6.4 Electric Arc Furnace Plant (hereinafter referred to as EAF)

6.4.1 Decision of Furnace Capacity

Simplified calculation from the furnace production capacity indicates that one furnace (300 t/heat) or two furnaces (150 t/heat respectively) are enough to obtain the annual crude steel production of 810,000 t. Following factors, however, must be taken into consideration to determine the furnace capacity the most appropriate for this works:

- Subsequent casting process
- Operability
- Economical aspect

In this project, which is intended for round bars as a final product, the billet caster is the most feasible in terms of economy. Not a few countries adopt 8-strand or 6-strand billet caster. Except for some developed countries, however, their actual operation results generally prove that the nominal capacity is not achieved. Practically, this billet caster presents itself as a bottleneck, deteriorating the productivity.

In the study for this project, the operability was given the priority, and the furnace capacity was determined on the assumption that 4-strand billet caster ensuring the most effective operation would be adopted.

Billet size being determined at 130 x 130 mmϕ from the rolling conditions (refer to 6.7, "Bar and Rod Plant"), the furnace capacity must meet the demand of 4-strand billet caster, which can cast billets about one hour. Though the machine manufacturer guarantees the 130 x 130 mmϕ billet casting speed of maximum 2,600 mm/min, its averaged casting speed is estimated at 2,200 mm/min when the reduction of casting speed at a beginning of casting and the adjustment at an end of casting are considered. Accordingly, the capacity of electric arc furnace is determined at 70 t/heat as follows:

[60 min x {(0.13 x 0.13) x 2.2 x 7.8 }] x
4 str's ≑ 69.6 T/heat ≑ 70 T/heat

6.4.2 Production Program

Capacity of the EAF to be employed in this plant is determined at 70 t/heat. The number of furnaces, their availability, and productivity, which are required to enable this 70-t furnace to achieve the annual production of 81,000 t by using sponge iron, are as follows.

6.4.2.1 EAF availability

On the basis of total hours expected for various repairs, accidental troubles, non-production on Table 6.4.1, the furnace operating days were estimated at 300 days a year.

Table 6.4.1 Furnace availability

Item	Frequency and Time	Total Hours Per Year
Root Change	1 time/100 heats x 3 hrs	86.6 hrs/Y
Wall Repair	1 time/120 heats x 25 hrs	601.2 "
Overall Repair	1 time/2 years x 7 days	84.0 "
Periodical Repair	1 time/1 week x 8 hrs	417.1 "
Adjusting (waiting) Time	EAF: 1.7% x 8,760 hrs/Y	148.9 "
Accidents or Troubles	CC[Note 1]: 1.83% x 8,760 "	160.3 "
Total		1,498.1 hrs/Y (= 62.4 day/Y)

365 - 62.4 = 302.6 days ⟹ 300 days

Note 1: Including the waiting time (1.1%) for the adjustment of casting timing of caster.

6.4.2.2 Number of EAF's

For the annual production of 810,000 t, daily production at above said furnace availability is 2,700 t. On the other hand, productivity of EAF using sponge iron is 180 ∿ 200 min/heat (tap-to-tap) in average and 150 min/heat in the most effective operation on existing works. For this project, average tap-to-tap time of 150 min/heat, which can be ranked at the highest level in the present world, is planned.

At this tap-to-tap time, production per furnace is:

$(1,440 \div 150) \times 70 = 672$ t/furnace

thus, the required number of furnaces is:

$(810,000 \div 300) \div 672 = 4.02$ furnaces $\Longrightarrow$ 4 furnaces

Table 6.4 - 2 shows the production program for EAF.

Table 6.2 - 4 EAF Production Program

	Molten Steel Production	Number of Heats
Annual Production	810,000 tons	11,571 heats
Monthly	67,500 "	2,964 "
	2,700 "	338.57 heats (9.64 heats/ f'ce)

6.4.3 Unit Consumption and Yield

6.4.3.1 Molten steel yield

By assuming that Fe-content in purchased scrap and sponge iron is 95% and 92.6% respectively, the molten steel yield was estimated at 93% in charged Fe loss.

The basis for this is as follows:

FeO in slag = 15% (Fe 12%)
Slag Volume = 12%
Loss of Iron = 12 x 0.12 - 1.44%
Dust = 1%
Evaporation in Arc = 1.5%
Others = 2.06%
Skull = 1% → Home scrap

Total = 7%

6.4.3.2 Demand of Raw Materials

Table 6.4 - 3 Raw Materials

Raw Materials	Metallic Fe Content	Quantity (Fe)	Specific Gravity
Sponge Iron	92.6 %	651,000 Tons	-
Home Scrap	100 %	78,000 "	1.4
Purchased Scrap	95%	142,000 "	0.6

6.4.3.3 Consumption of Fluxes and Others

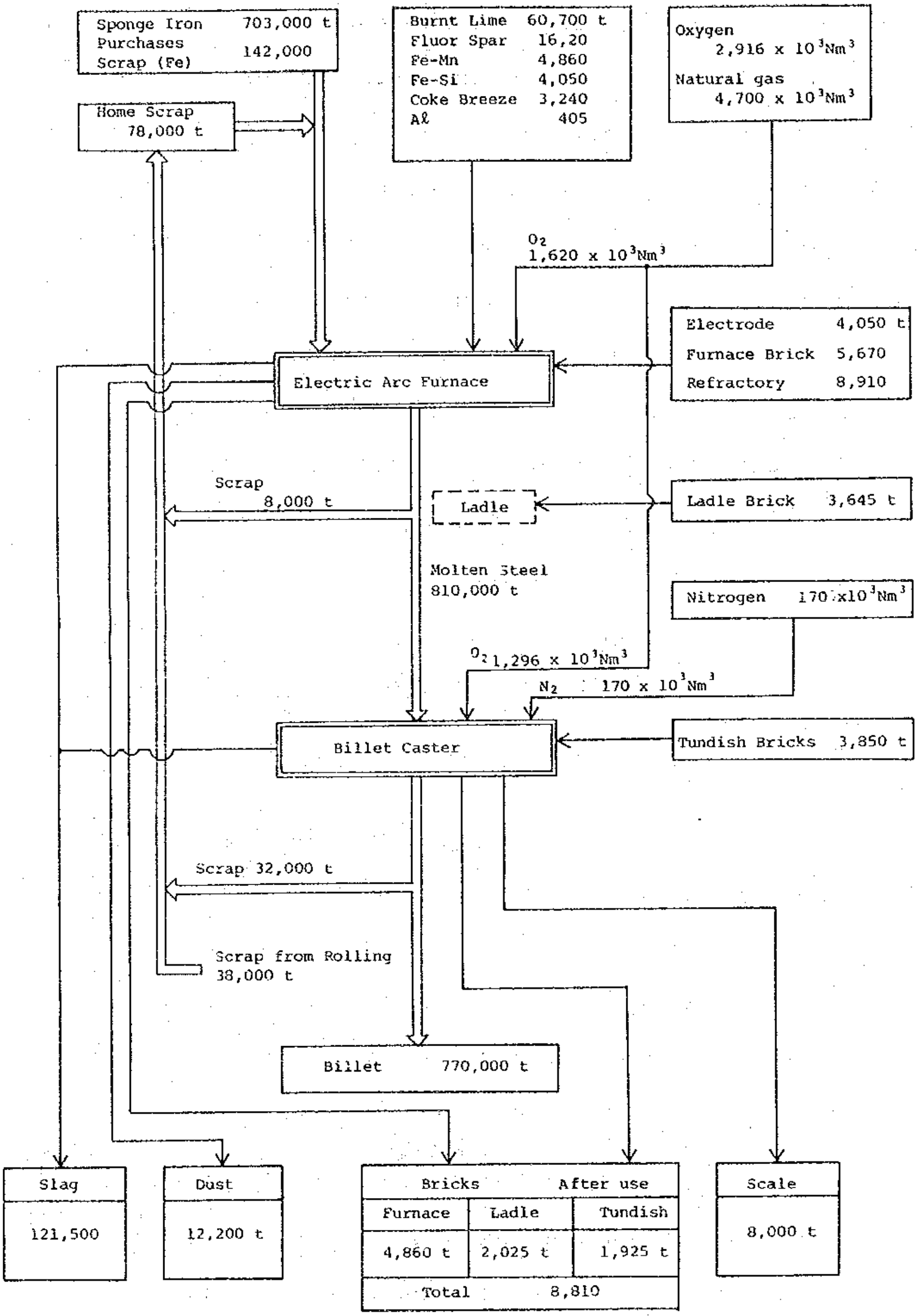
Table 6.4 - 4 Fluxes and Others

	Unit Consumption	Quantity (tons)		
		Annual	Monthly	Daily
Burnt Lime	75 kg/t	60,700 t	5,058	202.5
Fluor Spar	2 "	1,620	135	5.4
Fe - Mn	6 "	4,860	405	16.5
Fe - Si	5 "	4,050	338	13.5
Coke Breeze	4 "	3,240	270	10.8
Aℓ	0.5 "	405	34	1.35
Furnace Brick	7 "	5,670	473	18.9
Refractory for Repairing	11 "	8,910	743	29.7
Ladle Brick	4.5 "	3,645	304	12.2
Electrode	5	4,050	338	13.5

Table 6.4 - 5 Utilities

	Unit Consumption
Electric Power	700 KWH/t
Makeup Water	3.4 m^3/t
Compressed Air	15 Nm^3/t
Natural Gas	2 "
Oxygen	2 "

6.4.3.4 Material flow for steelmaking (annual value)



6.4.4 Description of Main Facilities of EAF

6.4.4.1 Handling facilities and storage of sponge iron and burnt lime

$50m^3$x 4 sponge iron bunkers of each furnace are provided, each storing sponge iron equivalent to 2-shift of each furnace. Each bunker has a level detector, which detects the decrease in stored sponge iron and starts automatically the supply from the product bunker of direct reduction plant. Also the continuous charging from the bunker to furnace is adopted. As in the case of sponge iron, burnt lime is carried on the belt conveyor to be supplied to the bunker. Charging of burnt lime into furnace is made in the same manner as for sponge iron. $50m^3$ bunker for burnt lime is provided to each furnace.

6.4.4.2 Scrap handling

The area between Ⓐ - Ⓑ of the steelmaking plant layout (see draw. No.6-4-01) is used as a scrap handling yard, which can stock the scrap for about four days (determined after due consideration on drawing during rainy season).

Space to stock burnt lime for one day is also provided to enable charging of both scrap and burnt lime by the scrap charging bucket.

Scrap charging bucket will charge scrap into the furnace. Four buckets are provided for this purpose, each having inner volume of $45m^3$.

Amount of scrap to be charged during the normal operation using sponge iron is:

(70 T/heat ÷ 0.93) x 25% ≑ 19 T/heat

With the specific gravity of scrap 0.5, required inner volume is $38m^3$. When the home scrap and purchased scrap are mixed as above described, the specific gravity becomes 0.8 ∿ 0.9.

Prior to the operation start of direct reduction plant, however, scrap has to be charged three times because of all scrap charging.

Scrap is first fed to the bucket on the weighing machine by means of 10t/5t magnet crane, transported to the EAF yard (Ⓑ - Ⓒ) by two scrap transfer cars, and charged into the furnace by 70t/20t crane.

6.4.4.3 Ferro-alloys and additives handling facilities

Nine storage bunkers ($6m^3$ each) are provided on the furnace yard between two furnaces, totalling 18 bunkers. These are to stock ferro alloys such as Fe-Mn, Fe-Si, Fe-Cr, etc. for about two to three days. Coke breeze, Aℓ, and furnace relining materials are to be stored on the furnace yard. Transportation from the warehouse outside the plant is made by the portable bin ($1m^3$) while the charging into furnace is made by the charging machine, steel ladle is fed by charging chute. Two weighing machines (max. 3t each) are provided.

6.4.4.4 Furnace

Furnace size is 4,250 mm x 5.8 mϕ, and the ultra-high power transformer is fed as will be described in the subsequent item.

In view of Egypt's capability to produce refractories, water cooling is designed for approximately 60% of the wall of furnace to minimize the use of bricks.

Also for 70% of roof, the water cooling is designed, and bricks are to be used only for the arc around the electrode. As a countermeasure against electrode trouble and power loss, the auto-arc system is adopted.

6.4.4.5 Determination of transformer capacity for furnace

Capacity of transformer is determined as follows.

With the power consumption for melting 620 kWH/ Melt-ton, the power consumed to obtain the tapping volume of 70t is estimated at 43,000 kWH. Corresponding power level at the melting time of 84 minutes is:

$$P_1 = 43{,}400 \text{ kWH} \times \frac{60}{84} = 31{,}000 \text{ kW}$$

By dividing this value with the power input efficiency,

$$P_2 = \frac{31{,}000}{0.91} = 34{,}066 \text{ kW}$$

Apparent power to obtain this power level by short arc (power factor 0.68) is:

$$P_3 = \frac{34{,}066}{0.68} = 50{,}096 \text{ kVA}$$

Accordingly, capacity of transformer is:

$$P_4 = \frac{50{,}096}{1.2} = 41{,}747 \text{ kVA}$$

Thus, the rated capacity is set at 42,000 kVA.

6.4.4.6 Flicker compensating unit

As will be described in 6.8, "Electric Power", this site has a problem in terms of electricity, and detailed investigation was made as follows to determine the flicker compensating unit.

a) Principle to suppress flicker

Due to high reliability and past achievements, a reactor control type unit with thyristor is adopted to suppress flicker. Below described is the principle of this reactor control type flicker compensating unit.

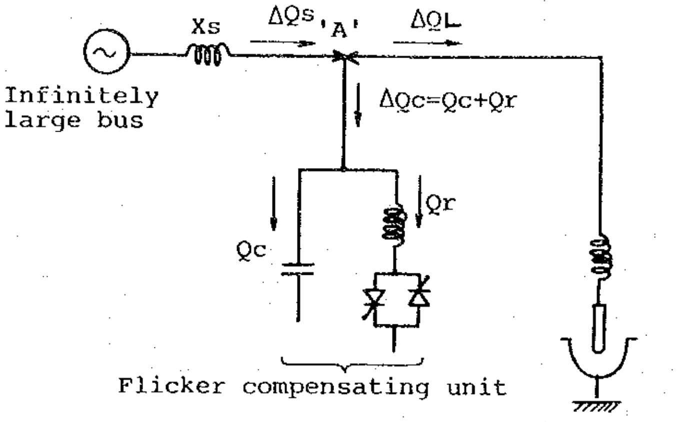


Fig. 6.4 - 1 Power Diagram

In Fig. 6.4 - 1, power fluctuation at power receiving point "A", which occurs when the reactive power ΔQs is transmitted through the transmission line, is:

$$Vd = \Delta Qs \cdot \frac{Xs}{10}$$

If the flicker compensating unit is not incorporated, reactive power ΔQL in the electric arc furnace is equal to that ΔQL in the transmission line, so that the voltage fluctuation Vd_1 at Point A becomes as follows:

$$Vd_1 = \Delta Q_L \cdot \frac{Xs}{10}$$

When this unit is incorporated, on the other hand, condensive reactive power ΔQ_L corresponding to ΔQ_L controlled by thyristor flows to this unit, so that the reactive power flowing through the transmission line becomes as follows:

$$\Delta Q_s = \Delta Q_L - \Delta Q_c$$

Voltage fluctuation Vd_2 at Point A is as follows:

$$Vd_2 = Xs \cdot \frac{(\Delta Q_L - \Delta Q_c)}{10}$$

This means that the voltage fluctuation can be reduced by $\Delta Q_c \cdot \frac{Xs}{10}$ by incorporating the flicker compensating unit.

Assume here, for example, that the reactive power fluctuates as Q_L on Fig. 6.4 - 2. Condensive capacitor removes a given condensive reactive power Q_c while the thyristor controls lagging reactive power Q_R as shown in Fig. 6.4 - 2. And $(Q_c + Q_R)$ becomes as shown by broken line on the figure (b). $(Q_c + Q_R)$ and Q_L compensate each other, and fluctuation of reactive power Q_s on the power source side is compensated, thereby reducing the voltage fluctuation V_d.

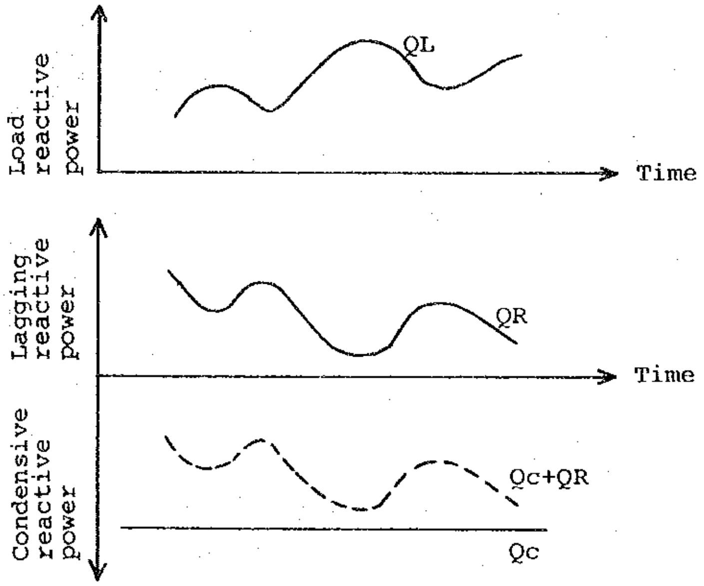


Fig. 6.4 - 2 Reactive Power Compensating Method

This flicker compensating unit also contributes to the improvement in power factor.

Namely, lagging reactive power during the normal EAF operation is controlled to $\frac{Q_R}{2}$. Condensive reactive power in this case is Q_c. Q_c being equal to Q_R, $\frac{Q_R}{2}$ is equivalent to $\frac{Q_c}{2}$, meaning improved power factor.

b) Harmonic current

Due to its load characteristics, EAF produces higher harmonic current. Flicker compensating unit, which phase-controls reactor by means of thyristor, also produces higher harmonic current.

As a countermeasure for this, the flicker compensating unit uses a capacitor in parallel with reactor as higher harmonic filter.

c) Determination of capacity for flicker compensating unit

(1) Design condition

Flicker compensating unit is assessed on the basis of the system diagram (Fig. 6.4 - 3) and following design conditions. Its capacity is calculated in compliance with the UK Standard P 7/2.

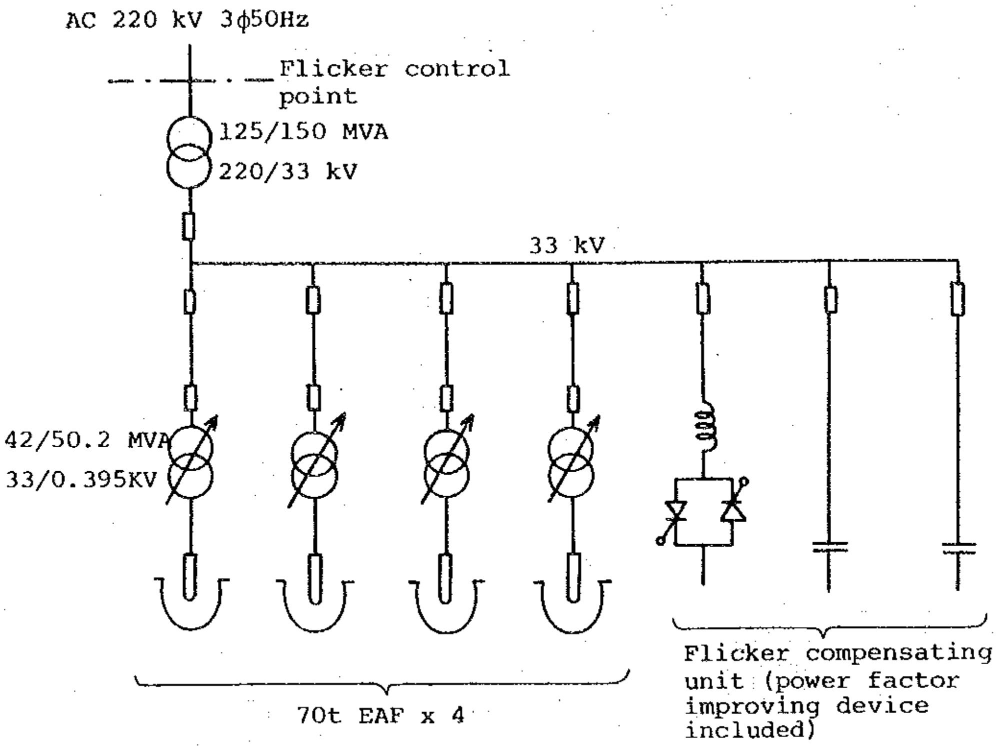


Fig. 6.4 - 3 Power System Diagram

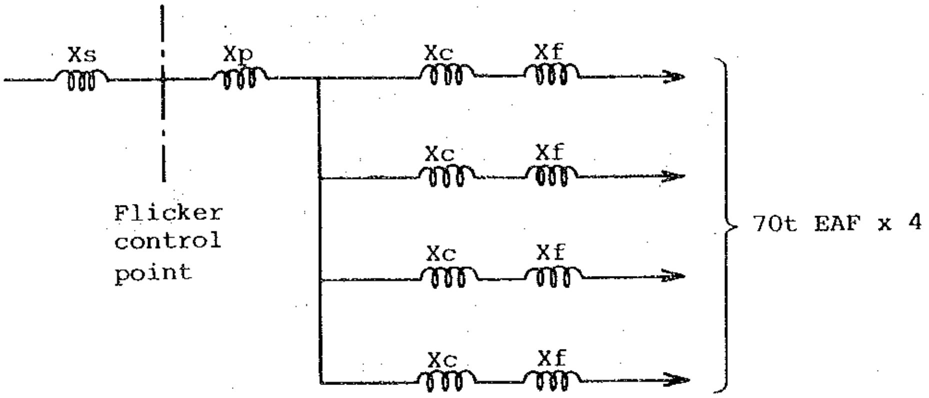
Shortcircuit capacity at flicker control point : 2,500 MVA

Flicker control requirement : Voltage fluctuation at furnace internal shortcircuit is reduced to 2%.

Improved power factor : $\cos\phi_2 = 0.9$

(2) Calculation of capacity for flicker compensating unit

Impedance map (10 MVA base)



Xs : System reactance at control point

$$Xs = \frac{10}{2500} \times 1000 = 0.4\%$$

Xp : Reactance of 150 MVA transformer

$$Xp = 14.9 \times \frac{10}{150} = 0.993\%$$

Xc : Reactance of 33 kV cable

$$Xc = \frac{10 \times 0.12}{30^2} \times 100 = 0.133\%$$

Xf : Reactance of furnace and its transformer

$$Xf = \frac{10^7 \times 3.3 \times 10^{-3}}{495^2} \times 100 = 13.468\%$$

Voltage fluctuation at internal short-circuit in one furnace is as follows:

$$Vt = \frac{Xs}{Xs + Xp + Xc + Xf} \times 100 = 2.67\%$$

Reactive power in this case is:

$$Qmax = \frac{10}{Xs + Xp + Xc + Xf} \times 100 =$$

66.7 MVAR

Combined voltage fluctuation for four furnaces is as follows:

$$Vtr = Vt \times 1.4 = 3.74\%$$

Reactive power in this case is:

$$Qmaxr = Qmax \times 1.4 = 95.4 \text{ MVA}$$

Flicker improvement factor is:

$$K = \frac{Vtr - 2.0}{Vtr} = 0.465$$

Compensating factor of the flicker compensating unit is:

$$d = 0.49$$

And thus the compensating factor is determined at 50 MVA.

$$QFC = Qmaxr \times d = 45.8 \text{ MVA}$$

(3) Calculation of capacity for power factor improving capacitor

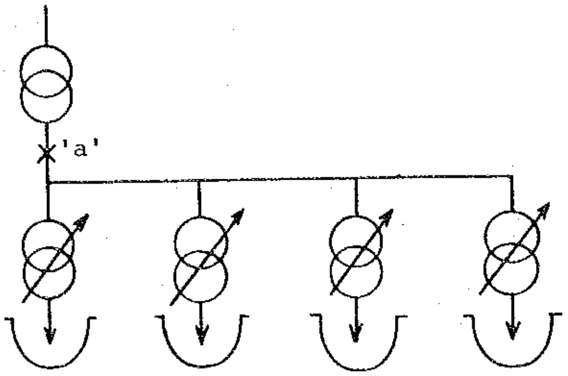


Fig. 6.4 - 4 Power System Diagram

Capacity required to keep the power factor at Point 'a' at 0.9 is calculated as follows:

$$Qsc = (P_1 \text{ x } 3 + P_2) \text{ x } (\tan\phi_1 - \tan\phi_2)$$

$$= 69.8 \text{ MVA} \approx 70 \text{ MVA}$$

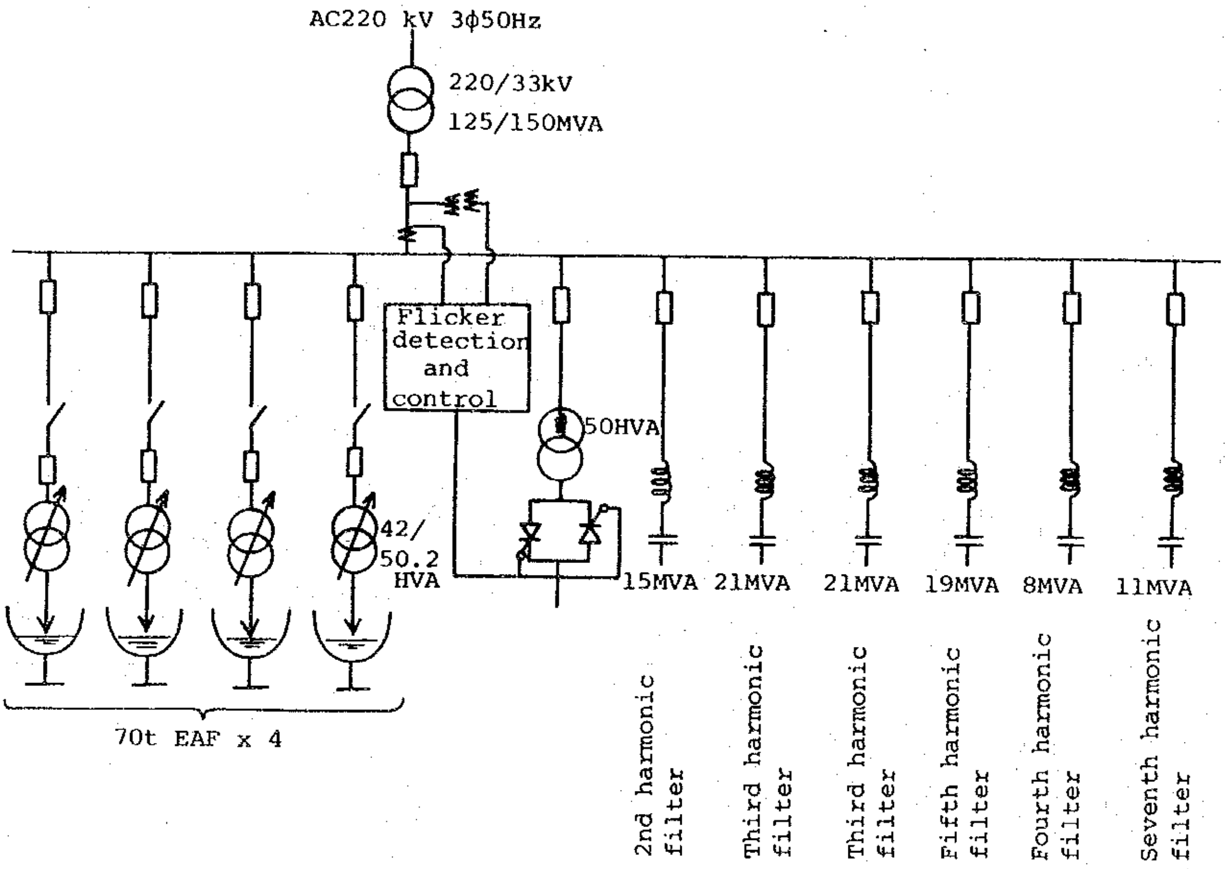
where P : Power at melting

P : Power at refining

As the phase advance equivalent to 25 MVA is achieved by the flicker compensating unit, the capacitor covering the remaining 45 MVA is enough. Accordingly total capacity of the capacitor is 95 MVA.

d) Configuration of flicker compensating unit

Flicker compensating unit and power factor improving capacitor have the configuration as shown below:



6.4.4.7 Steel ladle

a. Capacity and number of ladles

Ladle capacity was determined to cover "70t molten steel = approx. 3t slag".

12 ladles are planned, whose breakdown is as follows:

For actual service : 3 ladles
For sequence casting: 2 "
For brick repair : 3 "
For heat retention : 2 "
For accident : 1 ladle (to return the molten steel to EAF in the case of CC trouble)
For ladle repairing : 1 ladle
Total : 12 ladles

b. Ladle valve

For this plant, the mechanically operated ladle valve - rotary nozzle system is planned instead of conventional stopper nozzle system. The planned system is superior to the conventional system in that it contributes greatly to reducing the molten steel leakage trouble, enhancing the CC availability.

c. Ladle relining

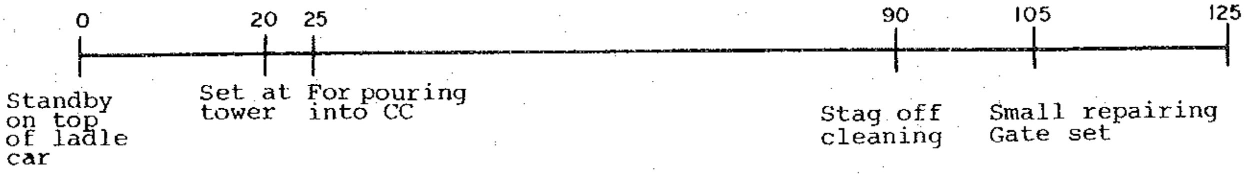
Between Ⓖ - Ⓔ, the relining yard having the capacity to reline four ladles is provided. The relining work is to be made during daytime. It is planned to carry out three relinings including replacement of all working bricks for one ladle life. As intermediate relining during service period, wall bricks in the slag line and at the bottom and in three to four tyres from the bottom are to be replaced in the first relining, and bricks in the area which is left untouched in the first relining are to be replaced in the second lining.

Estimated 1st relining : 15 ∿ 20 heats
2nd relining : 25 ∿ 30 "
Total services: 33 ∿ 38 "
⟶ Major repair

d. Ladle work flow

Molten steel tapped from EAF is poured into the ladle on the ladle car under the furnace, and transferred to Ⓓ-Ⓔ by the ladle car. There, the ladle is lifted by the 130/50/20 ton ladle crane to be set on the ladle slewing tower. After the casting, which requires about 60 minutes, the ladle is tilted for slag-off, then placed on the ladle stand. On the stand, skull and slag sticking to bricks are removed, and the ladle valve is assembled to the ladle. Now the ladle is ready for the next heat.

In the normal operation, the ladle using cycle becomes as follows:



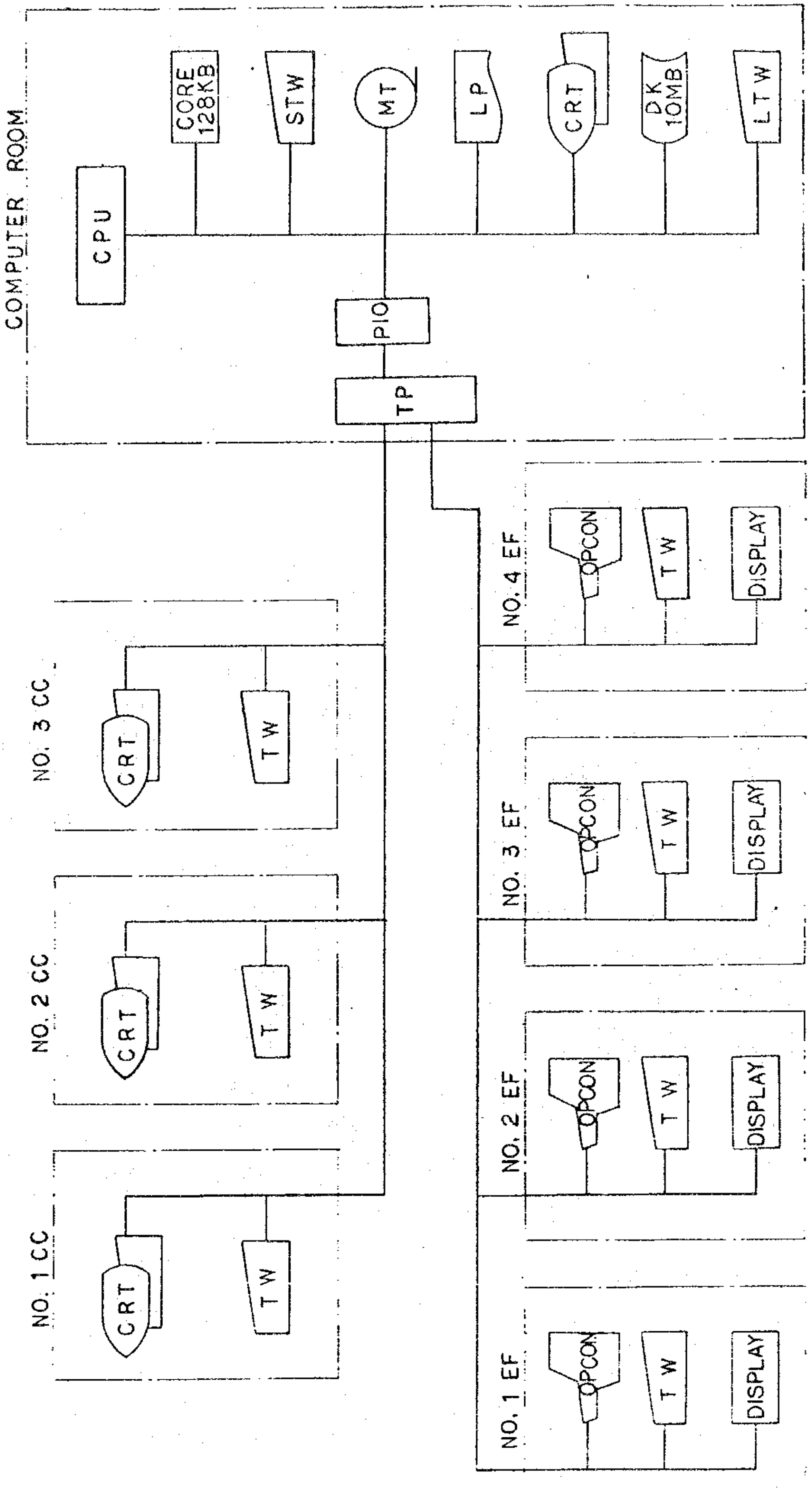
6.4.5 Computer Control System

It is planned to install a small capacity computer, which carries out operation guidance, automatic control of a part of equipment, and data logging. Control items are as follows:

6.4.5.1 Control function

a. Data logging

Data tracking during the process from raw material to final product and printing out of


COMPUTER ROOM
CPU
CORE 128KB
STW
MT
LP
CRT
DK 10MB
LTW
PIO
TP
NO. 4 EF
OPCON
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NO. 2 CC
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CRT
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obtained data as an overall information, so as to contribute to the production control.

b. Operation guidance

Checking the boundary condition by comparing the set value or calculated results with the process data so as to maintain the normal condition. If any abnormal condition is found, the function issues alarm signal.

c. Automatic control

Control of arc power, and automatic operation control of melting process and power demand.

6.4.5.2 Equipment

To achieve above described control functions in the steelmaking facilities (i.e., electric arc furnace and continuous casting system), the central processing unit is provided.

The computer is installed in the computer room provided with air conditioning system. Operation terminals and detectors are arranged in the operation room and other related control room.

6.4.5.3 EAF controlling software

a. Data logging

Data collection

Following data are collected:

- a) Raw material consumption
- b) Stock level in hoppers for reduced iron, limestone, and ferro alloy
- c) Energy consumption
- d) Time data
- e) Molten steel temperature
- f) Analyzed value of molten steel

b. EAF operation guidance

From the data collection and calculated results, following data are given.

Guidance data are indicated on the digital display or by pilot lamp on the operation panel.

- a) Storage volume and level for each brand in the hopper
- b) Progress of melting and refining processes
- c) Consumption of major raw materials
- d) Required power
- e) Power consumption

f) Molten steel temperature

g) Reduced iron charging speed

h) Analyzed value of molten steel

i) Alarm

c. Automatic control

By operating the selector switch on the operation panel, operation mode can be set to either automatic or manual.

Following functions can be automatically controlled:

a) Power input to melting process

b) Continuous charging speed of reduced iron

c) Power demand of all EAF's

6.4.5.4 Continuous casting system software

a. Data logging

Data collection

Following data are collected:

a) Molten steel temperature in the ladle and tundish

b) Weight of molten steel in the ladle and tundish

c) Cooling water volume for mold and spray

d) Cooling water pressure for mold and tundish
e) Casting speed
f) Cutting length and billet numbers
g) Target billet size
h) Alarm

6.4.6 Man-Power Requirement and Organization

The steelmaking plant consist of EAF (furnace) CC and lime calcining branch. Organization and manpower are as shown on Table 6.4 - 6.

Table 6.4-6 Man Power and Organization

Plant	Branch	Work Group		Man Power				
				Super-intendent	Assist. Super-intendent	Engineer	Office Staff	Worker
Steel-making	Furnace	Furnace	Day time		1	3		6
			Shift work					148
		Refractory	Day time					20
			Shift work					44
	Casting	Casting	Day time		1	3		6
			Shift work					136
		Crane	Day time					4
			Shift work					76
	Lime Calcining		Day time		1	1		1
			Shift work					40
	Total			1	3	7	8	483

6.4.7 Facility List

Fig. 6.4-5 shows the facility list of EAF plant.

6.4.8 Layout

Layout plan of steelmaking plant is shown on DWG. 6.4-01.

Fig. 6.4-5 Specification Plan of Main Facilities

No.	Facility	Q'ty	Specification
1.	Electric Arc Furnace		
1-1	Mechanicals		
(1)	Furnace platforms, rockers and pedestals	4 sets	
(2)	Furnace shells	4	Type: Non-split, Inside dia.: 5,800 mm, Height: 4,250 mm
(3)	Water cooled panels for shell	4	Area: approx. 60%
(4)	Pouring spouts	4	
(5)	Furnace doors and door hoisting devices	4	For deslagging and feeding ferro-alloys Driving by hydraulic cylinder
(6)	Access platforms	4	
(7)	Swing bed and roof support beams	4	
(8)	Roof lift devices	4	Driving by hydraulic cylinder
(9)	Roof swing devices	4	Driving by hydraulic cylinder
(10)	Roof rings and additional roof rings	8	Outer dia.: 6,100 mm
(11)	Water cooled panels for roof	8	Area: 70%
(12)	Tilt lock and swing lock devices	4	Driving by pneumatic cylinder
(13)	Tilting devices	4	Motor drive, forward tilt: 45°, backward tilt: 15°, with tilt back system under own weight
(14)	Electrode hoisting devices	4	Mech.: motor drive
(15)	Electrode holding devices	4	Mech.: pneumatic cylinder drive
(16)	Economizer	4	

No.	Facility	Q'ty	Specification
(17)	Secondary conductor and secondary bus tube	4 sets	
(18)	Hydraulic power system	4	
(19)	Centralized lubricating system	4	
(20)	Piping for water cooling system	4	
(21)	Piping for compressed air system	4	
(22)	Anchor bolts and liners	4	
			1-1 Total weight : 900 T
1-2	Electrical		
(1)	Furnace transformer	4 units	3 phase, 42/50.2 MVA, 30 kV/F 495V ∿ R395V ∿ 195V, 25V step 13 taps, secondary 61390A, OFWF
(2)	Furnace circuit switch & others		
	1) Furnace circuit switch	4 pcs.	3PST, vacuum, heavy duty type, with cubicle, rated 30kV, 1,200A, rup. cap. 350 MVA
	2) Disconnecting switch	4 pcs.	3PST, rated 30kV, 1,200A
	3) PT, power fuse & arrestor	4 sets	
(3)	Secondary flexible cable	48 pcs.	Water cooled type, 2,500 sqmm, 10m
(4)	Electrode regulating system		
	1) Electrode hoisting motor	12 pcs.	Totally enclosed, forced air cooled, wound rotor induction type, AC380V, 3 phase, 45kW, 6P, with secondary resistor, brake, etc.

	Facility	Q'ty	Specification
	2) Blower for above	4 pcs.	Multi-wing type, motor rating AC380V, 3 phase, 11 kW, 4P
	3) Electrode regulating panel	4 sets	Enclosed, self standing type, mounting magnetic contactor, thyristor, control unit, etc.
(5)	Control panels		
	1) Centrizing supervisory panel	1 set	For EF, calcining, handling, fume extraction, CCM, power distribution, etc., enclosed, self standing type, mounting graphic, indicating meter, control switch, annunciator, etc.
	2) Metering panel	4 sets	For EF, fume extraction, enclosed, self standing type, mounting indicating meter, protective relay, etc.
	3) Motor control center	4 sets	Enclosed, self standing type, mounting MCCB, magnetic contactor, control switch, control transformer, etc.
	4) Auxiliary control panel	4 sets	Enclosed, self standing type, mounting magnetic contactor, auxiliary relay, etc.
	5) Control desk	4 sets	For EF, handling, fume extraction, enclosed, self standing type, mounting control switch, indicating meter, indicating lamp, etc.
	6) Control post for furnace tilt	4 pcs.	Enclosed, pipe standing type, mounting master controller, push button switch, etc.
	7) Control post for hydraulic unit	4 pcs.	Enclosed, wall mounted type, mounting push button switch, etc.
(6)	Battery charging device	1 set	Enclosed, self standing type, alkaline storage battery, 120 AH/5 hour rate, with charger
(7)	Instrument		
	1) Furnace bath temperature measurement	4 sets	Recorder, removable immersion type thermo couple
	2) Furnace bottom temperature measurement	4 sets	Recorder, thermo couple

No.	Facility	Q'ty	Specification
	3) Roller lever type limit switch	100 pcs.	
	4) Cam type limit switch	4 pcs.	
	5) Water flow switch	24 pcs.	
(8)	Tilting motor	4 units	Totally enclosed, wound rotor type, AC380V, 3 phase, 45kW, 6P, 40%, ED, with secondary resistor & brake
1-3	Flicker and Power Factor Compensation Equipment		
(1)	Transformer with reactor	1 unit	3 phase, 30/1.2 kV, 50 MVA
(2)	Thristor	1 set	50 MVA, de-ionized water cooled
(3)	Cooling device for above	1 set	Heat exchanger
(4)	Higher harmonic filter (second)	1 bank	Rated 15 MVA, 30kV, with series reactor (L=25%)
	Higher harmonic filter (third)	2 banks	Rated 21 MVA, 30kV, with series reactor (L=11.1%) and discharging coil
	Higher harmonic filter (fourth)	1 bank	Rated 8 MVA, 30kV, with series reactor (L=6.25%)
	Higher harmonic filter (fifth)	1 bank	Rated 19 MVA, 30kV, with series reactor (L=4%) and discharging coil
	Higher harmonic filter (seventh)	1 bank	Rated 11 MVA, 30kV, with series reactor (L=2.04%) and discharging coil
	Control panels		
	1) Thyristor control panel	1 set	Enclosed, self standing type, mounting reactive power detecting unit, phase control unit, etc.

No.	Facility	Q'ty	Specification
	2) Supervisory panel	1 set	Enclosed, self standing type, mounting indicator, control switch, etc.
	3) Auxiliary control panel	1 set	Enclosed, self standing type, mounting MCCB, magnetic contactor
1-4	Refractory	4	
1-5	Graphite Electrodes		
(1)	Graphite electrodes	4	
(2)	Nipples	4	
2.	Handling Facilities		
2-1	Steel Handling Facilities		
(1)	Steel ladles	12	Capacity: 70 T
(2)	Ladle valve	12	With preparation and off-line system
(3)	Ladle transfer cars	4	Type: electric self-travelling car with wound cabtyre cable
(4)	Refractories for ladle	12	
2-2	Scrap Handling Facilities		
(1)	Scrap charging buckets	4	Type: clam-shell, Capacity: 45 m^3

No.	Facility	Q'ty	Specification
(2)	Scrap transfer cars	2	Type: electric self-travelling car with wound cabtyre cable
(3)	Track weighbridge	2	Type: load cell, with digital indication on site
2-3	Sponge Iron and Burnt Lime		
(1)	Storage system		Excluding control system
(2)	Belt conveyors	5	Type: stringer, Capacity: 300 T/h
(3)	Junction house	3	
(4)	Shuttle conveyors	2	
(5)	Receiving hopper for lime	1	Capacity: 30 m^3
2-4	Feeding System		
(1)	Storage bunkers for sponge iron	16	Capacity: 50 m^3 with level detector
(2)	Discharging equipment below storage bunkers for sponge iron	16	Type: vibrating feeder, Capacity: 100 T/h
(3)	Storage bunker for lime	4	Capacity: 50 m^3 with level detector
(4)	Discharging equipment below storage bunkers for lime	4	Type: vibrating feeder, Capacity: 60 T/h
(5)	Weigh hoppers for sponge iron	8	Type: load cell, Capacity: 8 T
(6)	Discharging equipment below weigh hopper for sponge iron	8	Type: vibrating feeder, Capacity: 70 T/h
(7)	Weigh hopper for lime	4	Type: load cell, Capacity: 6 m^3

No.	Facility	Q'ty	Specification
(8)	Discharging equipment below weigh hopper for lime	4	Type: vibrating feeder, Capacity: 10 T/h
(9)	Conveyor	8	Type: stringer type, Capacity: 80 T/h
(10)	Bucket conveyors	4	Type: bucket (IB conveyor), Capacity: 80 T/h
(11)	Swing chute	4	Type: Swing-aside single-feed pipe, Driving by pneumatic air cylinder
(12)	Charging chute	4	Fixed on the roof and water cooled
2-5	Ferro-Alloy and Additives Handling Facilities		
(1)	Charging boxes	24	Capacity: 0.25 m^3
(2)	Charging machines	4	Capacity: 2 T, Driving by diesel engine
(3)	Benches for charging boxes	4	
(4)	Portable weighing machines	2	Capacity: 3 T
(5)	Portable bins for filling the ferro-alloy	16	Capacity: 1 m^3
(6)	Storage bunkers	18	Capacity: 6 m^3 with vibrating feeder
(7)	Lorry cars	2	Capacity: 3 T
(8)	Vibrating hopper for ladle addition	4	Capacity: 1 m^3
2-5	Electrical		
(1)	Power distribution board	1 set	Enclosed, self standing type, mounting MCCB

No.	Facility	Q'ty	Specification
(2)	Control panels		
	1) Motor control center for transportation system	1 set	Enclosed, self standing type, mounting MCCB, magnetic contactor, control switch, etc.
	2) Motor control center for feed system	4 sets	Enclosed, self standing type, mounting MCCB, magnetic contactor, control switch, etc.
	3) Feeder control panel	4 sets	Enclosed, self standing type, mounting MCCB, magnetic contactor, adjuster, etc.
	4) Programmable controller	1 set	Micro computer
	5) Auxiliary control panel	4 sets	Enclosed, self standing type, mounting auxiliary relay, etc.
	6) Control post	19 sets	Enclosed, wall mounted type, mounting push button switch & indicating lamp
	7) Level detector panel	2 sets	Enclosed, wall mounted type, mounting MCCB
	8) Termination station panel	2 sets	Enclosed, self standing type
(3)	Instrument & sensors		
	1) Level detector	60 pcs.	
	2) Speed switch	20 pcs.	
	3) Chute plug-up detector	16 pcs.	
	4) Limit switch	100 pcs.	

No.	Facility	Q'ty	Specification
3.	Arc Furnace Fume Extraction System		
3-1	Mechanical		
(1)	Bag filter	4	
(2)	Accessories of bag filter	4	Two way damper, Reverse damper, Double damper, Manhole, etc.
(3)	Filter bags and accessories	1,488	ø292 x 10,000 mℓ, glass filter
(4)	Elbow and sleeve	4	ø800 x ø1,000, water cooled
(5)	Slide motor	4	
(6)	Slide duct and motor	4	
(7)	Combustion chamber	4	ø2,600 x ø2,800 x 1,000, water cooled
(8)	Water cooled duct	4	ø1,200 x ø1,350 x 185,000
(9)	Air-cooled duct	4	ø1,350 x (10,000 x 20,000)
(10)	Stack	2	ø2,000 x 20,000
(11)	Chain conveyor	6	2 T/h x 22,000, 4 T/h x 10,000
(12)	Bucket conveyor	2	4 T/h x 25,000
(13)	Dust bunker	2	
(14)	Pelletizer	2	2 T/h x 7.5 kW
(15)	Fan	4	2,000 m^3/min. x 700 mm H_2O at 220°C
(16)	Motor	4	470 kW x 4P
			Total: - 1,167 T

No.	Facility	Q'ty	Specification
3-2	Electrical		
(1)	3 kV switchboard		
	1) HT motor starter panel	4 sets	Enclosed, self standing type, mounting power fuse, HT contactor, starting compensator, control switch, etc.
(2)	Control panels		
	1) Motor control center	4 sets	Enclosed, self standing type, mounting MCCB, magnetic contactor, control switch, etc.
	2) Auxiliary control panel	4 sets	Enclosed, self standing type, mounting auxiliary relay, etc.
	3) Control post	12 pcs.	Enclosed, wall mounted type, mounting push button switch, indicating lamp, etc.
(3)	Instrument & sensors		
	1) Bag filter temperature measurement	4 sets	Indicator, thermocouple
	2) Flow switch	16 pcs.	
	3) Pressure switch	20 pcs.	
	4) Limit switch	40 pcs.	
	5) Differential pressure switch	4 pcs.	
(4)	AC motor		
	1) HT motor for IDF	4 pcs.	Totally enclosed, cage rotor type, AC 3 kV, 550 kW

No.	Facility	Q'ty	Specification
4.	Slag Handling Facilities		
4-1	Slag Pots	28	Capacity: 8 m^3
4-2	Mobile Slag Pot Carriers	3	Capacity: 30 T, Self loading type
5.	Preparation Facilities		
5-1	Ladle Preparation Facilities		
(1)	Nozzle preparation stand	2	Stationary type
(2)	Ladle relining pit	1	Capacity: 4 ladles
(3)	Ladle driers	6	Vertical type, Fuel: Natural gas
5-2	Electrode Stands	2	
5-3	Roof Breaking and Lining Facilities		
(1)	Roof breaking equipment	2	
(2)	Steel and concrete template	4	
5-4	Shell Lining Decks	2	

No.	Facility	Q'ty	Specification
6.	Miscellaneous Items		
6-1	Wet Guns	4	Capacity: 2.2 m^3
6-2	Dry Guns	4	Capacity: 2.2 m^3
6-3	Motor Mixers	4	
6-4	Immersion Pyrometer System	8	
7.	Cranes and Hoist		
7-1	10/5-ton EOT crane	3	Srap aisle, 20m span, with magnet of 1,800ø
7-2	70/20-ton EOT crane	2	Furnace aisle, 24m span
7-3	130/50/20-ton EOT crane	2	Ladle aisle, 20m span
7-4	25/10-ton EOT crane	2	Casting aisle, 30m span
7-5	20-ton EOT crane	2	Billet aisle, 30m span
7-6	Hoist		
(1)	10-ton	4	Lift 30m
(2)	5-ton	2	Lift 30m
(3)	1-ton	1	Lift 6m

No.	Facility	Q'ty	Specification
8.	Common Electrical		
8-1	Power Distribution System		
(1)	3 kV switchboard	1 set	Enclosed, self standing type, mounting CB (rated 3 kV, 600A rup. cap. 250 MVA) protective relay, indicating meter, control switch, etc.
(2)	Transformer	3 units	3P4W, 3/0.38/0.22 kV, 1,000 kVA, with bus duct
(3)	Transformer	1 unit	3P4W, 3/0.38/0.22 kV, 1,500 kVA, with bus duct
(4)	Load center for EF	1 set	Enclosed, self standing type, with CB (rated 3 kV, 600A rup. cap. 250 MVA) protective relay, indicating meter, control switch, etc.
(5)	Load center for handling & others	1 set	same as above
(6)	Load center for lighting, air conditioning/ventilator & small power	1 set	same as above
(7)	Load center for crane	1 set	Enclosed, self standing type, with CB (rated 3 kV, 600 ∿ 1,200A, rup. cap. 250 MVA), protective relay indicating meter, control switch, etc.
(8)	Power distribution board for miscellaneous & others	2 sets	Enclosed, self standing type, with MCCB
(9)	Battery and charging device	1 set	Enclosed, self standing type, alkaline storage battery 120 AH/5 hours rate, with charger
(10)	Inverter	1 set	Enclosed, self standing type, 10 kVA, alkaline storage battery 120 AH/5 hours rate, with charger

No.	Facility	Q'ty	Specification
8-2	Lighting and Small Power		
(1)	Sub-power distribution board	6 pcs.	Enclosed, self standing type, with MCCB MCCB: 225AF x 6
(2)	Lighting power distribution board	40 pcs.	Enclosed, self standing type, with MCCB MCCB: Incoming 225AF x 1 Outgoing 50AF x 12
(3)	Sodium vapour lamp for high-bay	400 pcs.	Projector type, bulb 400W, 220V, with blaster
(4)	Incandescent lamp for high-bay	40 pcs.	Projector type, bulb 1,000W, 220V
(5)	Incandescent lamp for walking-way	50 pcs.	Bracket type, bulb 100W, 220V
(6)	Fluorescent lamp for low-bay	650 pcs.	
(7)	Fluorescent lamp for low-bay	200 pcs.	
(8)	Fluorescent lamp for low-bay	280 pcs.	
(9)	Fluorescent lamp for emergency	120 pcs.	
(10)	Fluorescent lamp for emergency	60 pcs.	
(11)	Fluorescent lamp for emergency	60 pcs.	
(12)	Mercury vapour lamp for outdoor	60 pcs.	
(13)	Battery charging device	1 set	Enclosed, self standing type, 80 AH/5 hour rate, with charger
(14)	Outlet socket	30 pcs.	380V, 100A, 4P, with interlocked switch
(15)	Outlet socket	30 pcs.	220V, 16A, 3P, with interlocked switch

No.	Facility	Q'ty	Specification
8-3	Intercommunication		
(1)	Despatcher system		
	a) Main control device	1 set	Enclosed, dust-proof type, mounting amplifier, relay, calling push button switch, signal lamp, etc., lime capacity: 50 lime
	b) Battery charging device	1 set	Enclosed, self standing type, 36 AH/10 hour rate, DC 50V
	c) Telephone	18 pcs.	Dust proof, non-dialing type
(2)	Loudspeaker system		
	a) Main control device	4 sets	Enclosed, dust proof type, mounting amplifier, power source unit, signal lamp, etc., 12 channel
	b) Main control device	1 set	Enclosed, dust proof type, mounting amplifier, power source unit, signal lamp, etc., 24 channel
	c) Operator station	60 sets	Table mounted type, mounting mic., speaker, selector switch, indicating lamp, etc.
	d) Terminal box	5 sets	
(3)	Radio communication system		
	a) Main control device	5 sets	Handset type, receiver, mic., speaker, selector switch, etc.
	b) Stationary station	10 sets	Crane top type, receiver, mic., speaker, selector switch, etc.
	c) Mobile station	3 sets	Portable type, receiver, mic., speaker, selector switch, etc.
	d) Portable station	1 set	Camera, monitor

No.	Facility	Q'ty	Specification
(4)	T.V. for supervisory		
	a) Camera	9 pcs.	Fixed type with wide angle lens and dust proof case.
	b) Video monitor	6 pcs.	Monochrome, 17 inch type
	c) Power unit and amplifier	1 set	Automatic voltage regulator, wire compensating amplifier, video changer and accessories.
9.	Ventilation/Air Conditioning		
9-1	Ventilation for Furnace Electric Room		
(1)	Air filter	4 pcs.	Roll-O-Matic, 2,000 m^3/min.
(2)	Blower	4 pcs.	40 mmAq, 2,000 m^3/min., motor 37 kw
(3)	Exhaust fan	40 pcs.	
(4)	Starter panel	4 sets	Enclosed, self standing type, with MCCB conductor
(5)	Duct	180 m	
9-2	Air Conditioning for Control Room and Others		
(1)	Air conditioner	6 pcs.	Air cooling, package type, 9,000 Kcal/H
(2)	Air conditioner	4 pcs.	Air cooling, package type, 12,000 Kcal/H
(3)	Air conditioner	19 pcs.	Air cooling, package type, 18,000 Kcal/H
(4)	Air conditioner	29 pcs.	Air cooling, package type, 24,000 Kcal/H
(5)	Power distribution board	4 sets	Enclosed, self standing type, with MCCB, etc.

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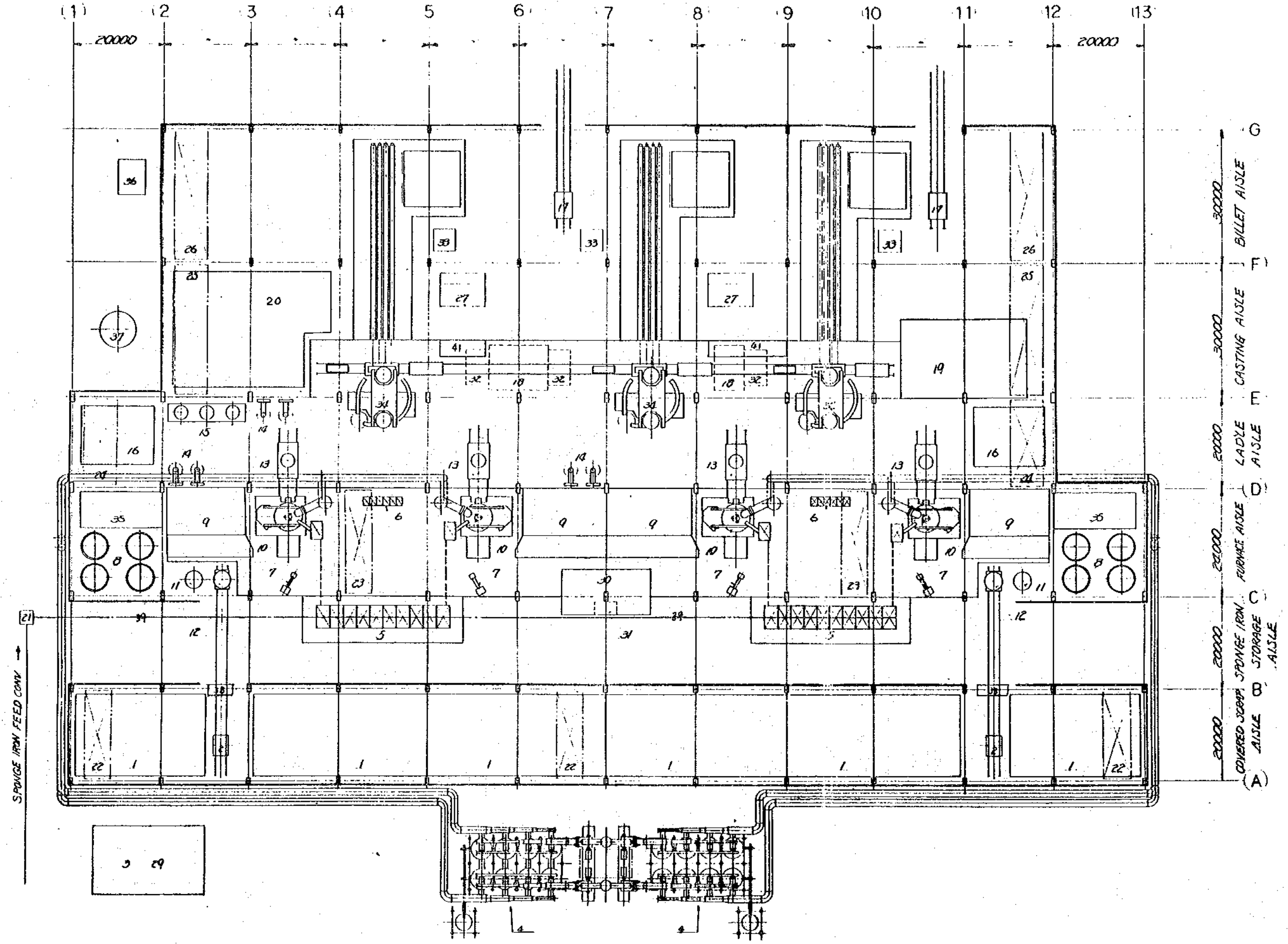
BIBLIOGRAPHY

MARK	DESCRIPTION	DATE	SIGN



LEGEND

1	SCRAP BINS
2	WEIGHBRIDGE
3	LOAD CENTER SUBSTATION
4	FUME EXTRACTION & CLEANING SYSTEM
5	SPONGE IRON & BURNT LIME STORAGE BUNKERS
6	FERROALLOYS & ADDITIVES BUNKERS
7	FLOOR CHARGER
8	FURNACE ROOF RELINING AREA
9	FURNACE TRANSFORMER ROOM (42 MVA)
10	70-TON ELECTRIC ARC FURNACE (5800)
11	CLAM SHELL BUCKET
12	SCRAP TRANSFER CAR
13	LADLE TRANSFER CAR
14	VERTICAL LADLE DRIER
15	LADLE RELINING AREA
16	LADLE DESKULLING AREA
17	BILLET/BLOOM TRANSFER CAR
18	C.C. ELECTRIC & TRANSFORMER ROOM
19	C.C. MACHINE REPAIR AREA
20	TUNDISH RELINING & PREPARATION AREA
21	JUNCTION HOUSE
22	10/5-TON EOT MAGNET CRANE
23	70/20-TON EOT CRANE
24	130/50/20-TON EOT CRANE
25	25/10-TON EOT CRANE
26	20-TON EOT CRANE
27	SCALE PIT
28	TRANSFER CAR CONTROL ROOM (included in 35)
29	SITE OFFICE
30	CENTER CONTROL ROOM & COMFORT STATION
31	SLAG TRANSFER HEAD ROOM
32	CCM HYDRAULIC ROOM
33	GAS CUTTER & COOLING BED CONTROL ROOM
34	4-STRAND BILLET CCM
35	BRICK STORAGE AREA
36	OIL WARE HOUSE
37	EMERGENCY COOLING TOWER
38	SCRAP OPERATOR ROOM
39	BELT CONVEYOR
40	LIME RECEIVING HOPPER
41	CCM MAIN PULPIT

EL DIKHEILA PROJECT
DWG. NO. JICA-6-4-01
TITLE
STEEL PLANT LAYOUT
SCALE 1:500
DATE APRIL 1979

6.5 Continuous Casting Plant

6.5.1 General

The continuous billet casting plant shall be composed of three 4-strand continuous casting machines. This plant will produce billets continuously for bars and rods from molten steel which is melted and refined in the electric arc furnace plant as already mentioned in Chapter 6.4. It shall have a nominal annual capacity of 770,000 tons.

6.5.2 Production Plan

6.5.2.1 Operation Time

The continuous casting plant shall be operated for 330 days per year on the basis of 4 crews working 3 shifts.

6.5.2.2 Production Capacity

The molten steel which is supplied from the electric arc furnace plant shall be continuously cast into billets. The annual production of cast billets shall be 770,000 tons. The kind of steel to be cast into billets shall be mild low carbon steel. The design capacity of the continuous casting plant is given in Table 6.5-1. This table shows the capacity of one (1) casting machine.

Table 6.5-1 Design Capacity

1	Unit Weight per Meter	130 Kg/m (at 130 mm sq.)
2	Casting Speed	2.2 m/min
3	Theoretical Production	130 Kg/m x 2.2 m/min x 4 strands = 1,144 Kg/min
4	Operation Ratio	Approx. 0.61 Casting time/casting cycle per one heating = 62 ÷ 102
5	Yield Ratio	Approx. 0.95
6	Production Capacity	1.144t/min x 60 min/h x 0.61 x 0.95 = Approx. 39.8 t/h 39.8 t/h x 24 h x 330 days = Approx. 315,000 t/y

6.5.2.3 Unit Consumption for Consumables

The unit consumption per cast billet ton is shown in Table 6.5-2.

Table 6.5-2 Unit Consumption

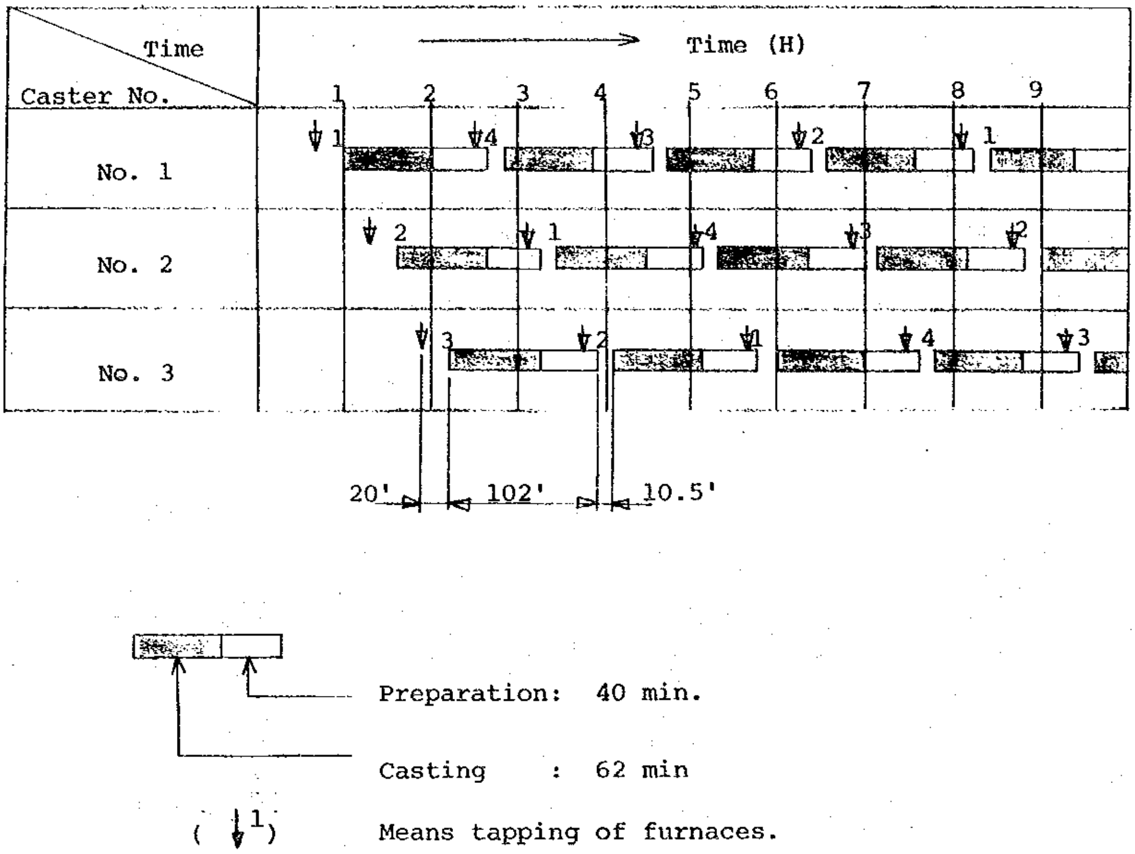
	Item	Unit Consumption per Cast Billet Ton
1	Electric Power	20 Kwh
2	Industrial Water	0.5 m^3
3	Compressed Air	25 Nm^3
4	Nitrogen	0.22 Nm^3
5	Natural Gas	4 Nm^3
6	Oxygen Gas	1.6 Nm^3
7	Mould Lubricant	0.2 Kg
8	Other Lubricants	0.02 Kg
9	Al Wire	95 g
10	Refractories	5 Kg
11	Moulds (Copper tubes)	1 g
12	Rollers	0.022kg

Note: The above industrial water means make-up water.

6.5.2.4 Time Chart of Operation

The casting schedule of this plant is shown in Table 6.5-3.

Table 6.5-3 Casting Schedule



Preparation: 40 min.

Casting : 62 min

Means tapping of furnaces.

Note: 1. Number of furnaces : 4

2. Capacity of each furnace : 70 tons

3. Number of casting machines: 3

4. Number of strands : 4

5. Size of billets : 130 mm sq.

6. Tapping interval : 37.5 min.

7. Casting cycle time : 102 min.

8. Preparation time : 40 min.

6.5.2.5 Material Balance and Flow

The material balance is shown in Fig. 6.5-1 and the material flow is shown in Fig. 6.5-2.

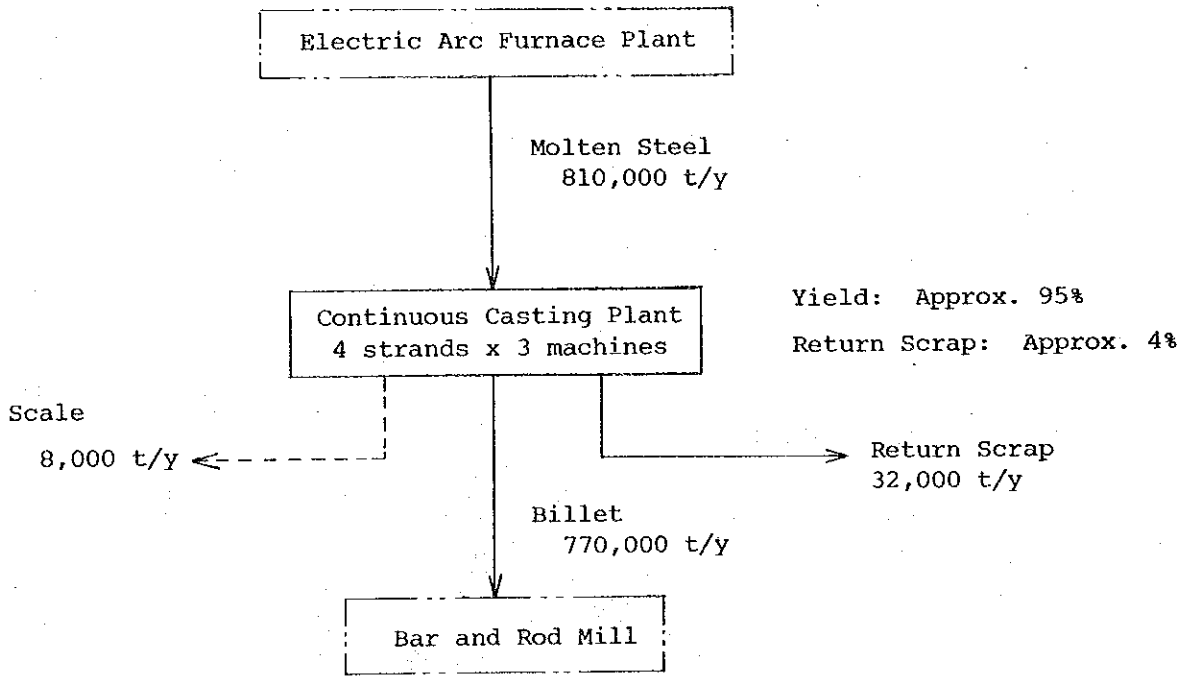


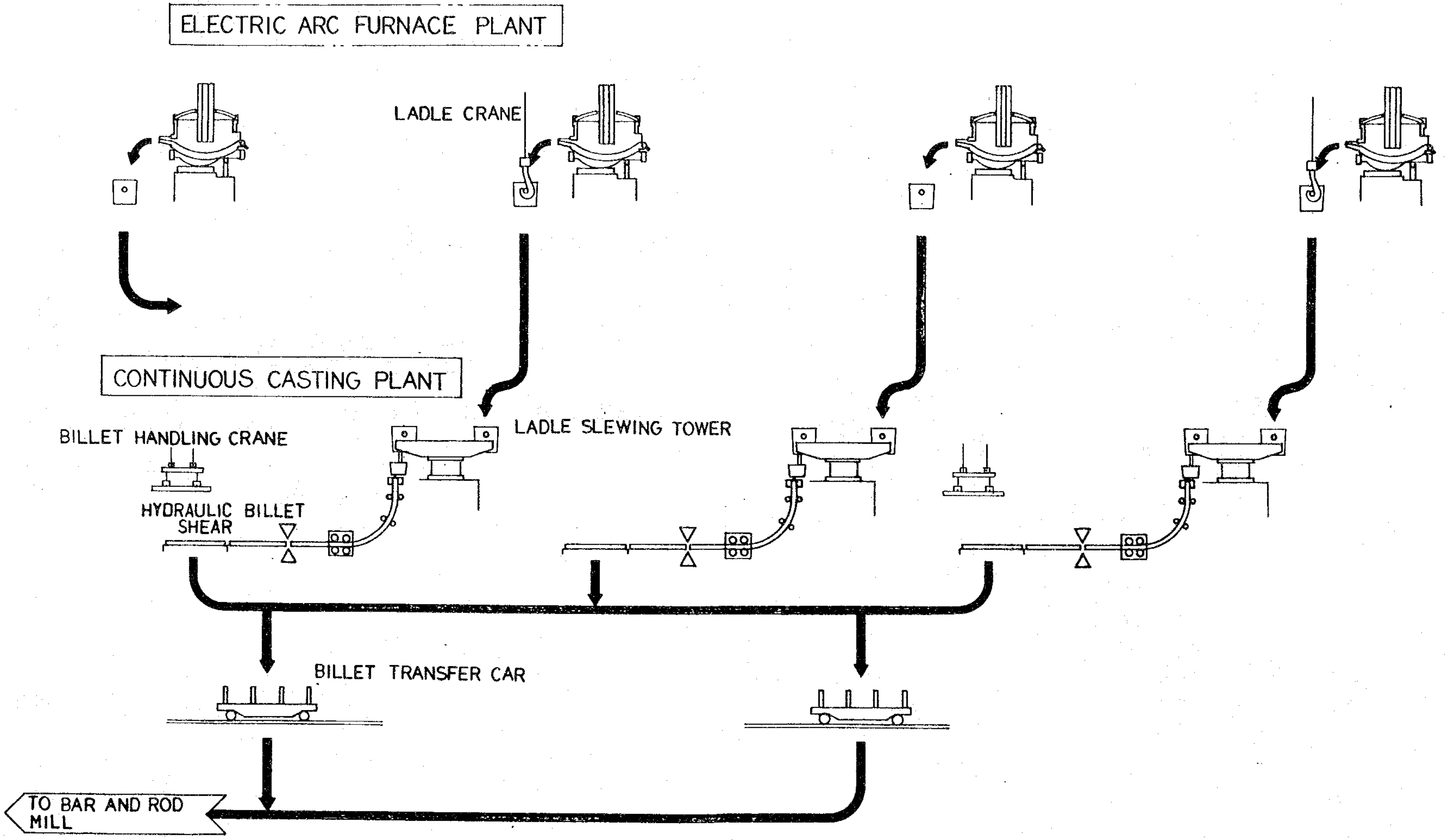
Fig. 6.5-1 Material Balance Sheet

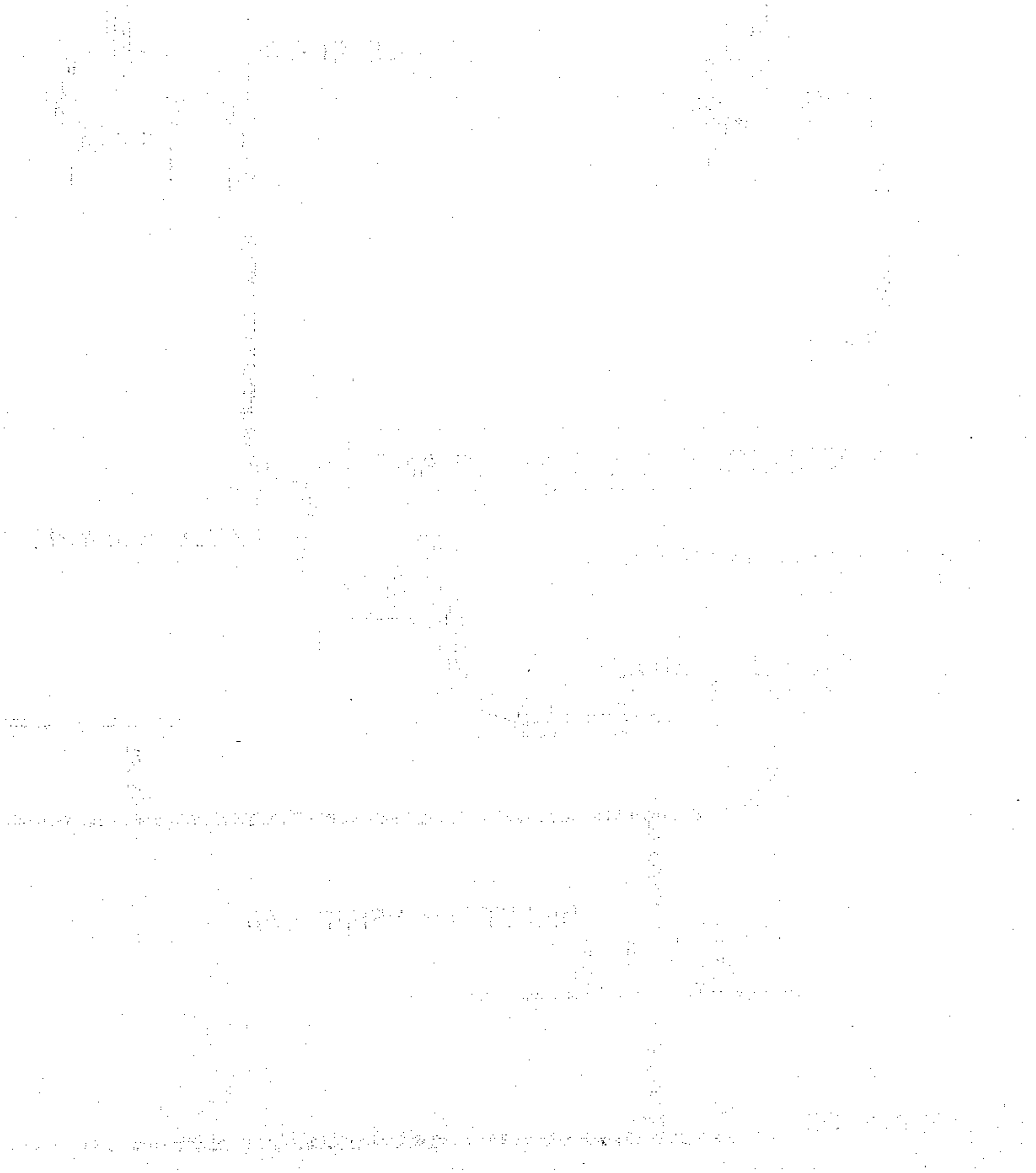
6.5.3 Equipment Specifications

6.5.3.1 Layout

The ladle aisle of the electric arc furnace plant and the casting aisle of the continuous casting plant are located separately and the ladle exchange between the two aisles shall be carried out by

Fig. 6. 5. 2 MATERIAL FLOW SHEET





an overhead crane in the ladle aisle and by the ladle slewing tower located between the two aisles.

Therefore, the exchange of ladle and tundish shall be done without interrupting the operation of other casting machines. The plant shall be designed so that the so-called "Continuous-Continuous" casting operation can be done easily.
An outline of the continuous casting process is as follows:

The ladle, teemed with molten steel, shall be loaded on the arm of the ladle slewing tower by overhead crane in the ladle aisle and shall be slewed to the casting position.

The molten steel contained in the ladle shall be poured into the tundish and fed through it into the mould assembled at the top of the continuous billet casting machine, in which a dummy bar shall be set beforehand.

When monten steel has reached a specified level in the mould, the withdrawing of the dummy bar and the mould oscillation shall take place, and the casting operation shall commence. Cast billets shall be continuously withdrawn through the withdrawal/straightening roll unit. At the cutting section, the cast billets shall be cut into the specified lengths by the hydraulic billet shear.

Cast billets of specified length shall further be transferred to the cooling bed through the shear rear table, the dummy bar storage table, the run-out table and the billet transfer. At the end of the run-out table, each billet shall automatically be marked with heat number and cutting number by means of a billet marker in every two strands.

The marked and cooled billets shall be loaded on billet transfer cars by overhead travelling cranes with lifting magnets and transferred to the bar and rod mill. The main specifications of the machine are shown in Table 6.5-4, and the layout is shown in Dwg. No. JICA-6.4-01, JICA-6.5-01 and JICA-6.5-02.

Table 6.5-4 Main Specifications of the Casting Machine

1	Type of Machine	Low head straight mould radial type
2	No. of Strands	4 strands x 3 machines
3	Source of Molten Steel	4 electric arc furnaces
4	Radius of Curvature	6,500 mm
5	Billet Dimensions,	
	Cross Section	130 x 130 mm (Normal) (100 x 100 - 150 x 150 mm)
	Length	16,000 mm max.
6	Unit Weight	2 tons max.
7	Driving Speed	
	Casting	3 m/min max.
	Dummy Bar Setting	4.5 m/min

6.5.4 Manpower Requirements

The plant personnel requirements for operation of the continuous casting plant is shown in the following Table 6.5-5, and is based on a 4 crew - 3 shift operation.

Table 6.5-5 Manpower Requirements

Position	Man Power	Day-Employee	Shift-Employee
C.C. Operator			
Manager	1	1	
Engineer	4	4	
Foreman	4		1/shift x 4 crews
Assistant Foreman	24		2/shift x 4 crews x 3 machines
Laborer	108		9/shift x 4 crews x 3 machines
Total	141	5	136

Note: 1. Crane operators are not included in the above personnel list.

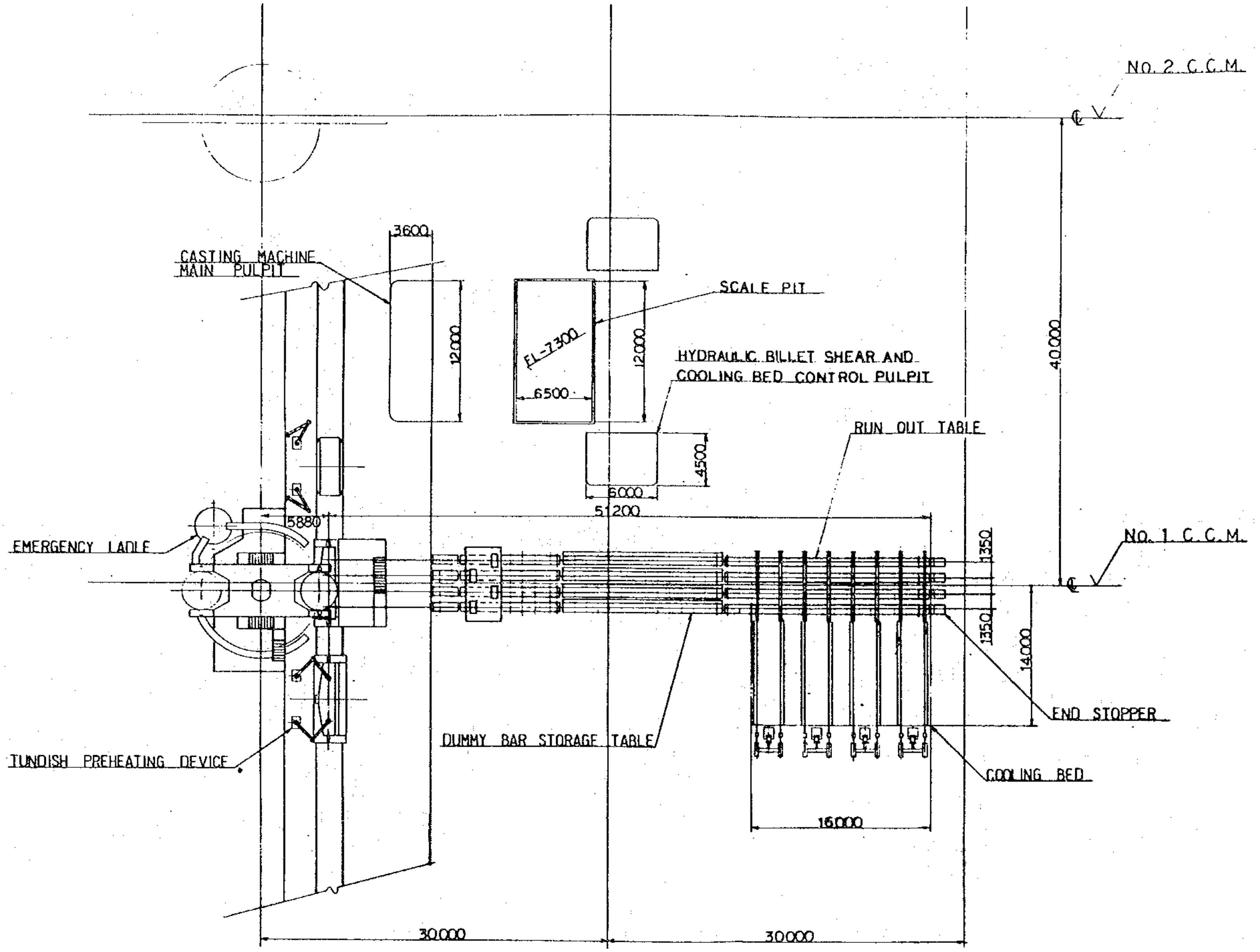
6.5.5 Equipment List

Major equipment of the continuous casting plant is shown in Table 6.5-6.

Table 6.5-6 Equipment List

Equipment	Q'ty	Description
1 Molten Steel Handling Equipment	1 set	Ladle slewing tower: 3 Tundish with cover : 18 Tundish car : 6
2 Continuous Casting Machine	1 set	Mould assembly : 12 Mould centering device : 12 Secondary cooling equipment : 12 Steam exhausting system: 3 Withdrawal/straightening roller unit : 12 Dummy bar : 12
3 Discharging Equipment	1 set	Hydraulic billet shear : 12 Shear front table : 12 Shear rear table : 12 Dummy bar storage table: 12 Run out table : 12 Dummy bar storage : 12 Billet marker : 6 Cooling bed : 3 Billet transfer car : 2
4 Hydraulic System	1 set	
5 Lubrication System	1 set	

Equipment	Q'ty	Description
6 Interconnecting Piping	1 set	Cooling water, compressed air, oxygen gas, potable water piping, etc.
7 Repair and Assembly Equipment	1 set	Mould maintenance deck, roller apron aligning stand, etc.
8 Tundish Preparation Equipment	1 set	Tundish cooling stand, tundish nozzle setting stand, tundish drying device, etc.
9 Water System	1 set	Scale pit water pump : 6 Scale sluice circulation water pump : 3 Booster pump for mould cooling water : 6
10 Auxiliary Matter	1 set	Refractories, hydraulic oil, lubricant, etc.
11 Steel Structure	1 set	
12 Electrical Equipment	1 set	
13 Instrumentation	1 set	



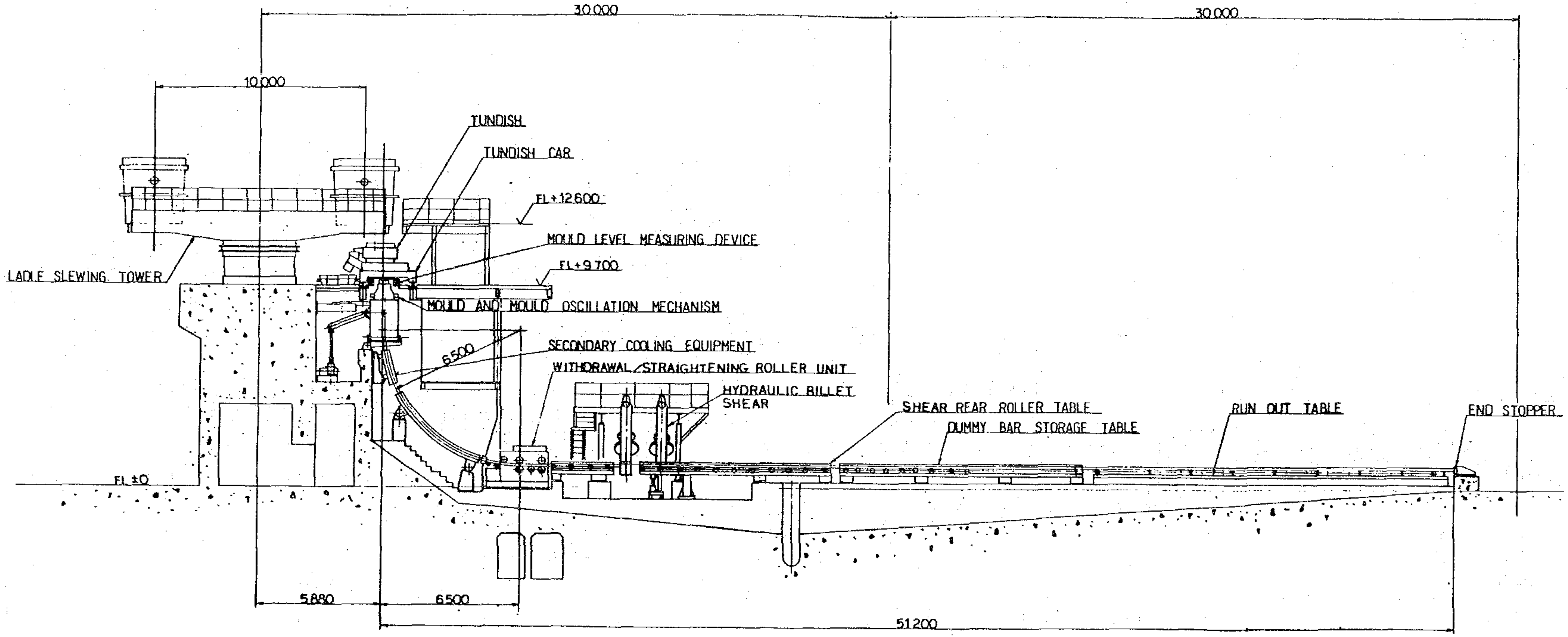
ELDIKHEILA PROJECT

Dwg. NO. JICA-6.5-01

CONTINUOUS BILLET CASTING PLANT
LAYOUT PLAN

Scale 1/400

Date APRIL, 1979



ELDIKHEILA PROJECT

Dwg. NO. JICA - 6.5-02

CONTINUOUS BILLET CASTING PLANT
SIDE VIEW

Scale 1/200

Date APRIL, 1979

6.6 Limestone Calcining Plant

6.6.1 Concept of Plant

Burnt lime required to enable the molten steel production of 810,000 t/year from EAF amounts to

75 kg/T x 810,000 = 60,750 t/year

Calcining furnace to produce burnt lime is classified into a shaft furnace and rotary kiln. In this project, the shaft furnace is employed due to following reasons:

- ° Heat efficiency: Higher by 150% than the case of rotary kiln
- ° Construction cost: 70% of the case of rotary kiln
- ° Quality: By the use of steam burner, quality equivalent to that of rotary kiln is reached or (gotten).

On the basis of annual availability of 330 days, one furnace of 180 t/day (6705 ÷ 330 ≒ 185 t/day) capacity is installed. For Stage 2, one more furnace is planned adjacent to this furnace.

As the unwashed limestone raw material is provided, this plant will have the water washing equipment, which pretreats the limestone before charging into the furnace. Burnt lime product is crushed to the size of 5 ∿ 40 mm, the size suitable for charging into EAF. Grains less than 5 mm size are separated by the product screen and stored in the product hopper as briquette. Grains of sizes ranging 5 ∿ 40 mm are also stored in the product hopper.

6.6.2 Presuppositions for Equipment Plan

6.6.2.1 Raw limestone

a. Grain size: 40 ∿ 90 mm (-40 mm 10%)

b. Chemical composition:

CaO : 52% or more
SiO_2 : 1.5%
S :

6.6.2.2 Production program for limestone sintering furnace is shown on Table 6.6-1.

Table 6.6-1

		Production
EAF requirement		60,750 t/year
Production of lime calcining furnace	Yr.	60,750 t
	Mo.	5,063 t
	Day	184 t

6.6.2.3 Yield and Operating Conditions

Yield is shown on Table 6.6-2 while the operating conditions on Table 6.6-3.

Table 6.6-2 Yield

Process	Yield
Raw limestone water washing yield (Raw limestone/water washed limestone x 100)	90%
Raw limestone filter yield (Limestone charged into calcining furnace/washed limestone x 100)	82.5%
Calcining yield (Burnt lime product/washed limestone x 100)	45%

Table 6.6-3 Operating conditions

		Planned value
Operating days	Annual	330 days
	Monthly	27.5 days
Furnace down time	Annual t.d.t.	35 days
Operating availability		90.0%
Calcining furnace capacity	Annual	180 t/day
	Maximum	220 t/day

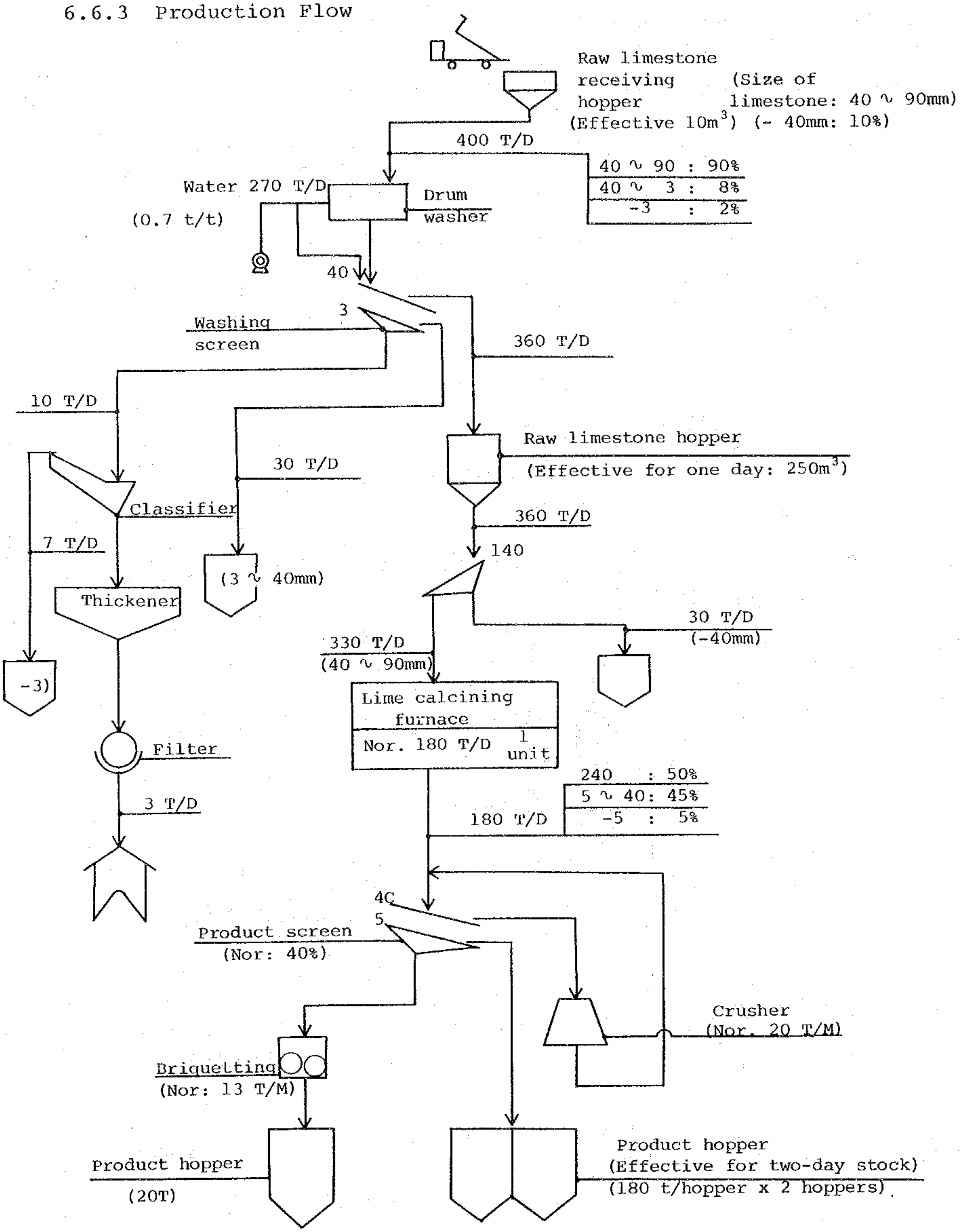
6.6.2.4 Utility consumption

Utility consumption is shown on Table 6.6-4.

Table 6.6-4 Utility

Item	Consumption
Fuel Natural Gas	Pressure 4 kg/cm^2
Fuel Consumption	
Kcal/kg CaO	950 Kcal/kg CaO
Kcal/T CaO	950 x 10^3 Kcal/T CaO
Annual natural gas consumption	6,363 x 10^3 Nm^3
Make up water	1 m/T CaO
Steam (4 ∿ 7 kg/cm^2)	230 kg/hr
Compressed Air(4 ∿ 7 kg/cm^2)	82 Nm^3/T CaO
Electric Power	55 KWH/T CaO

6.6.3 Production Flow



6.6.4 Description of Main Facilities

6.6.4.1 Receiving of raw limestone and washing equipment

Raw limestones are transported from the place about several kilometers of work site by the dump truck. For the raw limestone yard within the works, the space enabling the storage of 5,000 t (for about 15 days) is planned.

Limestone transfer from the yard to the hopper of washing equipment is made by the shovel loader. Washing drum shaft has the capacity of 400 ∿ 450 t/day.

Washed limestones pass through the washing screen, where limestones of 40 ∿ 90 mm are separated to be stored in the raw limestone hopper. Undersizes of less than 40 mm are directed via the crusher and thickener, and discharged.

6.6.4.2 Raw limestone hopper

Limestones are transported on the 30 t/hr belt conveyor from the washing screen to the limestone hopper. This hopper has the storage capacity of 250 m^3, which is equivalent to about 360 t. Screen is provided between the hopper and calcining furnace to charge only limestones of 40 ∿ 90 mm. Undersizes of less than 40 mm are to be discharged.

6.6.4.3 Calcining furnace

Averaged calcining furnace capacity is planned at 180 t/day. To cover the furnace relining or accidental troubles or to meet the EAF production program, the planned furnace is designed to maintain the product quality even under over- and underload operations ranging from 150 to 220 t/day.

As compared with the rotary kiln, the vertical type furnace generally suffers from slightly deteriorated reactivity. This project attempts to overcome this problem by providing the lance in the furnace, which jets the steam. 19 lances are used in this furnace and the steam jet rate amounts to 230 kg/hr.

6.6.4.4 Finished product transportation and storage facility

Finished product is transported on the 40 t/h belt conveyor. At half way of the conveyor route, the 20 t/hr crusher is provided to obtain the size of 5 ∿ 40 mm appropriate for the use in the furnace. Product of less than 5 mm is briquetted by the 1.3 t/h briquetting machine and transported to the product hopper.

The hoppers prepared are 180^3 m x 2 and 20 m^3 x 1, which can ensure the storage for about two days.

6.6.4.5 Layout

Layout of the limestone sintering plant is shown on DWG 6.6-01.

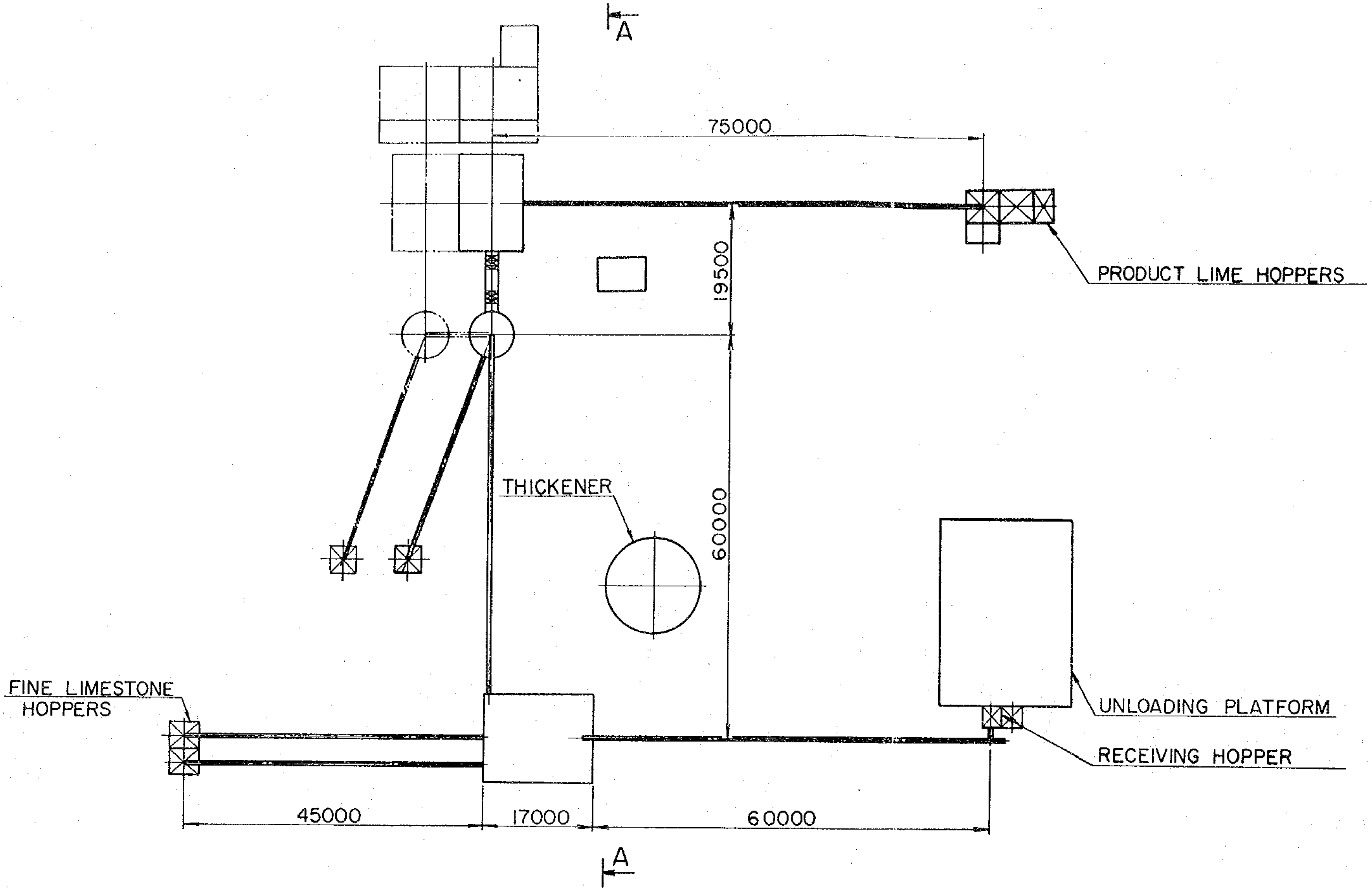
6.6.4.6 Equipment list

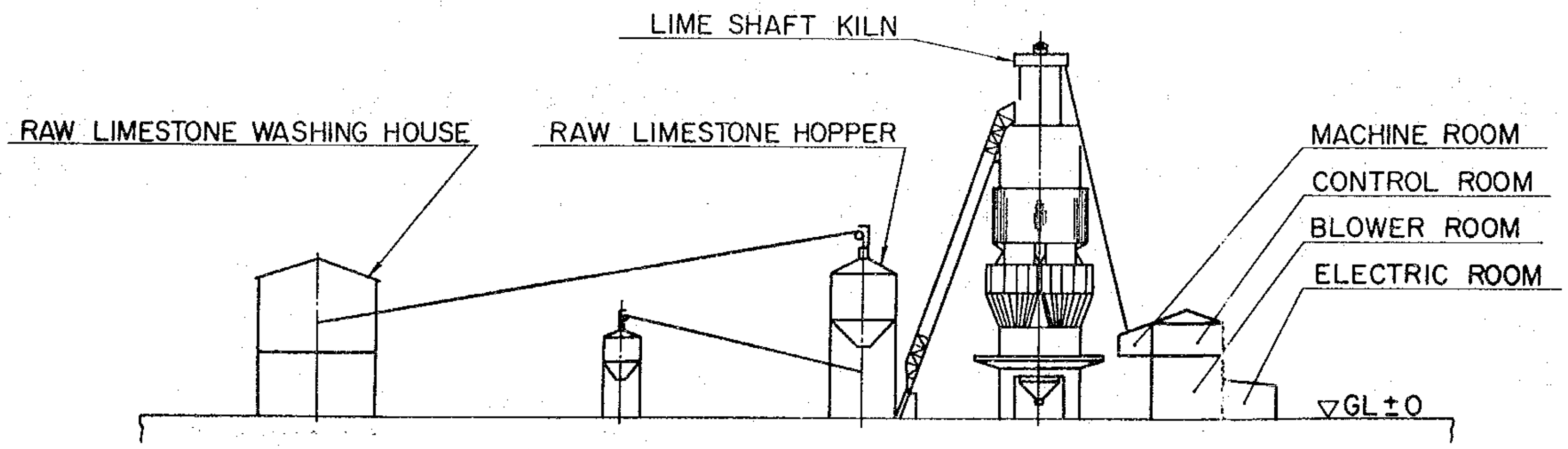
Specification of major equipment is shown in Fig. 6.6-1.

Fig. 6.6-1 Facility List

No.	Facility	Q'ty	Specification
1.	Raw Limestone Receiving System		
1-1	Receiving hopper	1	Capa. : 10 m^3
1-2	Belt feeder	1	Capa. : 80 t/h
1-3	No.1 Belt conveyer	1	Capa. : 160 t/h
2.	Raw Limestone Washing System		
2-1	Building	17m x 13m	
2-2	Drum washer	1	Capa. : 160 t/hr
2-3	Washing screen	1	Capa. : 160 t/hr
2-4	Classifier	1	Capa. : 10 t/hr
2-5	Thickener	1	Size : 14m^{ϕ} x 3m^{H} steel structure
2-6	Filters	2	Size : 2.4m^{ϕ} x 2.4^{L}
2-7	Dust hoppers	2	Capa. : 30 m^3
2-8	Conveyers	3	Capa. : 30 t/h 10 t/hr 5 t/hr
3.	Raw Limestone Charging System		
3-1	Limestone hopper	1	Capa. : 250 m^3
3-2	Dust hopper	1	Capa. : 30 m^3
3-3	Belt conveyers	2	Capa. : 40 t/h, 10 t/h

No.	Facility	Q'ty	Specification
4.	Lime Calcining Kiln	1	Capa. : 180 T/day Type : Vertical with gas lance Lance 19 P.S.
5.	Product Handling System		
5-1	Product hoppers	3	Capa. : 180 m^3 x 2, 20 m^3 x 1
	Screen	1	Capa. : 40 t/hr
	Crusher	1	Capa. : 20 t/hr
	Belt conveyers	3	Capa. : 40 t/hr, 20 t/hr x 2
	Bucket conveyer	1	Capa. : 20 t/hr
6.	Kiln Service System		
6-1	Boiler	1	Capa. : 1 t/hr
6-2	Blower room, control room		
7.	Product Briquetting		
	Briquetting machine	1	Capa. : 1 t/hr
	Belt conveyer	1	Capa. : 2 t/hr





VIEW A-A

EL DIKHEILA PROJECT

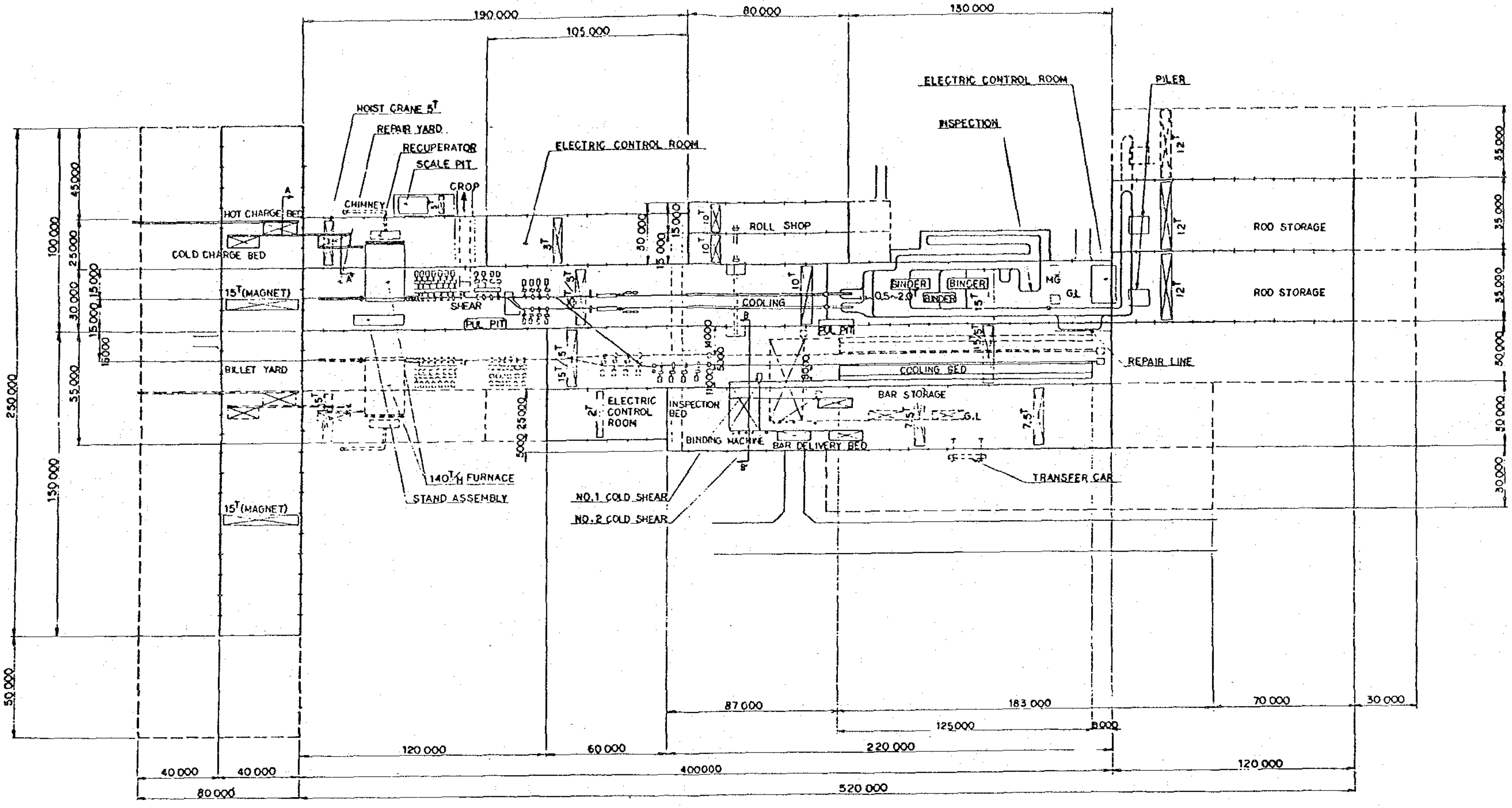
DWG. NO. JICA-6-6-01

TITLE
CALCINING PLANT
GENERAL LAYOUT

SCALE 1 / 500

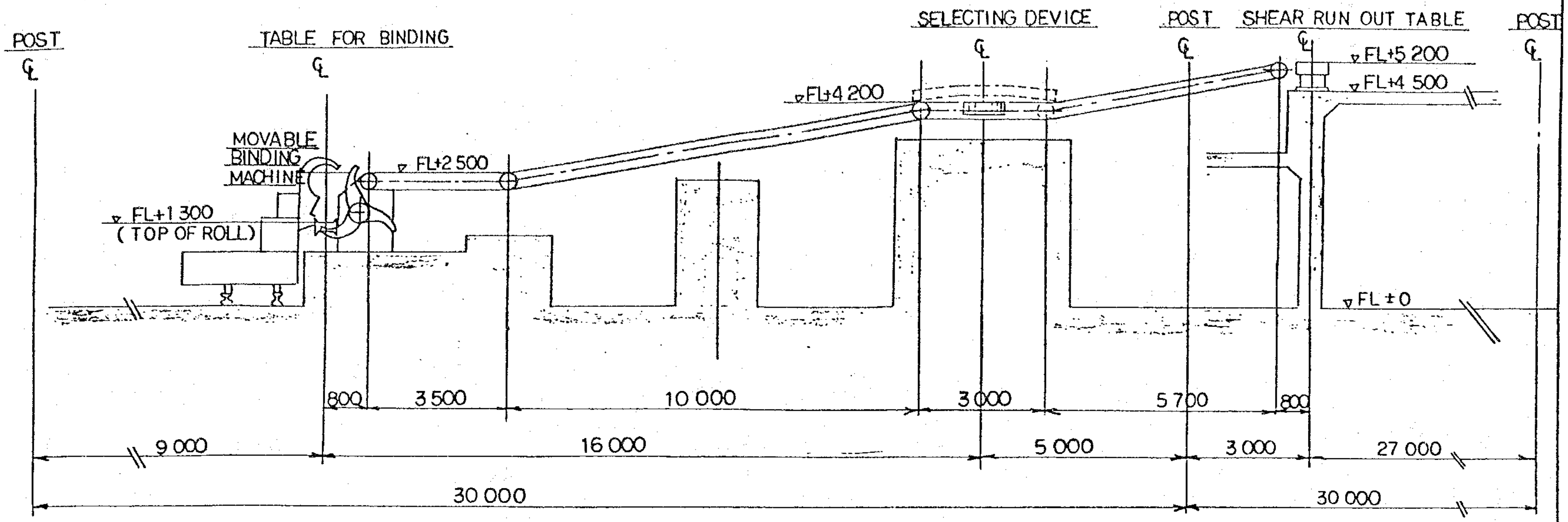
DATE APRIL 1979

BIBLIOGRAPHY

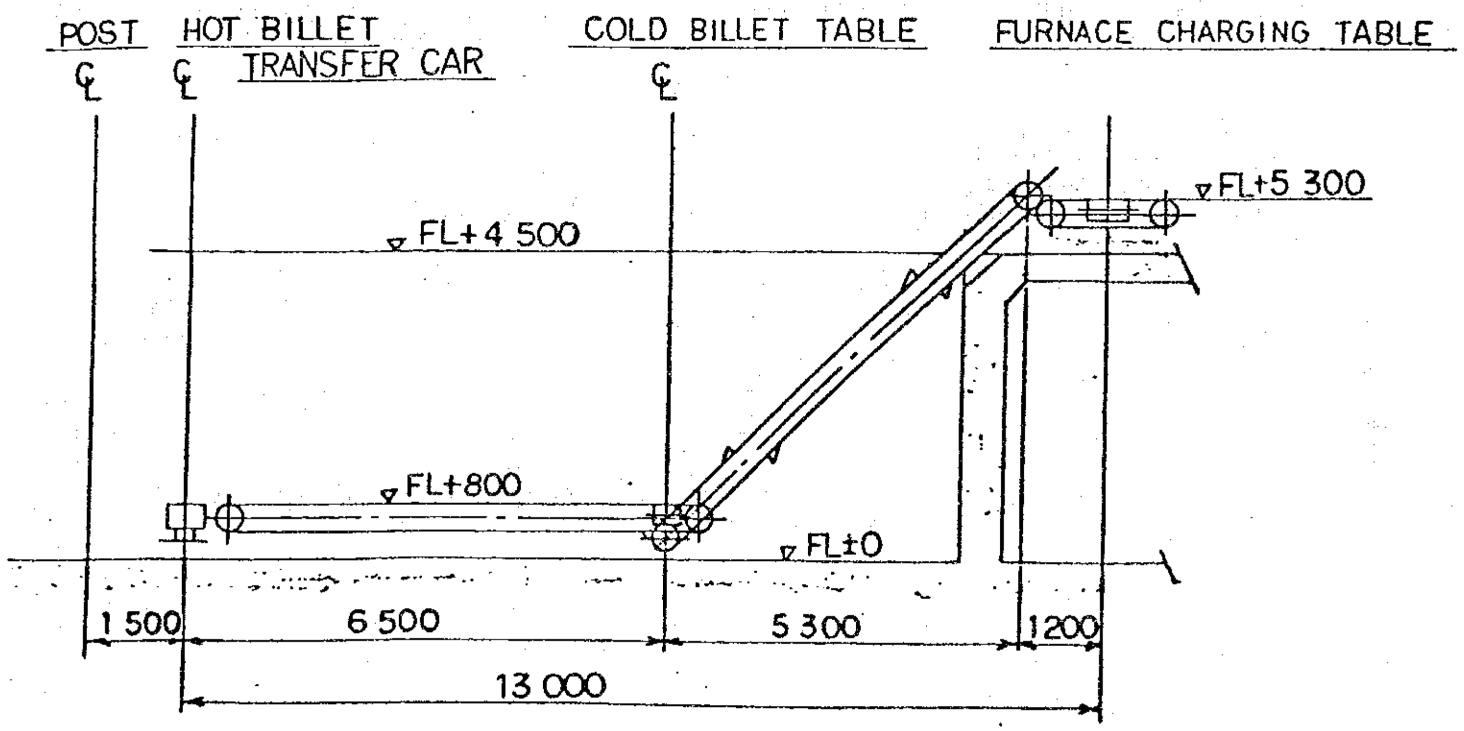


EL DIKHEILA PROJECT
DWG.NO. 6·7 −14
TITLE
GENERAL LAYOUT FOR BAR AND ROD MILL
SCALE 1/2.000
DATE APRIL 1979

SECTION B-B' BUNDLING & BINDING FACILITIES FOR BARS



SECTION A-A' FURNACE CHARGING EQUIPMENT



EL DIKHEILA PROJECT

DWG. NO. 6·7—15

TITLE
SECTIONAL DRAWING
(FURNACE CHARGING AND
BUNDLING & BINDING FACILITIES)

SCALE 1/1 000

DATE APRIL 1979

6.7 Bar and Rod Mill

6.7.1 Basic plan

1) General

Annual production of this mill is planned at 723,000 t at its full production. As compared with the bar and rod mills of similar scale, this production can be rated substantially high.

Products of this mill include steel bar and wire rod for concrete reinformcement and with the size range of 6 ∿ 13 mm^{ϕ} for wire rod and 13 ∿ 38 mm^{ϕ} for bar steel. In terms of shape, this mill produces deformed bar and plain bar. Kind of steel includes 52 kg steel (deformed bar of 52 kg/mm^2 or more tensile strength in compliance with Egyptian Standard 262-1974, "Steel Bar for Concrete Reinforcement") and 37 kg steel (plain bar of 37 kg/mm^2 or more tensile strength). The mill has sufficient flexibility to meet the change more or less in the size and kind of steel.

As a basic plan, the mill will be the combination type mill which will incorporate one bar finishing line and two rod finishing lines.

To keep the initial construction cost minimum, the combination mill type will be adopted, in which both bar and rod lines commonly use the reheating furnace, roughing rolling mill line, and intermediate rolling mill line. Production increase, if required in future, can be realized by adding the same line to this commonly used line (from reheating furnace to intermediate mill line) to separate the bar mill and rod mill into independent plant. (As details of this plan, please refer to 6.7.9.) Since the productivity of the combination mill is requested to be higher by 20 to 30% than that of the normal mill, this combination mill is to be designed inorder to ensure high rolling productivity and high mill availability.

For this perpose to be achieved, following prerequisites must be satisfied:

(1) Import program and product distribution with regard to existing Egyptian mill must be arranged in such a manner that rolling is made placing priority on the products mix of high rolling productivity.

(2) 3-shift 4-crews work system is to be adopted to increase the operating hour and, by strengthening the management and providing operators with training and education, the working ratio must be enhanced.

All mill equipment are planned to be imported. For the election assistance partially given from abroad plus the employment of local labour are planned.

2) Material

As the material billet, CC billet produced from the electric arc furnace in this plant will be used entirely. Billet size is 130mm ⌀ x 16,000mm, with the unit weight or 2,100 kg. This value is chosen to enhance the rolling productivity. Also the design coil unit weight of 2t is responsible for this choice.

Since these products are for concrete reinforced and thus the requirement for the surface quality is not so stringent, surface conditioning for billets don't basically practice.

To reduce the fuel consumption, hot charge operation is basically adopted, so that the transfer car to transport billet from CC yards is connected to the reheating furnace charging table via the table roller.

As a billet storage yard, the space enabling storage for about 10-day operation is provided on the mill side. This arrangement will ensure rolling operation without being affected by the trouble in the steelmaking shop, if any.

3) Rolling system

This system includes following principle equipments to roll from the 130mm□ billet (weight: about 2t) into 6 ∿ 13mm$^{\phi}$ rod and 13 ∿ 38mm$^{\phi}$ bar:

° Reheating furnace

Capacity: 140 T/hr.

Type: Walking beam type

Fuel: Natural gas

° Rolling mill

Roughing mill train: 7 stands

No. 1 intermediate rolling mill train:
4 stands

No. 2 intermediate rolling mill train:
4 stands

° Finishing mill train:

Rod: Block mill 10 stands

Bar: 4 stands

Cooling equipment

Rod: Coil cooling unit - 2 line

Bar: Cooling bed - 1 (Length - 120 m)

Maximum rolling speed is 75 m/s for rod and 18 m/s for bar.

4) Finishing system

This system includes various equipment to cut, inspect, and bind the rolled rod and bar and the stock yard for the temporary stock and storage of products. Stock yard has the stock area enabling about five-day storage respectively for rod and bar.

Standard coil weight is 2t. If lighter coil is required because of user's application requirements, the coil can be cut to 1-ton coil in the Stelmore unit.

5) Buildings

In the designing of the coil cooling lines, floor line principle mechanical equipment is planned to be raised to the floor level of GL + 4.5m (planning value) because in the Stelmore unit coils are blown by cooling air from under the conveyor. FL = 4.5m is designed only for the yard where the reheating furnace yard and principle rolling mill equipment yard are installed. For other yards, normal GL is applied. It is also designed to transport billets and products to and from the yard of FL - 4.5m by means of conveyors.

6.7.2 Production plan

Production plan at start-up will be separately determined. Here at 723,000 t/y rolling after full operation, it will be discussed on the rolling productivity, operating ratio, and work system.

1) Product mix

In the market study, the annual production by size is discussed. Production by size after 1986 in the full operation is shown in Table 6.7-1. This table is made, considering priority of rolling the higher productivity sizes.

Since the production analysis is made on the basis of monthly figures on the billet base, values in Table 6.7-1 are converted to those in Table 6.7-2. For this conversion from the product amount to billet amount, yield as shown in Table 6.7-3 is used.
As for the case of producing all demand for 6 mm coil and 8 mm coil, please refer to 6.7.8.

Table 6.7-1 Production by Size (after full operation) - (Product base, yearly)

(Unit: 1,000t/y)

Calender Year	Rod					Bar								Gross
	6mm	8mm	10mm	13mm	Total	13mm	16mm	19mm	22mm	25mm	28mm	32mm∿	Total	
1986	-	173	220	187	580	-	13	67	21	38	4	-	143	723
87	-	126	243	211	580	-	-	68	26	44	5	-	143	723
88	-	77	267	236	580	-	-	54	31	51	6	1	143	723
89	-	23	293	264	580	-	-	40	36	59	7	1	143	723
90	-	-	286	294	580	-	-	24	42	67	8	2	143	723
91	-	-	255	325	580	-	-	7	48	76	9	3	143	723
92	-	-	209	361	570	-	-	-	54	85	10	4	153	723

Table 6.7-2 Product by Size (Billet base, monthly)

(Unit: 1,000t/month)

Calender year	Rod					Bar								Gross
	6mm	8mm	10mm	13mm	Total	13mm	16mm	19mm	22mm	25mm	28mm	32mm∿	Total	
1986	-	15.1	19.3	16.4	50.8	-	1.3	6.0	1.9	3.4	0.4	-	13.0	63.8
87	-	11.0	21.3	18.5	50.8	-	-	6.2	2.4	4.0	0.4	-	13.0	63.8
88	-	6.7	23.4	20.7	50.8	-	-	4.9	2.9	4.6	0.5	0.1	13.0	63.8
89	-	2.0	25.7	23.1	50.8	-	-	3.6	3.3	5.4	0.6	0.1	13.0	63.8
90	-	-	25.1	25.7	50.8	-	-	2.1	3.8	6.2	0.7	0.2	13.0	63.8
91	-	-	22.3	28.5	50.8	-	-	0.6	4.3	7.0	0.8	0.3	13.0	63.8
92	-	-	18.3	31.7	50.0	-	-	-	4.9	7.6	0.9	0.4	13.8	63.8

Table 6.7-3 Product Yield for Rod and Bar

(Unit: %)

Item	Rod	Bar	Average	Remarks
Charge amount	100%	100%	100%	(Amount of billet used)
Mill scale	1.0	1.0	1.0	
Crop	2.0	5.0	3.0	Shear crop, trimming short-size product
Miss-roll	2.0	2.0	2.0	
Loss total	5.0	8.0	6.0	
Second grade product	0	0	0	
First grade product	95.0	92.0	94.0	(Yield of first grade product)

2) Rolling productivity by size

Table 6.7-4 shows the rolling productivity by size. Products of not more than $13mm^{\phi}$ are rolled in the rod line while those of more than $16mm^{\phi}$ are rolled in the bar line. Products of $13mm^{\phi}$ can be rolled in both the rod and bar lines. In the calculation, however, this size is assumed to be rolled in the rod line since this line has the rolling productivity from users, straightening is possible before delivery.

Table 6.7-4 Rolling Capacity by Size

Mill	Size (mm)	Area of Section (mm^2)	Weight (kg/m)	Total Length of Rod or Bar (m)	Finishing Speed (m/s)	Pass time			Rolling Capacity		
						Actual time (s)	Idle time (s)	Total time (s)	Per. strand (T/Hr)	Number strand	Total Capacity (T/Hr)
Rod	6	28.3	0.222	9.460	75	126	5	131	58	2	116
	8	50.3	0.395	5.316	47	113	5	118	64	2	128
	10	78.5	0.616	3.409	30	113	5	118	64	2	128
	13	132.7	1.042	2.015	19	106	5	111	68	2	136
Bar	13	132.7	1.042	2.o15	18	112	5	117	65	1	65
	16	201.1	1.579	1.330	18	74	5	79	96	1	96
	19	283.5	2.225	944	16	59	5	64	118	1	118
	22	379.9	2.982	704	14	50	5	55	137*	1	137
	25	490.9	3.854	545	12	45	5	50	140(151)	1	140
	28	615.4	4.831	435	1.0	44	5	49	140(154)	1	140
	32	804.2	6.313	333	7.5	44	5	49	140(154)	1	140

* Capacity enclosed in parantheses applies only to rolling operation.

3) Averaged rolling productivity by year

From the rolling productivity by size as above described, averaged annual rolling productivity when the annual rolling production (by size) in Table 6.7-2 is achieved can be calculated as follows:

Averaged annual rolling productivity

$$n = \frac{1}{\sum_{i} \frac{ai}{mi}} \quad (T/hr)$$

Rolling productivity by size: mi (T/hr)

Construction ratio by size for each year: ai

Calculated result is shown on Table 6.7-5.

Year	n
1986	129.0
1987	130.4
1988	131.1
1989	132.6
1990	132.6
1991	133.2
1992	134.4

Value for the year 1986, which is the lowest in the above table, is used in the analysis of subsequent items.

4) Work system and operatable hours

As work system, 3-shift 4-crews plan and 3-shift 3-crews plan are considered. Table 6.7-6 shows the estimated operatable hours for each plan.

Table 6.7-6 Estimated operatable hours

Item	Code	Calculation Formula	3-shift 4-crews	3-shift 3-crews
Days per year	A		365 days	365 days
Weekly holiday	B		0 "	52 "
Major repair			13 "	13 "
Minor repair			13 "	0 "
Operatable days	C	(A-B)	339 "	300 "
Operatable hours	D	(Cx24)	8136 hrs.	7200 hrs.
Monthly operatable hours	E	(D÷12)	678 "	600 "
Roll change	F		90 "	90 "
Roll conditioning			30 "	30 "
Down time			50 "	50 "
Operatable hours	G	(G-F)	508 hrs.	430 hrs.
Operation ratio	H	(G/E)	74.9%	71.7%

In the case of 3-shift 4-crews system:

129 T/hr x 508 hr/M = 65,532 T/M > 63,800 T/M

In the case of 3-shift 3-crews system:

129 T/hr x 430 hr/M = 55,470 T/M   63,800 T/M

Evidently, 3-shift 4-crews system is recommended.

As for calculations for the operatable hours of rod line and bar line separately, the example of 1986 year is shown as follows.

Rod line: (15,100 ÷ 128) + (19,300 ÷ 128)
+ (16,400 ÷ 136)
= 118 + 151 + 121 = 390 Hr/month

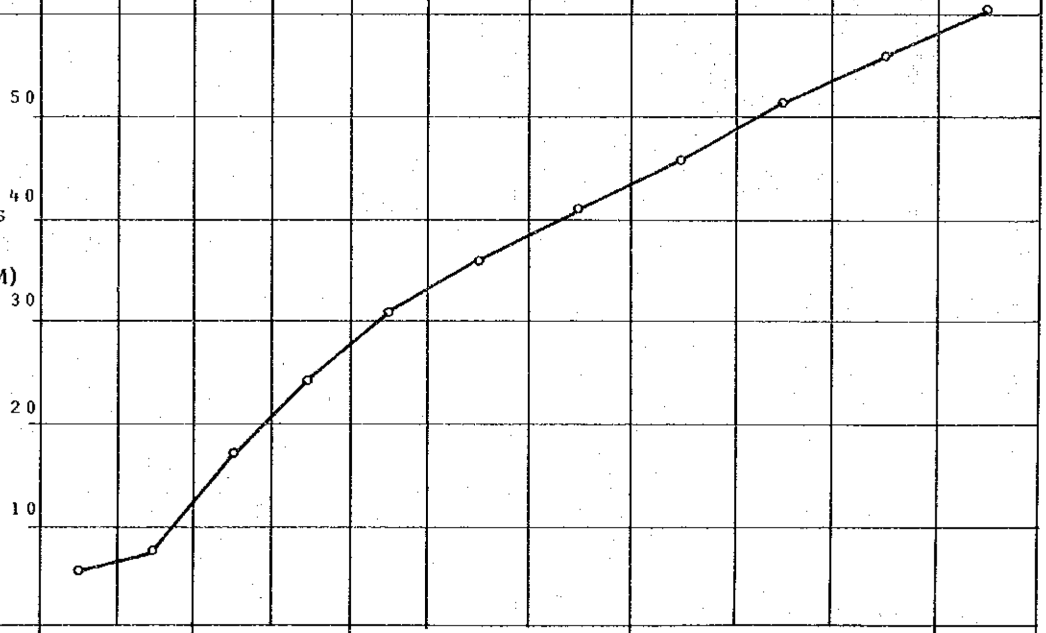
Bar line: (1,300 ÷ 96) + (6,000 ÷ 118) + (1,900 ÷ 137)
+ (3,400 ÷ 140) + (400 ÷ 140)
= 14 + 51 + 14 + 24 + 3
+ 106 Hr/month

Rod line + Bar line = 390 + 106 = 496 Hr/month

5) Rolling schedule at start-up

Table 6.7-7 shows the rolling schedule at start-up.

Table 6.7-7 Rolling schedule at start-up

Months after start-up	1	2	3	4	5	6∿8	9∿11	12∿14	15∿17	18∿20	21
Shift system	1 shift		2 shift		3 shift						
Products (10^3xT/M)	5.1	6.8	17.0	23.8	30.6	35.7	40.8	45.9	51.0	56.1	60.3
Products (10^3xT/M)											
Stage	I		II		III		IV				Full operation

For the rolling productivity and operating hours at each stage, below values are taken into consideration:

I stage: 50T/hr x 7hr/D x 21D/M = 7,350T/M
II stage: 75T/hr x 16hr/D x 21D/M = 25,200T/M
III stage: 100T/hr x 20hr/D x 22D/M = 44,000T/M
IV stage: 125T/hr x 22hr/D x 22D/M = 60,500T/M

6.7.3 General description of equipment

1) Billet yard and billet charging equipment

Features of billet charging equipment in this plant are described.

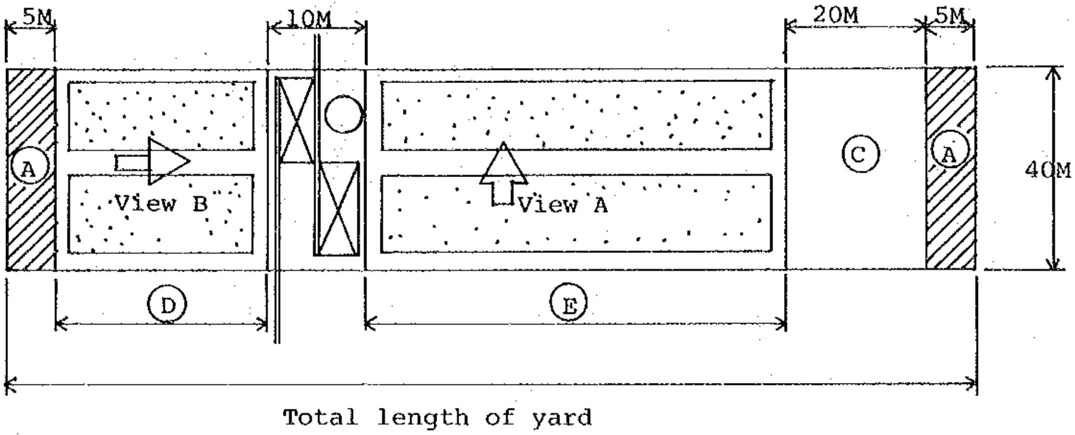
(1) Basically, hot charging operation is proposed. CC billet as is produced from electric arc furnace is charged into the reheating furnace at high temperature. For this purpose, the transfer car from the electric arc furnace and table roller are connected on-line. Hot charging ratio generally varies depending upon the rolling schedule, number of kind of steel, products mix billet surface condition, and the balance between steelmaking shop and bar and rod mill in terms of work

hours. In this plant, whose conditions are considered extremely favourable, the said ratio is estimated at 70%.

(2) To stock billet, 40m x 250m yard is provided. The yard has the space for about 10-day stock, and is to be used for the temporary storage of billet transferred from the steelmaking shop during the bar mill failure or down time or for the stock of surplus billet produced in the process operation.

Area of the yard is calculated as follows.

Fig. 6.7-1 Billet yard plan

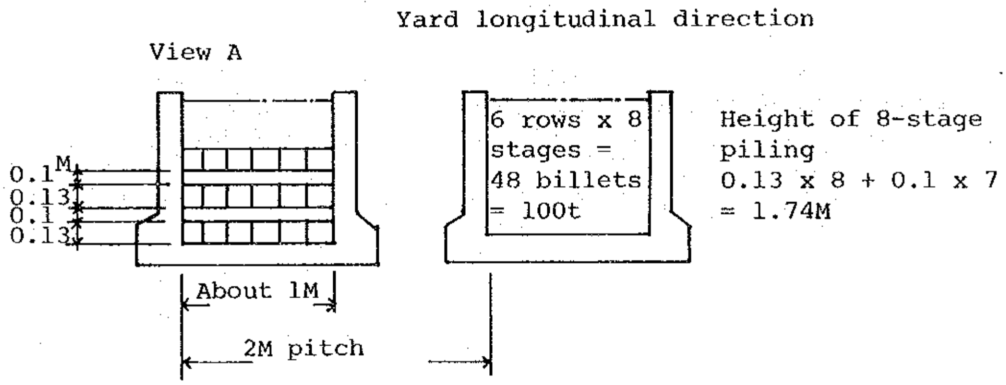


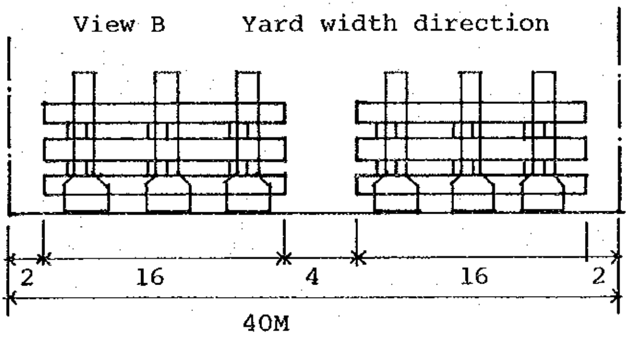
A: Movable limit of crane B: Billet transfer equipment

C: Hand-scarfing and billet straightening equipment

D + E: Yard effective length

Fig. 6.7-2 Billet stocking method





° Amount of billet per meter in the yard longitudinal direction

Amount of billet per pitch (2m):

100T x 2 = 200T

Amount of billet per meter of yard:

200T ÷ 2M = 100T/M

° Stock for 10 days:

$$63,800T/day \times \frac{10\ days}{30\ days} = 21,000T$$

° Required yard length for stock:

21,000T ÷ 100T/M = 210M

° Total yard length:

210 + (5 + 10 + 20 + 5) = 250M

2) Reheating furnace facilities

Reheating furnace capacity is determined so as to obtain balance with the rolling capacity. Rolling productivity is 116 ∿ 136 t/hr (with 2 strands) for rod and 65 ∿ 154 t/hr (with 1 strand) for bar. If the production is restricted by the furnace capacity, influence as a whole can be held light because of low rolling production ratio for bar large size at high productivity. To ensure highest economy, 140 t/hr furnace is chosen. As the furnace length is about 25m and the furnace floor load is limited to about 350 kg/m^2h (generally 700 ∿ 800 kg/m^2h), overcapacity burning is possible. This furnace can also meet the future demand for production increase.

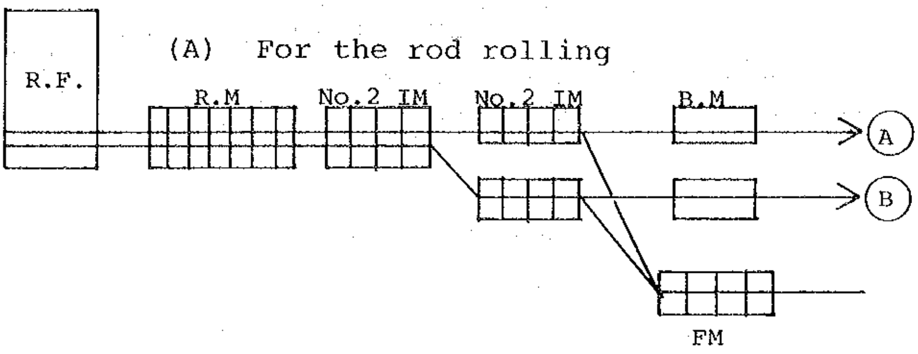
Furnace type chosen is of a walking beam type. This type is preferred to the pusher type and walking hearth type because the former type is not applicable as high-performance furnace and the latter, though excellent in performance, costs 1.3 ∿ 1.5 times the walking beam type and thus considered over-quality for this mill. As fuel, natural gas produced here is used.

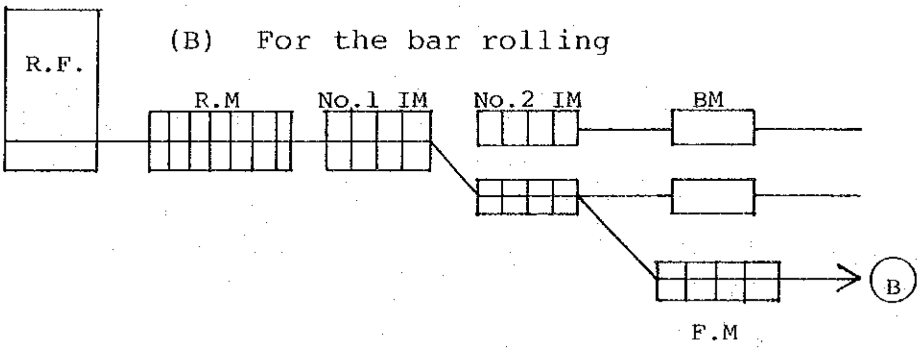
3) Rolling facility

To produce $6mm^{\phi}$ ∿ $13mm^{\phi}$ rod and $13mm^{\phi}$ ∿ $38mm^{\phi}$ bar, the roughing mill train (7 stands), No. 1 intermediate rolling mill train (4 stands), No. 2 intermediate rolling mill train (4 stands), and finishing mill train (block mill with 10 stands for rod, and 4 stands for bar) are installed. After the finishing mill, rod and bar are rolled in the separate line. In view of large demand for rod size product, two rod lines are provided while the bar line is one.

Arrangement of each stand train is shown in Fig. 6.7-3. For the rod rolling, the route (A) including two strands is used, and the route (B) is used for the bar rolling. In this case, either upper or lower train of No.2 intermediate rolling mill is used.

Fig. 6.7-3 Arrangement of each stand train


(A) For the rod rolling


(B) For the bar rolling

If the production increase is intended in future, the rod line and bar line can be separated to enable to produce the layout as shown in Fig. 6.7-4

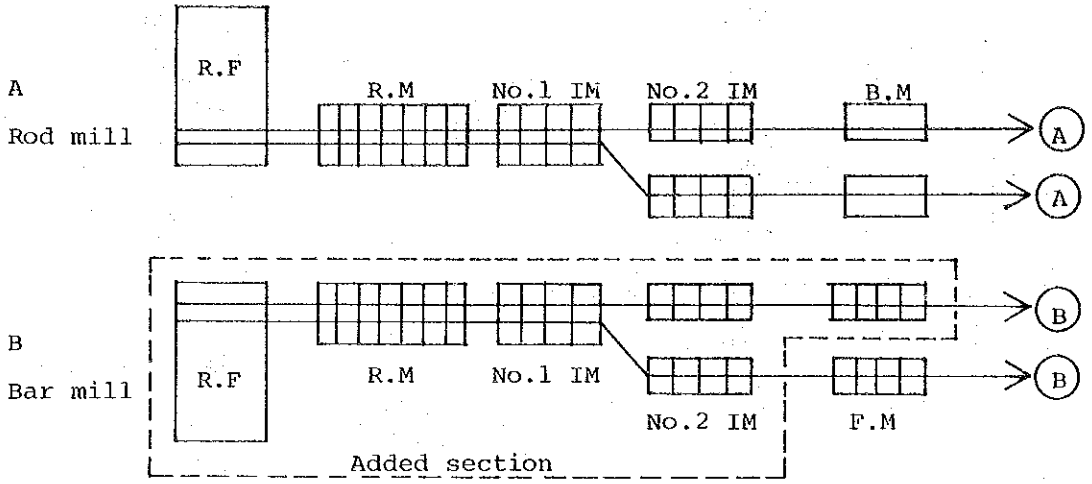


Fig. 6.7-4 Arrangement of stand train for production increase

Fig. 6.7-5 shows pass schedule described the name of stand, configuration, and approximate dimensions of rolling for each size.

Fig. 6.7-5 (1) WIRE ROD MILL ROLLING SCHEDULE

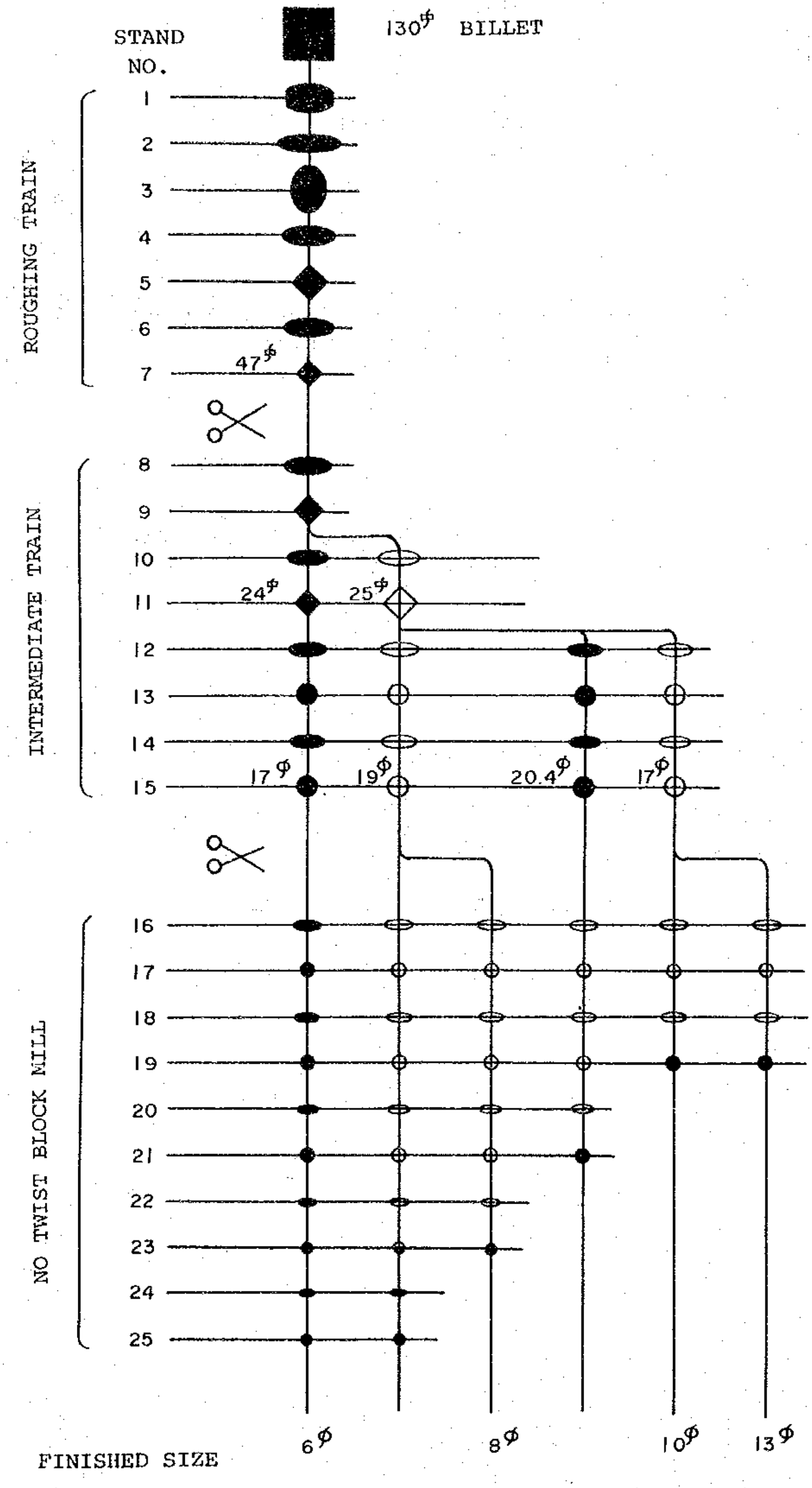
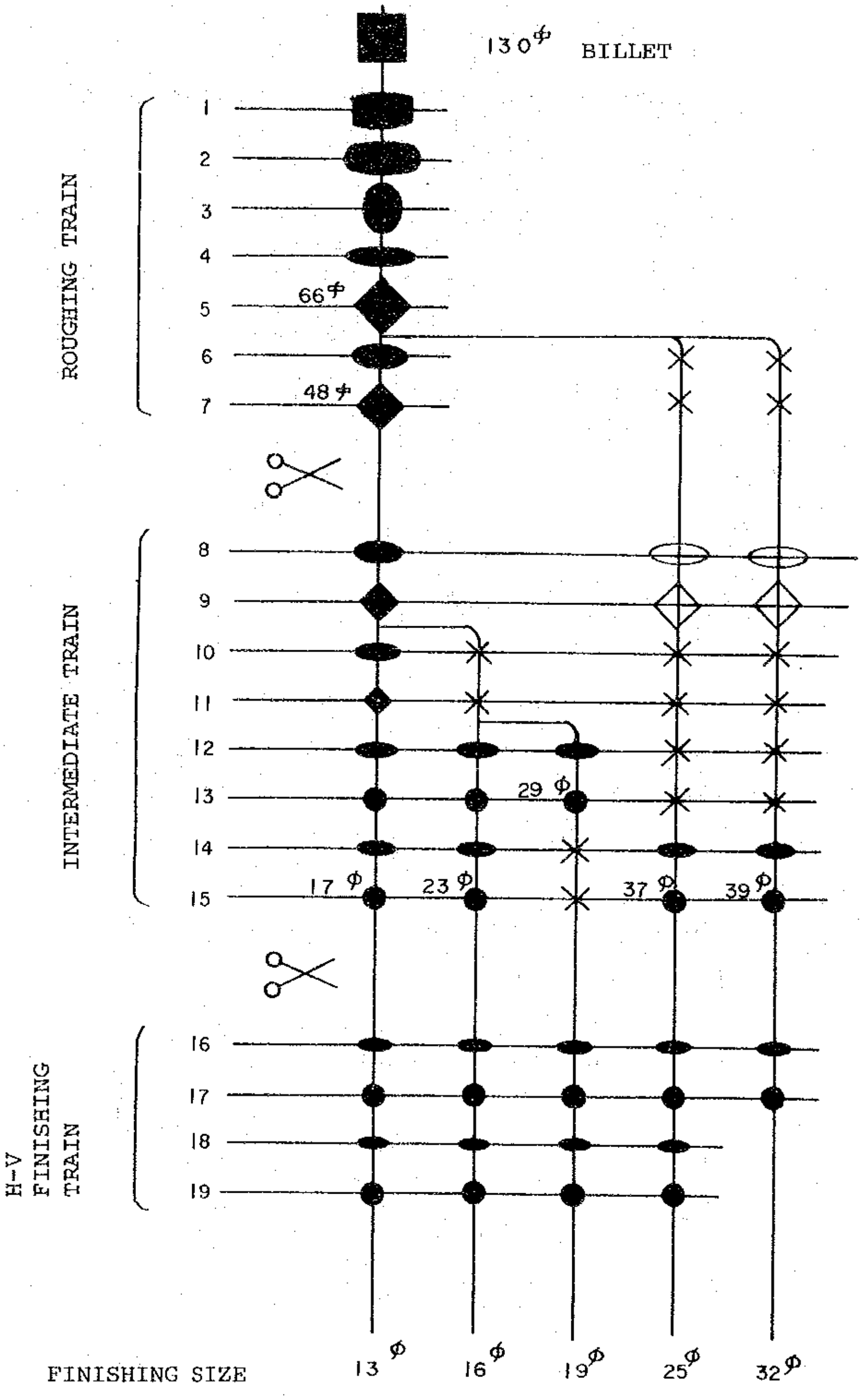


Fig. 6.7-5 (2) BAR MILL ROLLING SCHEDULE



The number of stands is calculated in such a manner that the averaged reduction of area through the process from billet to product remains within 20 ∿ 24%. In the case of this plant, the lowest size is 6mmø for rod and 13mmø for bar. For each of these sizes, the averaged reduction of area and the number of stands are determined from the formula below, and their relationship is shown in Fig.6.7-6.

As a results, it is decided to provide 25 strands for rod and 19 strands for bar.

Calculation formula

Averaged reduction of area $R = 1 - \left(\frac{Am}{Ad}\right)^{\frac{1}{n}}$

Am: Sectional area of product (mm^2)
6mmø → $28.3mm^2$, 13mmø → $132.7mm^2$

Ad: Sectional area of billet (mm^2)
130mm☐ → $16900mm^2$

n: Number of stands

Table 6.7-8 Description of rolling mill

Group	Stand No.	Stand		Roll Change	Motor		Remarks
		Type	HorV		Kw x Number	DC or AC	
Rough-ing mill train	1	Closed -top	H	Roll change mill	400 x 1	DC	
	2	"	"	"	"	"	
	3	"	"	Stand change	"	"	
	4	"	"	"	800 x 1	"	
	5	"	"	"	700 x 1	"	
	6	"	"	"	800 x 1	"	
	7	"	"	"	700 x 1	"	
No.1 inter-mediate rolling train	8	"	"	"	800 x 1	"	
	9	"	"	"	700 x 1	"	
	10	"	"	"	900 x 1	"	
	11	"	"	"	800 x 1	"	
No.2 inter-mediate rolling train	12	"	V	"	450 x 1	"	
	13	"	H	"	400 x 1	"	
	14	"	V	"	450 x 1	"	
	15	"	H	"	400 x 1	"	
Fini-shing mill train	16 ∿ 25	10 Stands mono block	Canti lever	Roll change mill	(1900x2) x 2	"	For rod F
Fini-shing mill train	16	Closed -top	V	Stand change	700 x 1	"	For bar
	17	"	H	"	600 x 1	"	
	18	"	V	"	700 x 1	"	
	19	"	H	"	600 x 1	"	
Total					21,000		

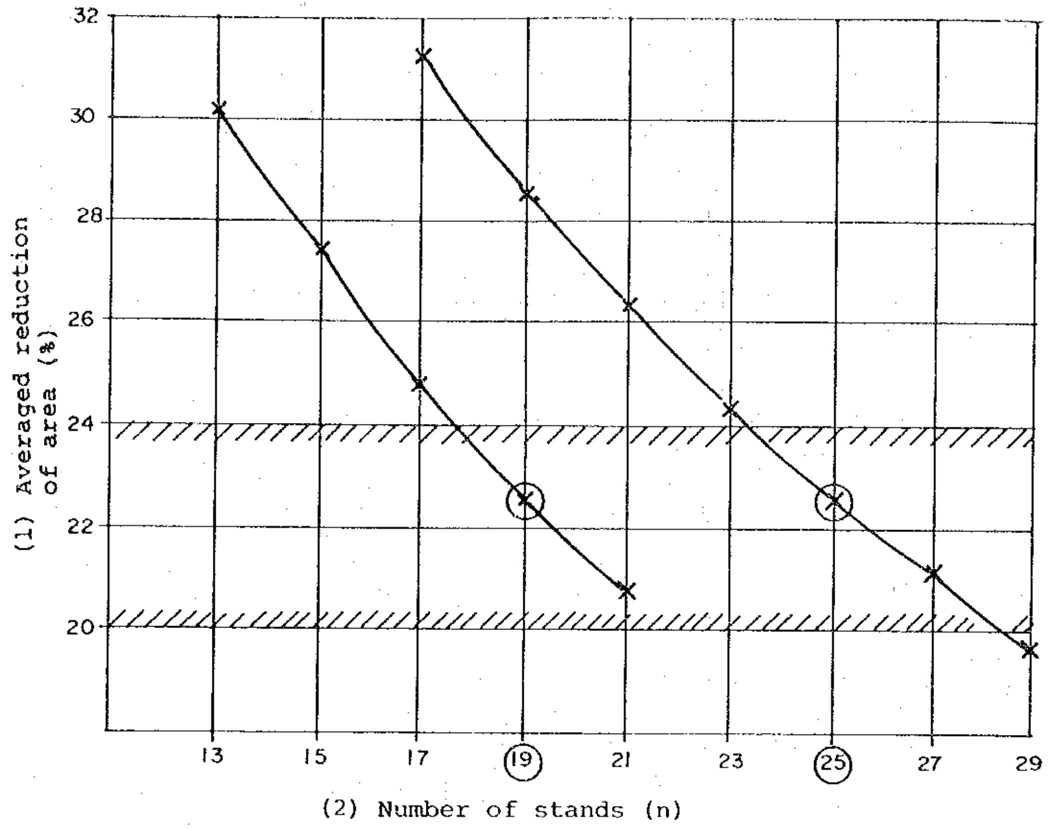


Fig. 6.7-6 Relationship between averaged reduction of area and the number of stands

As regards the mill type, the roughing mill train and No. 1 intermediate mill train are made up from horizontal roll stands. For the rod, two stands rolling is possible. In the case of No. 2 intermediate rolling mill train and bar finishing mill train, vertical roll stand and horizontal roll stand are arranged alternatively. V-H alternative arrangement eliminates the necessity of turning the hot metal between pass, ensuring accurate shape and dimensions, minimizing the miss-roll, and so that to enable stabilized operation. Rod finishing mill train is a block mill consisting of 10 roll stands, and enables high speed rolling under well-balanced roll speed achieved between stands with proper reduction ratio. Rolls used in block mill are made of tungsten carbide having high wear resistance. Thus the roll change frequency can be reduced.

Rolling control method employed is a tension control for the roughing and intermediate train. To ensure easily this control, individual drive method is used. As a motor for main equipment, DC motor is incorporated, which has electrical and mechanical properties adequate to thyristor driving and speed control method. Intermediate rolling mill and bar finishing mill have a loop detector to carry out loop control.

Table 6.7-8 shows the type of stand, roll change method, and motor capacity.

Standard production of this rolling facility is 600,000 t/y (product 544,000 t/y) and that, at the charge amount of 769,000 t/y (product 723,000 t/y), highly productivity size is chosen from product mix to ensure high operation ratio. In case of doubling the production, optimum products mix condition is difficult to obtain. Therefore, production in the mill of the layout as shown in Fig. 6.7-4 is 1,200,000 t/y (product 1,088,000 t/y) at most. If the production is to be increased more than 1,200,000 t/y, different rod mill must be newly installed.

4) Rod cooling facility

Rod cooling facility comprises equipment shown in Fig. 6.7-7. Water cooling equipment cools hot steel of about 900 ∿ 1000°C at delivery side of the finishing stand while the steel is passing through the double-pipe type water cooling pipe. After this equipment, the steel is cooled down to about 700°C.

Laying head turns the straight wire rod, rolled at high speed, into a ring-like shape and places it correctly on the air cooling conveyor.

Subsequent to this head, the air cooling equipment comprising a coil conveyor, blower, and duct is provided, cooling the coil by blowing air from below.

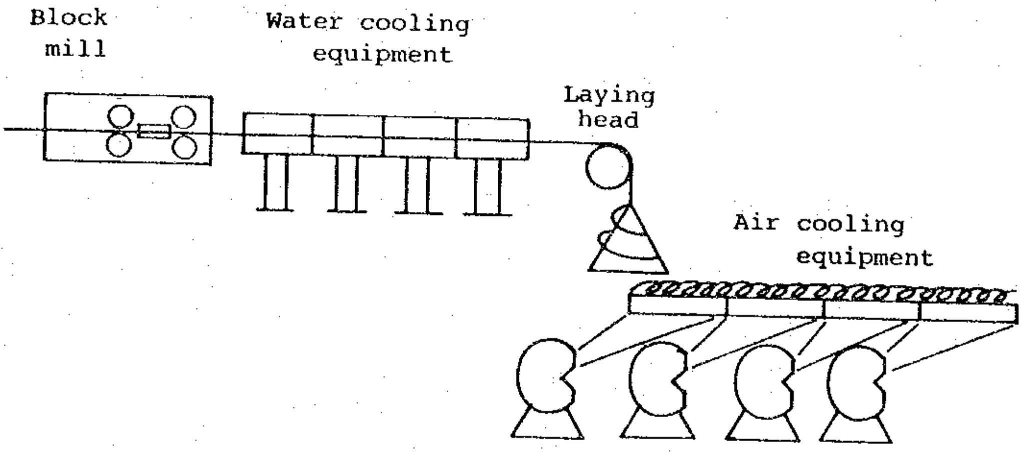


Fig.6.7-7 Coil cooling equipment

5) Bar cooling facility

As a bar cooling facility, 120m long cooling bed is provided. Length of 120m, which is required to receive the bar rolled at high speed, is designed from the aspect of rolling capacity and has proved satisfactory in various applications in Japan.

6) Coil finishing facility

Coil finishing facility comprises a reforming tub, coil conveyor, inspection yard, binding machine, tag attaching yard, weighing machine, etc. In the facility the ring-like coil, is inspected, binded, attached a tag, and weighed, then transferred to the coil stock yard via the hook conveyor.

As principal mechanical equipment, three binding machines are provided. The number of machines is determined by the following formula:

Number of binding machines

$$N = \frac{T/hr}{\frac{3600}{t} \times W}$$

t: Binding cycle (90 seconds)
T/h: Rolling productivity (Max. 140 t/hr)
W: Coil weight (2 t or 1 t)

According to the calculation result, the number of machines becomes 3.5 units for 1 T coil and 1.7 units for 2 T coil. In view of 1 T coil expected to be included in substantial amount, three units of machines are to be provided.

7) Bar finishing equipment

Main bar finishing equipment includes those shown on Table 6.7-9.

Table 6.7-9. Main bar finishing equipment

Name of equipment	Q'ty	Remarks
No. 1 Cold shear	1	Shear gauge included. For main cut products
Inspection conveyor	1	
Binding machine	1	Counter included. For main cut products.
No. 2 Cold shear	1	Shear gauge included. For products of various length
Delivery Bed	3	

Products are cut into the length of 12m (standard) by No. 1 cold shear. No. 2 cold shear principally cut materials of various length for the final cutting. Bar products are bound at 3 to 4 points by using a hoop. Though 2T binding is assumed, this can be changed according to user's acceptance requirements.

8) Auxiliary equipment of rolling mill

The mill is provided with auxiliary equipment of shown in Table 6.7-10.

Table 6.7-10 Auxiliary equipment of rolling mill

No.	Name of equipment
1	Circulating oil lubrication system
2	Grease lubrication system
3	Hydraulic system
4	Scrap removal system
5	Various auxiliary cutting machines Crop and cobble shear Rotary shear Toggle shear Snap shear
6	Cobble bundler

9) Roll shop

Equipment arrangement in the roll shop is shown in Fig. 6.7-8. Name of equipment is listed on Table 6.7-11.

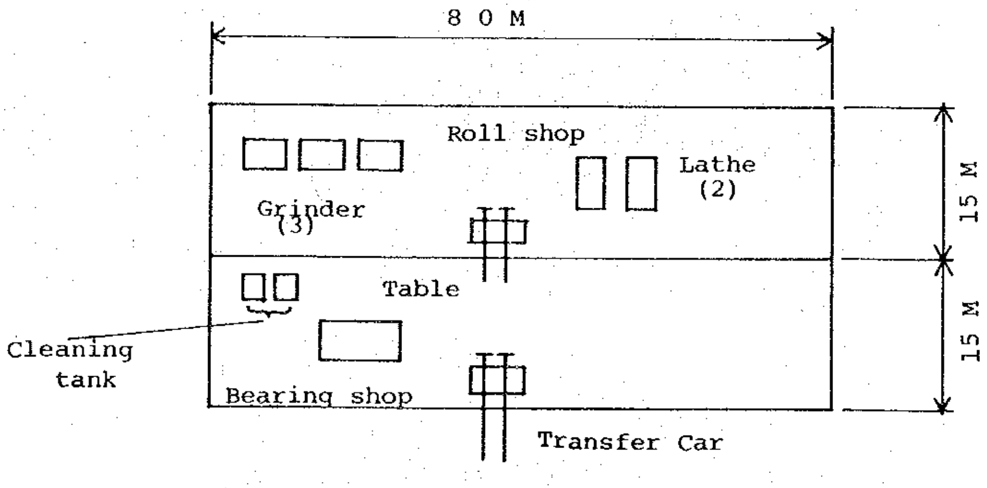


Fig. 6.7-8 Equipment arrangement plan

Table 6.7-11 Main equipment

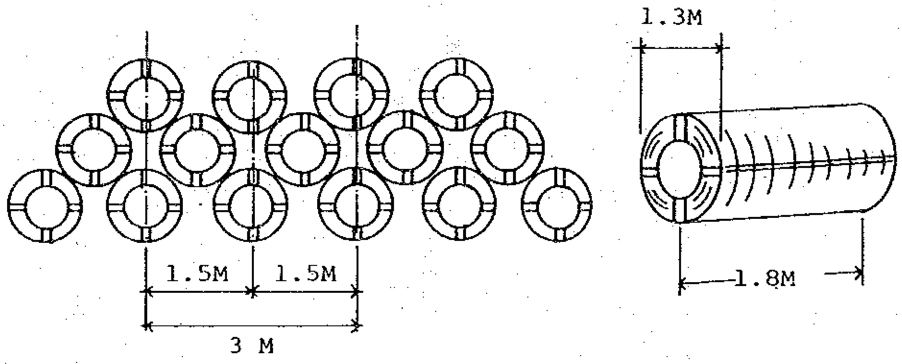
Name of equipment	Q'ty	Remarks
NC Lathe	2	For cast iron rolls
Electrolytic Grinder	3	For W.C. rolls
Bearing shop Tank Table	1 set	For bearing cleaning For disassembling chock

10) Coil stock yard

Coil stock yard adjacent to the mill yard has a capacity for five days and used as buffer for delivery yard.

Coils are stocked piling by size and grade in the coil yard as follows:

° Method of piling and T/M^2 (Fig. 6.7-9)



$$T/M^2 = \frac{(2x3)^{coil} \text{ x 2J coil weight}}{3M \text{ x } 2M} = 2T/M^2$$

° Layout

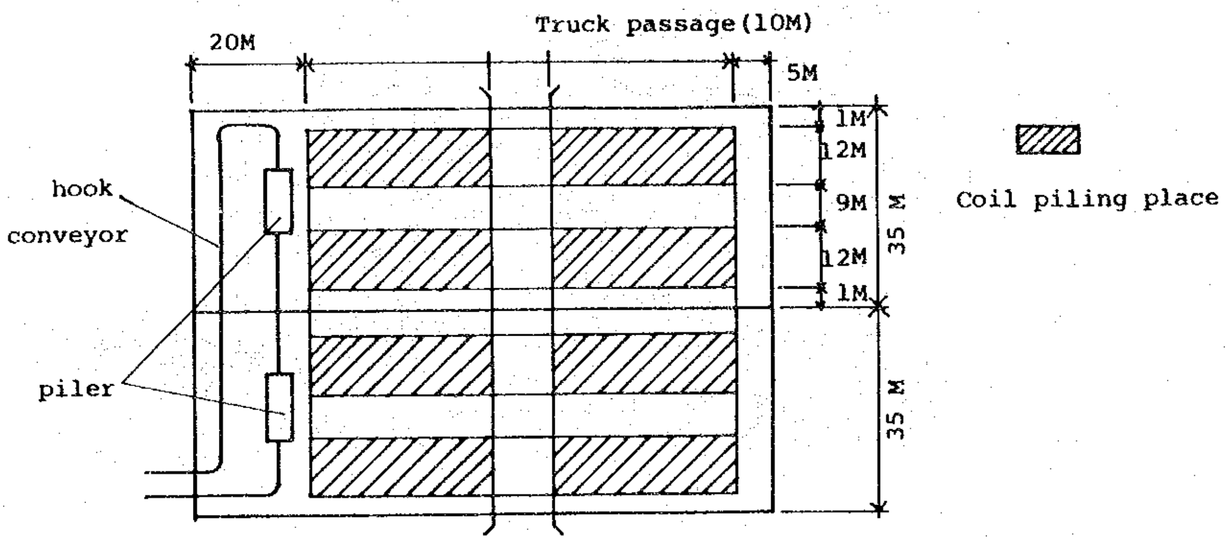


Fig.6.7-10

Coil yard length is calculated as follows:

° Stock amount for 5 days

580,000 T/Y ÷ (12 months x 30 days)
x 5 days = 8,050 T

° Required yard length

$$L = \frac{8050\text{T}}{12\text{M} \times 4 \text{ bays} \times 2 \text{ T/M}^2} = 83.8\text{M}$$

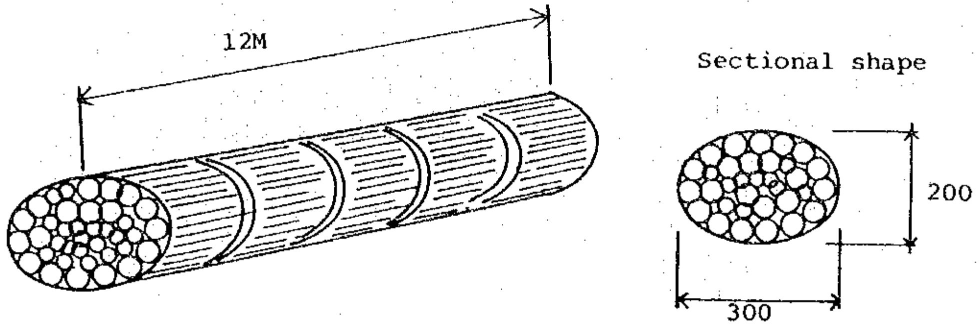
° Total yard length

83.8M + 20M + 10M + 5M ≒ 120M

11) Bar stock yard

Bar stock yard adjacent to the mill yard has a capacity for 5-days stock and used as a temporary storage yard.

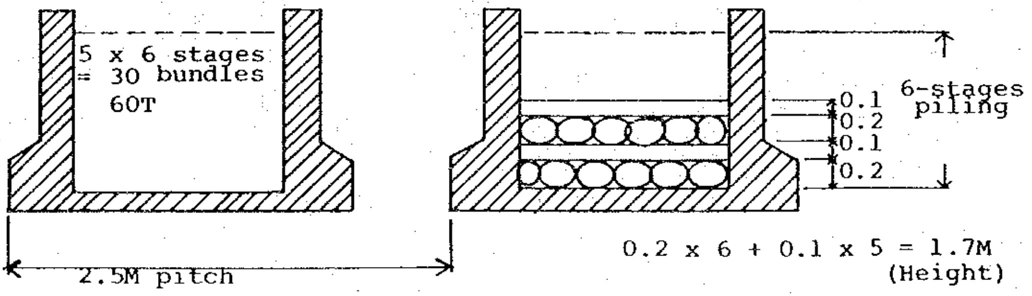
- Binding condition (Fig.6.7-11)

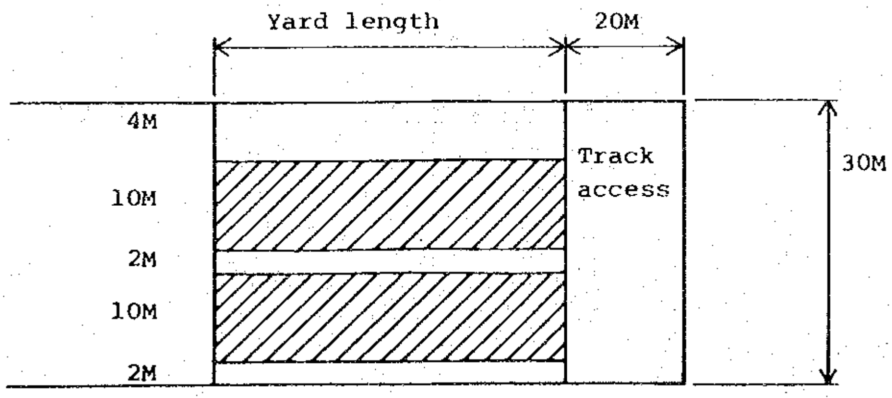


- Typical dimensions

16mmø (1.579 kg/M) x 12m x 100 bars in bundle ... Weight 2t

- Stock method (Fig.6.7-12)





- Bar weight per 20m length in the yard longitudinal direction

  $$\frac{10m}{2.5m} \times 2 \text{ bays} \times 60T = 480T$$

  Bar stock yard length is calculated as follows:

- Stock amount for 5 days

  $$143{,}000T \div (12 \text{ month} \times 30 \text{ days}) \times 5 \text{ days} = 2000T$$

- Required yard length

  $$2000T \div 480T \times 20M \fallingdotseq 80M$$

- Total yard length

  $$80M + \underset{\text{Yard for various length products}}{20M} + \underset{\text{Track access}}{20M} = 120M$$

12) Conditioning facilities

- Coil straightening & cutting machine

  This machine, which straightens and cut the the coiled products, is provided in the shipping yard.

° Bar bending machine

This machine, which bends the bars into half size to make transportation work easier, is also provided in the shipping yard.
(Max length for handling is 12 m)

13) Crane

Cranes to be provided to the bar and rod mill are listed on Table 6.7-12.

Table 6.7-12 Crane List

Yard Name	Type	Load	Q'ty
Billet yard	O.H. with lifting magnet	15T	2
Mill yard	" "	25T/5T	1
"	" "	10T	1
Cooling bed yard	" "	15T/5T	2
Bar yard	" "	7.5T	2
Coil stock yard	O.H. turning C hook	12T	2
Reheating yard	Hoist crane	5T	1
Elec. cont room	" "	3T	1
Roll shop	" "	10T	2
Elec. room	" "	2T	1
Scale pit	O.H. with bucket	3T(Bucket below)	1
Coil cooling yard	"	15T	1
Total			17

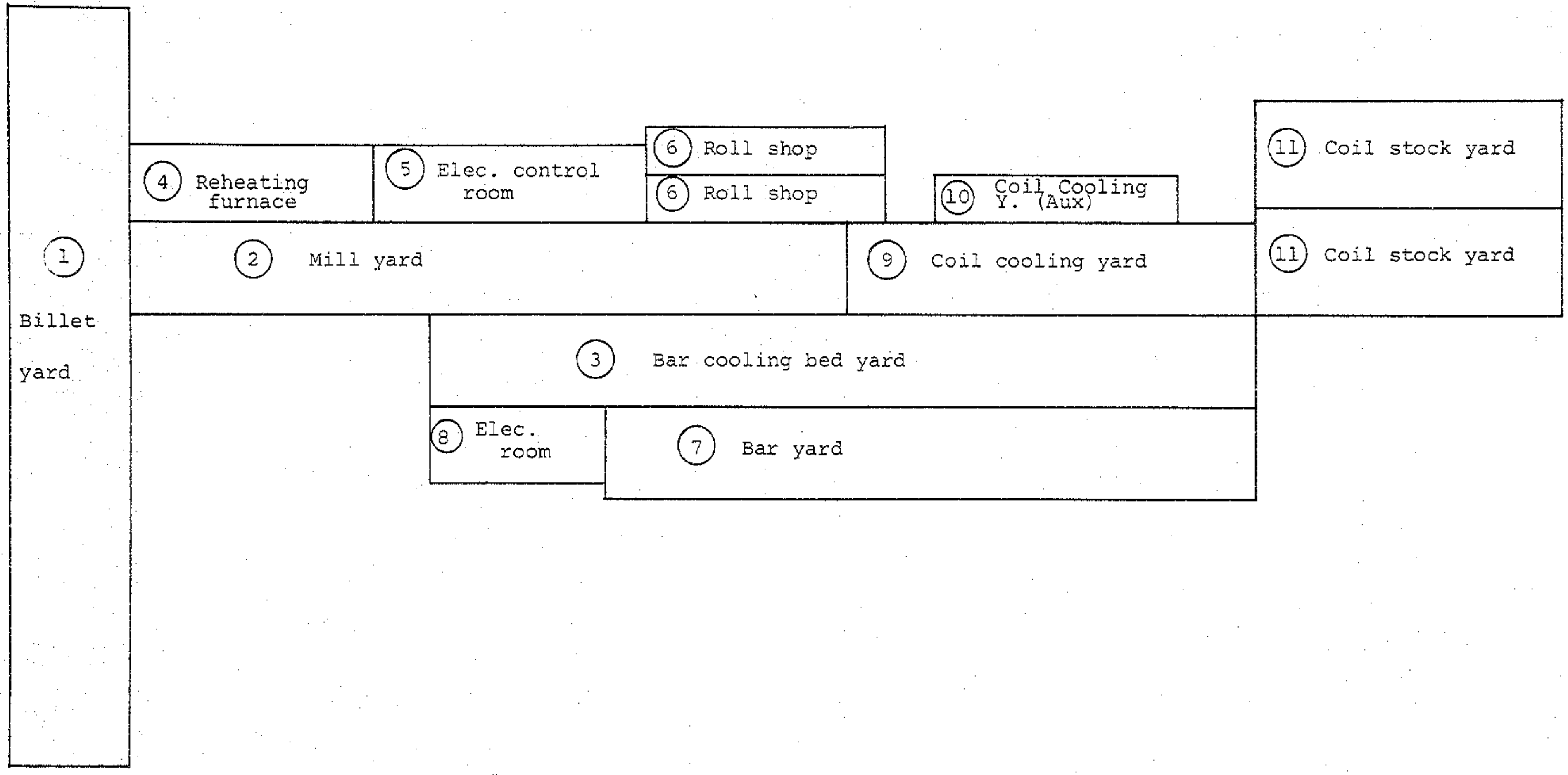
14) Building

Buildings for bar and rod mill are shown in Fig.6.7-13 and Table 6.7-13.

Table 6.7-13 Building

No.	Name	Floor		Crane	Building
		1st	2nd	L x W x H x Q'ty	area
①	Billet yard	o		250 x 40 x 7	10,000 m^2
②	Mill Y.		o	260 x 30 x 13	7,800
③	Bar cooling bed Y.		o	280 x 30 x 13	8,400
④	Reheating furnace Y.		o	85 x 25 x 10	2,125
⑤	Elec. control room	o	o	105 x 25 x 11	2,625
⑥	Roll shop	o		80 x 15 x 5.5 x 2	2,400
⑦	Bar Y.	o		220 x 30 x 7	6,600
⑧	Elec. room	o	o	60 x 25 x 11	1,500
⑨	Coil cooling Y.	o		140 x 30 x 5.5	4,200
⑩	" " (Aux)	o		80 x 15 x 5.5	1,200
⑪	Coil stock Y.	o		120 x 35 x 7 x 2	8,400
	Total				55,250 m^2

Fig. 6.7-13 Buidling Layout



15) Computer system

① Operator guidance

② Data logging - Rolling mill data,
daily report, etc.

16) Internal communication system

① Paging is provided to ensure communication between each operating room and with principal work station in the mill.

② ITV is provided at appropriate places to help the operator in the operation.

6.7.4 Equipment List

Table 6.7-14

No.	Equipment	Q'ty	Specification
[Machinery]			
1	Reheating furnace	1 unit	Capacity: 140t/hr Type: Walking beam (1) Reheating furnace 1) Combustion equip. 2) Recuperator 3) Chimney (2) Refractory (3) Automatic combustion control equip.
2	Furnace charging equip.	1 set	(1) Billet receiving table and bed (2) Inclined chain conveyor (3) Billet charger (4) Push out machine
3	Mill (Roughing, Intermediate train)		(1) Roughing mills (1 set) 1) Furnace pullout 2) Billet switch 3) Toggle shear 4) No. 1 ∿ No. 7 roll stands 5) Drive equip. for No. 1 ∿ No. 7 stands (2) Crop and cobble shears

No.	Equipment	Q'ty	Specification
			(3) No. 1 intermediate mills (1 set) 1) No. 8 ∿ No. 11 roll stands 2) Drive equip. for No. 8 ∿ No. 11 stands (4) No. 1 side looper (5) Snap shear (6) No. 2 intermediate mills (2 sets) 1) No. 12 ∿ No. 15 roll stands 2) Drive equip. for No. 12∿ No. 15 stands
4	Wire rod blockmill, cooling and finishing equip.	2 trains	(1) Blockmills 1) No. 16 ∿ No. 25 mill stands 2) Drive equip. for blockmills (2) Crop and chop shears (3) Water cooling equip. (4) Laying heads (5) Air cooling equip. (6) Coil reforming tub (7) Downender (8) Tram rail conveyor line (9) Binding machine (10) Weighing scale

No.	Equipment	Q'ty	Sepcification
5	Bar, finishing mill, cooling bed, cold shear and finishing equip.	1 train	(1) Finishing mills 1) No. 16 ∿ No. 19 mill stands 2) Drive equip. for No. 16 ∿ No. 19 stands (2) Rotary shear (3) Cooling bed (4) No.1 cold shear, guage stopper (5) No.2 cold shear, guage stopper (6) Bar transfer equip. (7) Binding machine (8) Collecting bed
6	Lubrication and hydraulic system	1 unit	(1) Oil circulation system (2) Central grease lubrications system (3) Hydraulic system
7	Utilities		(1) Water piping (2) Pressure water system and valves (3) Compressed air piping (4) Natural piping
8	Roll shop		(1) NC-lathes (2 sets) (2) W.C. rod grinders (3 sets) (3) Bearing shop (4) Transfer cars

No.	Equipment	Q'ty	Sepcification
9	Miscellaneous equipment		(1) Scrap removal equip. (2) Scrap removal equip. (3) Special tools (4) Coil straightening and cutting machine (5) Bar bending machine (6) Others
10	Cranes and hoists	17	
11	Spares	2 years	
	[Electrical Equipment]		
1	Power distribution		
2	D.C. main drive motors and control		
3	Auxiliary motors and control		
4	Control desks and posts		
5	Detector		
6	Computer system		
7	Lighting and small power system		Including; Air conditioning, obstruction lighting
8	Intercommunication system		
9	Spares, special tools and miscellaneous		

6.7.5 Operating Crew

For the full operation, 4-crew system is planned. Table 6.7-15 shows the composition of operating crews.

Tab. 6.7-15 Composition of Operating Crews

(1) Rolling mill branch

Branch	Assignment	Foreman	Assistant foreman	Worker	Total
Furnace	Billet yard Charge check Charging table Extractor Furnace operation BT yard crane	1 x 4^{s}	2 x 4^{s}	8 x 4^{s}	
	Total:	4	8	32	44
Rolling	Mill operator Roughing Intermediate Finishing Oil cellar Coiler operation (or Cooling bed) Mill yard crane	1x4^{s}+1	2 x 4^{s}	9 x 4^{s}	
	Total:	5	8	36	49
Roll shop	NC-Lathe WC-Grinder Rib forming Bearing assembly Stand assembly Guide handling	1	2 x 4^{s}	10x4^{s}	
	Total:	1	8	40	49
Grand Total:		10	24	108	142

(2) Finishing branch

Branch	Assignment	Foreman	Assistant Foreman	Worker	Total
Finishing (Coil)	Conveyor operation Piler operation Binder operation Flow control Inspection Weighing Trimming Labeling Crane Coil yard control Bar yard control	$1x4^s+1$	5×4^s	$24x4^s$	
	Total:	5	20	96	121
Finishing (Bar)	No. 1 Shear (Ope. gauge) No. 2 " (") Test piece Inspection Inspection bed Binder ope. Piler ope. Labeling Handling Crane Coil yard control Bar yard control	$1x4^s+1$	5×4^s	$24x4^s$	
	Total:	5	20	96	121
Grand Total:		15	44	204	263

6.7.6 Unit consumption

Unit consumption is shown in Table 6.7-16.

Table 6.7-16

No.	Item	Unit	Rod	Bar	Mean
1	Fuel	Kcal/T	315×10^3	315×10^3	315×10^3
2	Electric power	KWH/T	135	105	125
3	Roll				
	a) Cast metal roll	Kg/T	0.2	0.25	0.22
	b) W.C. roll	"	0.018	–	0.012
4	Utilities				
	a) Water	m^3/T	1.3	1.3	1.3
	b) Air	Nm^3/T	15	15	15
5	Operation				
	a) Oil and grease	ℓ/T	0.2	0.2	0.2
	b) Mill guide	Kg/T	0.3	0.3	0.3
	c) Strap	"	2	1.5	1.8
	d) Miscellaneous	*	2.5	2.5	2.5

* Per rolling mills variable cost.

6.7.7 Layout

Layout is shown in DWG. 6.7-14 and Section drawing is shown in DWG. 6.7-15.

6.7.8 Additive study - Examinations relating to the prodution plan centering on small-sized products.

6.7.8.1 Precondition for production plan

Based on the Memorandum dated June 25, 1979, examination of the Rod & Bar Line has been made on the basis that the small-sized products given in Table 3.4-4 Demand Forecast for Different Sizes (1977 ∿ 1992) are to be manufactured. Consequently, these examinations will result to indicate the theoretically minimum production capacity of the Combination Mill recommended in the present report.

6.7.8.2 Bars and rods

Table 6.7-4 Rolling Capacity by Sizes is used to derive the production outputs. The rate of operation adopted is 74.9% by 508 hours/month on a 3-shift/4 crew basis. Compared with the 723,000 tons/year established in the basic plan, the present examination has resulted in an annual production output of approximately 10% less. Table 6.7-17 shows the annual production outputs for different sizes at the peak operation after 1986.

Table 6.7-17 Annual production outputs for different sizes

(In 1,000 tons)

Year	Rod					Bar								Gross
	6mm	8mm	10mm	13mm	Total	13mm	16mm	19mm	22mm	25mm	28mm	32mm ∿	Total	
1986	88	192	286	-	566	84	-	-	-	-	-	-	84	650
87	97	211	258	-	566	84	-	-	-	-	-	-	84	650
88	105	232	229	-	566	84	-	-	-	-	-	-	84	650
89	115	254	195	-	564	84	-	-	-	-	-	-	84	648
90	125	278	160	-	563	84	-	-	-	-	-	-	84	647
91	136	304	121	-	561	84	-	-	-	-	-	-	84	645
92	148	332	80	-	560	84	-	-	-	-	-	-	84	644

6.7.8.2 Production cost

Reduction of bar and rod product will adversely affect the subsequent line production and raw materials balance. The present examination is made on the basis that the unit consumption for each plant is as established by the basic plan. And production cost is determined on the premise that a less amount of scrap will be purchased. Table 6.7-18 shows the production by the amount of scrap allotted for each plant. In addition, the sponge iron production established in the basic plan remains unchanged in the present examination. The production cost calculations are given in the financial analyses in Chapter 11.

6.7.9 Additive study - Study of Separate Mill Type

The basic plan is studied assuming that the combination mill type is to be employed. In addition, the separate mill type is also studied as requested by the memorandum of June 25, 1979 as describe below.

6.7.9.1 Additional Facilities and Budget to Basic Plan

While some facilities are used in common in bar and rod line of the basic plan, separate facilities are required for each line if the separate mill type is to be employed.

Major additional facilities are listed below.

1) Additional facilities

° Heating furnace	160 to 200 t/hr. (for bar line) x 1
° Billet charging facilities	1 set
° Roughing strand	1 set
° Intermediate strand	1 set
° Lubrication system	1 set
° Hydraulic system	1 set
° Water supply system	1 set
° Scrap disposal facilities	1 set
° Spare parts	1 set
° Others	

2) Additional budget

The increase in the facilities investment resulting from the addition of the above facilities is estimated as follows (in price prevailing as of March 1979):

Unit: $1,000

	Combination mill	Separate mill
Facilities CIF	75,870	117,522
Foundation	28,075	36,497
Building	20,425	22,671
Installation	11,860	15,121
Total	136,230	191,811

Namely, the adoption of the separate mill instead of the combination mill requires additional investment cost of $55,581,000.

6.7.9.2 Plant Layout

As the rod line and the bar line are installed in separate buildings, the rod mill and the bar mill are separated as shown by the bar and rod alternative plan in Table 4-7.

6.7.9.3 Number of Shifts and Operating Hours

The operating hours of 3 shift/4 crew system and three shift/three crew system are shown in Table 6.7-19.

Compared with combination mill, roll replacing time and loss time by trouble will be increased. This results from that, as rod line and bar line are alway in operation, operable time is shortened by replacing the rolls and that it is impossible to make a change-over to the resting line during trouble time.

Table 6.7-19 Estimated Operatable hours (Separate mill)

Item	Code	Formula	3-shift 4-crew	3-shift 3-crew
Days of year	A		365	365
Weekly holiday	B		0	52
Major repair			13	13
Minor repair			13	0
Operatable days	C	(A - B)	339	300
Operatable hours	D	(C x 24)	8136	7200
Monthly operatable hours	E	(D ÷ 12)	678	600
Roll change	F		150	150
Roll conditioning			30	30
Down time			80	80
Operable hours	G	(E - F)	418	340
Operation ratio	H	(G/E)	61.7%	56.7%

6.7.9.4 Rolling Capacity and Product Mix by Different Shift and Crew System

Taking the product mix of 1986 through 1988 following the start of full capacity operation as an example, the production and availability by different shift and crew system are shown in Table 6.7-20.

The product mix is based on Table 6.7-1. However, the max. availability for 3-shift/3-crew system is 56.7% and therefore the availability exceeds it in the case of rod production. Therefore, excess volume was shifted to bars.

As shown in Table 6.7-20, two lines can be operated simultaneously if separate type mill is employed. This results in an increased rolling time available, which makes even the 3-shift 3-crew system operable.

Table 6.7-20 Production and Availability by the Type of Working System

(Production unit: 1,000 t/y)

Shift		3-shift 4-crew			3-shift 3-crew		
Year		1986	1987	1988	1986	1987	1988
Rod	6mm	-	-	-	-	-	-
	8mm	173	126	77	173	126	77
	10mm	220	243	267	220	243	267
	13mm	187	211	236	139	148	153
	Total	580	580	580	532	517	497
Bar	13mm	-	-	-	-	-	-
	16mm	13	-	-	61	54	49
	19mm	67	68	54	67	77	88
	22m	21	26	31	21	26	31
	25mm	38	44	51	38	44	51
	28mm	4	5	6	4	5	6
	32mm	-	-	1	-	-	1
	Total		143	143	191	206	226
Total		723	723	723	723	723	723
Operation ratio (%)	Rod	54.1	56.0	58.0	56.7	56.7	56.7
	Bar	15.2	14.7	14.6	24.6	26.3	37.7
	Max		61.7			56.7	

6.7.9.5 Manpower

As the production is operable with 3-crew operation, the manpower requirement for such operation is shown in Table 6.7-21.

Table 6.7-21 Manpower

Mill	Branch	Foreman	Assistant foreman	Worker	Total
Rod mill	Furnace	3	6	30	39
	Rolling	4	6	33	43
	Roll ship	1	6	36	43
	Finishing	4	15	81	100
	Total	12	33	180	225
Bar mill	Furnace	3	6	30	39
	Rolling	4	6	33	43
	Roll shop	1	3	12	16
	Finishing	4	15	81	100
	Total	12	30	156	198
G. total		24	63	336	423