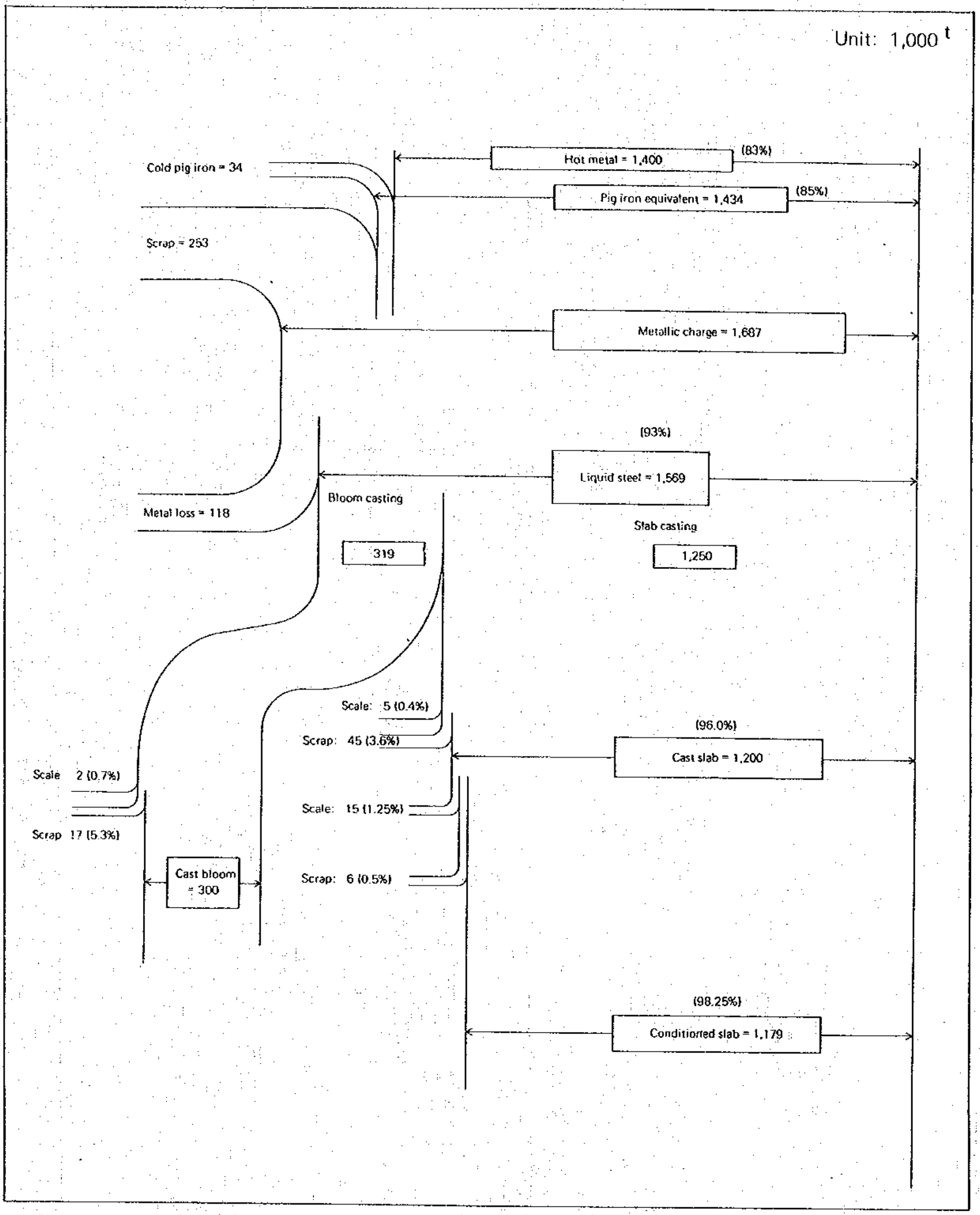


Fig. 13-8-2 Material balance in the steel making plant

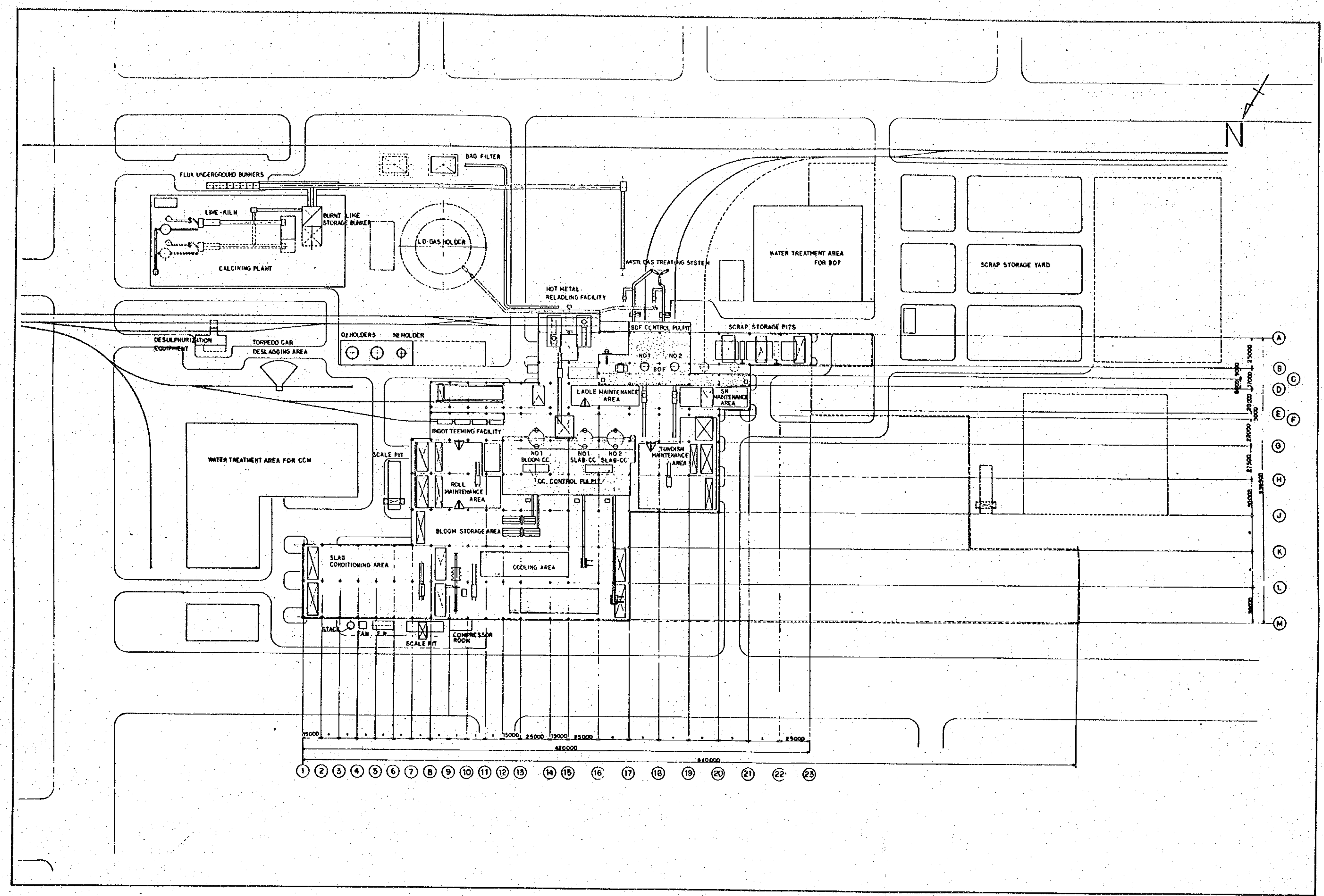


Fig. 13-8-3 Lime calcining, B.O.F. and CC plant layout

(5) Relationship with stage II equipment

In stage II, one furnace shall be additionally installed to enter into "2 out of 3" frunaces operation mode. As space for furnace 3 is reserved adjacent to furnace 2, furnace 3 and the related lance, sublance, waste gas processing equipment and molten steel ladle car shall be easily added.

In case of necessity for the introduction of degassing unit in the future, space on the south west side of the furnace 3 shall be used.

As for the torpedo car desulphurization eqipment, extension is not considered to be necessary in stage II; however, the layout shall allow doubling the capacity as necessary.

(6) Production and consumption units

Table 13-8-6 lists the production and consumption units.

Table 13-8-6 Production and consumption of B.O.F. plant operation

Item			Unit consumption or production	Annual consumption and production		Remarks
				Stage I	Stage II	
Product	0	Molten steel		1,569.0 10^3 t	3,147.0 10^3 t	
	1	Hot metal	892.5 kg/t	1,400.4 10^3 t	2,808.8 10^3 t	83%
Raw material	2	Cold pig iron	21.5 kg/t	33.7 10^3 t	67.7 10^3 t	2%
	3	Scrap	161.3 kg/t	253.1 10^3 t	507.6 10^3 t	15%
	4	Burnt lime	60.0 kg/t	94.1 10^3 t	188.8 10^3 t	
	5	Limestone	5.0 kg/t	7.8 10^3 t	15.7 10^3 t	
	6	Iron ore	20.0 kg/t	31.4 10^3 t	62.9 10^3 t	
	7	Fluorspar	3.0 kg/t	4.7 10^3 t	9.4 10^3 t	
	8	Coolant	5.0 kg/t	7.8 10^3 t	15.7 10^3 t	
	9	Ferro-alloy	6.8 kg/t	10.7 10^3 t	21.4 10^3 t	
	10	Aluminum	1.4 kg/t	2.2 10^3 t	4.4 10^3 t	
	11	Coke (breeze and lamp)	0.7 kg/t	1.1 10^3 t	2.2 10^3 t	
Byproducts	12	Furnace slag	* 120 kg/t	188.3 10^3 t	377.6 10^3 t	
	13	Furnace sludge	* 12 kg/t	18.8 10^3 t	37.8 10^3 t	
	14	Dust	* 2 kg/t	3.1 10^3 t	6.3 10^3 t	
	15	Ingot slag	* 20 kg/t	31.4 10^3 t	62.9 10^3 t	
	16	Skull and steel scraps	* 20 kg/t	31.4 10^3 t	62.9 10^3 t	
Utilities	17	O_2	55 Nm^3/t	86.3 10^6 Nm^3	173.1 10^6 Nm^3	
	18	N_2	9 Nm^3/t	14.1 10^6 Nm^3	28.3 10^6 Nm^3	
	19	COG	2 Nm^3/t	3.1 10^6 Nm^3	6.3 10^6 Nm^3	
	20	Electric power	30 Kwh/t	47.1 10^6 Kwh	94.4 10^6 Kwh	
	21	Industrial water	0.25 m^3/t	0.39 10^6 m^3	0.79 10^6 m^3	
	22	Soft ware	0.05 m^3/t	0.08 10^6 m^3	0.16 10^6 m^3	
Materials	23	Furnace bricks	6 kg/t	9.4 10^3 t	18.9 10^3 t	
	24	Ladle bricks	7 kg/t	11.0 10^3 t	22.0 10^3 t	
	25	SN bricks	0.5 kg/t	0.8 10^3 t	1.6 10^3 t	
	26	Brick waste	* 4 kg/t	6.3 10^3 t	12.6 10^3 t	
Torpedo car desulphurization	27	Quantity of desulphurization		1,200 10^3 t	2,400 10^3 t	85%
	28	CaC_2	3 kg/t hot metal	4.2 10^3 t	8.4 10^3 t	
	29	Castable refractory	0.2 kg/t hot metal	0.14 10^3 t	0.3 10^3 t	
	30	N_2	1 Nm^3/t	700 10^3 Nm^3	1,400 10^3 Nm^3	
	31	Torpedo car slag	* 12 kg/t	14.4 10^3 t	28.8 10^3 t	

13-8-4 Technical explanation

1) Furnace capacity

The furnace capacity necessary for the production of molten steel of $1,569^{thous. t/y}$ is set at the nominal capacity of $160^{t/heat}$ and the average capacity of $155^{t/heat}$, which is planned considering the following conditions:

1. As the average tap-to-tap time, 36 minute is selected, which is being considered as a standard value of a modern B.O.F. plant.
   In view of the larger furnace size than that in the pre-feasibility study and the adoption of all-CC system, sublance system shall be used to attain a stable tap-to-tap time.
2. The annual number of operating days is set at 341 days by subtracting the number of periodical maintenance ($2^{d/month} = 24^{d/y}$) for preventive maintenance from the number of calendar days. That is, the annual operable hours shall be $8,184^{hr}$. By subtracting non steelmaking time such as hot metal waiting time, crane interference time, unexpected stoppage, and idle time from un-matching between a converter and continuous casters from the annual operable time, the actual steel making time shall be $6,074^{hr/y}$. The operating rate is 74% of the operable time and 70% of the calendar hours.
3. The furnace capacity is set as follows from the relationship between the tap-to-tap time, the actual steel making time, and the production plan:

a) $$\text{Heats/y} = \frac{6074^{hr/y} \times 60^{min/hr}}{36^{min/heat}} = 10,123$$

b) $$\text{Average heat capacity} = \frac{1,569,000^{t/y}}{10,123^{heats/y}} = 155$$

The nominal furnace capacity is set at 160^{t}, considering the fluctuation of production lot size and tapping yield.

2) Torpedo car desulfurization equipment

The necessity of the torpedo car desulfurization equipment was explained in 13-8-3, (1), 1)"Torpedo car desulfurization equipment."

It is the general tendency that low-price and high-sulfur heavy oil is usually used in the blast furnaces, and by contraries, low-sulfur-steel is required from the viewpoint of product quality.In these backgrounds and especially in case the sulpher content of hot metal is as high as 0.045% and all-CC system has been introduced, introduction of desulfurization equipment is inevitable.

① The reasons for the selection of the torpedo car desulfurization equipment.

a) Since it is installed independetly in between the converter plant and blast furnace plant, the torpedo car desulfurization equipment is free from interfering with the B.O.F. plant and being interfered with by the B.O.F. plant, enabling to maintain high operating rate.

b) Enables mass processing of hot metal.

c) Ultralow-sulfur iron (sulfur content = 0.003%) can be attained by selecting a quantity of desulfurization agent and N_2 blowing time.

d) Low desulfurization cost.

② Outline of the torpedo car desulfurization equipment

i) Desulfurization agent receiving and storage equipment
ii) Desulfurization agent air transportation equipment
iii) Lance lifting equipment
iv) Splash prevention cover
v) Hood and dust collection equipment
vi) Lance repair equipment
vii) Temperature mesuring and sampling equipment

Related equipment

i) Torpedo car deslagging yard
ii) Dust collection equipment

Fig. 13-8-3 outlines the torpedo car desulfurization equipment.

③ Specifications (outline) of torpedo car desulfurization equipment

Item	Specifications
One processing volume	290 tons (320-ton torpedo car)
Desulphurization agent	CaC_2 powder
N_2 blowing time	25 min (15 min for CaC_2 blowing)
Processing cycle time	45 min
Lance duration	10 or more uses

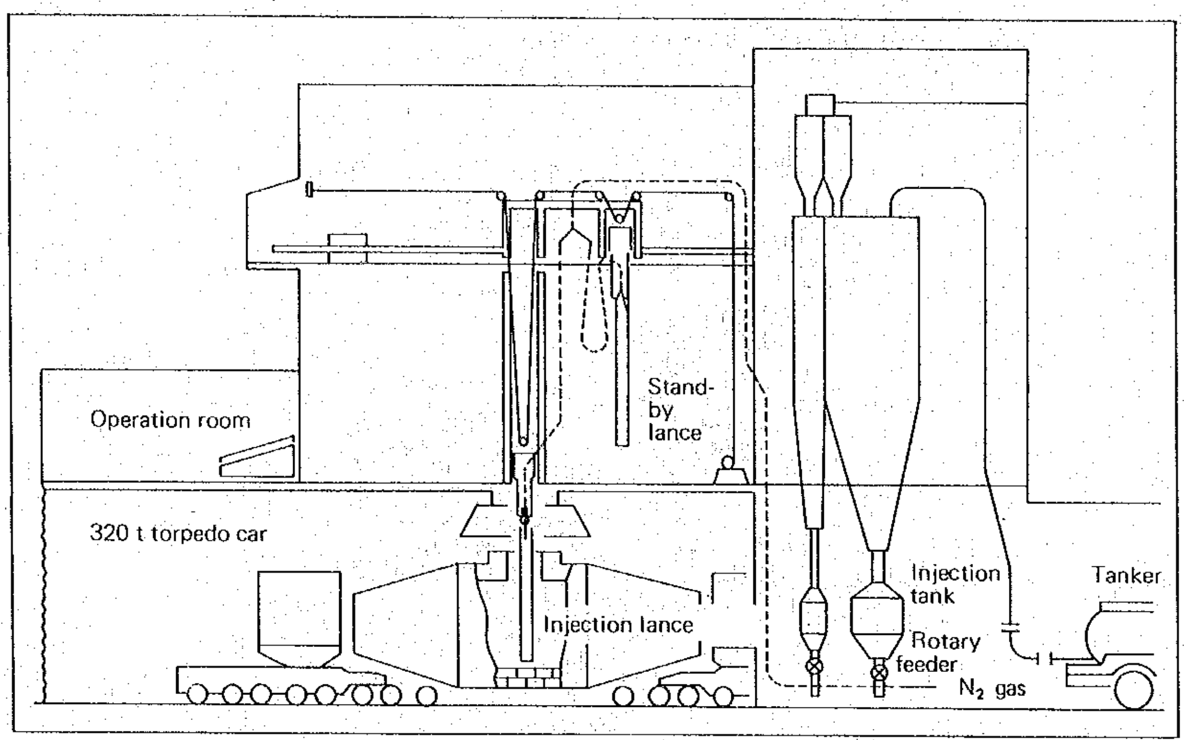


Fig. 13-8-3 Outline of torpedo desulphurization equipment

3) Sublance equipment

The importance of the blowing control was explained in 13-8-3, (1), 6) "Sublance equipment." The simulataneous hitting ratio of carbon and temperature was as low as 30~40% because of the following reasons:

i) Blowing time is extremely short ($12\sim18^{min}$).

ii) The internal conditions of a furnace (temperature and composition transiency) during blowing were not known by the conventional static control.

Various research programs related to sublances have been carried out to solve these problems, and sublances are commonly used in furnaces recently in Japan, which enables measuring bath temperature and carbon content , and sampling for analysis during blowing.

① Outline of sublance equipment

i) Probe mounting/dismounting device
ii) Sublance proper
iii) Sublance guide
iv) Guide slewing device
v) Winch
iv) Instrumentation and control devices

Fig. 13-8-4 outlines sublance equipment.

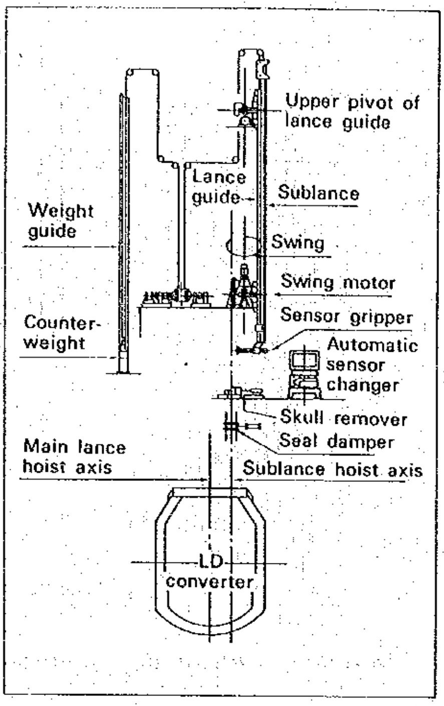


Fig. 13-8-4 Outline of sub-lance equipment

2. Functions of sublance equipment

   The sublance shall be lowered during blowing to measure steel bath temperature and carbon content (carbon content is estimated by solidification temperature of molten steel) and to take samples.

   The probe shall be recovered for sample collection, and a new prove shall be mounted.

   Sublance measurement is usually made 2~3 minutes prior to the pre-estimated blow-end, and the measured results are used to corrects the timing of the blow end and to calculate the weight of coolant as necessary.

3. Specifications (outline) of sublance device

Item	Specifications
Measuring items	Temperature, carbon ratio (%), surface level, and sampling
Operation mode	Probe mounting and recovery
Measuring cycle time	1.5 ~ 2.0 min/cycle

4) LDG recovery

The total energy of the gas (LDG) generated in the B.O.F. furnace is $240 \times 10^{3 Kcal/t\cdot steel}$, of which 70% can be recovered as energy by noncombustive gas recovery. The saved energy amounts to 6% of all by-product gas energy generated in an integrated steelworks.

① Outline of gas recovery equipment

Fig. 13-8-5 shows the gas recovery system.

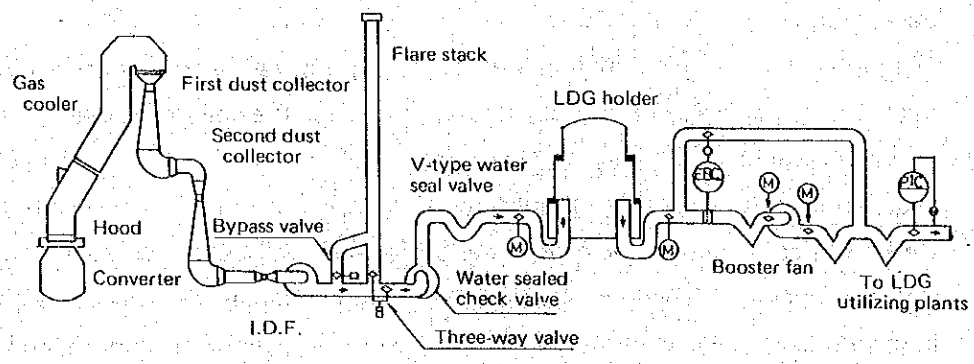


Fig. 13-8-5 LDG recovery system flow

② Features of the recovered gas

Item	Feature
CO ratio (%)	64% or more
SO_2 ratio	0.5 ppm or less
H_2S ratio	0.1 ppm or less
Dust density	0.1 g/Nm^3 or less

③ Gas recovery volume

A gas recovery volume varies according to furnace operating conditions, gas recovery conditions, gas holder capacity, etc. The gas volume recovered recently in Japan ranges between 70 and $110^{Nm^3/t}$.

5) Conception of planning the start up of B.O.F. plant, especially CC machines.

The start-up plan and backup equipment of continuous casters must be set carefully, considering the following special features of this project:

i) This project is the first integrated iron and steel project using the B.F.-B.O.F.-CC method in the Philippines.

ii) This project adopts the all-CC method.

① Startup plan

A certain transition period must be includied in the plant startup time for machine adjustment, fault prevention, operaters' experience, confirmation and establishment of quality, etc. Considering the data obtained in Japan and conditions in the Philippines, the startup time of the coverters have been set at 12 months, and the startup time of the continuous casters at 18 months, (actual startup time is set at 16 months, to meet the demands).

② Backup equipment for the continuous casters

The pig casting machine, molten steel returning traverser, and ingot making equipment are considered as the backup equipment for the failure of starting up and routine operation of the continuous casters.

In Japan, Oita Steelworks is the only steelworks originally planned as an all-CC steelworks. The continuous casters were started-up after well-planned preparation by the staff and operators having experience with continuous casters, who were gathered from various steelworks of the company: however, the ingot making method had to be incorporated.

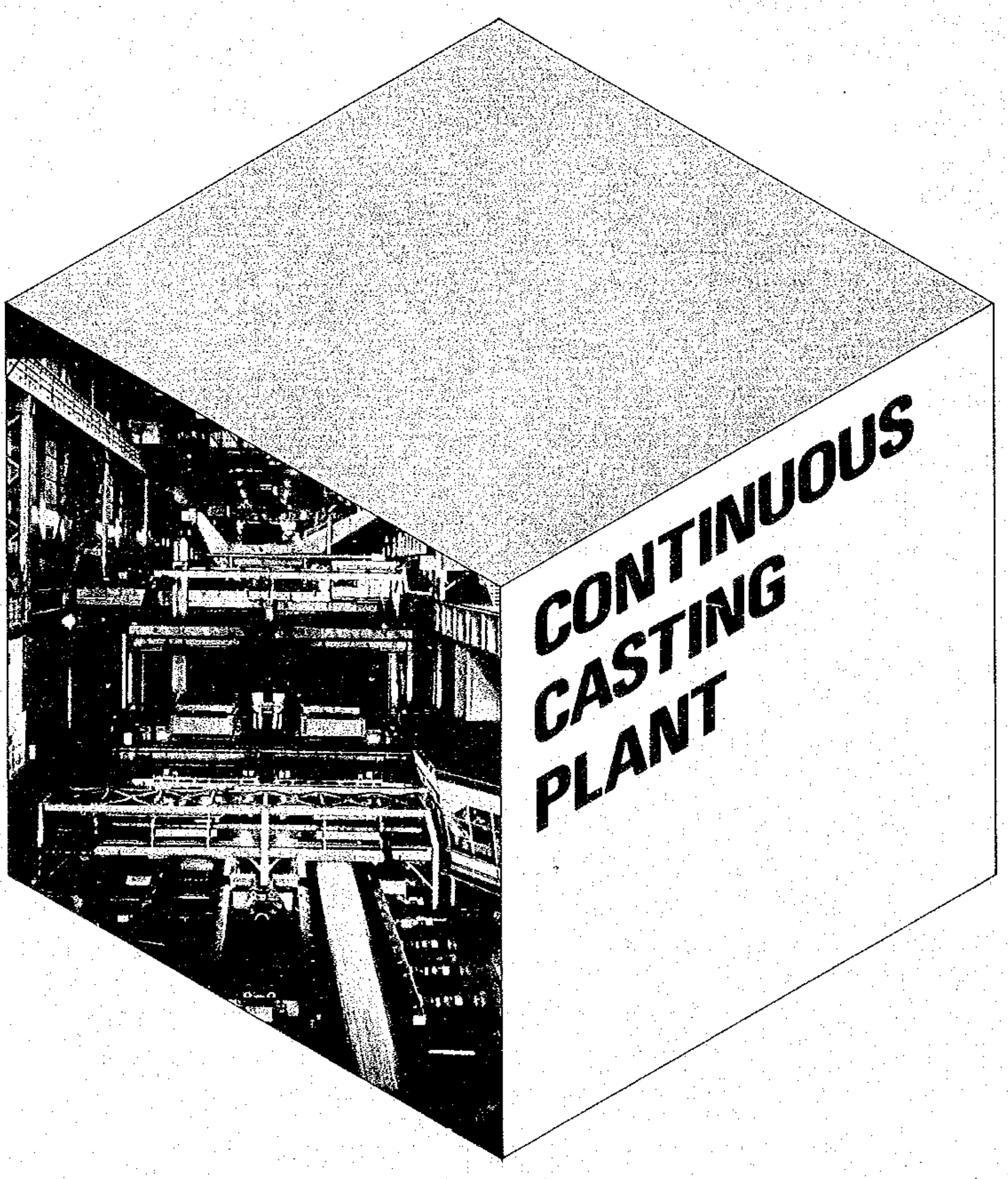
That is, as the furnace side needs some practice to manufacture proper molten steel (with appropriate composition, temperature and deoxidation) acceptable for the continuous casters, a certain period is required before the continuous casters reach their full capacities.

During this startup time, the molten steel returning traverser is of little use, and should be considered as an emergency meausre.

③ Ingot making equipment capactiy

On the assumption of failure of one of the three continuous casters, the capacity is set to handle 20% of the furnace capacity ($30^{heat/d}$), i.e., $6^{heats/d}$.

CHAPTER 13-9



13-9 Continuous casting equipment

13-9-1 General

2 units of 1-strand machines for slab and 1 unit of 4-strand machine for bloom as continuous casting facilities shall be installed so as to treat, in general, all the molten steel manufactured by BOF. These continuous casting facilities shall produce annually 1,200,000^t of slab for hot strip mill and plate, and 300,000^t of blooms for billet mill. With respect to the extension of BOF facilities in stage II, the layout is so designed that extension of continuous casting facilities shall not affect the operations of existing facilities and that the additional continuous casting facilities shall be constructed to the west of the plant, almost in symmetry with these in stage I.

13-9-2 Preconditions

(1) Conditions of the preceding process

Table 13-9-1 shows the molten steel production in stage I when it has reached the stable period of each process.

Table 13-9-1 Production

Process	Production of liquid steel (t/y)	Production of castings (t/y)
Slab continuous casting	1,250,000	1,200,000
Bloom continuous casting	319,000	300,000
Total	1,569,000	1,500,000

(2) Production plan

1) Slab production plan

Table 13-9-2 shows the production of continuous cast slabs by width.

Table 13-9-3 shows the details of slab flows.

Table 13-9-2 Production of slabs by width

Slab width	Production of as-cast slabs (t/y)	Percentage distribution (%)
3 ft	130,000	11
4 ft	545,500	45
5 ft	50,760	4
6 ft	473,740	40
Total	1,200,000	100

Table 13-9-3 Flow of slabs

Nominal width		As-cast slab (t/y)	Conditioned slab (t/y)	Sheared slabs (t/y)	Slabs to be rolled (t/y)
for hot strip	3 ft	130,000	128,050	–	128,050
	4 ft	545,500	537,317	–	537,317
	5 ft	–	–	–	–
	6 ft	422,980	416,635	413,469	413,469
	Total	1,098,480	1,082,002	413,469	1,078,836
for plate	5 ft	50,760	50,000	–	* 50,000
	6 ft	50,760	50,000	–	* 50,000
	Total	101,520	100,000	–	* 100,000
Total		1,200,000	1,182,002	413,469	1,178,836

* Slabs for plate are transported without secondary cutting

2) Bloom production plan

The size of continuous cast bloom has two types. *Table 13-9-4* shows the bloom production.

Table 13-9-4 Production of blooms

Nominal cross sectional dimensions	Production of as-cast bloom (t/y)	Percentage distribution (%)
200φ	264,000	88
250φ	36,000	12
Total	300,000	100

(3) Dimensions of slabs and blooms

1) Slab

Table 13-9-5 Dimensions and unit weight of as-cast slabs

Nominal dimensions		Thickness (mm)	Width (mm)	Length (mm)	Unit weight (t)
for hot strip	3 ft	203	913	8,000 ~ 9,200	13.3 max.
	4 ft	203	1,218	8,000 ~ 9,200	17.7
	5 ft	–	–	–	–
	6 ft	203	1,841	8,000 ~ 9,200	26.8
for plate	5 ft	203	1,523	4,980 ~ 6,100	14.7
	6 ft	203	1,841	4,980 ~ 6,100	17.8

Table 13-9-6 Dimensions and unit weight of conditioned slabs

Nominal dimensions		Thickness (mm)	Width (mm)	Length (mm)	Unit weight (t)
for hot strip	3 ft	200	910	8,000 ~ 9,200	13.1 max.
	4 ft	200	1,215	8,000 ~ 9,200	17.4
	5 ft	–	–	–	–
	6 ft	200	1,838	8,000 ~ 9,200	26.4
for plate	5 ft	200	1,520	4,980 ~ 6,100	14.5
	6 ft	200	1,838	4,980 ~ 6,100	17.5

Note ① Slabs of double length are secondarily cutted after conditioning.
② 6 ft length slabs for hot strip are sheared after conditioning.

2) Bloom

Table 13-9-7 Dimensions and unit weight of blooms

Nominal cross sectional dimensions (mm)	Length (mm)	Unit weight (t/m)	Weight of a bloom (t)
200ϕ	6,100 max.	0.312	1.90 max.
250ϕ	6,100 max.	0.488	2.98 max.

(4) Operating conditions

Table 13-9-8 Operating conditions

		Planned value
1) Operating days	1 Annual operating calendar days	341 d
	2 Monthly operating days	28 d
	3 Periodical repairs	2 d/month (12 hr x 4 repairs/month)
2) Average tapping tonnage per heat		155 t/heat
3) No. of heats to be cast	1 Annual	10,123 heats
	2 Monthly	844 heats
	3 Daily	30 heats
4) No. of heats to be cast by casting machine	Monthly	Daily
No. 1 slab CCM	339 heats/month	12.1 heats/d
No. 2 slab CCM	333 heats/month	11.9 heats/d
Bloom CCM	172 heats/month	6.1 heats/d
	(844)	(30)

(5) Yields of each process

Table 13-9-9 Yield rates by process

	Yield rate (%)
1) Slab casting yield (Cast slabs to molten steel)	96.0
2) Bloom casting yield (Cast blooms to molten steel)	94.0
3) Slab conditioning yield (Conditioned slabs to cast slabs)	98.5
4) Slab shearing yield *	99.24
5) Total slab conditioning yield (Slabs to be rolled to as-cast slabs)	98.24

* Percentage of sheared slabs to total slabs is 35.2.

(6) Production process

Fig. 13-9-1 and *13-9-2* show the production process.

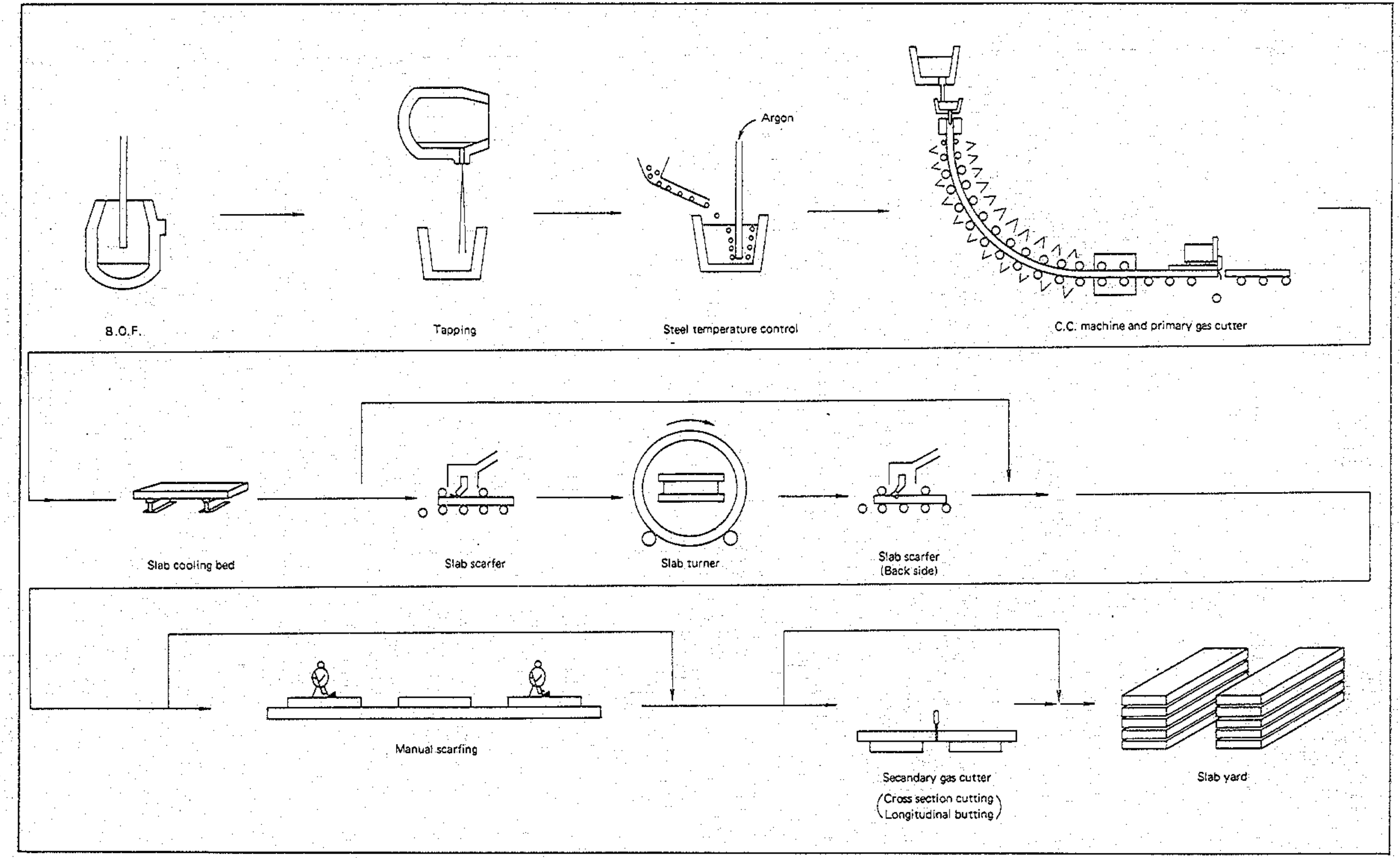


Fig. 13-9-1 Process flow of slab making

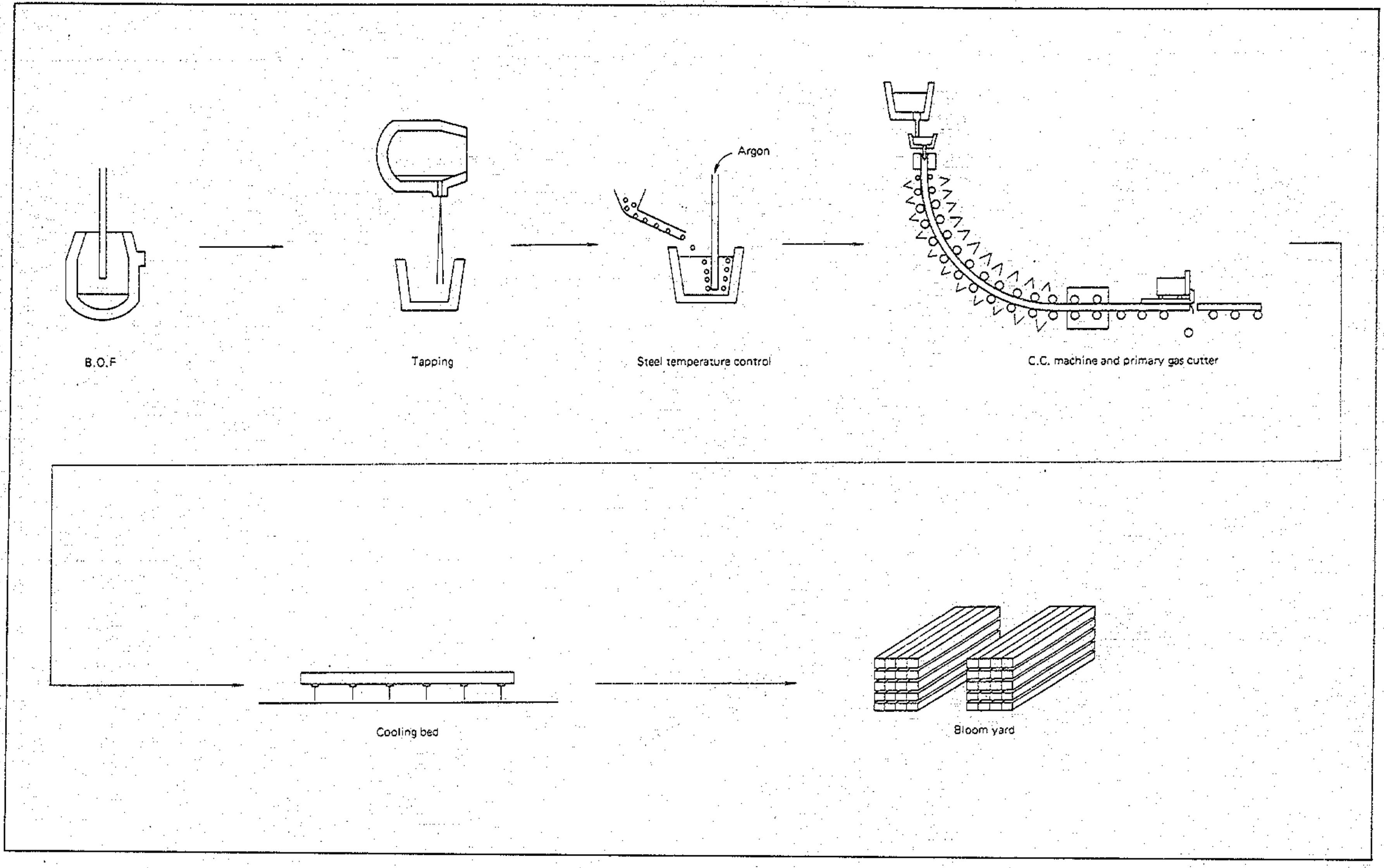


Fig. 13-9-2 Process flow of bloom making

13-9-3 Equipment plan

(1) Layout

The molten steel handling bay shall be arranged adjacent to the the basic oxygen furnace bay. Two 240ᵗ/40ᵗ cranes or molten steel ladles, which shall be mounted on the bay, shall be used to carry molten steel ladles to the continuous casting machines. In this bay, the slag left in the ladles after casts shall also be discharged into a slag ladle.

To make the transfer of the molten steel ladles smooth, maintenance works of tundishes or ladles shall not be generally performed in the bay.

Three continuous casting machines shall be placed at the middle of and at right angles to the building, and a machine maintenance yard shall be placed on the east side of the machines and a tundish repair yard shall be on the west side.

This arrangement of the yards will offer an appropriate environment for the machine maintenance yard with natural air ventilation.

The buildings for cooling, conditioning, secodndary cutting and loading of cast slab and bloom shall be placed parallel to the buildings of the continous casting plant.

For energy conservation, these buildings are so designed that hot slabs can be directly delivered to the hot strip mill if a roller table reaching to the mill is connected to the middle of the buildings in stage I and stage II.

In stage I, however, transportation of slabs shall be performed by trailer.

In the slab conditioning yards, a machine scarfer shall be installed so as to enhance slab finishing efficiency and make it easer to check the surface of slabs. Blooms, the size of which is designed to suit the capacity of the rolling mill in the next process, shall be simply inspected after cooling and shall be shipped by trailers without being cut to pieces, considering to avoid the complexity of the bloom handling.

Since a bloom cooling and loading yard is rather compact in scale, it shall be placed parallel to and in between the main buildings of the continuous casters and the slab conditioning buildings.

Under these multilateral considerations, in the plan of stage II, it is intended that handling and transportation of slabs, blooms and scale, and transfer of machine parts or refractories shall not be disturbed during the construction period.

For layout, see *Fig. 13-8-3*

(2) Equipment specifications

1) Molten steel handling equipment

A ladle turret shall be used as a molten steel ladle holding and charging device, the use of which shall reduce the interference between cranes and make the molten steel ladle transportation smooth.

The ladle turret will have the capacity of 240ᵗ (moltensteel + ladle weight) and has a maximum 1ʳᵖᵐ of rotating speed.
The ladle turret is provided with a back-up device which can operate to rotate ladles during power failure.
As for molten steel flow controlling equipment for ladles and tundishes, a slide valve system that operates hydraulically shall be adopted for the pourpose of stable teeming operation under the conditions of high temperature and long casting time.

2) Outline of the continuous casting machines

① Productivity

2 units of 1-strand slab continuous casting machines and 1 unit of 4-strand bloom continuous casting machine will be installed.
The productivity of continuous casting machines is much higher than that of converters, as shwon in *Table 13-9-10.*

Table 13-9-10 Productivity of continious casting machines

	Productivity* (t/hr.)
Continuous casting machines	
No. 1 slab continuous casting machine	Average 97
No. 2 slab continuous casting machine	Average 97
Bloom continuous casting machine	95
Total	289
B.O.F plant	258**

* Productivity of continuous casting machines was calculated on the basis of the 2-ladle continuous – continuous casting with set-up time of 50 minutes.
** Productivity of B.O.F. plant was calculated at the tapping cycle of 36 minutes.
Both figures were based on 155 t/heat of liquid steel.

② Slab continuous casting machine

Several types of continuous casting machines are being used throughout the world.
In this plan, however, single radius curved low head casters, the most typical type, shall be used. This type of caster is rather complicated in structure, compared with vertical type caster, but its construction cost may be cheaper because of the low head structure.
Withdrawal speeds are specified at 0.95 to $1.10^{m/min.}$ considering the slab quality, slab size and the heat size of furnace.

Table 13-9-15 shows casting rates and required casting time at the selected withdrawal speeds and main specification is shown in the *Table 13-9-11.*

Table 13-9-11 Main specifications of slab continuous casting machine

1	No. of strand	1
2	Radius of curvature	Approx. 10,500 ^{mm}
3	Dimensions of slab Thickness	200 ^{mm}
	Width	900 ~ 1,900 ^{mm}
	Length	4,980 ~ 9,200 ^{mm}
4	Unit weight of slab	26.8 ^{t} max.
5	Driving speed (during casting)	1.5 $^{m/min}$ max.
	(when setting dummy bar)	5.0 $^{m/min}$ max.

③ Bloom continuous casting machine

The type of the bloom continuous casting machine shall be the same as that of the slab continuous casting machine.

Bloom dimensions are specified at 200 and 250^{mm} square in order to match with the mill capacity.

Considering that the quality requirements for the products (concrete bar and steel section etc.) from the blooms are not so severe and enhancing the productivity per one strand to minimize the number of strands, withdrawal speed of 1.1 to 1.7$^{m/min}$, which is fairly higher than those of slab caster's, has been selected.

Table 13-9-12 shows the main specifications of bloom continuous casting machine.

Table 13-9-12 Main specifications of bloom continuous casting machine

1	No. of strands	4
2	Radius of curvature	10,500 ^{mm}
3	Dimensions of bloom Cross section	200 ф
		250 ф
	Length	3,600 ~ 6,100 ^{mm}
4	Unit weight	2.98 ^{t} max.
5	Driving speed (during casting)	2.0 $^{m/min}$ max.
	(when setting dummy bar)	5.0 $^{m/min}$ max.

④ Slab conditioning and delivery equipment

After being cut into a specified size by an automatic gas cutting machine, a slab is automatically sent to the slab conditioning building by roller table, and pushed out to a piler (45^{t}) by a pusher (capacity: 15^{t}). The slab is transported onto a cooling bed by a tong crane (45^{t}), to be naturally cooled.

Conditioning of slabs is mainly performed by a slab machine scarfer located in between two slab handling bays, and after that partly done by hand scarfing. A lifting magnet crane (30^{t}) with reverse function shall be used to cut the slabs longitudinally or transversally. The lifting magnet crane is also used to carry the finished slabs onto trailers.

The transversal cutting of slabs for plate shall not be performed in the continuous casting plant, because it is more advantageous for the plate manufacturers to cut slabs into pieces at their slab receiving yards, from the view point of slab transportation.

⑤ Specifications of continuous casting equipment

Table 13-9-13 shows continuous casting equipment specifications.

(3) Relationship with equipment in stage II.

The continuous casting equipment installed in stage I is independent of facilities (2 slab casting machines and 1 bloom casting machine) to be installed in stage II.

(4) Material consumption and by-products.

Table 13-9-14 shows the material consumption and by-products in continuous casting operation.

Table 13-9-13 Continuous casting equipment specifications

	Equipment	Main specifications			
		Quantity	Stage I	Quantity	Stage II
1.	Slab continuous caster				
(1)	Liquid steel handling equipment				
01	Ladle turret	2 units	Load capacity: 240 t Swivelling speed: 1 rpm	2 units	Same as left
02	Sliding nozzle device	1 set	Hydraulic type	1 set	Same as left
03	Tundish	15 units	Capacity: Approx. 18 t	15 units	Same as left
04	Tundish car	4 units	Loading capacity: Approx. 50 t with lifting device	4 units	Same as left
05	Tundish auxiliary equipment	1 set	Preheater: 6 units, etc.	1 set	Same as left
(2)	Continuous caster	2 units	Type: Low head curved mould type 1-strand slab caster Slab size: 200x900x4,980 mm, min. 200x1,900x9,200 mm, max. Driving speed: For casting: 1.5 m/min, max. For dummy bar: 5.0 m/min, max. Machine length: Approx. 21.5 m	2 units	Same as left
01	Equipment of caster proper	8 units	Water cooled copper mould	8 units	
		2 units	Mould oscillator	2 units	
		2 units	Casting support and guide	2 units	
		2 units	Casting and straightening equipment	2 units	
		2 units	Cooling chamber	2 units	
		2 units	Steam discharge equipment	2 units	Same as left
		2 units	Dummy bar and its support	2 units	
		2 units	Gas cutter	2 units	
		2 units	Casting cropping and delivery equipment	2 units	
		2 units	Hydraulic equipment	2 units	
		2 units	Slab stamper	2 units	

	Equipment	Main specifications			
		Quantity	Stage I	Quantity	Stage II
(3)	Castings transport equipment				
01	Roller table	17 units	Roll dia.: Approx. 400 mmφ Roll pitch: 1,200 and 1,500 mm Roll barrel length: 2,200 mm Table length: 9,000 mm	17 units	Same as left
02	Pusher	2 units	Capacity: 15t Stroke: Approx. 4,000 mm	2 units	Same as left
03	Piler	2 units	Capacity: 45 t	2 units	Same as left
04	Cooling bed	2 units	20 m x 75 m = 1,500 m^2	2 units	Same as left
05	Machine scarfer and associated equipment	1 set	2 side type machine scarfer, slab turner, roller table: Ep, oil unit, slab transfer car	1 set	Same as left
(4)	Electrical equipment				
01	Power supply equipment	1 set		1 set	
02	Continuous casting electrical equipment	1 set		1 set	
03	Casting transport electrical equipment	1 set		1 set	
(5)	Instrumentation				
01	Continuous casting control instrumentation	2 units		2 units	
02	Casting cutting program control equipment	2 units		2 units	
(6)	Crane equipment	2 units 2 units	Slab delivery tong cranes: 45 t Slab delivery lifting magnet cranes: 30 t	2 units 2 units	Same as left Same as left
		2 units	Slab conditioning lifting magnet cranes (With slab turning equipment): 30 t	2 units	Same as left
2.	Bloom continuous caster				
(1)	Liquid steel handling equipment				
01	Ladle turret	1 unit	Load capacity: 240 t Swivelling speed: 1 rpm	1 unit	Same as left

	Equipment	Main specifications			
		Quantity	Stage I	Quantity	Stage II
02	Sliding nozzle device	1 set	Hydraulic type	1 set	Same as left
03	Tundish	8 units	Capacity: Approx. 18 t	8 units	Same as left
04	Tundish car	2 units	Loading capacity: Approx. 50 t with lifting device	2 units	Same as left
05	Tundish auxiliary equipment	1 set	Preheater: 3 units, etc.	1 set	Same as left
(2)	Continuous caster	1 unit	Type: Low head curved mould type 4-strand bloom caster Bloom size: 200ϕ x 6,100 mm, max. 250ϕ x 6,100 mm, max. Driving speed: For casting: 2.0 m/min, max. For dummy bar: 5.0 m/min, max. Machine length: Approx. 24.5 m	1 unit	Same as left
01	Equipment of the caster proper	8 units	Water cooled copper mould	8 units	Same as left
		4 units	Mould oscillator	4 units	
		4 units	Casting support and guide	4 units	
		4 units	Casting and straightening equipment	4 units	
		4 units	Casting cooling equipment	4 units	
		1 unit	Cooling chamber	1 unit	
		1 unit	Steam discharge equipment	1 unit	
		4 units	Dummy bar and its support	4 units	
		4 units	Gas cutter	4 units	
		2 units	Casting cropping and delivery equipment	2 units	
		4 units	Hydraulic equipment	4 units	
		4 units	Bloom stamper	4 units	
(3)	Casting transport equipment				
01	Roller table	1 set	Roll dia.: Approx. 300 mmϕ Roll pitch: 1,200 and 1,500 mm Roll barrel length: 450 mm Table length: 6,000 mm	1 set	Same as left
02	Pusher	2 units	Capacity: 80 ton Stroke: Approx. 2,000 mm	2 units	Same as left
03	Cross conveyor	2 units	Capacity: 3 t Speed: 20 m/min	2 units	Same as left
04	Cooling bed	2 units	5 m x 15 m = 75 m^2	2 units	Same as left

	Equipment	Main specifications			
		Quantity	Stage I	Quantity	Stage II
(4)	Electrical equipment				
01	Power supply equipment	1 set		1 set	
02	Continuous casting electrical equipment	1 set		1 set	
03	Casting transport electrical equipment	1 set		1 set	
(5)	Instrumentation				
01	Continuous casting control instrumentation	4 units		4 units	
02	Casting cutting program control equipment	4 units		4 units	
(6)	Crane equipment	1 unit	Bloom delivery lifting magnet crane (with bloom rotating equipment): 15 t	1 unit	Same as left
3.	Common equipment				
(1)	Liquid steel handling equipment				
01	Lqiuid steel temperature control device	1 unit	Stopper rod type argon top blow	1 unit	Same as left
(2)	Continuous caster				
01	Equipment of caster proper	1 unit	A casting floor common to three continuous casters Height: Approx. 11,000 mm Area: Approx. 104x45=4,725 m^2	1 unit	Same as left
(3)	Instrumentation				
01	Fluidic measuring equipment	1 set		1 set	
(4)	Gas piping system	1 set	Oxygen, LPG, argon, COG, air and other piping systems	1 set	Same as left
(5)	Water piping system	1 set	Direct cooling, indirect cooling and emergency cooling water piping systems	1 set	Same as left

	Equipment	Main specifications			
		Quantity	Stage I	Quantity	Stage II
(6)	Auxiliary equipment				
01	CC machine maintenance equipment	1 set		1 set	
02	Tundish maintenance equipment	1 set		1 set	
03	CO_2 automatic fire extinguishing systems	1 set		1 set	
04	General service air compressors	1 set		1 set	
05	Instrumentation air compressors	1 set		1 set	
06	Transfer cars	3 units		3 units	
07	LPG station	1 set		1 set	
08	Slab scarfing tools	1 set		1 set	
09	Slab cutting tools	1 set		1 set	
10	Air conditioner	1 set		1 set	
11	Industrial TV system	1 set		1 set	
12	Intercommunication system	1 set		1 set	
13	Others	1 set		1 set	
(7)	Crane equipment	1 unit	Roll maintenance crane: 40/5 t	1 unit	Same as left
		1 unit	Roll maintenance crane: 30/5 t	1 unit	
		1 unit	Tundish maintenance crane: 50/10 t	1 unit	
		3 units	Roll maintenance crane: 5 t	3 units	
		1 unit	CCM service crane: 120/40 t	1 unit	
		2 units	Scale delivery grab bucket: 3 t	2 units	
		3 units	Wall cranes: 2 t	3 units	
		10 units	Crane maintenance hoists: 2 ~ 7 t	10 units	

Table 13-9-14 Summary of consumption and generation

Equipment	Stage I						
	Output 10^3 t/y	Utilities			By-products		
		Utilities	Specific consumption	Consumption/y	By-products	Specific consumption	Consumption/y
Continuous slab caster	Slab 1,200	C. O. G	6 Nm^3/t	7.2×10^6 Nm^3	Scrap	41 kg/t	49.2×10^3 t
		Oxygen gas	15 Nm^3/t	18×10^6 Nm^3	Scale	16.5 kg/t	19.8×10^3 t
		Argon gas	0.25 Nm^3/t	300×10^3 Nm^3			
		L. P. G	1.33 kg/t	1,596 t			
		Industrial water	3.94 m^3/min	2.1×10^6 m^3			
		Potable water	0.1 m^3/min	52.6×10^3 m^3			
		Power	29 KWH/t	34.8×10^6 KWH			
Continuous bloom caster	Bloom 300	C. O. G	6 Nm^3/t	1.8×10^6 Nm^3	Scrap	53 kg/t	15.9×10^3 t
		Oxygen gas	2.5 Nm^3/t	0.75×10^6 Nm^3	Scale	7 kg/t	2.1×10^3 t
		Argon gas	0.25 Nm^3/t	75×10^3 Nm^3			
		L. P. G	0.475 kg/t	142 t			
		Industrial water	0.98 m^3/min	0.515×10^6 m^3			
		Portable water	0.03 m^3/min	15.8×10^3 m^3			
		Power	29 KWH/t	8.7×10^6 KWH			

Stage II						
Output 10^3 t/y	Utilities			By-products		
	Utilities	Specific consumption	Consumption/y	By-products	Specific consumption	Consumption/y
Slab 2,000	C. O. G	6 Nm^3/t	12 x 10^6 Nm^3	Scrap	41 kg/t	82 x 10^3 t
	Oxygen gas	15 Nm^3/t	30 x 10^6 Nm^3	Scale	16.5 kg/t	33 x 10^3 t
	Argon gas	0.25 Nm^3/t	500 x 10^3 Nm^3			
	L. P. G	1.33 kg/t	2,600 t			
	Industrial water	3.94 m^3/min	3.x 10^6 m^3			
	Potable water	0.1 m^3/min	87.7 x 10^3 m^3			
	Power	29 KWH/t	58 x 10^6 KWH			
Bloom 1,000	C. O. G	6 Nm^3/t	6 x 10^6 Nm^3	Scrap	53 kg/t	53 x 10^3 t
	Oxygen gas	2.5 Nm^3/t	2.5 x 10^6 Nm^3	Scale	7 kg/t	7 x 10^3 t
	Argon gas	0.25 Nm^3/t	250 x 10^3 Nm^3			
	L. P. G	0.475 kg/t	475 t			
	Industrial water	0.98 m^3/min	1.72 x 10^6 m^3			
	Potable water	0.03 m^3/min	52.7 x 10^3			
	Power	29 KWH/t	29 x 10^6 KWH			

13-9-4 Technical explanation

(1) Productivity

Table 13-9-15 shows the casting rates and times of slab and bloom casting. When the 3- and 6-feet slabs are cast by the No.1 slab continuous casting machine and the 4- and 5-feet slabs are cast by the No.2 slab continuous casting machine, the casting time ratio is obtained, as shown in *Table 13-9-16*.

Table 13-9-15 Casting rates and casting time

Dimensions		Unit weight (t/m)	Average withdrawal speed (m/min)	Casting rates (t/min)	Casting time (min)
Slab	3 ft	1.45	1.1	1.6	97
	4 ft	1.93	1.1	2.1	74
	5 ft	2.41	1.1	2.6	60
	6 ft	2.92	0.95	2.8	55
Bloom	200ϕ	0.312	1.7	2.12	73
	250ϕ	0.488	1.1	2.15	72

Table 13-9-16 Casting time ratio of each continuous caster

CCM	Production of casting t/y		Heats/y	Heats/month	Casting time (hrs)	Casting time ratio
No. 1 CCM	3 ft	130,000	874	73	118	
	6 ft	473,740	3,184	265	243	
	Total	603,740	4,058	338	361	50%
No.2 CCM	4 ft	545,500	3,666	305	376	
	5 ft	50,760	341	29	29	
	Total	596,260	4,007	334	405	56%
Bloom CCM	200ϕ	264,000	1,811	151	184	
	250ϕ	36,000	247	21	25	
	Total	300,000	2,058	172	209	29%
Total		1,500,000	10,123	844		

These casting time ratios are almost the same as the actual values which have been reported from the plants with all continuous casting in Japan.

(2) How to determine slab dimensions

1) Thickness

The slab thickness is specified at 200^{mm} in consideration of slab supply to the hot mill plant.

Many continuous casting plants in Japan, as well as in other countries, produce about 200^{mm}thickness slabs for hot strip and plates.

As this 200^{mm} thickness slabs make rolling operation easy and enable the production of 25 to 33^{mm} finished plates, very competitive products in cost and quality can be manufactured from this size of slabs.

2) Width

As the slabs discussed in this chapter shall be used for the hot strip mill and plate mills, the slab width must be determined to suit the customer's equipment or the width of the finished products.

As the present plan specifies the mill width of the hot strip mill at a maximum of approx. 4 feet, the supply of the slabs of approx. 4 feet wide at maximum is necessary, and on the other hand the slabs to be supplied to the plate will have to have the width of 5 and 6 feet in view of the demand of the plates. From these, the maximum slab width is determined to 6 ft. In consideration of the operationability and productivity of slab casting, the machine width is specified at 900 to 1900^{mm}

It is not recommended that the minimum casting width be made less than 900^{mm} because such excessive minimization of width shall have a bad effect on the operation and productivity of slab casting.

In this paln, as the slabs to be supplied to the hot strip mill are specified at 600 to 1300^{mm} wide, the slabs with the width of 600 to 900^{mm} shall be cast in double width (i.e. 1,200 to 1,800^{mm}) in casting machines and then be split longitudinally by using a cutting device.

(3) Number of strands of slab casters.

The number of strands of slab casters is specified at 1 strand/1 unit × 2 units, cpnsidering the following items:

1) As the average tap-to-tap time of a furnace is 36$^{min.}$, 55 to 74$^{min.}$ (94$^{min.}$ for 3 feet width) of the averrage casting time of a 1 strand-slab caster makes such an operation mode as one marchine casts one heat while one furnace taps 2 heats.

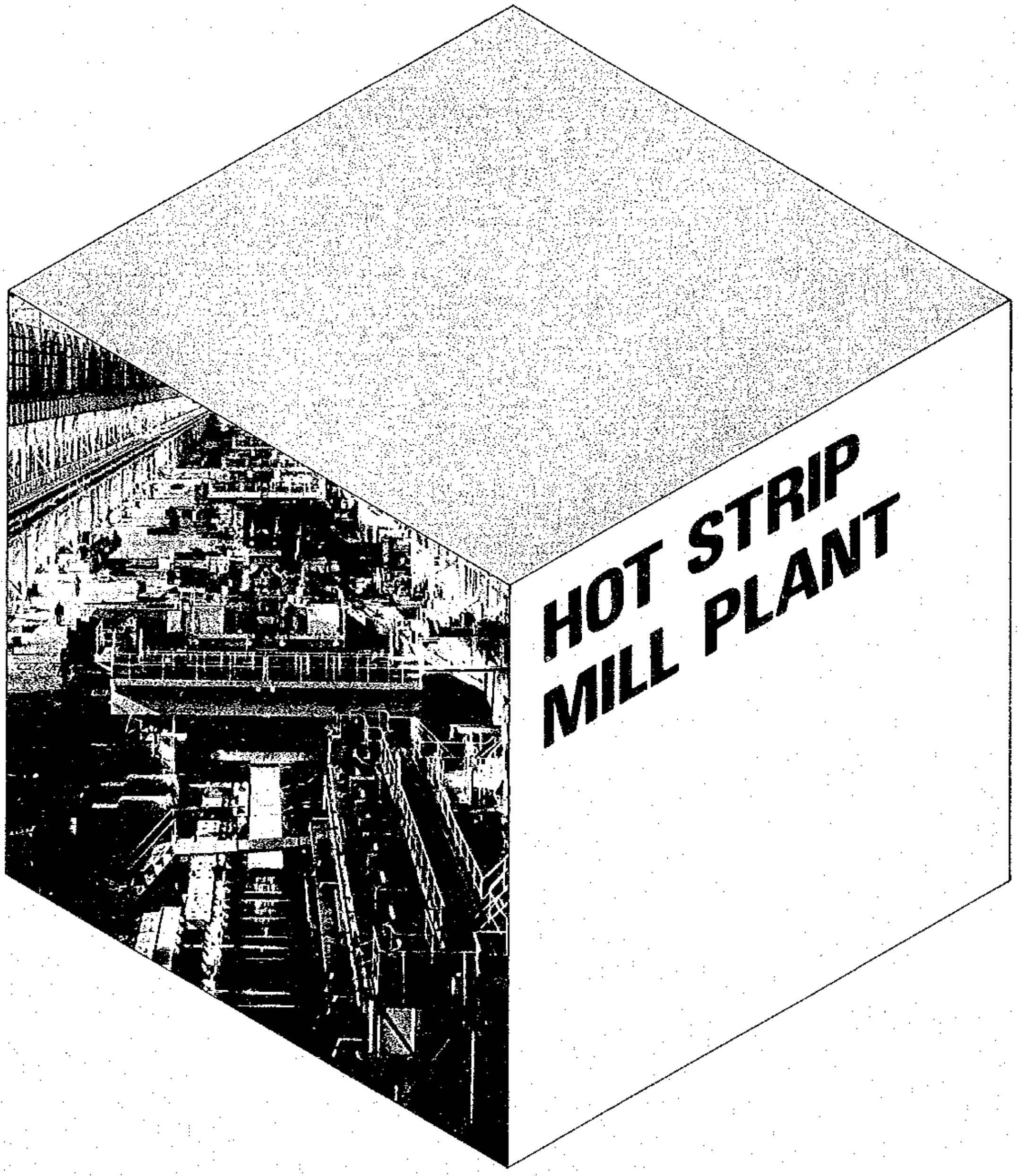
28 to 37^{min} (47^{min} for 3 feet width) of the average casting time of a 2 strand machine matches the tap-to-tap time of a furnace. Accordingly, blowing cycles and casting cycles in both cases will match in regard to the cycle time.

However, two 1 strand-slab casters are more flexible for the scheduling and production balance between slabs and blooms and give more receivers of molten steel than one 2 strands-slab machine, in consideration that the average casting time of a bloom caster is 72 to 73$^{min.}$ and all the molten steel manufactured from a furnace generally have to be treated in the continuous casters.

2) Two 1-strand casters offer less operational troubles and production losses in case of accidental stops of machines than one 2-strand caster.

3) A 2-strand caster requires more complex maintenance work and more maintenance personnel for its periodical check or repair than a 1-strand caster.

CHAPTER 13-10



13-10 Hot strip mill

13-10-1 General

This hot strip mill shall use 200^{mm} thick and 600 to 1300^{mm} wide slabs which are supplied from the continuous casting plant, so as to produce hot coil as the basic material for the following products;

(1) Hot rolled sheets and coils
(2) Pipes and tubes
(3) Cold rolled sheets and coils
(4) G.I sheets
(5) Tin plates

As shown in *Table 13-10-1,* the hot strip mill shall have facilities capable of satisfying the requirement in stage I and stage II and its facilities are planned for effective investment.
In stage I, the hot strip mill shall have the minimum facilities to fulfill the requirement of stage I. In stage II, however, the hot strip mill shall enhance the facility's capacity by installing an additional reheating furnace, roughing mill and coiler.
In stage I, the hot strip mill is planned to provide each user with all of the hot coils as they are. Furthermore, in stage II, a set of hot coil shearing line shall be installed so as to supply hot rolled sheets directly to the users.

Table 13-10-1 Amount of required production

Step	Amount of required production (Slab) x 10^3 t/y	Yield (%)	Amount of required production (Hot coil) x 10^3 t/y
Stage I	1,079	97.5	1,052
Stage II	1,765	97.5	1,721

As for the conservation of energy in the future, an effective transportation system for hot slabs is taken into consideration about the layout plan of the hot strip mill.
This means that the hot strip mill shall be constructed as close to the continuous casting plant as possible and that, in the future, slab transport tables shall be installed between the continuous casting plant and the hot strip mill so that slabs can be supplied directly from the continuous casting plant to the hot strip mill.

(1) Operative outline

1) Hot strip mill

Continuously casted slabs are inspected on surfaces of the front and back, both sides and on the cut section.

If any fault is found, it shall be removed by conditioning in C.C yards. After being cooled, slabs are transported to the slab yard of the hot roll mill plant by trailers. Containing two bays, the slab yard is provided with overhead cranes to receive slabs from the trailer, and it also stores the slabs.

2) The slabs to be rolled are transported by crane and piled beside a furnace approach table.
Then, the slabs are placed on the furnace approach table one by one by using gantry crane, and they are weighed by the slab weigher attached to the tail of the furnace approach table and given coil numbers.
Slab pushers charge the slabs into the slab reheating furnaces.

3) The slab is moved in the inside of reheating furnace by walking beam and heated to specified temperature.
Then, extractor installed at the outlet of the reheating furnaces extracts the slab onto a furnace delivery table.

4) A VSB (vertical scale breaker) approach table sends the slab to the VSB and then a high-pressured spray water removes primary scale from the surface of the slab. A rougher (1 stand in stage I, and 2 in stage II) rolls the slab into about 1 inch thick bar.

5) The bar has their fish tail which must be removed by a crop shear installed in front of the finisher, and secondary scale is removed from the bar surface by spraying high-pressured water of FSB (finishing scale breaker).

6) The bar is rolled into specified thickness of coil by finishers (6 stands) and, on a run-out table, water cools the bar for specified coiling temperature, and the bars are made into coil by winding them with down coilers.

7) The wound coils are pulled out by stripper cars, up-ended and transported to the coil yard by coil conveyors.

8) In the coil yard, the coils are laid eye-horizontal by using down enders and cooled in a single pile.
After cooling, the coils are stored in up to two piles.

(2) Hot shearing line (SHL) (equipment for stage II)

1) Some of the hot rolled coils are transported to the yard in front of SHL by coil conveyor and cooled down to specified temperature.

2) Coils to be shorn are transported onto the coil conveyor by overhead crane.
The coils are made into sheets through the process below.
Uncoiler — Side trimmer — Flying shear — Sheet leveller — Inspection table — Prime piler.
They are bound and packed for shipment.

13-10-2 Preconditions

(1) Slab

1) Type of steel: Mild steel, low alloy steel

2) Slab size: Thickness: 200^{mm}, Width: 600 to 1300^{mm},
Length: Maximum 9.2^{m}.

3) Weight: Maximum 18.7 tons (800 piw)

(2) Products

1) Hot rolled coil

(1) Use (a) Hot rolled sheet and coil
(b) Pipe and tube
(c) Cold rolled sheet and coil
(d) G.I sheet
(e) Tin plate

(2) Size: Thickness: 1.2 to 12.7^{mm}, Width: 600 to 1,250^{mm},
Inner coil diameter: 760^{mm},
Outer coil diameter: Maximum 1,800^{mm}.

(3) Weight: Maximum 18.3^{t}

2) Hot rolled sheets (only in stage II)

(1) Size: Thickness: 1.2 to 6.35^{mm}, Width: 800 to 1,250^{mm},
Length: 2 to 6^{m}.

(3) Production plan

Table 13-10-2 Production plan

Use	Amount of required production (Coil) x 10^3 t/y	
	Stage I	Stage II
(a) Hot rolled sheet & coil	259	478
(b) Pipe & tube	143	191
(c) Cold rolled sheet & coil	220	525
(d) G.I. sheet	239	286
(e) Tin plate	191	241
Total	1,052	1,721

(4) Representative size and weight according to use (size and weight are the same in both stage I and stage II).

Table 13-10-3 Product mix

Use	Size of representative hot coil	Slab weight (t)
(a) Hot rolled sheet & coil	3.2 mm x 1,050 mm x C	15.2
(b) Pipe & tube	4.5 x 1,050 x C	15.2
(c) Cold rolled sheet & coil	2.7 x 1,000 x C	14.4
(d) G.I. sheet	2.3 x 930 x C	13.4
(e) Tin plate	2.0 x 930 x C	13.4

(5) Operation conditions

1) Hot strip mill

Operation conditions are the same for stage I and stage II.

Table 13-10-4 Operation condition of rolling

		Time	Remarks
1) Calendar time	A	8,760 hr/y	24 hr/d x 365 d/y
2) Scheduled suspension			
a) Annual maintenance		120 hr/y	24 hr/d x 5 d/y
b) Periodical maintenance		918 hr/y	18 hr/w x 51 w/y
	B	1,038 hr/y	
3) Time to work	C	7,722 hr/y	A − B
4) Operating ratio	D	72 %	
5) Operating time	E	5,560 hr/y	C x D

2) Hot shearing line

Table 13-10-5 Operation condition of shearing line

		Time	Remarks
1) Calendar time	A	8,760 $^{hr/y}$	24 $^{hr/d}$ x 365 $^{d/y}$
2) Scheduled suspension	B		
(1) Annual maintenance		72 $^{hr/y}$	24 $^{hr/d}$ x 3 ^{d}
(2) Sunday		1,248 "	24 $^{hr/w}$ x 52 $^{w/y}$
(3) Periodical maintenance		510 "	10 $^{hr/chance}$ x 51 $^{chance/y}$
(4) Lunch time		659 "	{3 x (365–3–52) – 51} x 0.75^{hr}
		Total 2,489 "	
3) Time to work	C=A–B	6,271 $^{hr/y}$	
4) Operating ratio	D/C	78%	
5) Operating time	D	4,891 $^{hr/y}$	

13-10-3 Equipment plan

(1)

1) Layout

Considering such future processes as HCR (hot charge rolling) or CC-DR (CC-hot direct rolling), the hot mill plant shall be constructed as close to the continuous casting plant as possible. According to this layout the continuous casting plant and the hot mill plant can be directly connected by extending the reheating furnace approach table.

As for hot strip mill layout, one rolling line has the capacity to satisfy the production at the stage II (1,721 × 10$^{3t/y}$, hot coil base); that is to say, its line length will meet the production requirements at the stage II and each equipment will be extended according to the increase of the products.

2) Slab yard

The slab yard in the hot strip mill plant is designed as a prerequisite to receive and store the slabs which were cut in width, in length, and conditioned in the continuous casting plant.

Transported to the slab yard of the hot strip mill plant by trailer, the slabs are stored at a specified storage place after being carried by the slab yard's overhead cranes. The gantry crane, which shall be installed close to the furnace approach table delivers the slabs to the furnace approach table.

3) Reheating furnace equipment

The number of reheating furnaces is to be 2 units for stage I, and 3 for stage II, con-

sidering the operation condition and construction cost of the reheating furnaces.
The type of reheating furnace is specified as the walking beam type for skid mark reduction, and to reduce faults on surface of back.
In general, the fuel for the reheating furnaces shall be a mixture of blast furnace gas and coke oven gas.
In stage I, the gas supply to the reheating furnaces may be cut off when the blast furnace operation stops and the gas balance is affected.
In this case, equipment for heavy oil supply shall be applied. Furthermore, this equipment is designed to be able to operate 2 months before the blast furnace start-up.

4) Roughing mill equipment

A roughing mill may be either a continuous type, a semi-continuous type, or a three-quarter type. As for this hot strip mill equipment, the semi-continuous type of roughing mill is specified in consideration of capacity, quality, and equipment cost.
This means that a unit of reversing mill shall be installed in stage I and, in stage II, one more reversing mill shall be provided (totally, two reversing mills shall be used).

5) Finishing mill equipment

In stage I, 6 stands of finishing mill equipment shall be installed in consideration of stable quality (temperature and shape, etc) of products.
The same equipment shall be used in stage II and, therefore, extension of stands or increase of motor power is not necessary.
Work roll changing equipment shall be used to enhance the working ratio.
As for the quality aspects, AGC equipment shall be installed to improve the accuracy of the strip gauge.

6) Coiler

Since the coilers are used under very severe operating conditions (high temperature, humidity, high velocity or strong shock, etc), the coilers may suffer frequent troubles, or require frequent maintenance.
To maintain stable operation of coilers, the number of coilers to be installed is specified as 2 units in stage I, 3 units in stage II.

7) Coil yard

Since coils are cooled, stored and transported in eye-horizontal state, overhead cranes with a C-type hook shall be used. 20^t coil buggies shall be used for the transportation between coil bays.

8) Hot shearing line

The hot shearing line comprises coil supply equipment, uncoiler, side trimmer, shear, leveller, and piler. There are a few types of shear, such as up-cut shear, flying shear and die shear.

For this hot shearing line, a flying shear shall be used to keep dimensions highly accurate and productivity high. The products will be bound while they are transported from a piler to the next section by chain conveyor.

If the products need to be packed with paper or metal, the packing shall be performed off-line.

9) Number of main equipments at the stage I and stage II.

Table 13-10-6 Number of main equipment at the stage I and II

Line	Main equipment	Stage I	Stage II *
Rolling line	Reheating furnace	2	1
	Rougher	1	1
	Finishing mill	6	0
	Down coiler	2	1
Finishing line	Cutting line	0	1

* Additional equipment

(2) Main equipment specifications

Table 13-10-7 Main specification

	Equipment	Stage I		Stage II	
		Quantity	Main specification	Quantity	Main specification
1.	Reheating facility				
(1)	Reheating furnace	2	Capacity: 140 t/hr/each Type: Walking beam type	1	Same as left
(2)	Slab pusher	2	Motor driven rack pinion type	1	Same as left
(3)	Slab extractor	2	Up-down motion by oil pressure Motor-driven running	1	Same as left
2.	Roughing mill facility				
(1)	VSB	1	Motor power: AC 1,000 kw Speed: 70 mpm Roll size: $1{,}100^{\phi} \times 500^{\ell}$	—	
(2)	No. 1 Rougher	—		1	Mill type: 4 high-reverse Motor power: DC 4,00 kw Speed: 75/150 mpm Roll size: WR: $950^{\phi} \times 1{,}450^{\ell}$ BUR: $1{,}350^{\phi} \times 1{,}450^{\ell}$
(3)	No. 1 Edger	—		1	R_1 front edger Motor power: DC 1,000 kw Roll size: $850^{\phi} \times 450^{\ell}$
(4)	No. 2 Rougher	1	Mill type: 4 high-reverse Motor power: DC 5,500 kw Speed: 135/270 mpm Roll size: WR: $950^{\phi} \times 1{,}450^{\ell}$ BUR: $1{,}350^{\phi} \times 1{,}450^{\ell}$	—	
(5)	No. 2 Edger	1	R_2 front edger Motor power: DC 1,000 kw Roll size: $850^{\phi} \times 450^{\ell}$	—	

	Equipment	Stage I		Stage II	
		Quantity	Main specification	Quantity	Main specification
3.	Finishing mill facility				
(1)	Crop shear	1	Type: Drum type rotary shear Capacity: Max. 30 $^{mm(t)}$	—	
(2)	Finishing mill	6	Mill type: 4 high-tandem mill Stand: 6 Motor power: $F_1 \sim F_5$: DC 5,000^{kw} F_6: DC 4,500^{kw} Speed: Max. 950 ^{mpm} Roll size: WR: 750$^{\phi}$ x 1,450$^{\ell}$ BUR: 1,350$^{\phi}$ x 1,450$^{\ell}$	—	
(3)	Roll quick changing device	6	WR quick changing device	—	
4.	Runout table & strip cooling equipment	1	Strip cooler: Laminar flow type	—	
5.	Coiler	2	Type: 3-wrapper roll Mandrel dia.: 760$^{\phi}$ Motor power: DC 450^{kw}	1	Same as left
6.	Auxiliary equipment				
(1)	Roll grinder	2	for R-WR, BUR F-WR, BUR	2	Same as left
(2)	Pump	3 4 5	Descaling pump Booster pump Scale pit pump	1	Descaling pump
(3)	Compressor	3	Air compressor	2	Air compressor
(4)	Transfer car	1 1	Roll transfer car Coil transfer car	2	Coil transfer car

	Equipment	Stage I		Stage II	
		Quantity	Main specification	Quantity	Main specification
(5)	Coil conveyor	1	from coiler to coil yard (Approx. 220 m)	1	Same as left (Approx. 120 m)
(6)	Crane	17		10	
7.	Hot shearing line	—		1	Thickness: 1.2 ~ 6.35 mm Length: 2 ~ 6 m Line speed: 106 m/min Main equipment: Uncoiler, side trimmer, flying shear, leveller, piler
8.	Area of main buildings		Approx. 63 thous. m^2		Approx. 25 thous. m^2
9.	Capacity of slab yard		Approx. 20 thous. t for 7 days		Approx. 34 thous. t for 7 days
10.	Capacity of coil yard		Approx. 29 thous. t for 10 days		Approx. 40 thous. t for 10 days

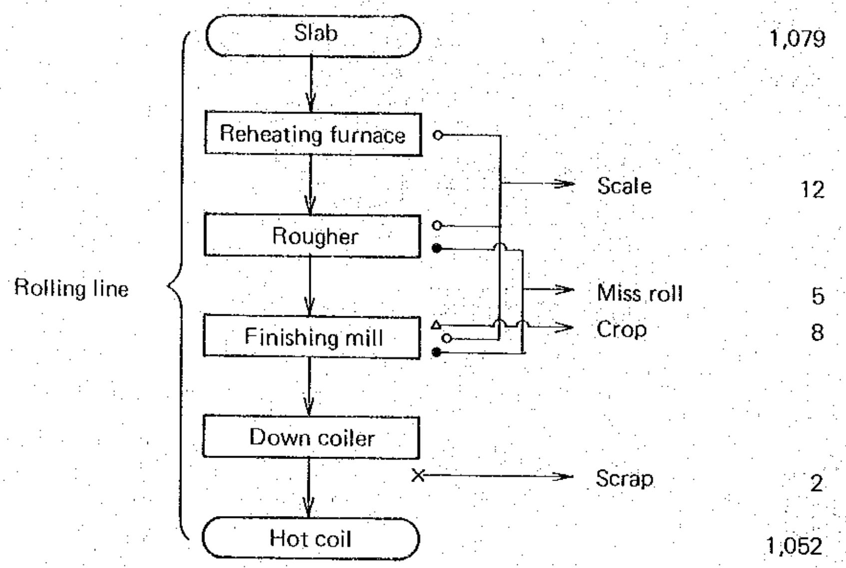
Note 1. Number of units for stage II means additional number.
Note 2. Some of these main specifications might be revised when they are designed in detail.

(3) Process flow

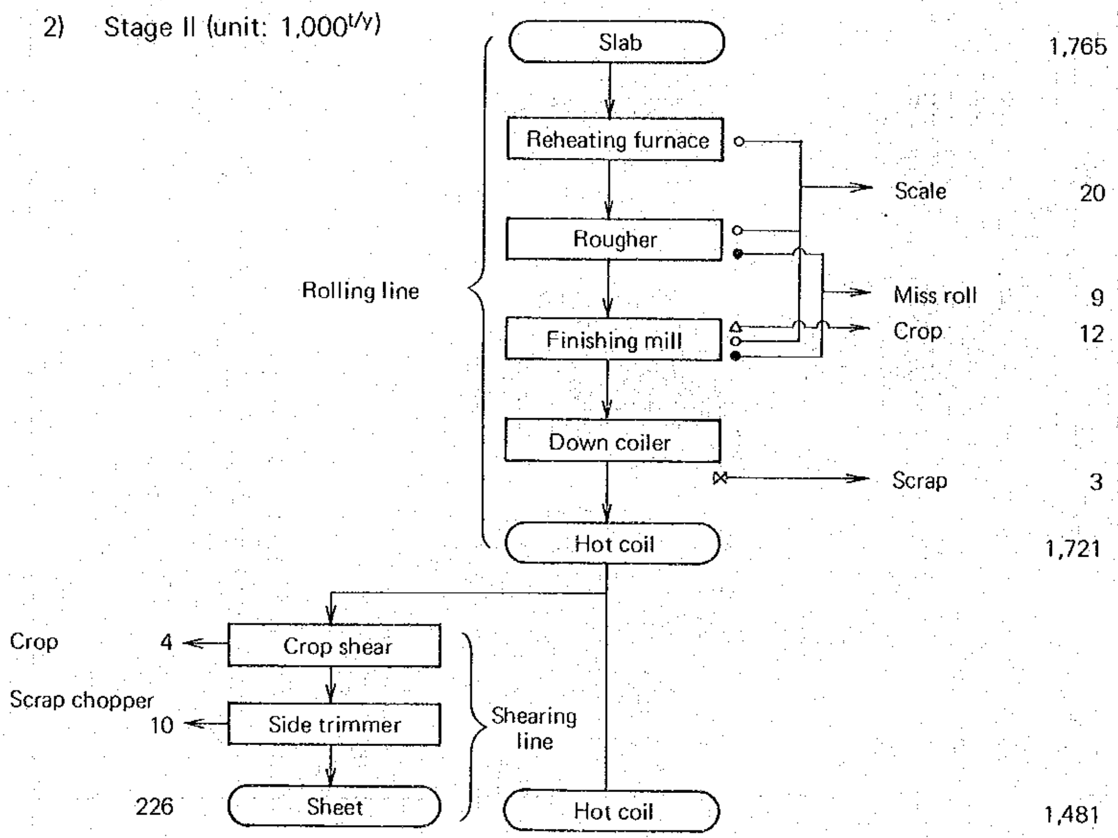
See appendix, *Fig. 13-10-1* (hot strip mill), and *Fig. 13-10-2* (hot shearing line).

(4) Balance of raw material and products

1) Stage I (unit: $1,000^{t/y}$)



2) Stage II (unit: $1,000^{t/y}$)



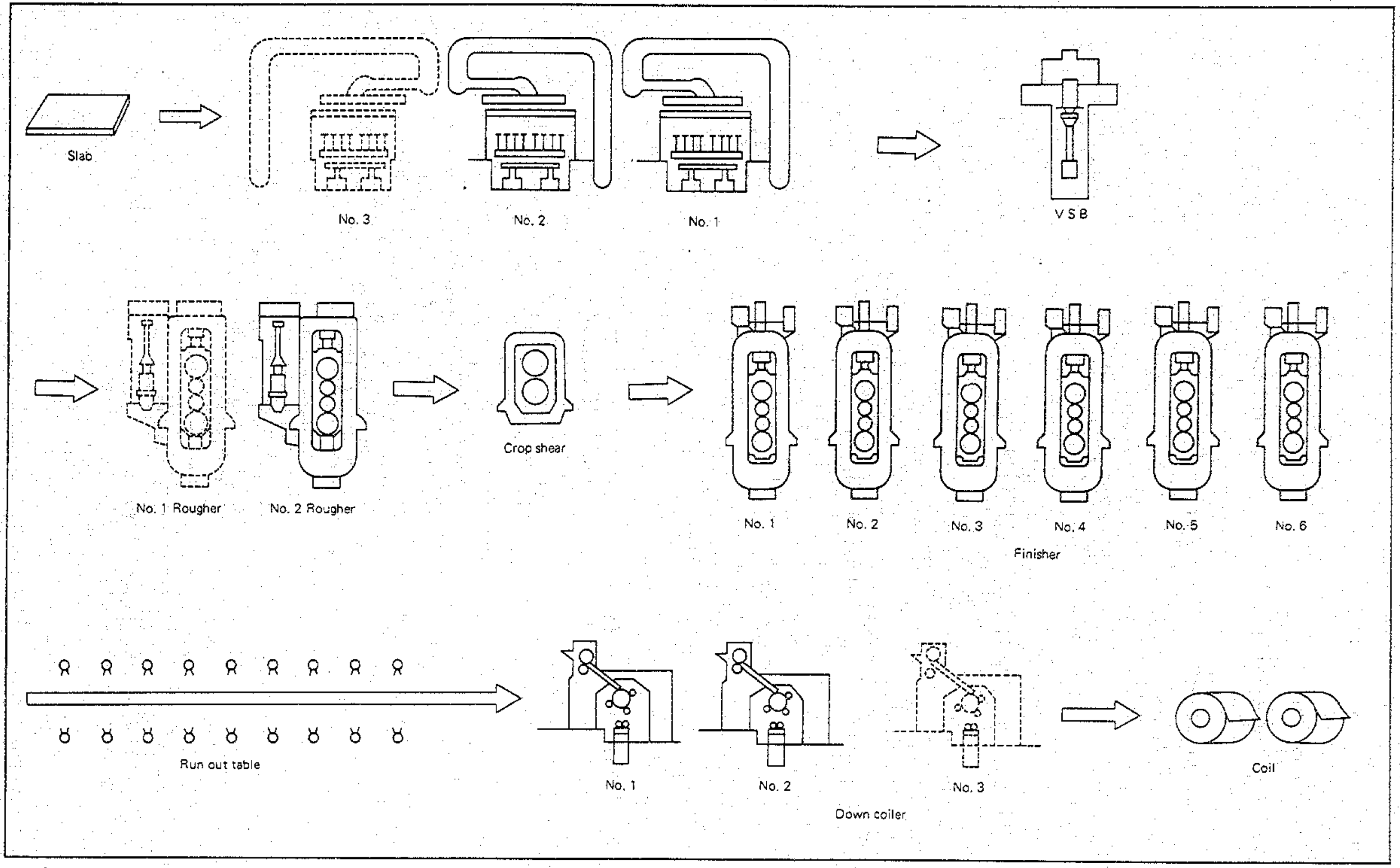


Fig. 13-10-1 Process flow of hot strip mill

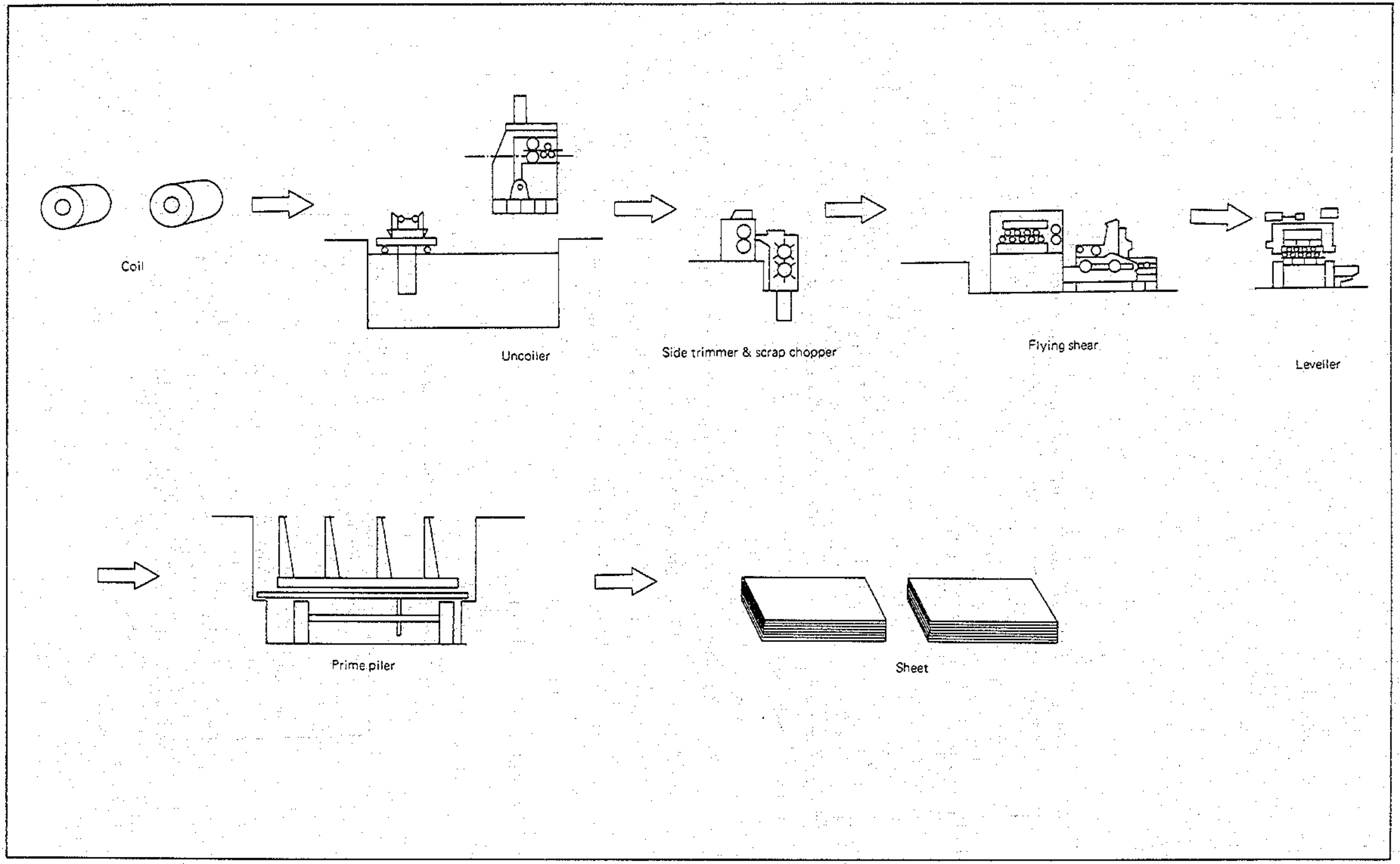


Fig. 13-10-2 Process flow of shearing line

(5) Equipment layout

Fig. 13-10-3.

(6) Others

1) Utility

Table 13-10-8 Utility consumption unit

Item	Consumption unit	General consumption	
		Stage I	Stage II
Mix gas	200 Nm^3/t	210 mil Nm^3/y	360 mil. Nm^3/y
Water	4 m^3/t	4.2 mil m^3/y	7.2 mil m^3/y
Treated water	0.2 m^3/t	210 thous. m^3/y	360 thous. m^3/y
Steam	12 kg/t	13 thous. t/y	22 thous. t/y
Electric power	110 kw/t	116 mil. kwh/y	198 mil. kwh/y

Note 1: Approximate consumption rate and volume of fresh water indicate those of make up.

2: Since heavy oil may be used for emergency purposes in stage I, its consumption is not listed in this table.

3: Nitrogen gas is used for purging mixed gas when furnace maintenance is being performed. The amount shall be approximately $1{,}500^{Nm^3/hr} \times 2^{hr}$.

2) Generation of by-products

Table 13-10-9 By-product generation

(Unit: 1,000 t/y)

Line	By-product	Stage I	Stage II
Hot rolling	Scale	12	20
	Crop	8	12
	Miss roll	5	9
	Scrap	2	3
Shearing	Crop	—	4
	Scrap chopper	—	10

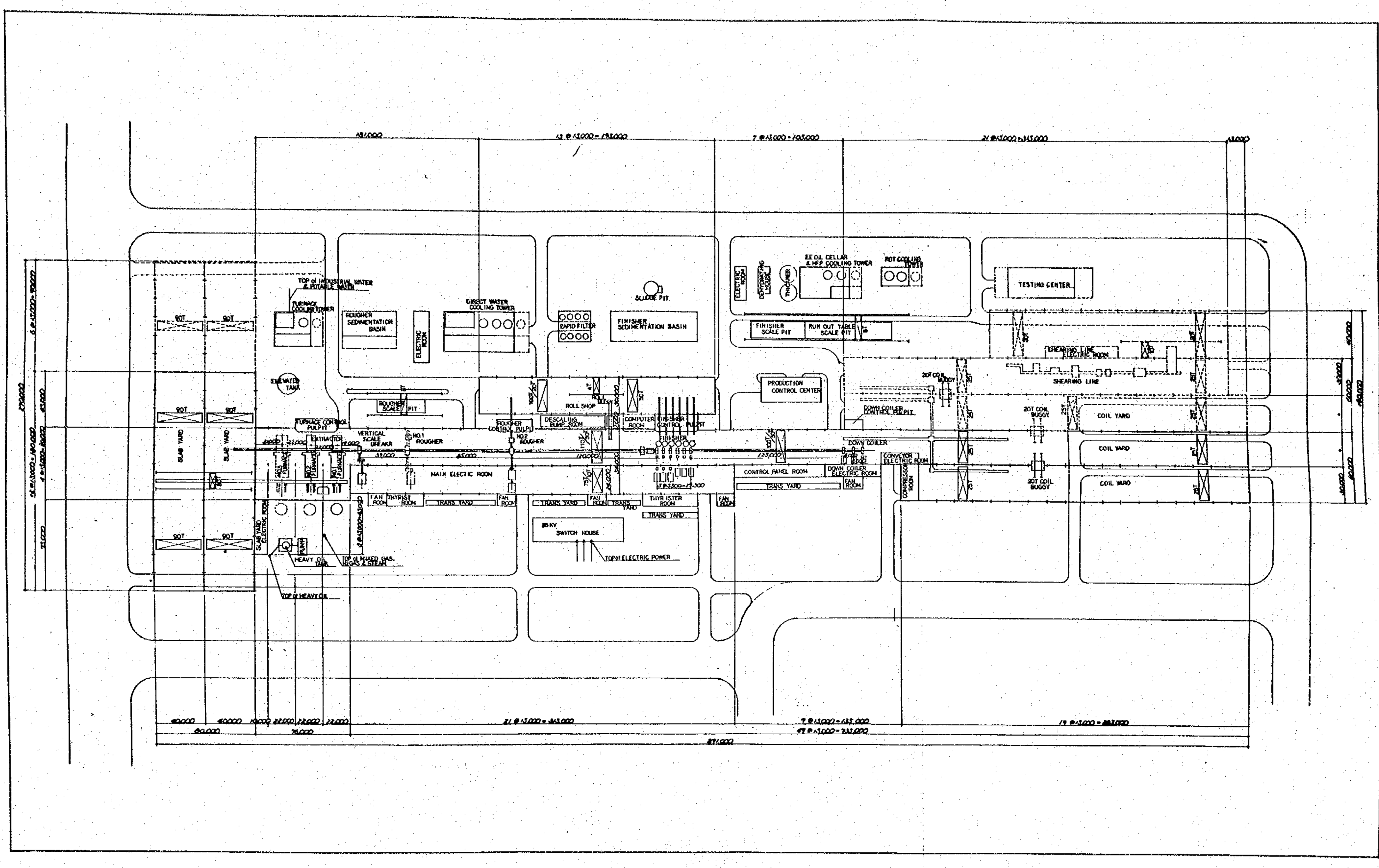


Fig. 13-10-3 Hot strip mill layout

13-10-4 Technical explanation

(1) Mill width

As mentioned in chapter 3 of the demand forecast study, 96.5% of the demand for mill product is less than 4 feet wide. Under consideration of investment cost and running cost, it is thought most profitable that the plant shall produce products less than 4 feet in size, and the hot strip mill width was decided to be "56" in this study.

(2) Unit weight of slab

In the Philippines, the unit weight of slab has been max. 10 to 14^t for hot coil receiving. However, each facility is being studied to accept larger unit weight of coil to improve productivity and yield in the future.

This attitude completely coincides with the world trends. Unit weight of hot coil that is produced in the hot strip mill of the new steelworks shall be max. 800 piw so that modification of each established facility of users can be minimized.

Accordingly, unit weight of slab shall be max. 18.7^t.

(3) How to determine slab thickness.

Once unit weight of slab is decided, slab thickness can be selected from the relation of slab length.

Thus, the relation of slab unit weight (piw), slab thickness (T) and slab length (L) can be presented as PIW = K (T × L) K: Fixed proportional ratio.

When slab unit weight is 800 piw, the relation of slab thickness and slab length is shown in *Fig. 13-10-4.* Slab thickness must be selected most adequately, considering the aspects of slab quality in the continuous casting plant and of rolling capacity

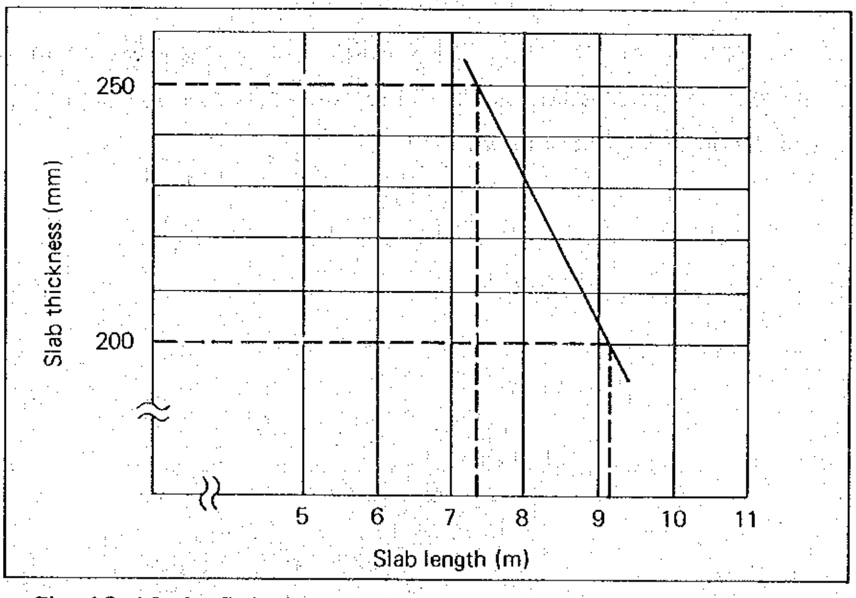


Fig. 13-10-4 Relationship between slab thickness and length

of the roughing mill facility, and also of the facility investments. To minimize investment in facilities in stage I, the roughing mill facility in stage I shall be one reversing mill. We studied slab thickness, considering stable rolling capacity that can be provided by only one roughing mill unit. *Table 13-10-10* shows the results of the studies.

Table 13-10-10 Study of slab thickness decision

Slab thickness	200^{mm}	230^{mm}	250^{mm}
1. Study item			
1) Slab unit weight (PIW)	800	800	800
2) Slab length (m)	9.2	8.0	7.4
3) Slab width (mm)	1,000		
4) Slab temperature (°C)	1,250		
5) Roll dia. (mm)	950		
6) Max speed (mpm)	270		
2. Study item			
1) Slab quality	O	O	O
2) Capacity of rougher			
a) Number of pass	7	9	9
b) Rolling t/hr	O (220)	X (190)	X (170)
3) Investment for Stage I	O (1 stand)	X (2 stands)	X (2 stands)
Total estimation	O	X	X

If the slab thickness is in the range ($200-250^{mm}$) as was studied in this project, the quality of slab can be considered as acceptable from the viewpoint of continuous casting techniques of Japan as well as the world.

If PIW is fixed, slab thickness is considered as the main element to determine rolling capacities of hot strip mill and roughing mill equipment and facility cost (number of stands). *Fig. 13-10-5* shows the results of studying slab thickness and passing times theoretically and operationally.

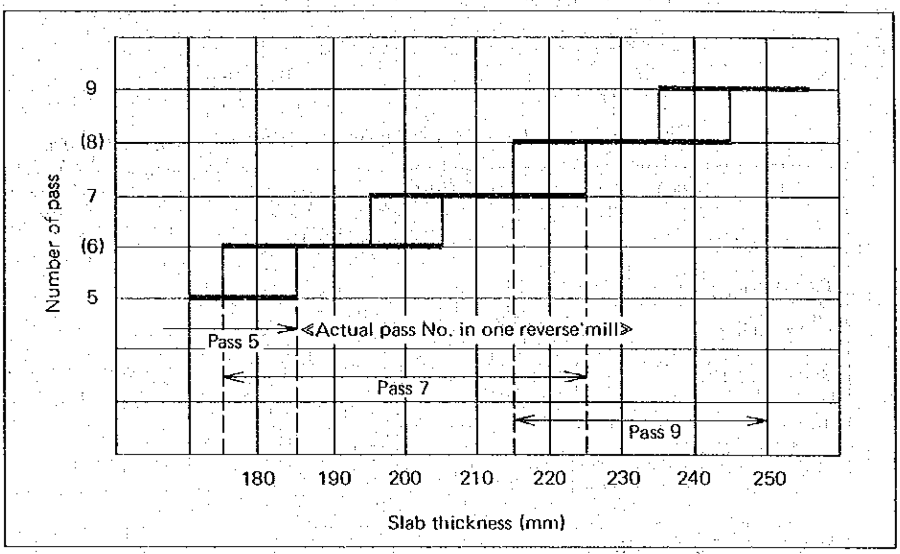


Fig. 13-10-5 Relationship between number of pass and slab thickness

Fig. 13-10-5 shows clearly that the number of passings in a roughing mill increases directly with slab thickness. In this study, a slab of more than 220^{mm} needs 9 passing times and rolling capacity (t/hr) and temperature become difficult to maintain. Therefore slab thickness 200^{mm} that can allow seven passings through a roughing mill and can attain stable roughing mill operations is recommendable in this study.

(4) Production capacity

① Rolling line

Table 13-10-11 Production capacity of rolling line

Item	Unit	Stage I	Stage II
Time to work	hr/y	7,722	7,722
Operating ratio	%	72	72
Yield	%	97.5	97.5
Average t/hr	Slab t/hr	219	330
Hot mill capacity	t/y	1,187 x 10^3	1,789 x 10^3
Amount of required production	t/y	1,052 x 10^3	1,721 x 10^3

Rolling line capacity

Stage I

$219^{t/hr} \times 0.975 \times 7{,}722^{hr/y} \times 0.72 = 1{,}187{,}000^{t/y}$

Stage II

$330^{t/hr} \times 0.975 \times 7{,}722^{hr/y} \times 0.72 = 1{,}789{,}000^{t/y}$

② Shearing line (Stage II)

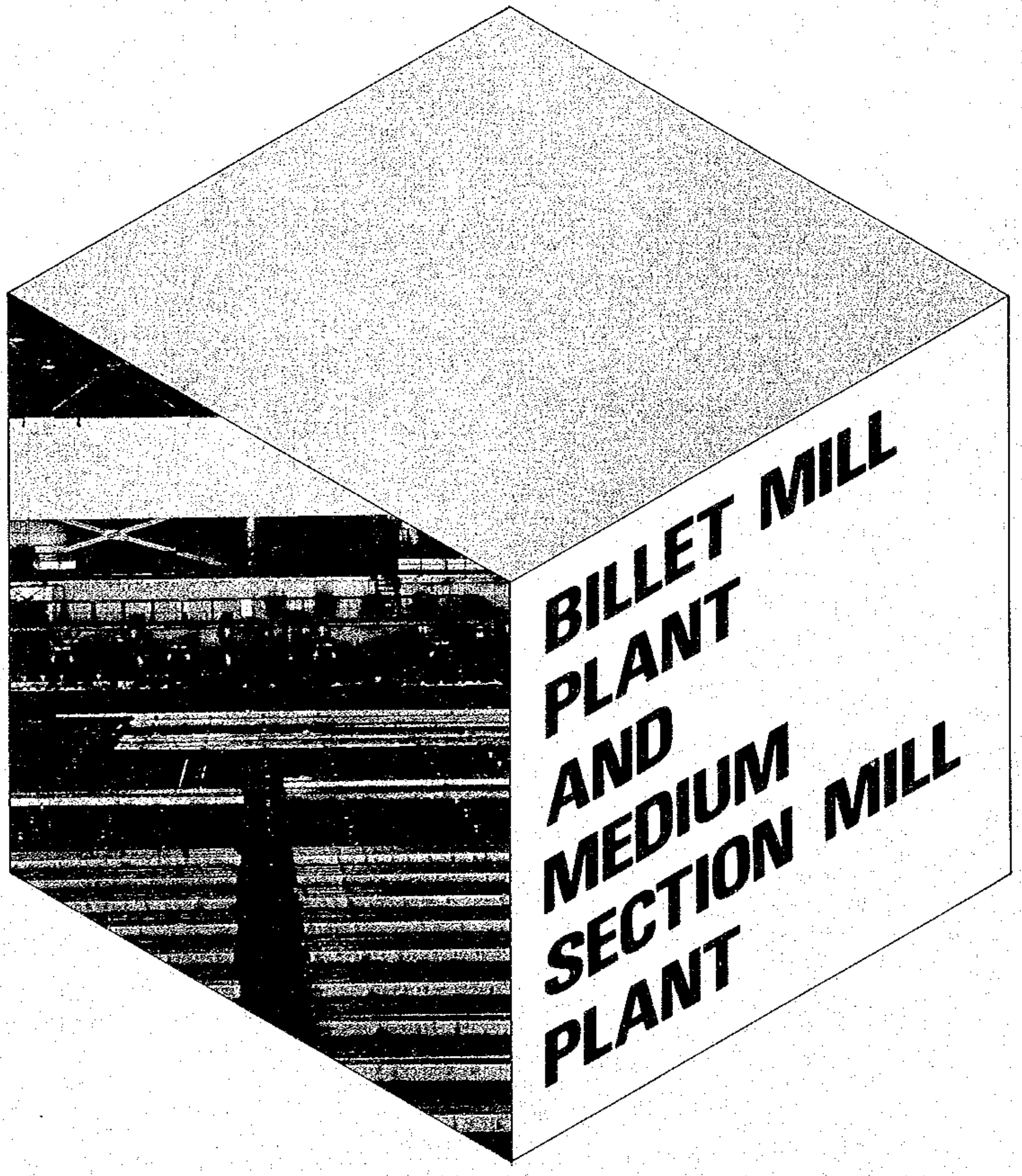
Table 13-10-12 Production capacity of shearing line

Item	unit	Stage II	Remarks
Time to work	hr/y	6,271	
Operating ratio	%	78	
Shear yield	%	94	
Average t/hr	Coil t/hr	58	Average size when 3.2 x 1,050 x 3,000
Line production capacity	thous. t/y	266	
Required processing amount	thous. t/y	226	

Shearing line capacity

$58^{t/hr} \times 0.94 \times 6{,}271^{hr/y} \times 0.78 = 266{,}000^{t/y}$

CHAPTER 13-11



13-11 Billet mill and Medium section mill

13-11-1 General

In stage I, a billet mill of 150,000 tons in annual billet production shall be constructed.
The billet mill, however, shall be so designed as to serve as a roughing mill of a medium section mill which is to be constructed in stage II.
This is because the billet mill in stage I and the medium section mill in stage II are almost similar in productivity and the equipment capacities (for reheating and rolling) and the rolling process.
Hence, it is believed that the plan presented should bring about the most economical billet manufacturing process, from the viewpoint of a whole investment cost at the time of stage I and stage II. In stage II, the above-mentioned medium section mill of 186,000 tons in annual production, using the billet mill (the rougher) of stage I, and another billet mill of $630{,}000^t$ in annual billet production shall be constructed. The new billet mill shall be located next to the medium section mill.
The outlines of the plants are given below.

(1) Billet mill (stage I)

The billet mill (stage I) shall be provided with a single rolling stand, that can produce annually $150{,}000^t$ of billets (135^{ϕ} and 100^{ϕ}) from the blooms which are produced $156{,}000^t$ per year at the continuous casting plant.

The continuously cast $6{,}100^{mm}$-long blooms are transported by trailer to the material yard and then, cut into two pieces each 3050^{mm} in length by a gas cutter.

Those divided blooms are delivered onto the approaching table timingly to the furnace operation for charging into the reheating furnace, by a EOT crane with lifting magnets.

The fuel for a reheating furnace shall use a mixture of BFG and COG, and a heavy oil combustion system shall also be provided for emergency such as shut-down of blast furnace or in shortage of the gases.

A hot bloom is processed five or seven passes at a three-high rolling stand, rolled into a billet of 135ϕ or 100ϕ, and sheared into the specific sizes of billet by a hot shear.

After being cooled on the cooling bed, the billets are bound up into a specified form of packing and shipped by trailer.

(2) Medium section mill (Stage II)

The medium section mill shall be constructed by adding the medium section manufacturing facilities at the successive line of the billet mill built in Stage I. The medium section mill, consisting of a rougher and a train of finishers, shall produce 186,000 tons per year of sections such as angles, I-beams, channels, round bars, etc. from the blooms (200φ) which are produced 200,000^t per year at the continuous casting plant.

In the same way as in the billet mill in stage I, 6,100^{mm} length of bloom is devided into 2 pieces 3,050 mm each, by means of a gas cutting device and then charged into the reheating furnace.

The heated bloom is broken down into a semi-finished sections specified the three-high roughing mill and then rolled into various forms of sections in the successive continuous finishing train.

The bars which are rolled and finished longer than the effective length (80^m) of the cooling bed will be cut into a proper length for cooling process by a flying shear which are located immediately after the continuous finishing train.

The said cooling is followed by the processes of the long sized bar cooling, the long sized bar straightening, and shearing into the specific size.

The sections, after being sheared, are automatically bound into various forms of packing for shipment.

(3) Billet mill (stage II)

From the blooms that are manufactured in the continuous casting facilities with 656,000^t of an annual production rate, the billet mill at stage II shall produce 630,000^t of billet (135φ and 100φ and 50φ) by a roughing mill and a six stand continuous finishing train. This continuously cast bloom (200φ × 6,100L) is transported to the material yard by trailer.

The bloom heated by two reheating furnaces is rolled into 135φ, 100φ and 50φ of billets by using a two-high reversing roughing mill and a six stand continuous finishing train which is alternately arranged with vertical and horizontal stand.

The rolled billets are devided to a specified length by a hot shear or a hot saw and then bound in a specified pack for shipment.

13-11-2 Preconditions

(1) Production plan

1) Billet mill (stage I)

The length of all billets produced in the billet mill at stage I is specified at 6^m (5 times a base length of 1.2^m). Since the temperature difference between the top and tail portions of rolled sections affect the quality of sections, the unit weight of a bloom is specified at less than 1.0^t.

Table 13-11-1 shows the dimensions and production plan of billets.

Table 13-11-1 Production plan

Bloom dimensions		Billet dimensions		Bloom processing amount	Billet production	Yield	Ratio
Cross-section area x length (mm²) (mm)	Unit weight (kg)	Cross-section area x length (mm²) (mm)	No. of billet blooms	(t/y)	(t/y)	(%)	(%)
200$^{\phi}$ x 3,050	952	135$^{\phi}$ x 6,000	1	37,440	36,000	96	24
		100$^{\phi}$ x 6,000	2	118,560	114,000	96	76
Total				156,000	150,000	96	100

2) Medium section mill (stage II)

Product mixture of the medium section is assumed by refering to the actual rate recently reported in Japan. *Table 13-11-2* shows the dimensions and production plan of medium sections.

Table 13-11-2 Production plan

Bloom dimensions		Finished product dimensions	Bloom processing Amount	production	Yield	Ratio
Cross-section area x length (mm) (mm)	Unit weight (kg)	(mm)	(t/y)	(t/y)	(%)	(%)
200$^{\phi}$ x 3,050	952	∢ 50 x 50 ~ ∢100 x 100	141,400	131,500	93	70.7
		[75 x 40 ~ [100 x 50	33,200	30,900	93	16.6
		I 100 x 75	400	400	93	0.2
		ϕ 25 ~ 50	25,000	23,200	93	12.5
Total			200,000	186,000	93	100

3) Billet mill (stage II)

The length of all finished billets is specified at 6^m (5 times a base length of 1.2^m). Since this mill produces billets exclusively, the length of bloom is specified at 6^m, considering the productivity and yield of the plant.

Table 13-11-3 shows the dimensions and production plan of billets.

Table 13-11-3 Production plan

Bloom dimensions		Billet dimensions		Bloom processing amount	Billet production	Yield	Ratio
Cross-section area x length (mm²) (mm)	Unit weight (kg)	Cross-section area x length (mm²) (mm)	No. of billet blooms	(t/y)	(t/y)	(%)	(%)
200$^{\phi}$ x 6,100	1,904	135$^{\phi}$ x 6,000	2	37,500	36,000	96	5.7
		100$^{\phi}$ x 6,000	4	520,600	500,000	96	79.4
		50$^{\phi}$ x 6,000	16	97,900	94,000	96	14.9
Total				656,000	630,000	96	100

(2) By-products

Generated by-products include scales collected in scale pit, crops and miss-rolled scraps, or faultily rolled scraps. *Table 13-11-4* shows the by-product of each mill.

Table 13-11-4 Quantity of by-product

Item \ Stage / Plant	Stage I	Stage II	
	Billet mill	Medium section mill	Billet mill
Scale (t/y)	3,000	4,000	13,000
Scrap (t/y)	3,000	10,000	13,000
Total (t/y)	6,000	14,000	26,000

(3) Unit consumption and annual consumption

Table 13-11-5 shows unit consumption and annual consumption of main utilities under normal operation.

Table 13-11-5 Specific consumption

Item	Stage I		Stage II			
	Billet mill plant		Medium section mill		Billet mill plant	
	Unit consumption	Annual consumption	Unit consumption	Annual consumption	Unit consumption	Annual consumption
Oxygen	1.7 Nm^3/t	255 x 10^3 Nm^3/y	1.7 Nm^3/t	316 x 10^3 Nm^3/y	–	–
LPG	0.04 Nm^3/t	6 x 10^3 Nm^3/y	0.04 Nm^3/t	7.4 x 10^3 Nm^3/y	–	–
Mixture gas	200 Nm^3/t	30 x 10^6 Nm^3/y	200 Nm^3/t	37 x 10^6 Nm^3/y	200 Nm^3/t	126 x 10^6 Nm^3/y
Electric power	75 kWh/t	11.3 x 10^6 Kwh/y	100 kWh/t	18.6 x 10^6 kWh/y	31.2 kWh/t	20.2 x 10^6 kWh/y
Water	2.0 m^3/t	300 x 10^3 m^3/y	3.7 m^3/t	688 x 10^3 m^3/y	1.4 m^3/t	882 x 10^3 m^3/y
Potable water	0.06 m^3/t	9 x 10^3 m^3/y	0.07 m^3/t	13 x 10^3 m^3/y	0.02 m^3/t	12.6 x 10^3 m^3/y

(4) Operating conditions

Table 13-11-6 shows the operating conditions of each mill.

The difference between the workable time and the rolling time includes delay time such as, roll changing, caliver changing, inspection and adjustment, troubles, waiting for heating up, etc.

Table 13-11-6 Operation conditions

Item		Stage I	Stage II		Remarks
		Billet mill plant	Medium section mill	Billet mill	
Calender time (A)		8,760 hr/y	8,760 hr/y	8,760 hr/y	24 hr/d x 365 d/y
Scheduled down time	Capital maintenance	336 hr/y	336 hr/y	336 hr/y	24 hr x 14 d
	Periodic maintenance	368 hr/y	368 hr/y	368 hr/y	8 hr x 4 times/month x 11.5 month/y
	Sub-total (B)	704 hr/y	704 hr/y	704 hr/y	
Workable time (C)		8,056 hr/y	8,056 hr/y	8,056 hr/y	(A) – (B)
Rolling time (D)		5,500 hr/y	4,800 hr/y	5,200 hr/y	
Working ratio (E)		68 %	60 %	65 %	(D) / (C)
Operating ratio (F)		63 %	55 %	59 %	(D) / (A)

13-11-3 Equipment specifications

(1) Billet mill (stage I)

1) Bloom storage

1) Since the bloom transported from the continuous casting plant is 6,100^{mm} long, a hand cutting device shall be prepared in the building so as to cut the bloom into two parts.

(2) The bloom shall be arranged and stored charge by charge and its storage capacity is assumed to be sufficient for approx. 10 days (approx. 5,700^{t}) of rolling operation.

2) Reheating furnace

(1) There are two types of continuous reheating furnace for heating 200ф blooms; pusher type and walking type.
In this plan, the pusher type is selected considering the overall assessment of steel grade to be heated, operation and maintenance of furnace, and investment cost.

(2) The capacity of a reheating furnace is specified at 30 tons per hour which is sufficient for the billet production plan of stage I.
Since the billet mill is to be replaced by the medium section mill in stage II, the capacity of a reheating furnace is so designed to attain easily a heating capacity of 45$^{t/h}$ which is required by the medium section mill.

(3) The fuel for heating the bloom in a reheating furnace shall be a mixture of BFG and COG.
However, a heavy oil combustion system shall also be installed for emergency purposes.

3) Rolling facilities

(1) Determination of billet rolling mill types requires a full study of the billet size, production rate, operation maintenance aspects, investment cost, etc. In this plan, a three-high rolling mill is selected for the reasons described below.
(a) The required rolling capacity is small.
(b) The numbers of the required passing and the numbers of pass series are relatively small.
(c) The initial investment cost can be reduced.

(2) *Table 13-11-7* shows the rolling capacity when 200ф blooms are rolled into 135ф and 100ф billets.
Rolling facilities are planned to meet the required capacity for the medium section mill in stage II.

Table 13-11-7 Rolling capacity

Bloom dimensions (mm²) x (mm)	Billet dimensions (mm²) x (mm)	No. of billets/ bloom	No. of passes	Rolling capacity (t/hr)	Production ratio (%)
200^{ϕ} x 3,050	135^{ϕ} x 6,000	1	5	59	24
	100^{ϕ} x 6,000	2	7	45	76
Total				48	100

4) Shearing and cooling facilities

(1) One set of stationary, motor-driven, down-cut type shear shall be installed after billet mill to shear the rolled billet into specified length of 6^{m}.

The maximum shearing capacity is limited to shear the 135^{ϕ} billet.

(2) For the type of cooling bed, there are the pusher type, the walking-type and the rotating type.

The pusher type is selected for this project because the billet length is fixed at 6^{m} and the initial equipment cost can be minimized.

(2) Medium section mill (stage II)

The medium section mill shall be constructed in stage II, by installation of the sections manufacturing facilities at the rear of the billet mill ($150{,}000^{t/y}$) built in stage I.

1) Reheating furnace

The basic specification of the reheating furnace is essentially the same as the one described for billet mill in stage I.

However, a combustion device shall be installed as expansion equipment to increase the reheating capacity from $30^{t/h}$ to $45^{t/h}$ according to the increase of the production quantity.

2) Rolling equipment

The rolling facilities installed in stage I shall be used in stage II also.

10 stands of the section rolling mill placed in continuous tandem arrangement shall be at the rear of the roughing mill facilities to roll sections of each size ($186{,}000^{t/y}$).

Table 13-11-8 shows the rolling capacity for typical size of sections.

Table 13-11-8 Rolling capacity of each representative size

Representative size (mm)	Production (t/y)	Ratio (%)	Yield (%)	Rolling quantity (bloom) (t/y)	Rolling capacity (t/hr)	Time required for rolling (hr/y)
50 x 50 x 4 (angle)	82,400	44.3	93	88,600	40	2,215
75 x 75 x 6 (angle)	26,600	14.3	93	28,600	45	2,475
100 x 100 x 10 (angle)	22,500	12.1	93	24,200	45	
100 x 50 x 5 (channel)	31,250	16.8	93	33,600	45	
ϕ 36	23,250	12.5	93	25,000	45	
Total	186,000	100	93	200,000	42.6	4,690

3) Dividing shear

One set of flying shear shall be installed behind the section finishing rolling equipment to cut off the finished rolled bars whose length is longer than the effective length of the cooling bed (80^m).

4) Cooling, straightening and shearing facilities

The working processes such as cooling of long sized bar → straightening of long sized bar → shearing into specified length are carried out to improve the working efficiency of cooling, straightening and shearing of the sections.

Considering to increase the cooling efficiency, the single side skew roller type cooling bed of $90^m \times 12^m$ is adopted in this plan.

One unit of cantilever type multi-roll straightener shall be installed behind the cooling bed and a set of stationary motor drive crank type shear shall be also adopted to shear products into a specified length.

5) Piling and binding device

The piling device and two automatic binding machines for packing of the section products are installed at the back side of the inspection bed.

(3) Billet mill (stage II)

1) Reheating furnace

Two sets of $75^{t/h}$ pusher type continuous reheating furnaces are installed to reheat the 200ϕ × 6,100 L blooms ($656,000^{t/y}$) to the optimal temperature.

2) Rolling mill

A two-high reverse roughing mill and six vertical-horizontal stand arrangement continuous billet mills shall be installed as the rolling mill for rolling the heated blooms into billets of each size, considering economy, operatability, and quality. *Table 13-11-9* shows the rolling capacity of each size.

Table 13-11-9 Rolling capacity of billet

Billet size (mm^2)	Billet production (t/y)	Yield (%)	Bloom rolling quantity (t/y)	Rolling capacity (t/hr)	Time required for rolling (hr/y)	Remarks
135$^{\phi}$	36,000	96	37,500	150	3,720 (135$^{\phi}$ and 100$^{\phi}$ combined)	
100$^{\phi}$	500,000	96	520,600	150		
50$^{\phi}$	94,000	96	97,900	75	1,305	
Total	630,000	96	656,000	130.5	5,025	

3) Shearing facilities

A stationary shearing facilities is installed to eliminate troubles in the continuous billet mill by shearing the defective portions of top and tail of semi-product rolled by a roughing mill. To shear the rolled billet in the continuous billet mill to the specified length, flying shear equipment and stationary hot shear shall be installed. Shearing capacity of the flying shear equipment is maximum 100$^{\phi}$ of billets with consideration of economical condition.

Hot saw is adopted for cutting 135$^{\phi}$ billets for possible production of large-sized round bars in the future.

4) Cooling and finishing facilities

A pusher-type billet cooling bed is selected because of the steel grade, cross-section and length of the billet and investment cost and maintenability.

Piling and binding devices are installed behind the cooling bed because of the restrictions on billet transportation.

Table 13-11-10 shows the equipment specifications of the billet mill (stage I) and medium section mill (stage II).

Table 13-11-11 shows the equipment specifications of the billet mill (stage II).

Fig. 13-11-1 shows the process flow of the billet mill of stage I and medium section mill of stage II, and *Fig. 13-11-2* shows the process flow of billet mill (stage II).

Fig. 13-11-3 shows the overall layout of the billet mill and medium section mill

Table 13-11-10 Equipment specifications for billet mill (stage I and medium section mill plant)

Number	Equipment	Stage I		Stage II	
		Quantity	Specifications	Quantity	Specifications
1	Bloom yard				
(1)	Bloom cutter	4 units	Type: Portable cutter Capacity: 100 m/min.	1 unit	The same as on the left
(2)	LPG source equipment	1 set	Type: LPG bottle packaged Capacity: 50 kg bottle x 20 P	—	
2	Heating facility				
(1)	Reheating furnace	1 unit	Type: Pusher type continuous reheating furnace Capacity: 30 t/hr. Fuel: Mixture gas Effective hearth area: 3.2 m x 25 m	—	Capacity: 45 ton/hr
(2)	Recuperator	1 unit	Type: Stack type metallic recuperator	—	
(3)	Pusher	1 unit	Type: Motor-driven rack pinion	—	
(4)	Extractor	1 unit	Type: Up-down motion (Oil-pressure) Traverse (motor-driven)	—	
(5)	Furnace front table	1 set	Type: Motor roller Table length: Approx. 42 m	—	
3	Roughing mill facility				
(1)	Roughing mill	1 unit	Type: 3-high mill Roll dimensions: 700 dia x 2,100 L Revolution of roll: 90 r.p.m Motor: AC 2,000 kW x 1 unit	—	
(2)	Shear	1 unit	Type: Motor-driven down cut Capacity: Max. 135 ϕ	—	
(3)	Tilting table	2 units	Type: Table: Motor-driven line shaft Tilting: Motor-driven lever type	—	
(4)	Front or back table of mill	1 set	Type: Motor roller	—	

Number	Equipment	Specifications			
		Quantity	Stage I	Quantity	Stage II
4	Finishing mill				
(1)	Rolling mill	——		10 units	Type: Continuous 2-high mill Roll dimensions: 600 dia. x 1,000 L Motor: DC 500 kW x 10 units
(2)	Flying shear	——		1 unit	Type: Motor-driven crank type
5	Billet cooling				
(1)	Cooling bed	1 unit	Type: Pusher type Area: 6 m x 15 m x 1 unit	——	
(2)	Delivery transfer	1 unit	Type: Chain transfer with dock	——	
(3)	Piler	1 unit	Type: Lifting magnet crane	——	
(4)	Binding machine	1 unit	Type: Automatic wire binding machine	——	
(5)	Delivery transfer	1 unit	Type: Chain transfer with dock	——	
(6)	Delivery bed	1 set	Type: Fixed skid	——	
6	Section steel cooling and finishing facility				
(1)	Cooling bed run-in table	——		1 set	Type: Motor-roller (Adjustable) Table length: Approx. 110 m
(2)	Cooling bed	——		1 unit	Type: Skew roller type Area: 12 m x 90 m
(3)	Cooling bed run-out table	——		1 set	Type: Motor roller Table length: Approx. 95 m
(4)	Straightener	——		1 unit	Type: Cantilever multi-roller type
(5)	Transfer	——		1 unit	Type: Rope transfer Area: 5 m x 90 m
(6)	Shear	——		1 unit	Type: Motor-driven crank type
(7)	Inspection and piling bed	——		1 unit	Type: Chain transfer (Attached with mechanical piling machine) Area: 7.5 m x 20 m x 2 units

Number	Equipment	Specifications of equipment			
		Quantity	Stage I	Quantity	Stage II
(8)	Binding machine	——		4 units	Type: Automatic wire binding machine
(9)	Delivery transfer	——		2 units	Type: Rope transfer with dock
7	Crane				
(1)	Bloom recieving cutting	2 units	Type: EOT lifting magnet type Capacity: 5^t	——	
(2)	Bloom delivery	2 units	Type: EOT lifting magnet type Capacity: 5^t	——	
(3)	Rolling mill yard	1 unit	Type: EOT hook type Capacity: $30^t/5^t$	1 unit	The same as on the left
(4)	Roll shop	1 unit	Type: EOT hook type Capacity: 15^t	1 unit	″ Capacity: $20^t/5^t$
(5)	Billet delivery	1 unit	Type: EOT lifting magnet type Capacity: 5^t	——	
(6)	Cooling straightening shearing yard	——		1 unit	Type: EOT hook type Capacity: 5^t
(7)	Product yard	——		3 units	Type: EOT beam type Capacity: 7.5^t
(8)	Scale lifting crane	1 unit	Type: Glove basket type Capacity: 2^t	——	

Table 13-11-11 Equipment specifications of billet mill (stage II)

Equipment	Quantity	Specifications
1 Reheating equipment		
1) Reheating furnace	2 units	Type: Pusher type continuous reheating furnace Capacity: 75 t/hr x 2 units Fuel: Mixutre gas Effective hearth area: 6.3 ^{m} (W) x 25 ^{m} (L)
2) Recuperator	2 units	Type: Stack type metallic recuperator
3) Pusher	2 units	Type: Motor-driven rack pinion type
4) Extractor	2 units	Type: Up-down motion (Oil-pressure), traverse (motor-driven)
5) Furnace front bed	1 unit	Type: Rope transfer Area: 6 m x 20 m
6) Furnace front table	1 set	Type: Motor roller Table length: Approx. 45 m
2 Rolling mill facility		
2-1 Roughing mill		
1) Roughing mill	1 unit	Type: Reversing 2-high mill Roll dimensions: 700 dia. x 2,100 L Motor: DC 2,500 kW x 1 unit
2) shear	1 unit	Type: Motor-driven down cut type Capacity: Max. 165 ф
3) Manipulator	2 units	Type: Motor-driven rack pinion type
4) Mill front and back table	1 set	Type: Motor roller
5) Shear front and back table	1 set	Type: Motor roller
2-2 Billet mill		
1) Rolling mill	6 units	Type: 2-high mill Vertical type: 3 units Horizontal type: 3 units Roll dimensions: 500 dia. x 1,000 L Motor: DC 500 kW x 6 units
2) Flying shear	1 unit	Type: Motor-driven crank type Capacity: Max. 100 ф
3) Hot saw	1 unit	Type: Motor-driven horizontal type Blade diameter: 1,400 ф
4) Hot saw front and back table	1 unit	Type: Motor roller
3 Cooling bed	2 units	Type: Pusher type Cooling bed area: 7.5 ^{m} (W) x 40 ^{m} (L) x 2 units
4 Piling and binding equipment		
1) Piler	1 unit	Type: Mechanical piling method
2) Binding machine	2 units	Type: Automatic wire binding machine
3) Delivery bed	1 unit	Type: Rope transfer Area: 7.5 ^{m} (W) x 30 ^{m} (L)

Equipment	Quantity	Specifications
5 Crane		
1) Bloom receiving crane	4 units	Type: EOT lifting magnet type Capacity: 10^t
2) Mill yard crane	3 units	Type: Overhead traveling hook type Capacity: $30^t/5^t$ x 2 units, 5^t x 1 unit
3) Roll shop crane	2 units	Type: EOT hook type Capacity: $20^t/5^t$, 15^t
4) Product yard crane	4 units	Type: EOT beam type Capacity: 7.5^t

13-11-4 Technical explanation

In order to manufacture high quality products in the billet mill and medium section mill, superior competitive design of grooves and guides, excellent maintenance and high level rolling techniques are necessary as well as the well-designed basic plan.

Since the billet mill to be constructed at stage I is the basic equipment for the operators to train how to operate the rolling equipment, the complete plan for the training and conducting schedule are necessary. The basic pass flow, the basis of the fundamental equipment plan, is shown in *Table 13-11-12* ~14 as a reference.

Table 13-11-12 Pass flow of billet (stage I)

Billet size	Bloom size	Pass number 1	2	3	4	5	6	7
100φ	200φ			T 170φ	T	T 135φ		T 100φ
135φ								

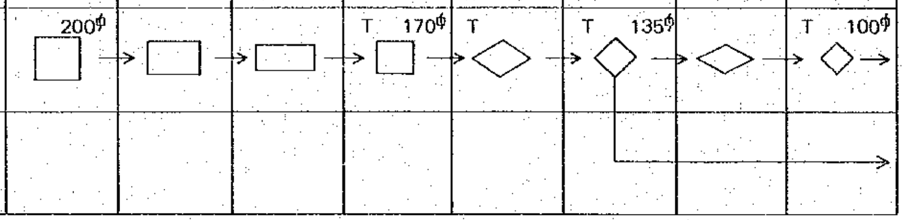


Table 13-11-13 Pass flow of sections (stage II)

Representative size	Roughing mill			Continuous section mill									
	Bloom dimensions	No. of passes	Semi-finished section	1	2	3	4	5	6	7	8	9	10
50 x 50 x 4 (angle)	200φ	7	100φ										
75 x 75 x 6 (angle)	200φ	7	100φ			—		E				—	—
100 x 100 x 10 (angle)	200φ	5	130φ			—		E				—	—
100 x 50 x 5 (channel)	200φ	5	80x150					E				—	—
φ 36	200φ	5	130φ										

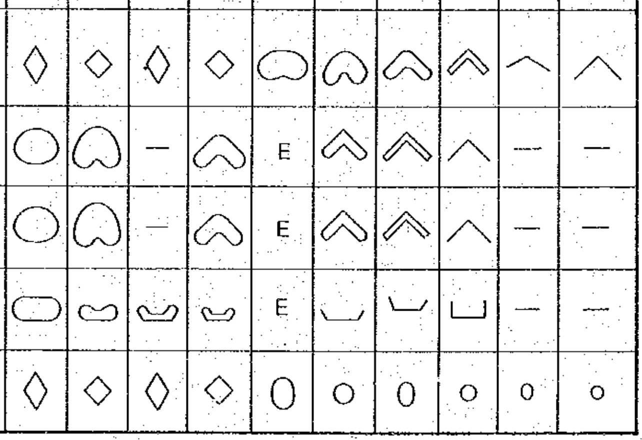


Table 13-11-14 Pass flow of billet (stage II)

Bloom size	Roughing mill							Billet mill					
	1	2	3	4	5	6	7	1	2	3	4	5	6
□ 200 ф	◇	◇	150ф ◇	◇	120ф ◇	◇	100ф ◇	◇	90 ф ◇	◇	70ф ◇	◇	50 ф ◇
			→	→	→	→	→	◇	120 ф ◇	◇	100ф ◇	—	—
□ 200ф	◇	◇	165 ф ◇	→	→	→	→	◇	135 ф ◇	—	—	—	—

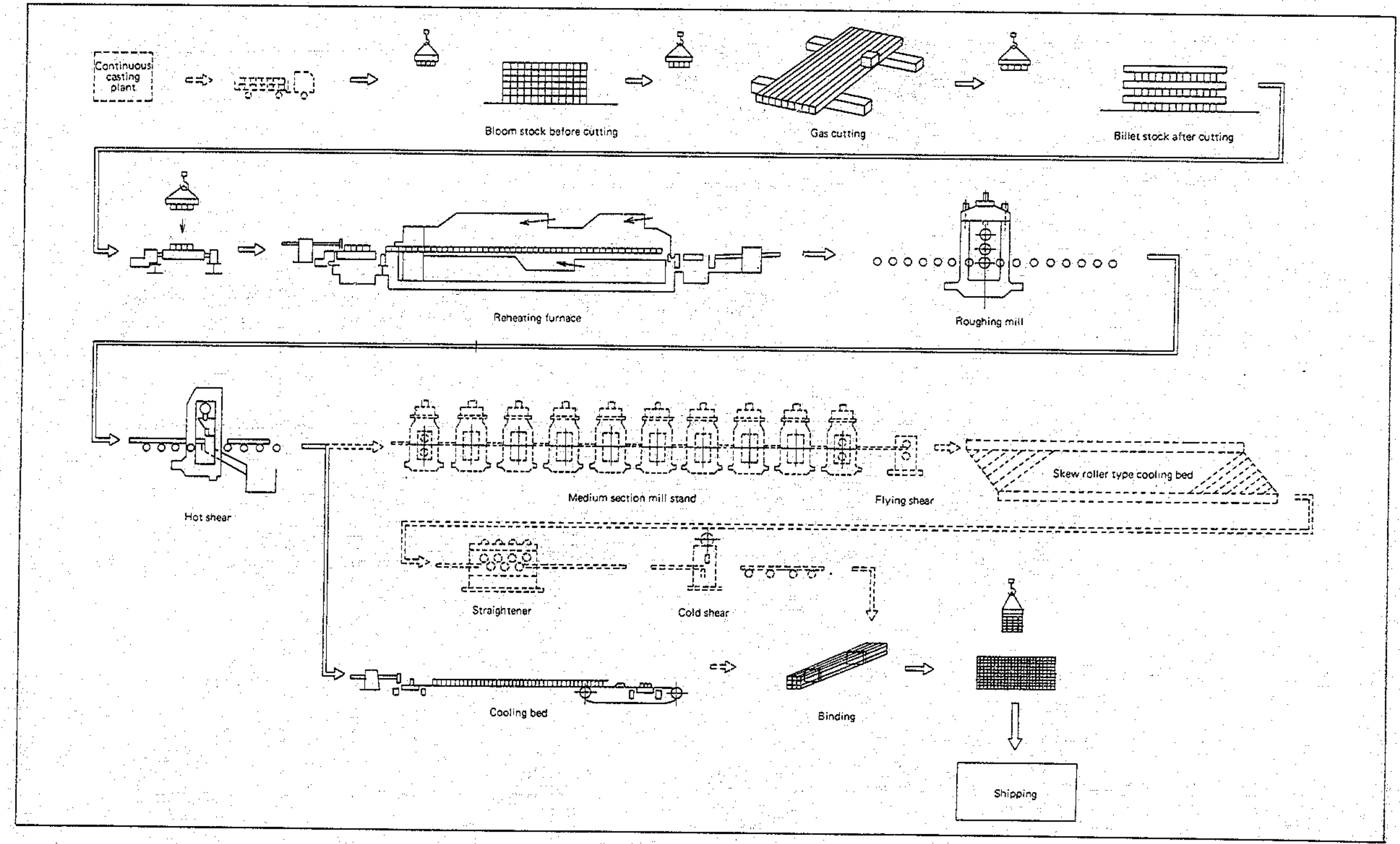


Fig. 13-11-1 Process flow of billet mill (stage I) and medium section mill (stage II)

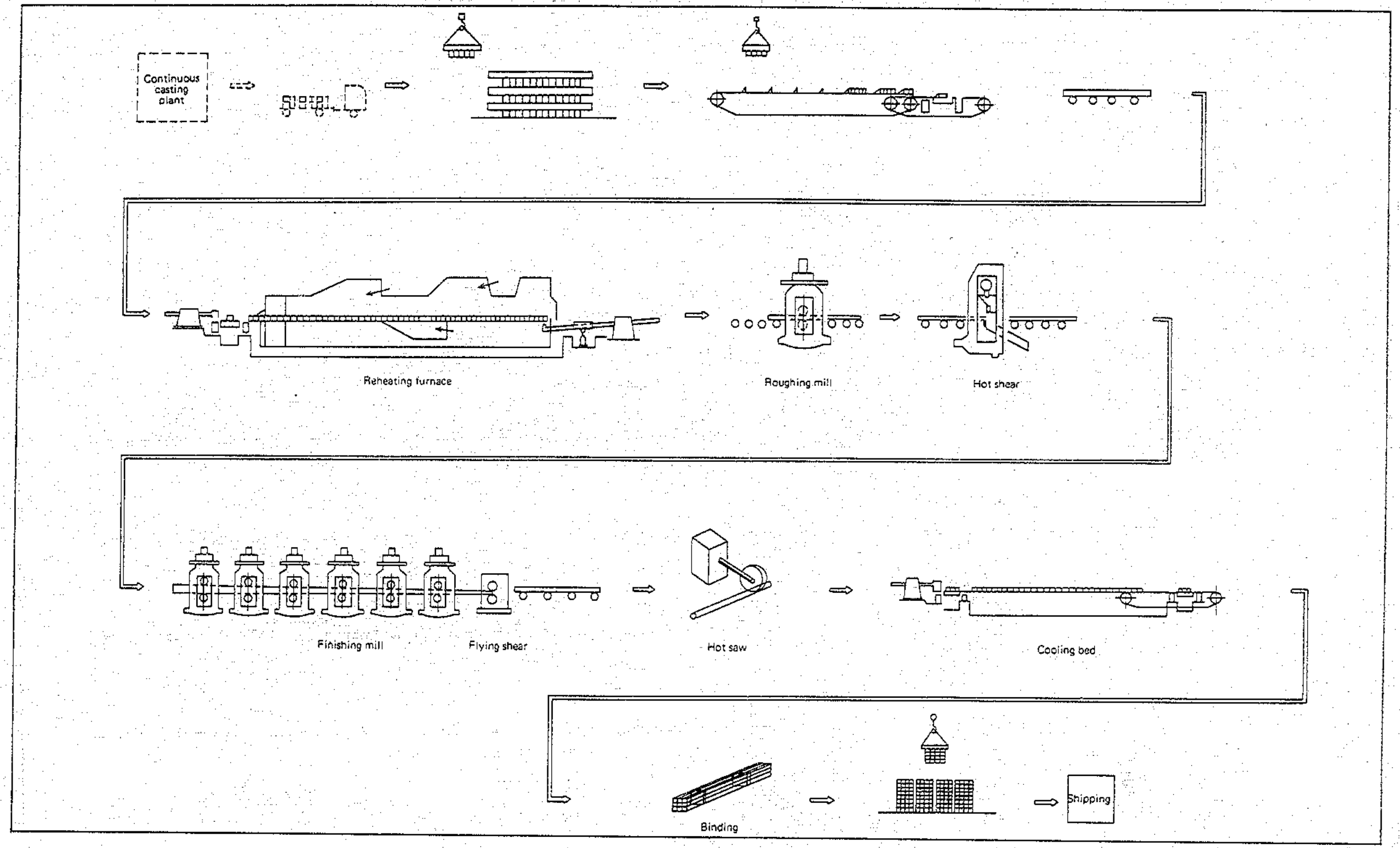


Fig. 13-11-2 Process flow of billet mill (stage II)

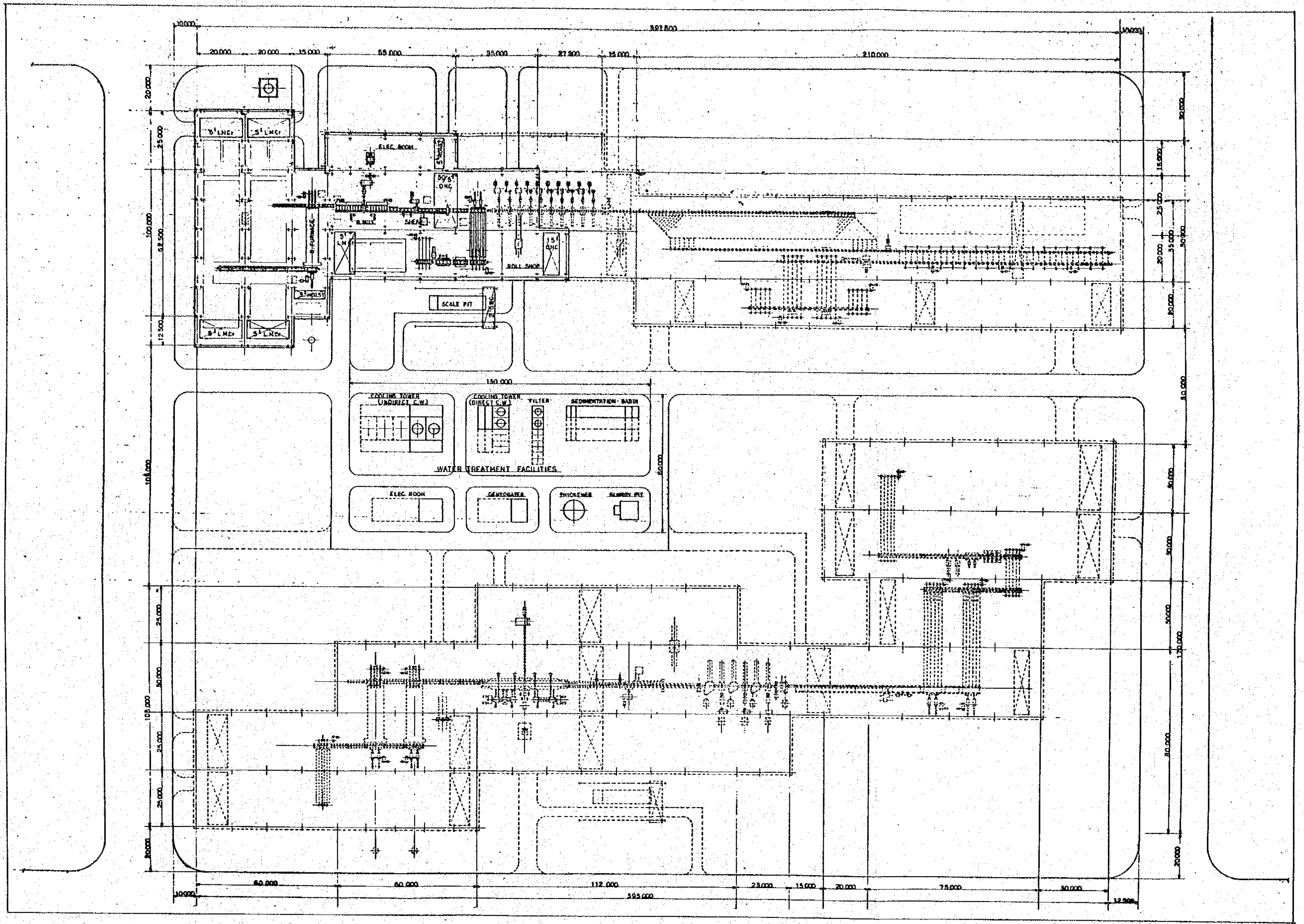


Fig. 13-11-3 Billet mill and medium section mill general layout