power consumption is concentrated on EAFs and almost all production plants are arranged in the vicinity of EAF plant, and therefore a central sub-station is installed adjacent to EAFs. The power is stepped down at the substation from 150 kV to 25 kV and 6.6 kV and distributed to plants. As maintenance shop and water pump station are located at separate places, power is supplied from the power plant at 6.6 kv.

As measures for flicker due to EAF operation, static var compensator is installed, but combined with harmonic wave filter, it is connected with 25 kV power line.

(4) Specifications of major equipment

Specifications of the substation is as shown in Table 7-6-31, and those of other electric equipment in Table 7-6-32.

Single line diagram is shown in Fig. 7-6-43.

(5) Layout

Fig. 7-6-44 shows layout of the substation.

Table 7-6-31 Specification of the Substation

Equipment	Quantity	Specification
Transformer	6 sets	100 MVA, 150 KV/25 KV, OFAF
	2 sets	30 MVA, 25 KV/6.6 KV, ONAN
Metal-clad Cubicle	37 units	25 KV, GCB
	17 units	7.2 KV, GCB
Static Var Compensator	2 units	25 KV, 120 MVar Thyristor-controlled reactor type
Harmonic Filter	2 sets	35 MVA 100 Hz 34 MVA 150 Hz 15 MVA 200 Hz 12 MVA 250 Hz 6 MVA 300 Hz 6 MVA 350 Hz
	1 set	20 MVA 250 Hz 10 MVA 350 Hz

Table 7-6-32 Specification of Electric Equipment

Equipment	Quantity	Specification
Wiring	1 set	Culvert 1500 m
	1 set	Duct 4200 m
Gas Insulated Switch Gear	19 units	150V Installed in Power Plant

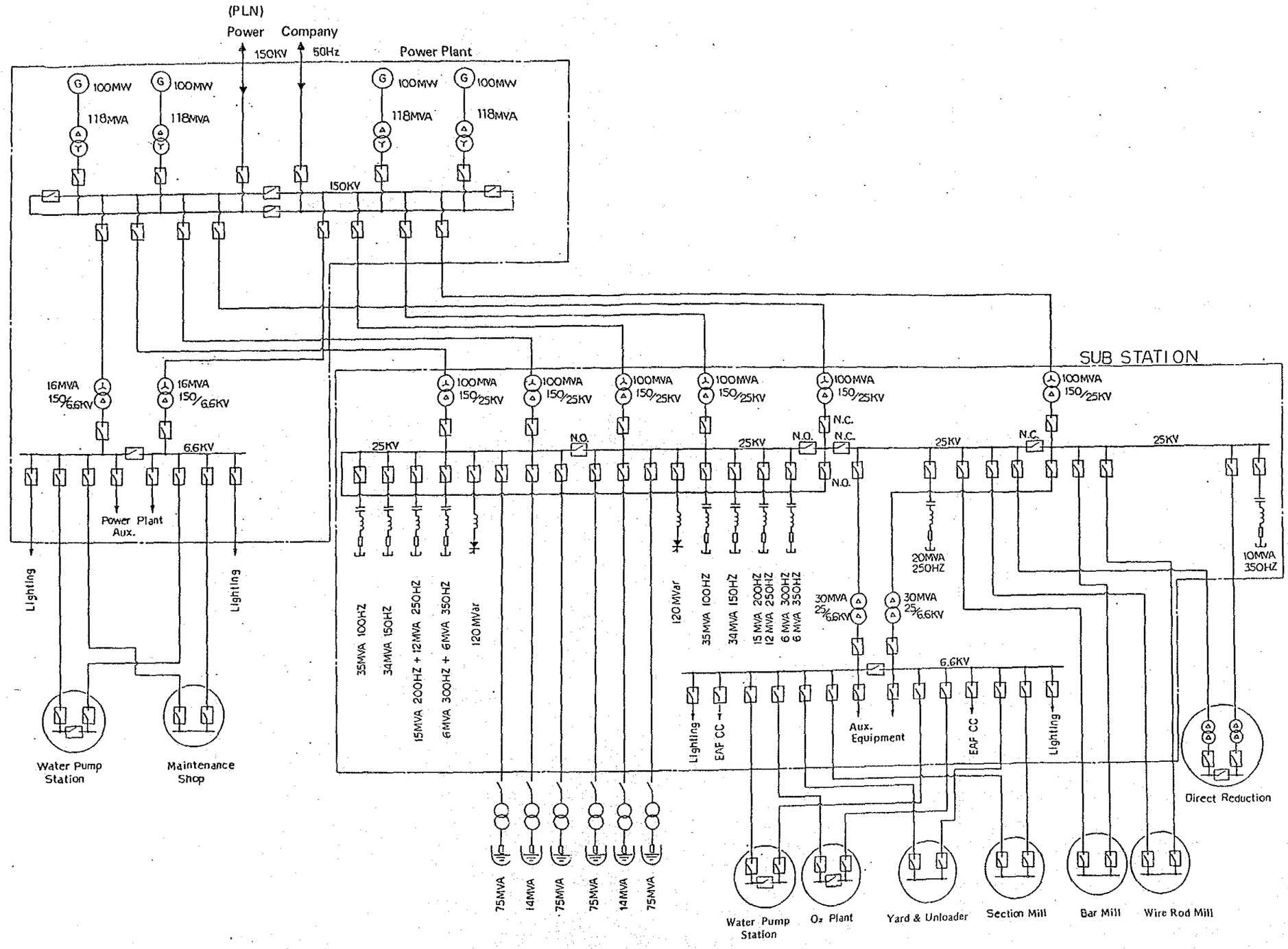
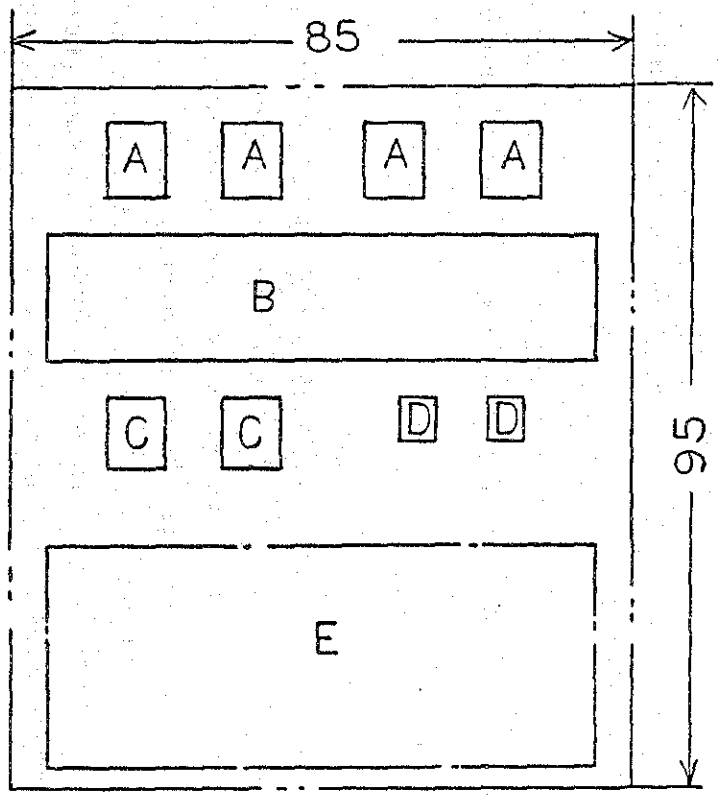


Fig. 7-6-43 Single Line Diagram



A. Transformer
B. Metal-clad Cubicle Room
C. Transformer
D. Transformer
E. Static Var Compensator and Harmonic Filter (outdoor type)

Fig. 7-6-44 Layout of Substation

6-10-3. Argon, nitrogen, oxygen & compressed air

(1) Basic idea

As a considerable amount of argon is required, there will be facilities which include air separator based on cryogenic method as main equipment.

(2) Premises for facilities plan

1) Purity

Argon	99.99%
Nitrogen	99.99%
Oxygen	99.6%

2) Tank and holder

Gas holders are used to cope with fluctuation of demand for nitrogen and oxygen while liquefied gas tank serves for argon.

3) Delivery pressure

Argon	10 kg/cm^2g	Oxygen	17 kg/cm^2g
Nitrogen	10 kg/cm^2g	Compressed air	7 kg/cm^2g

(3) Technical explanation

Air is compressed by air compressor and sent to the air separator where it is separated into oxygen, nitrogen and argon. Oxygen thus obtained is compressed by oxy-compressor and sent to the gas holder, from which it is supplied to plants. Nitrogen is handled similarly. Argon is stocked in liquefied argon storage tank and supplied to consuming plants. Compressed air is compressed by high efficient compressor and sent to each plant.

Generally, production of argon and oxygen in the plant is balanced at the ratio of argon 1 m^3 to oxygen about 25 m^3, but as shown in Fig. 7-6-46, the requirements in the new steel works show the ratio of argon 1 m^3 to oxygen about 19 m^3 ($7,090 \times 10^3/377 \times 10^3$). Therefore in order to produce the required quantity of argon, a considerable quantity of oxygen has to be discarded.

This plant consumes a little quantity of highly pure hydrogen, but it is assumed that it is purchased from outside.

Oxygen is used in the maintenance shop, but it is only 6 m^3N/h on an average and so oxygen is not supplied by piping from the oxygen plant but supplied by transport in gas cylinders.

(4) Specifications of major equipment

Table 7-6-33 shows specifications of major equipment.

Fig. 7-6-45 shows flow of the plant.

Fig. 7-6-46 shows supply of argon, nitrogen, oxygen and compressed air.

(5) Layout

Fig. 7-6-47 shows layout of the plant.

Table 7-6-33 Equipment and Specification of Facilities for Argon, Nitrogen, Oxygen & Compressed Air

Equipment	Quantity	Specification
Air Compressor for Air Separator	2 units	6000 m^3N/h x 5.6 kg/cm^2g
Air Separator	2 units	1000 m^3N/h (99.6%) of Oxygen
		100 m^3N/h of Nitrogen
		30 m^3N/h of Argon
Oxygen Compressor	2 units	1000 m^3N/h x 30 kg/cm^2g
Nitrogen Compressor	2 units	100 m^3N/h x 30 kg/cm^2g
Oxygen Gas Holder	3 units	66.7 m^3 x 33 kg/cm^2g
Nitrogen Gas Holder	3 units	66.7 m^3 x 33 kg/cm^2g
Liq. Argon Tank	3 units	5 m^3 x 12 kg/cm^2g
Liq. Oxygen Tank	1 unit	20 m^3 x 30 kg/cm^2g
Liq. Nitrogen Tank	1 unit	5 m^3 x 30 kg/cm^2g
Liq. Argon Vaporizer	1 unit	60 m^3N/h x 12 kg/cm^2g
Liq. Oxygen Vaporizer	1 unit	1000 m^3N/h x 30 kg/cm^2g
Liq. Nitrogen Vaporizer	1 unit	100 m^3N/h x 30 kg/cm^2g
Air Compressor	3 units	9000 m^3N/h x 7 kg/cm^2g
Packing Equipment for Argon, Nitrogen and Oxygen	1 set	

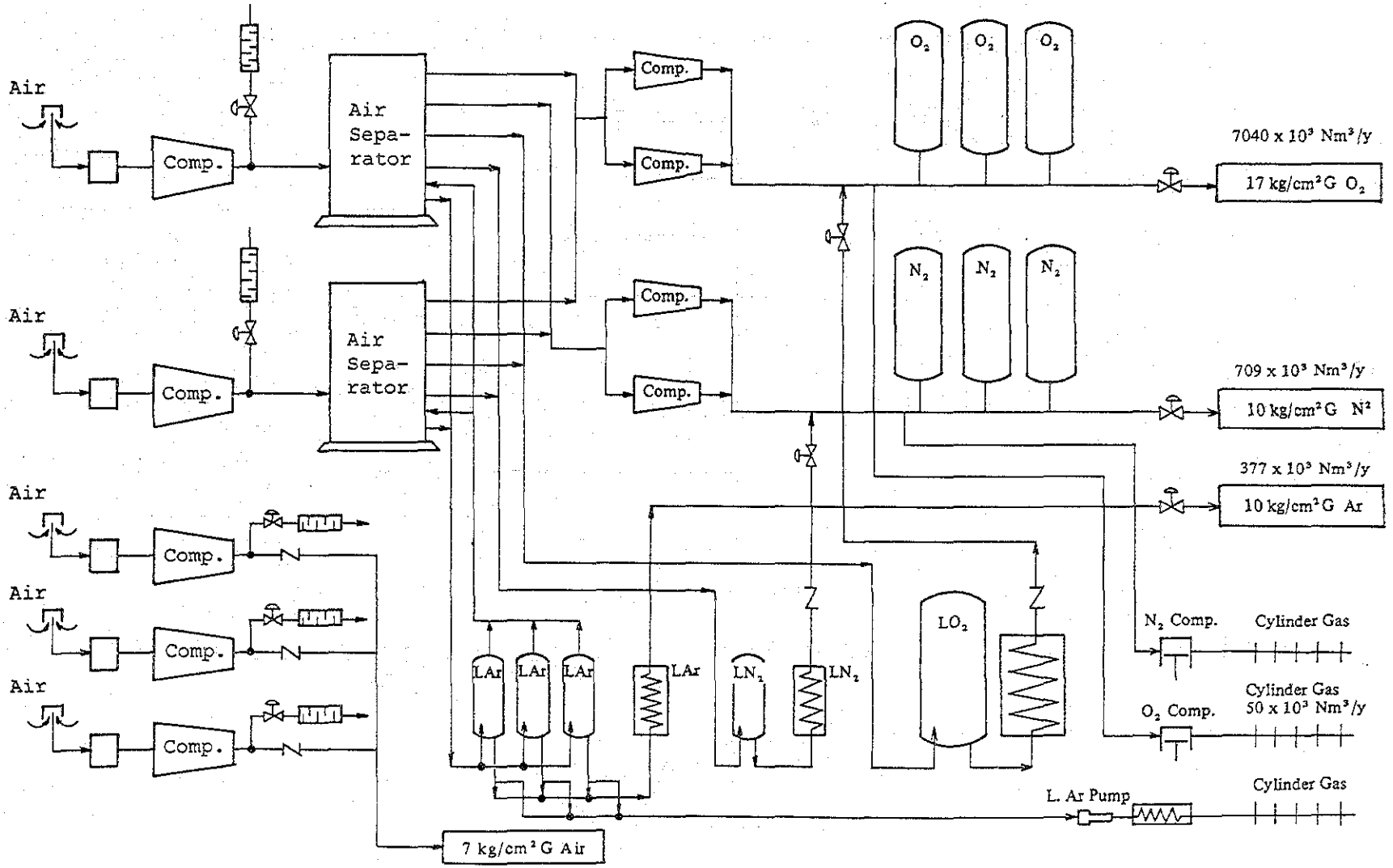


Fig. 7-6-45 Flow of Argon, Nitrogen and Oxygen Plant

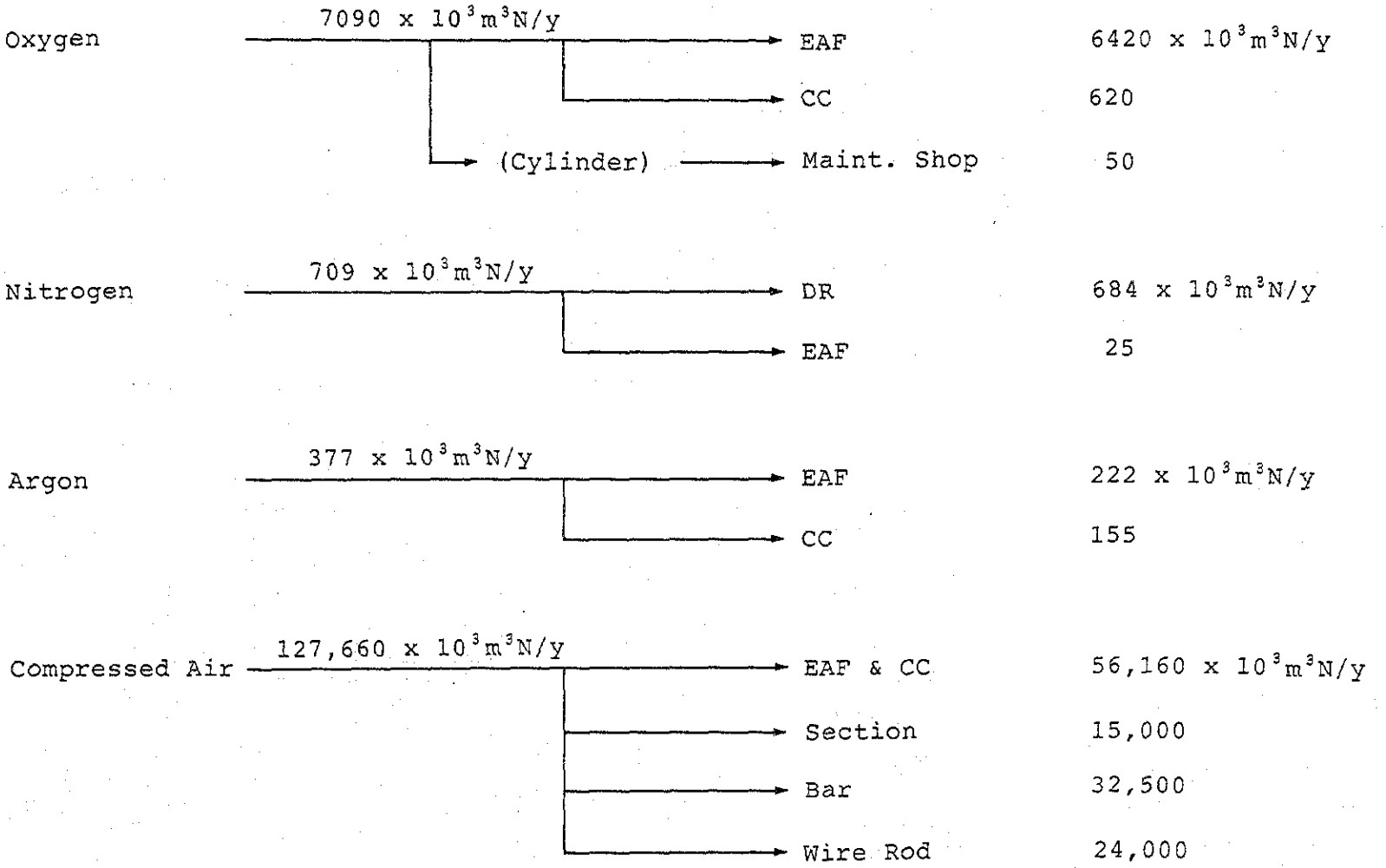
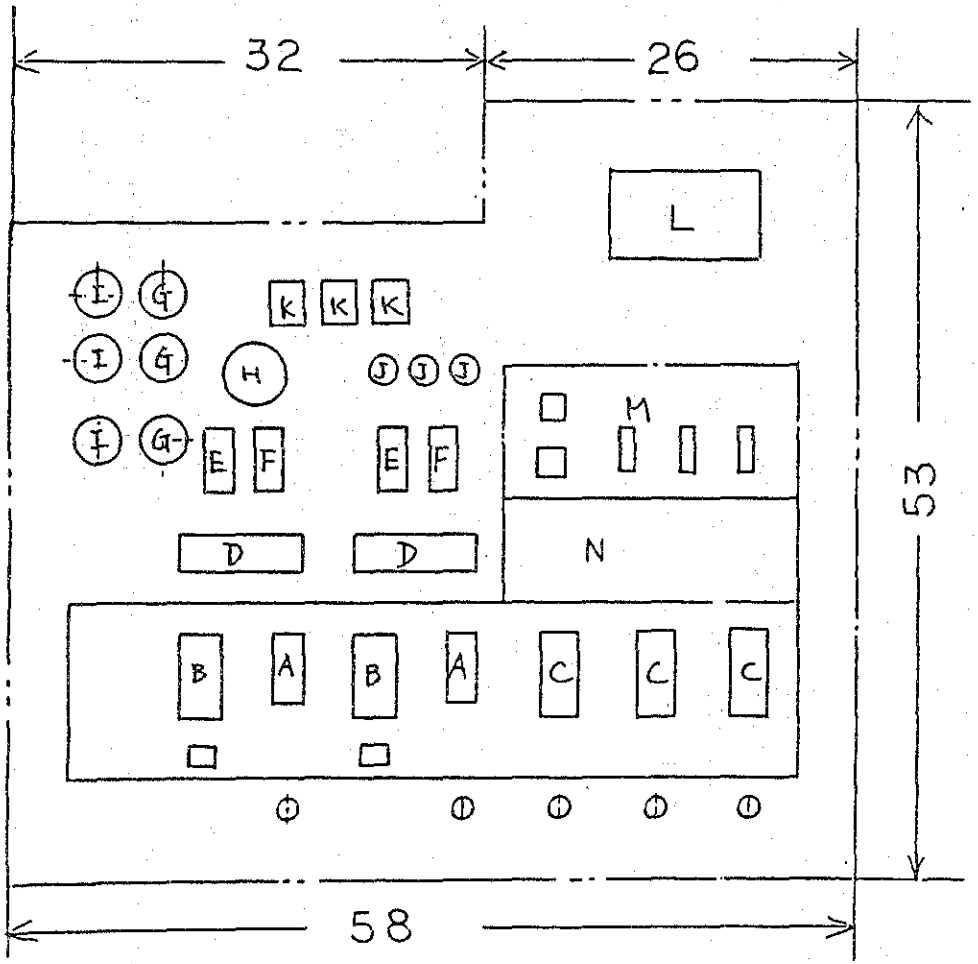


Fig. 7-6-46 Supply of Oxygen, Nitrogen, Argon and Compressed Air



A. Air Compressor for Air Separator
B. Oxygen Compressor
C. Air Compressor
D. Adsorber
E. Air Separator
F. Argon Absorb Tower
G. Oxygen Gas Holder
H. Liq. Oxygen Tank
I. Nitrogen Gas Holder
J. Liq. Argon Tank
K. Liq. Oxygen Vaporizer
L. Electric Room & Control Room
M. Packing Equipment of Argon, Nitrogen and Oxygen
N. Electric Room and Operation Room

Fig. 7-6-47 Layout of Argon, Nitrogen, Oxygen & Compressed Air Facilities

6-10-4. Water supply and sewage facilities and natural gas supply facilities

(1) Basic idea

Water is received from outside in water receiving pit, from which water is distributed to each plant and potable water facilities. At Cilegon site, turbidity of water is high and filters are to be added.

As natural gas is mostly consumed in DR furnace, piping introduced from outside the plant is arranged mainly around DR furnaces.

At all plants cooling water is recycled.

(2) Premises for facilities plan

1) Water supply

The scope included in the facilities expenses in this pre-F/S is the water receiving pit and other facilities which come following the pit. As for water in Cilegon site, there is a problem of possible shortage of fresh water in future and solution of the problem such as development of new water sources is not yet certain. But as the condition of water quality in the study, the data of the present water source in Cilegon, namely, the water of the Cidanah River are used. For Arun site, the quality data of water of the Krueng Peusangan River are used. The capacity of the water receiving pit is to be equal to 5-hour consumption.

2) Natural gas

The scope included in the facilities expenses covers the receiving piping in the works and subsequent equipment.

3) Sewage treatment facilities

The capacity of sewage treatment is for 10,000 persons, but the expenditures for sewage treatment facilities themselves are included in the section of administration facilities.

(3) Technical explanation

As turbidity of present fresh water in Cilegon is somewhat high, it is pretreated by filters. The receiving pit is so designed to hold water equal to 4 or 5-hour consumption. More than 80% of industrial water is consumed in DR furnace, EAF and CCM.

It is planned on the basis that cooling water for all plants is fresh water and recycled. Industrial water is used as so-called one-pass use and make-up water to recycled water.

Potable water is filtered and sterilization-treated and pumped up to head tank, from where water is supplied to each plant.

Natural gas storage system is equipped with flare stack.

(4) Specifications of major equipment

Table 7-6-34 shows specifications of major equipment.

Fig. 7-6-48 shows flow of water supply.

Fig. 7-6-49 shows flow of natural gas.

(5) Layout

Fig. 7-6-50 shows layout of water supply facilities.

Table 7-6-34 Equipment and Specification of Facilities for Water Supply, Sewage and Natural Gas

Equipment	Quantity	Specification
Water		
Receiving Pit	1 unit	5000 m^3
Feed Pump	3 units	550 m^3/h
Piping	1 set	
Potable Water System	2 units	100 m^3/h
Filter	3 units	550 m^3/h (only in Cilegon)
Filter Pump	3 units	550 m^3/h (only in Cilegon)
Natural Gas		
Piping	1 set	
Pressure Control System	1 set	
Flare Stack	1 set	

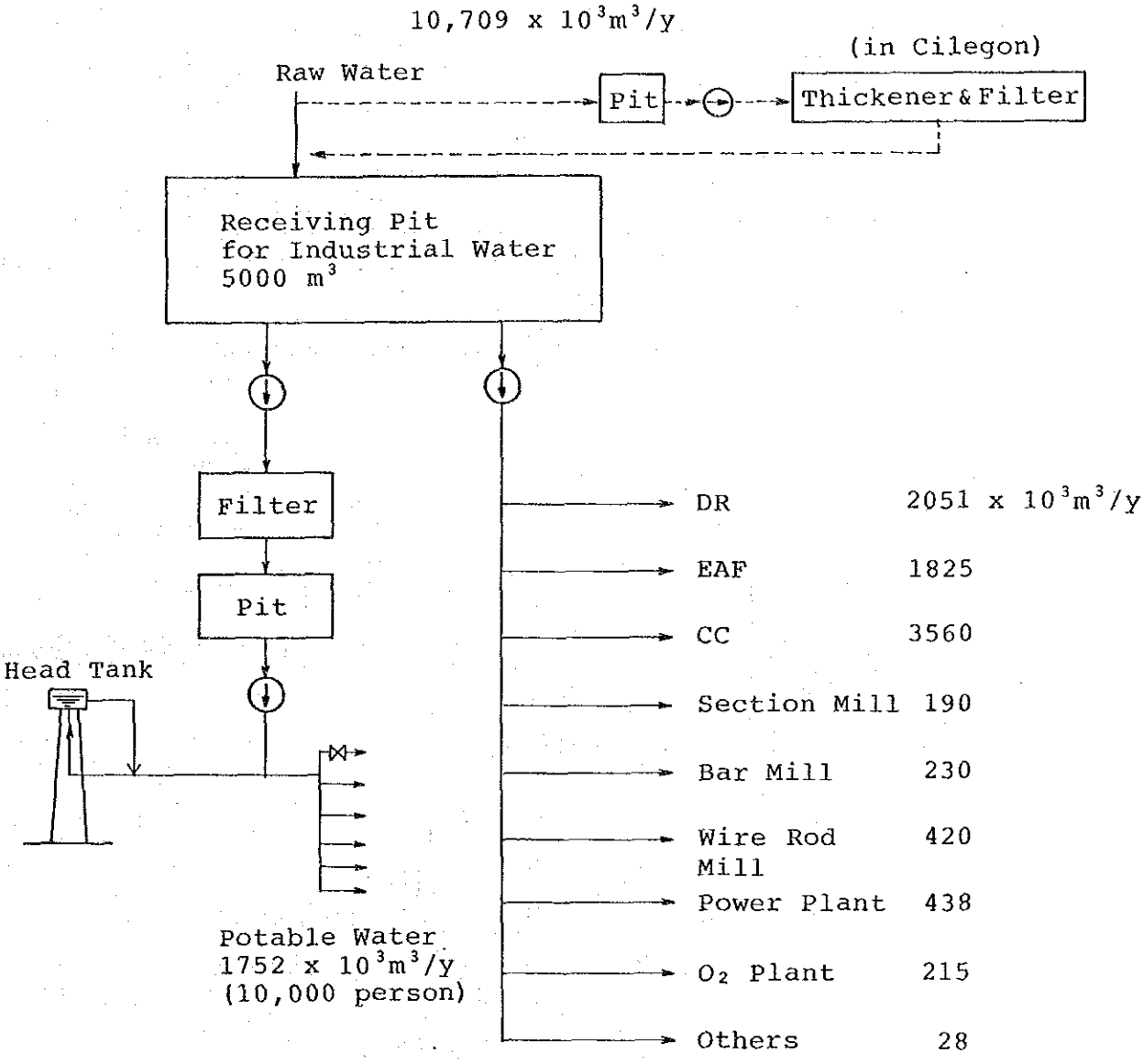


Fig. 7-6-48 Conceptional Flow of Feed Water

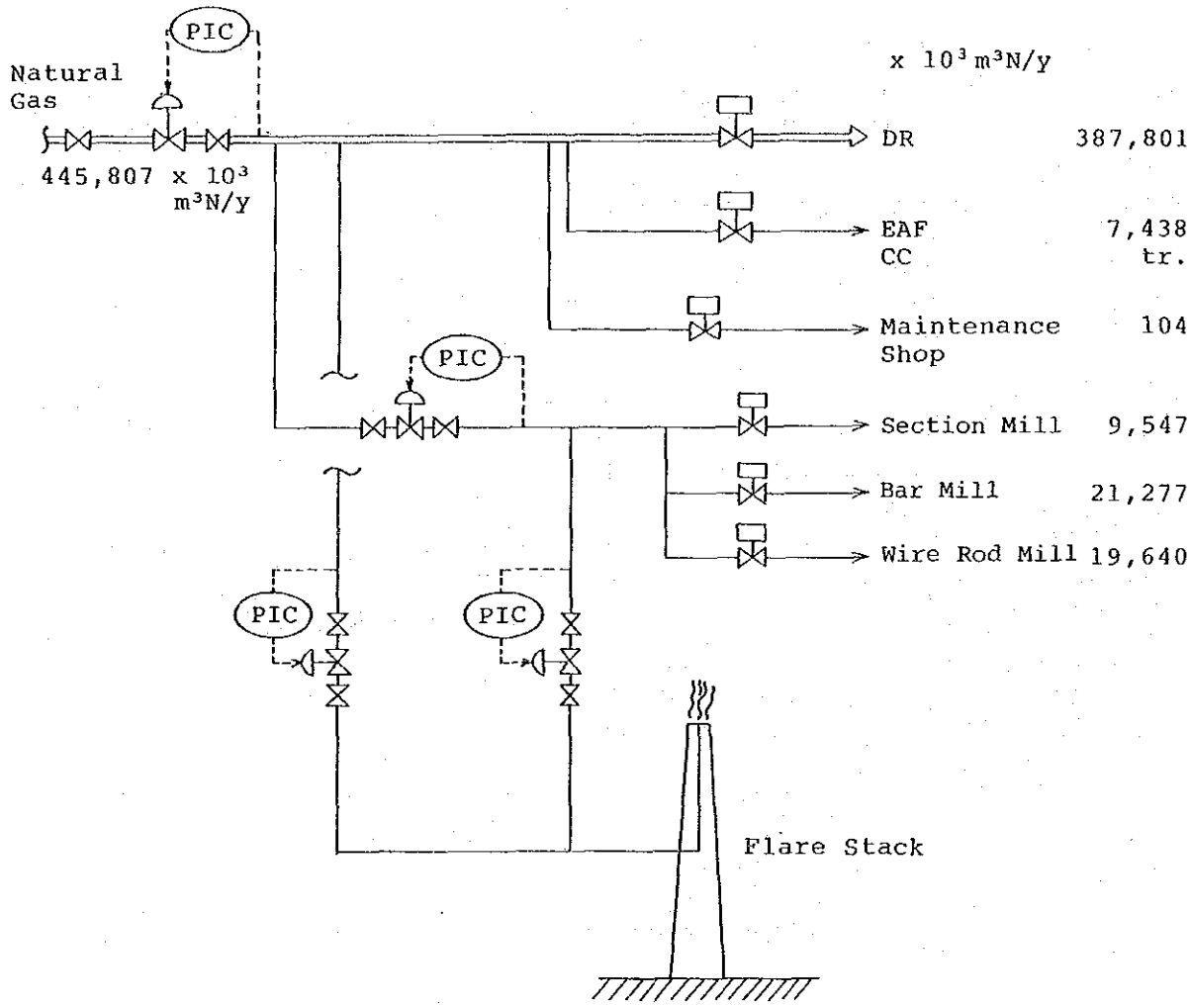
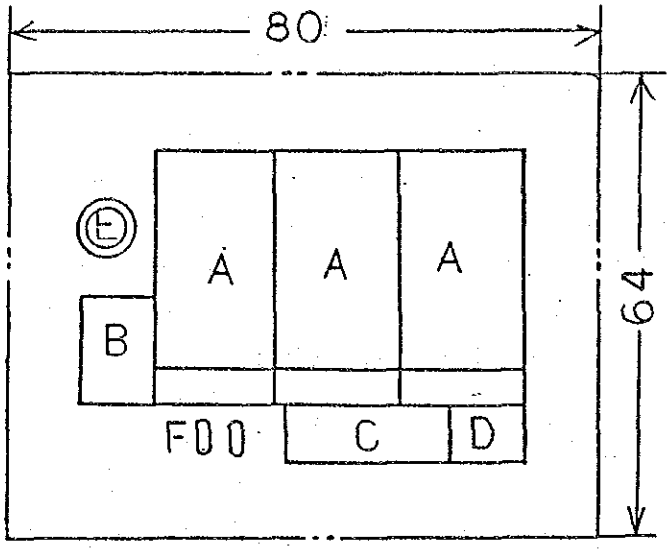
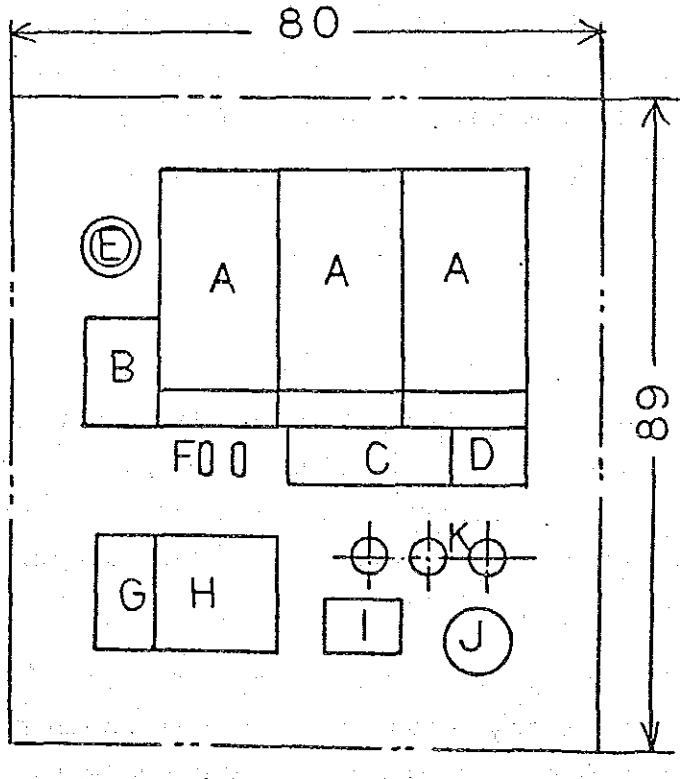


Fig. 7-6-49 Conceptional Flow of Natural Gas



A. Water Receiver
B. Potable Water Basin
C. Pump Station
D. Electric Room
E. Head Tank
F. Filtration Tank
G. Pump Station
H. Pit
I. Counterflow Washer
J. Thickener
K. Filter

(Arun)



(Cilegon)

Fig. 7-6-50 Layout of Water Supply Facilities

6-11. Intraworks transportation facilities

6-11-1. Basic idea

The facilities include means of transportation of raw materials, sub-materials, products and factory waste, etc. in the site of the new steel works and of transportation of goods required for maintenance of facilities of the works and vehicles required for movement of employees.

(1) Railway transportation

At Cilegon site, railways connected with the railway network in Jawa area are laid in the works, making it possible to ship products of each plant by rail.

At Arun site, however, there is inadequate railway network in the area, therefore intraworks railway is not laid. But the layout of the works is so designed that railways can be laid in the works to utilize the railway network in the Sumatera area once such network is completed in future.

(2) Road transportation

Scrap and limestone received at the berth are to be transported by dump trucks. For transport of products between each plant and product shipping berth, a system of road transportation (trailers, semi-trailers, and trucks) which provides good workability around loaders at the berth is used.

Trucks are used for transport of auxiliary materials and materials and machinery required for maintenance. Dump trucks are used for handling scrap and scale generated in the works, and bulldozers, shovel loaders,

crawler cranes and forklifts are used to handle these materials. As auxiliary facilities, truck scales are installed to grasp the amount transported and also automobile fuel station to fuel the vehicles installed.

6-11-2. Premises for facilities plan

(1) Amount of transportation

The amount of transportation as the base for planning was calculated from the material balance of production plan. Figs. 7-6-51 through 7-6-55 show flow charts of the amount to be transported.

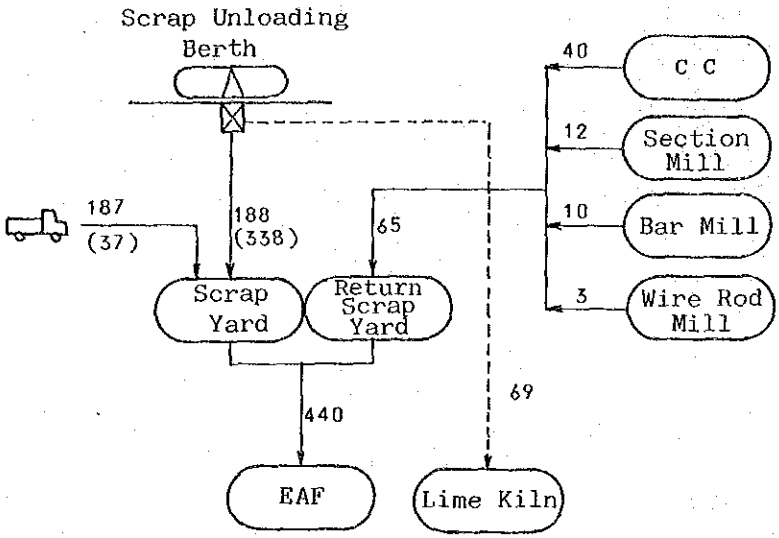
(2) Working condition

In principle, 3-shift continuous working is adopted, but for those which require not much transportation, daytime working or 2-shift working is used.

(3) Items transported and transportation facilities

Table 7-6-35 shows the items to be transported, type of vehicles used and their loading efficiency.

Unit: 1,000 t/y



Figures show Cilegon &
those in ( ) Arun.

Fig. 7-6-51 Scrap & Limestone Flow Chart

Unit: 1,000 t/y

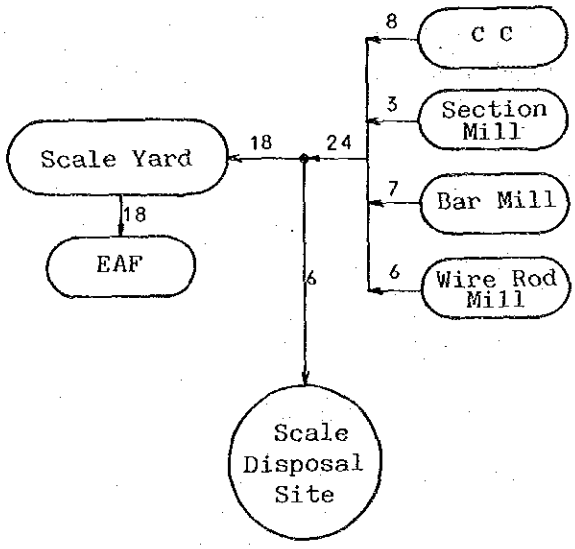


Fig. 7-6-52 Scale Flow Chart

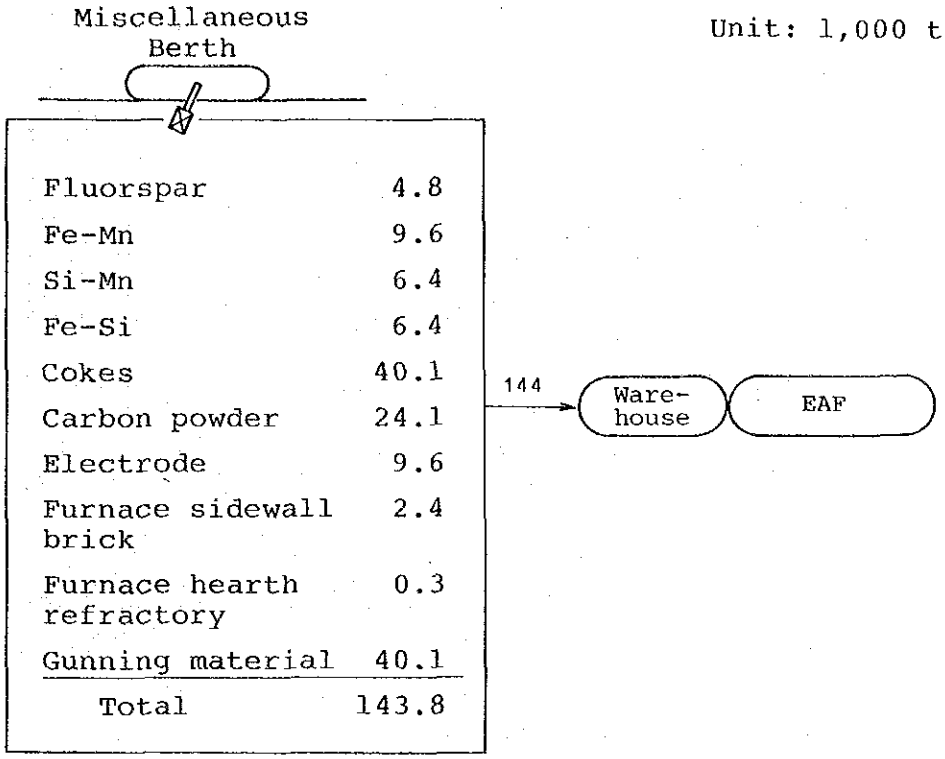


Fig. 7-6-53 Sub-material Flow Chart

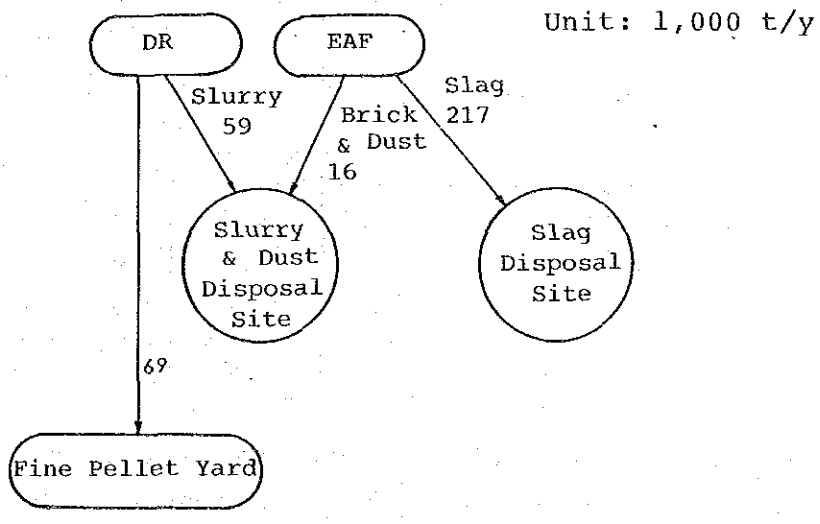


Fig. 7-6-54 Waste & Fine Pellet Flow Chart

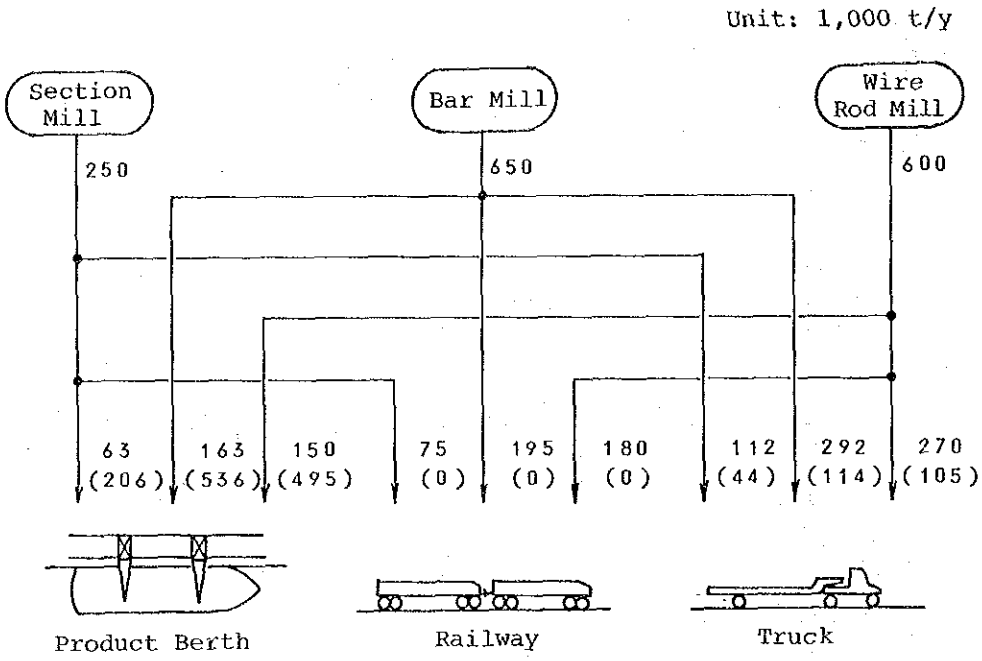


Fig. 7-6-55 Product Flow Chart (Unit: 1,000 t/y)

Transportation Equipment	Quantity of Shipment			
	CILEGON		ARUN	
	10^3t/y	%	10^3t/y	%
Truck or Trailer	674	45	263	18
Railway	450	30	0	0
Ship	376	25	1237	82
Total	1500	100	1500	100

Note: The table is drawn up on the basis of percentages of steel consumption by area in Indonesia as given in Step II Study Report.

Table 7-6-35 Type of Vehicles for Intraworks Transportation

Item	Type of Vehicles	Loading Efficiency (%)	Shift
Scrap & Lime Stone	10 ton Dump Truck	70	3
Scale	8 ton Dump Truck	60	3
Sub-Material	8 ton Truck	60	2
	or		
	8 ton Dump Truck	60	
Slurry	8 ton Dump Truck	50	2
Dust	8 ton Dump Truck	50	1
Fine Pellet	8 ton Dump Truck	50	2
Waste Brick	8 ton Dump Truck	60	1
Miscellaneous	8 ton Truck	50	1
Products			
Medium Profiles	12 ton Trailer	80	3
Bars	12 ton Trailer	80	3
Wire Rods	12 ton Trailer	80	3

6-11-3. Technical explanation

(1) Railway transportation

At Cilegon site, it is planned to install intraworks railway which connects with the railway network in Jawa area and to ship 30% of the production by rail. The railway network in the works is shown in the general layout (Fig. 7-3-1).

Railway sidings are installed to the product yards of section, bar and rod mill plants. The products of each plant are loaded on freight cars pulled into the sidings and taken by diesel locomotives of the works to the shunting yard, where they are arranged in trains by destination. The trains are then delivered to the railway company at the shunting yard. Control of the yard is performed from the control tower adjacent to the yard. Railway scale is installed at the yard and the weight can be measured as required.

At Arun area, however, railway network in Sumatera area is not yet complete and in use, and so no railway is planned in the works. But when the railway network is completed in Sumatera area in future, intraworks railway connected with the network will be laid so that the products can be shipped by rail. The layout of the steel works is planned by considering the matter.

(2) Road transportation

1) Product transportation

a) Shipment by land transport

The quantity of products shipped by trailer or truck accounts for about 45% (670,000 t/y) of the production at Cilegon site and 18% (263,000 t/y) at Arun.

The products are loaded on trailers or trucks of private land transport companies at the product yard of each plant and after weighing by the truck scale near the front gate of the works, transported to destinations.

b) Shipment by sea

The quantity of products shipped by sea is assumed to account for about 25% (376,000 t/y) of the production at Cilegon and 82% (1,237,000 t/y) at Arun.

Transportation of products between the product yard of each plant and the product berth is done by trailers. At the berth, the products are loaded by level luffing crane from the trailers onto the ships.

In order to prevent increase of loading cost, transport capacity between the product yard and the berth needs to correspond to the loading capacity of level luffing cranes. At Arun site, the major part of the production are shipped by sea, a number of trailers are required. Therefore it may be necessary to temporarily stock the products at the rear of the crane and within its working area before arrival of ships, thereby decreasing the required number of trailers.

2) Transport of scrap and scrap yard

Flow of scrap in the works is shown in Fig. 7-6-51. Scrap is carried by dump trucks. For weight control of scrap generated in the works and purchased scrap, truck scale is installed near scrap yard. At the scrap yard crawler cranes equipped with lifting magnets handle the scrap. The area of the scrap yard is 36,000 m^2, which is enough to hold scrap equal to 3-month consumption.

3) Transport of limestone

Capacity of level luffing crane to unload limestone is as big as about 600 t/h, and a great number of dump trucks have to be employed at a time to have transport capacity compatible with such tonnage. Therefore part of limestone unloaded is temporarily stocked at an area behind the level luffing crane and is later transported to the limestone yard close to the lime kilns by means of shovel loader and dump truck.

4) Transport of scale

Scale occurring in rolling mills is carried by dump trucks to scale yard or disposal site. Scale recycled to EAFs is stocked at the scale yard and the remainder is discarded. Area of the scale yard is so planned as to hold the quantity of scale not less than 2-month consumption at EAFs. At the yard, scale is loaded onto the dump truck by shovel loader.

5) Transport of sub-materials, materials and machinery for maintenance, etc.

At miscellaneous berth, fluorspar, ferro-alloys, coke, carbon powder and other sub-materials and materials and machinery for maintenance are unloaded. According to type of packing, they are transported by truck or dump truck and the sub-materials for steelmaking are transported to warehouses near EAFs and the others to the central warehouse or yards of plants where they are used. The work is performed by daytime shift in principle.

6) Transport of waste occurring in the steel works

Slurry, dust, waste bricks occurring at DR and EAF plants and other waste occurring at the other plants and offices are transported by dump trucks to disposal sites in the works.

There are bulldozers at the disposal sites, which are used for levelling ground. Quantities of slurry and fine pellet occurring at DR plant are considerable and 2-shift system is required for their transport, but day-time shift only is used for the other wastes. As fine pellet can be sold, it is stocked at fine pellet yard.

EAF slag is transported by slag pot cars to slag disposal site. After slag is cooled and metal recovered, it is disposed by bulldozers.

7) Transport of employees within the works

For the convenience of traffic of employees within the works, regular bus service is provided. Microbusses are under the central control of the steel works, and each department has motorcycles and uses as a means of communication.

Peak transport of employees at the time of entering and leaving the works and commuting means of employees are to be assigned to private bus companies by agreement and the steel works itself will not own vehicles for the purpose.

6-11-4. Specifications of major equipment

Main specifications of major transportation equipment used in the steel works are shown in Table 7-6-36.

Table 7-6-36 Specification of Transportation Equipment

Item	Specification		Quantities	
			CILEGON	ARUN
1. Railway Equipment				
(1) Flat-topped car	Load capacity	30 t	2	0
(2) Diesel locomotive	Own weight	25 t	2	0
(3) Shunting yard	Yard area 12,000 m²	6 lines	1	0
(4) Railway scale	Max.	60 t	1	0
(5) Control tower	25 m² x 2F - 8 m Height		1	0
(6) Tank lorry	Tank capacity	4 t	1	0
2. Road transportation equipment				
(1) Dump truck	Load capacity	10 t	29	33
(2) Dump truck	Load capacity	8 t	7	7
(3) Truck	Load capacity	8 t	11	11
(4) Flat body trailer	Load capacity	12 t	17	35
(5) Shovel loader	Capacity	7.7 m³	3	3
(6) Bulldozer	Engine power	105 HP	3	3
(7) Bulldozer	Engine power	267 HP	3	3
(8) Fork lift	Lifting capacity	5 t	2	2
(9) Fork lift	Lifting capacity	2 t	2	2
(10) Crawler crane	Lifting capacity	40 t	5	5
(11) Truck crane	Lifting capacity	40 t	3	3
(12) Vacuum truck	Capacity	2 t	1	1
(13) Motor sprinkler	Tank capacity	4 t	1	1
(14) Bus	Seating capacity	40 seater	5	5
(15) Minibus	Seating capacity	10 seater	10	10
(16) Motor cycle	Engine capacity	50 cc	30	30
(17) Truck scale	Capacity	40 t	3	3
(18) Automobile fuel station	Diesel & Gasoline		1	1
3. Buildings				
(1) Transportation division main office	Office area	500 m² x 2F	1	1
(2) Truck scale office	Office area	30 m²	2	2
(3) Office for disposal area	Office area	50 m²	1	1
(4) Office for fuel station	Office area	30 m²	1	1

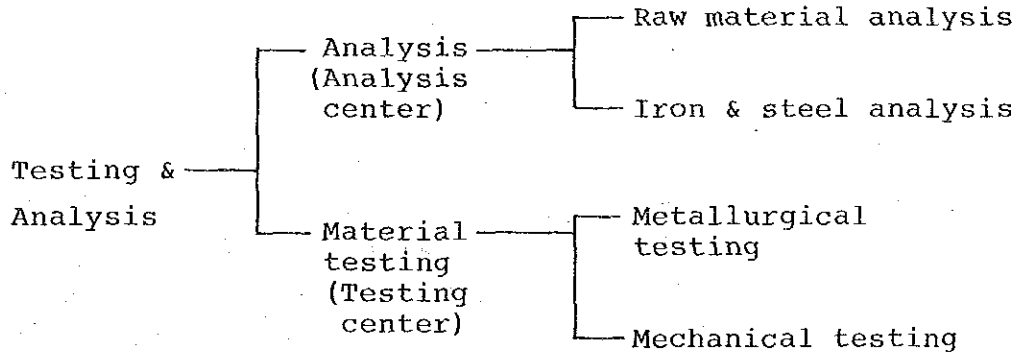
6-12. Material testing and analysis

6-12-1. General

Material testing and analysis equipment in this plan is the equipment required for normal production activity of the new steel works and corresponding to the production system principally for plain carbon steels and excludes the testing and analysis equipment aimed at a large scale plant experiments and R&D for quality improvement.

Also they do not include those for physical testing related to raw materials, acceptance inspection of consumables such as refractories and oil, and environmental (atomosphere & water) analysis for pollution control.

Therefore, the work of material testing and analysis is classified as shown below and an analysis center and a testing center are established considering production scale, layout and material flow of the steel works.



(1) Analysis center

1) Analysis of raw materials and sub-materials consumed in DR, EAF and LF
(pellet, ferro-alloys, scrap, DRI, limestone & burnt lime)

2) Rapid analysis of molten steel for quality confirmation and assurance in EAF and CC, and analysis of EAF slag and mold powder for continuous casting.

3) Check analysis of raw materials, semi-finished products and finished products for quality confirmation.

(2) Testing center

1) Metallurgical and mechanical testing of semi-finished products and finished products for quality confirmation and quality assurance (shipping inspection)

2) Study of causes for rejects in quality found in the works or at customers' plants

3) Quality checking in the steel works (mainly rolled products) and quality certification.

6-12-2. Premises for facilities plan

(1) Scope of the plan

Material testing and analysis are applied mainly to the product mix originally planned (chiefly plain carbon steels), but it is so planned that they can cope with some diversification of products (high grade steels). Such equipment as microanalyzer, electron microscope and fatigue testing machine which are mainly employed for basic research are not included.

1) Analysis

Materials to be analyzed and analysis items are as shown in Table 7-6-37. The purpose of raw material analysis is mainly for quality confirmation and as the lot sizes of raw materials are comparatively large, the raw materials are not analyzed so much.

On the other hand, steel analysis is mainly aimed at quality assurance and performed frequently; particularly analysis of molten steel at steelmaking stage is performed seven times/heat.

2) Material testing

Material testing is divided into metallurgical testing and mechanical testing. Though testing items depend on the specifications required by cutomers, the testings in the new steel works as shown in Table 7-6-38 can cover the requirements.

Metallurgical testing is performed mainly for quality confirmation, while, mechanical testing, especially tensile testing and bend testing, is indispensable for quality assurance. Therefore, the frequency of tensile testing and bend testing is high, and such tests are necessary at least once/lot for rebars, sections of structural steels for general use and high carbon wire rods subject to direct patenting.

(2) Automation of the apparatus and system

The testing and analysis operations require high technical skill and the results measured tend to reflect the difference among individuals. Consequently, in order to save labor force and at the same time to obtain stable results of testing and analysis by eliminating the individual difference among operators, complex and manual measuring methods are avoided as much as possible. In particular, it is planned that analysis work is performed by the instrumental method rather than by the wet chemical method.

Automation of the apparatus is confined to adoption of automatic or semi-automatic measuring apparatus and the full automation of measuring instruments, namely

the full-automated measurement where a series of pre- and post-handling including sample receiving, setting, measuring and test piece disposal is completely automated (e.g. full-automatic tensile tester) is not contemplated in this plan though it needs re-consideration in the future.

Simple data processing with mini-computer is included in the fluorescent X-ray analyzer and the optical emission spectrometer respectively, but their systems are of small scale and independent, and a large scale system integrating the quality control of the entire works by connecting all the testing and analysis apparatus is not included in this plan.

(3) Location of the centers

Analysis center: Around EAF in steelmaking area

Testing center: Close to bar mill in rolling area

Analysis work is divided into raw material analysis and steel analysis. Considering the purpose of jobs and transportation of samples, it seems to be advantageous that an analysis room is respectively provided in both raw material area and steelmaking area, but having an independent analysis room in each place results inevitably in increase of labor force and investment cost.

As the steel analysis is much more frequent than raw materials analysis, the analysis room is concentrated on one place and the equipment is installed in steelmaking area as analysis center. Samples for analysis of raw materials, semi-products and products are carried by manned truck to the center and cast samples of molten steel are automatically sent by the pneumatic carrier.