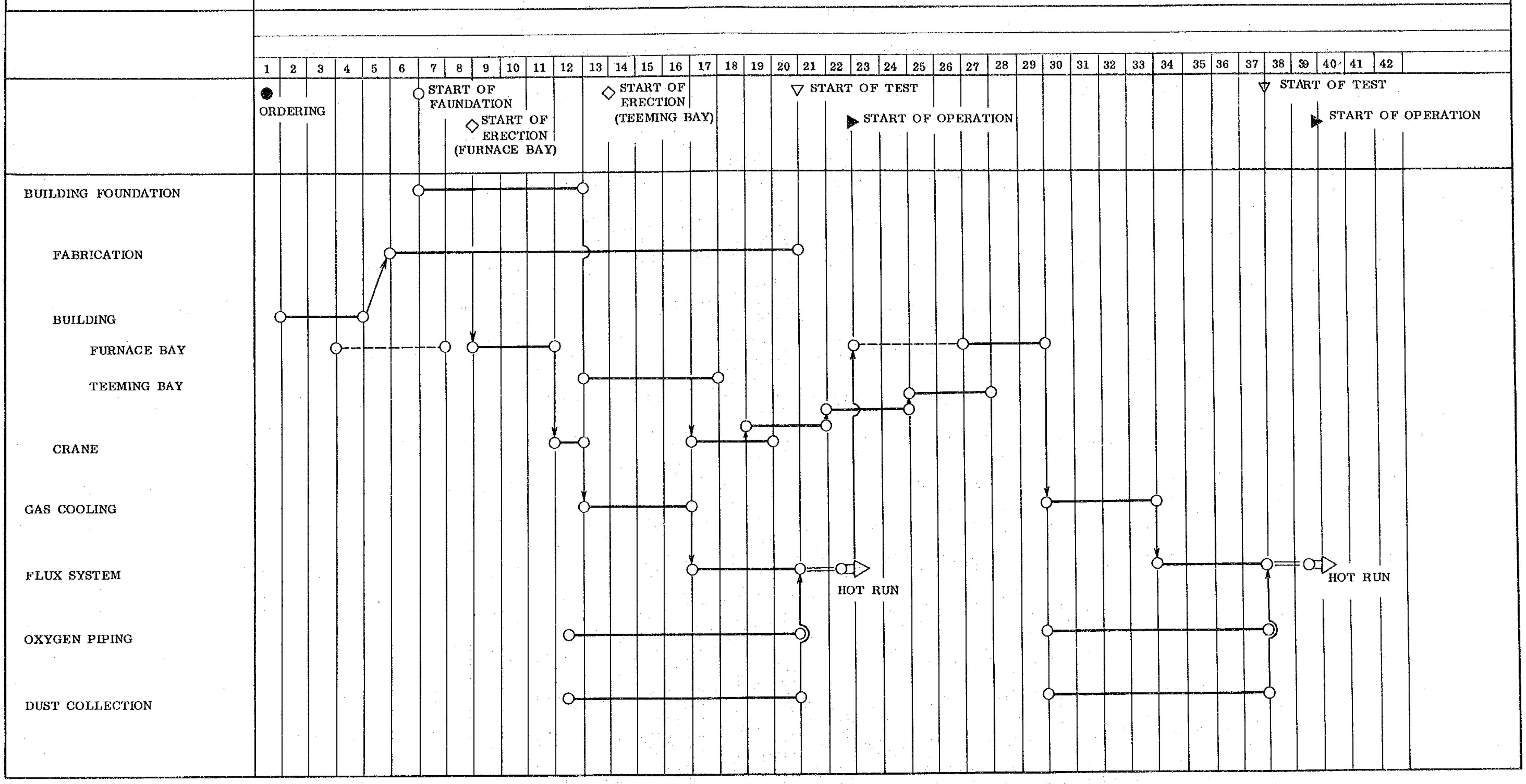
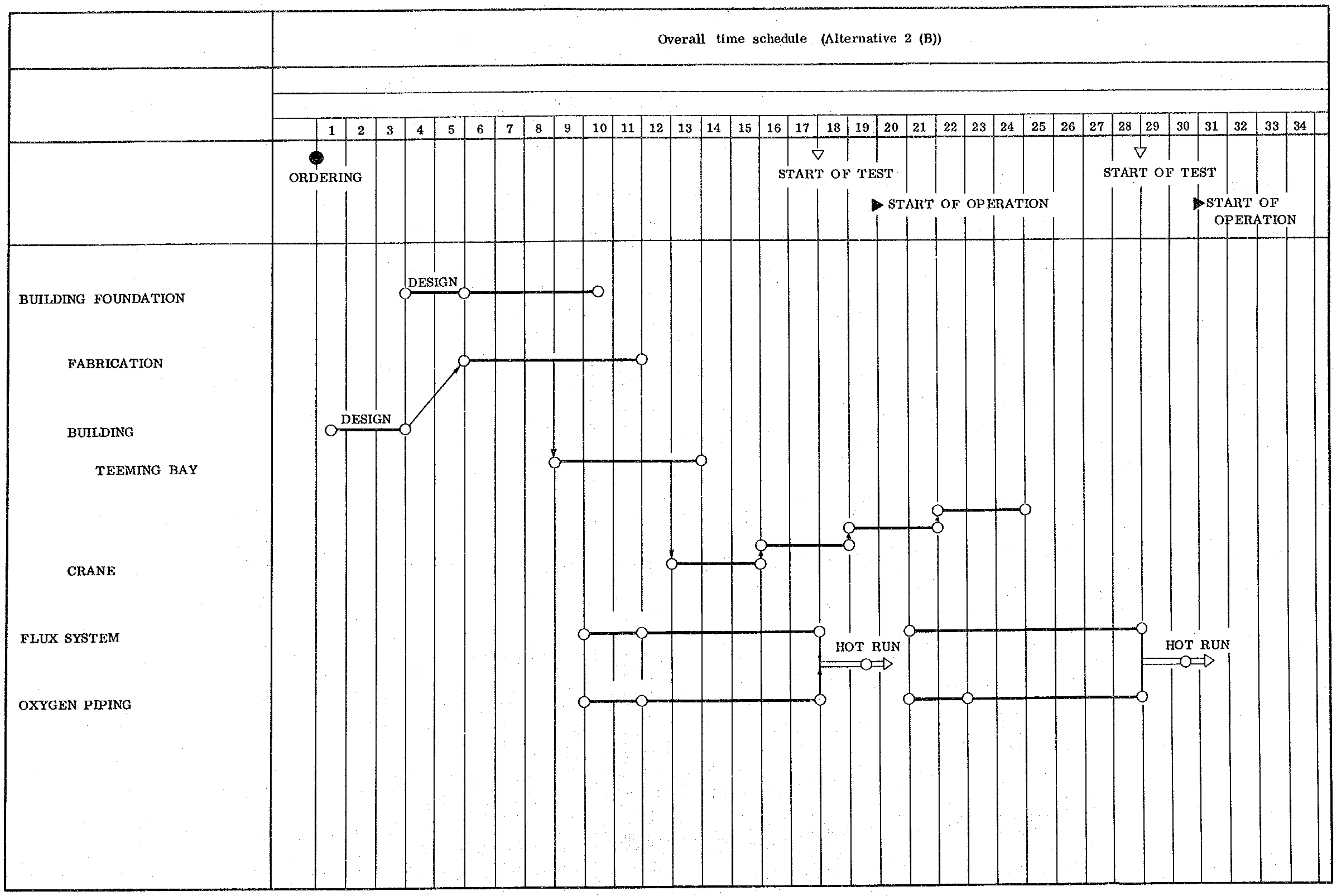
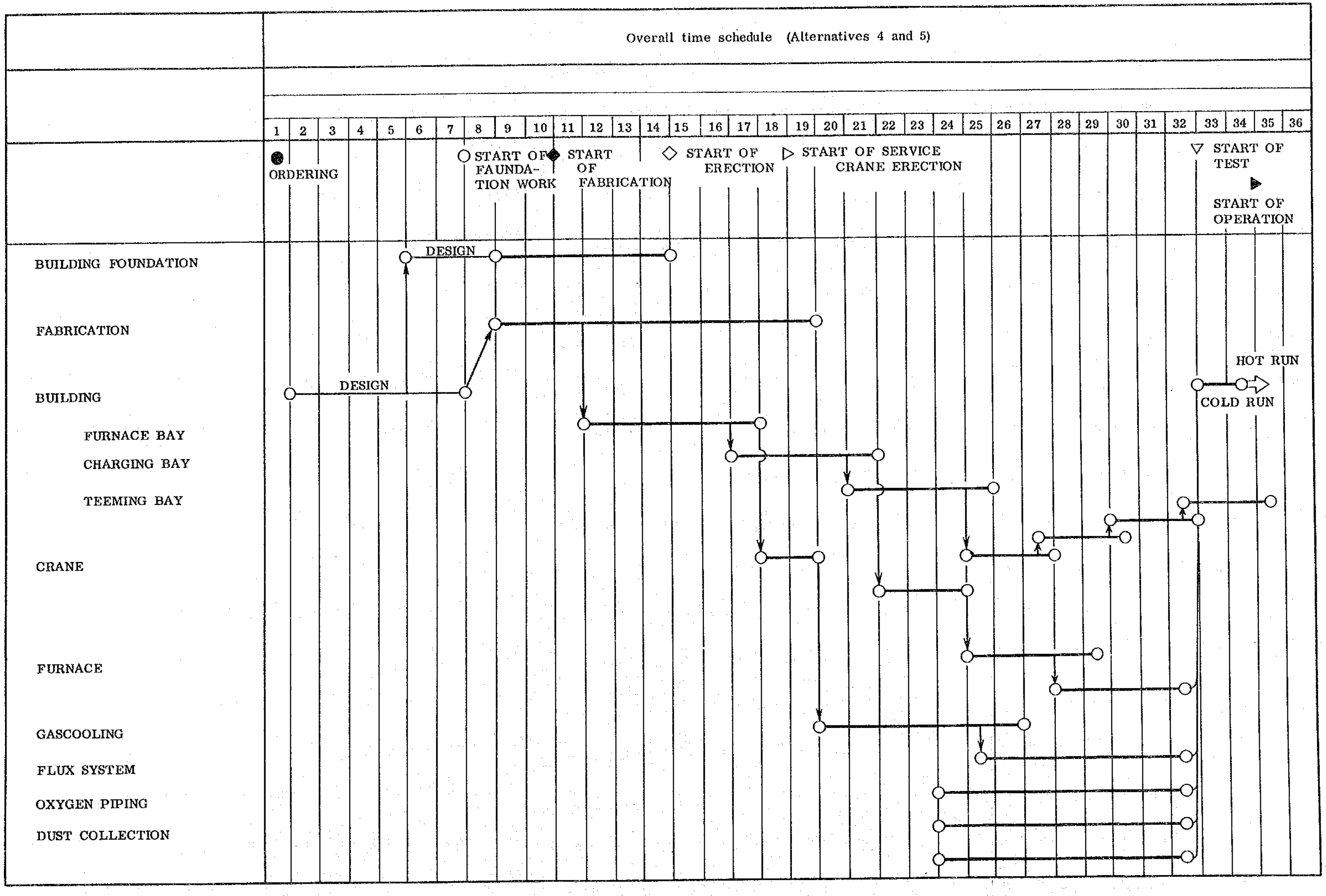
Overall, time schedule (Alternatives 2 (A) and 3)




Overall time schedule (Alternative 2 (B))
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
ORDERING
START OF TEST
START OF OPERATION
START OF TEST
START OF OPERATION
BUILDING FOUNDATION
DESIGN
FABRICATION
BUILDING
DESIGN
TEEMING BAY
CRANE
FLUX SYSTEM
HOT RUN
HOT RUN
OXYGEN PIPING


Overall time schedule (Alternatives 4 and 5)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
ORDERING
START OF FAUNDA-TION WORK
START OF FABRICATION
START OF ERECTION
START OF SERVICE CRANE ERECTION
START OF TEST
START OF OPERATION
BUILDING FOUNDATION
DESIGN
FABRICATION
BUILDING
DESIGN
HOT RUN
COLD RUN
FURNACE BAY
CHARGING BAY
TEEMING BAY
CRANE
FURNACE
GASCOOLING
FLUX SYSTEM
OXYGEN PIPING
DUST COLLECTION

6. Equipment Cost of Each Alternative

6.1 Breakdown of the equipment cost estimate of each alternative

In reviewing the equipment cost estimates, the required equipment for each alternative was chosen in accordance with the equipment items shown in Table II.1. Note that the ◯ mark in Table II.1 indicates within the scope of estimate and the — mark indicates outside the estimate.

Table II.1. Itemized list of the equipment cost estimate of each alternative

			Alternative 1	Alternative 2		Alternative 3	Alternative 4	Alternative 5
				(A)	(B)			
① Furnace-proper-related equipment	1	Furnace shell	—	—	—	Modifying top furnace portion	○	○
	2	Tilting device	—	—	—		○	○
	3	Electrical instrumentation	—	—	—	—	○	○
	4	Furnace proper bricks	—	—	—	—	○	○
	5	Brick laying	—	—	—	—	○	○
	6	Lance winch & guide	—	—	—	○	○	—
	7	Lance and flexible hose	—	—	—	○	○	—
	8	Tuyere & flexible hose	—	○	○	—	—	○
	9	Indoor oxygen piping	—	—	—	○	○	—
	10	Indoor piping for blowing	—	○	○	—	—	○
	11	Lance cooling water piping	—	—	—	○	○	—
	12	Lining breaker	—	—	—	—	○	○
	13	Furnace bottom exchange car	—	—	—	—	—	○
	14	Oxygen holder	—	○	○	○	○	○
	15	Natural gas holder	—	○	○	—	—	○
	16	N_2 gas holder	—	○	○	—	—	○

	Equipment Name		Alternative 1	Alternative 2 (A)	Alternative 2 (B)	Alternative 3	Alternative 4	Alternative 5
② Raw material-related equipment	1	Flux, ferro alloy facilities	—	○	◌ Replacing the bunker above furnace	○	○	○
	2	600t hot metal mixer	○ *1200 t	—	—	—	○	○
	3	600t hot metal mixer electrical components	○	—	—	—	○	○
	4	600t hot metal mixer bricks	○	—	—	—	○	○
	5	Hot metal mixer brick laying	○	—	—	—	○	○
	6	Hot metal weigher	○	—	—	—	○	○
	7	Scrap charging chute	—	○	○	○	○	○
	8	Scrap weigher	—	○	○	○	○	○
	9	Hot metal ladle	○	—	—	—	○	○
	10	Hot metal ladle bricks	○	—	—	—	○	○
	11	Hot metal ladle brick laying	○	—	—	—	○	○
	12	Hot metal ladle drier	—	—	—	—	○	○
	13	Turn table	—	○	○	○	—	—
	14	Scrap transport car	—	○	○	○	—	—
	15	Burnt lime crushing, sizing, transport and storage equipment	—	○	○	—	—	○

		Equipment Name	Alternative 1	Alternative 2 (A)	Alternative 2 (B)	Alternative 3	Alternative 4	Alternative 5
③ Ingot-making equipment	1	Ladle car	—	○	○	○	○	○
	2	Ladle	○	—	—	—	○	○
	3	Ladle bricks	○	—	—	—	○	○
	4	Ladle brick laying	○	—	—	—	○	○
	5	Ladle drier	—	—	—	—	○	○
	6	Slag pot	—	—	—	—	○	○
	7	Slag pot transfer car	—	—	—	—	○	○
	8	Bloom continuous casting machine	○	—	—	—	—	—
	9	Electrical instrumentation for the bloom continuous casting machine	○	—	—	—	—	—
	10	Incidental facilities for the bloom continoous casting machine	○	—	—	—	—	—

		Equipment Name	Alternative 1	Alternative 2		Alternative 3	Alternative 4	Alternative 5
				(A)	(B)			
④ Waste gas cleaning apparatus	1	Waste gas cleaning apparatus proper	—	○	—	○	○	○
	2	Induced draft fan	—	○	—	○	○	○
	3	Electrical components	—	○	—	○	○	○
	4	Instrumentation	—	○	—	○	○	○
	5	Water softening device	—	○	—	○	○	○
	6	Thickner	—	○	—	○	○	○
	7	Dehydrator	—	○	—	○	○	○
	8	Ventilation, dust collecting equipment	—	○	—	○	○	○
⑤ Crane-related equipment	1	Hot metal receiving crane	○	—	—	—	○	○
	2	Hot metal charging crane	—	—	—	—	○	○
	3	Scrap charging crane	—	—	—	—	○	○
	4	Teeming crane	—	○	○	○	○	○
	5	Stripper crane	—	○	○	○	○	○
	6	Converter bay service crane	—	○	—	○	○	—

		Equipment Name	Alternative 1	Alternative 2 (A)	Alternative 2 (B)	Alternative 3	Alternative 4	Alternative 5
	7	Tundish repair crane	○	—	—	—	—	—
	8	Continuous caster maintenance crane	○	—	—	—	—	—
	9	Bloom handling crane	○	—	—	—	—	—
	10	Hoist crane for brick transport	—	—	—	—	○	○
	11	Wall crane for ladle repair	—	—	—	—	○	○
⑥ Electrical equipment	1	Power supply equipment (primary side excluded)	○	○	○	○	○	○
	2	Lighting work	○	○	○	○	○	○
	3	Trolley line work	○	○	○	○	○	○
⑦ Waterworks	1	Water supply to the waste gas cleaning apparatus	—	○	—	○	○	○
	2	Equipment and apparatus for the continuous casting machine cooling water	○	—	—	—	—	—
	3	Water piping work for the continuous casting machine	○	—	—	—	—	—
	4	Other water piping work	○	○	○	○	○	○

		Equipment Name	Alternative 1	Alternative 2 (A)	Alternative 2 (B)	Alternative 3	Alternative 4	Alternative 5
⑧ Engineering equipment	1	Columns and ground facilities for the building sections to be added	○	○	○	○	○	○
	2	Ground facilities for the section of each equipment to be added	○	○	○	○	○	○
⑨ Erection equipment	1	One set of the building sections to be added and newly built	○	○	○	○	○	○
⑩ Blooming-related equipment	1	Installation of a new heating furnace	○	–	–	–	–	–
	2	Installation of a new bloom charging crane	○	–	–	–	–	–
	3	Installation of a new claw crane	○	○	○	○	○	○
	4	Roller table remodelling	○	–	–	–	–	–
	5	Engineering works	○	○	○	○	○	○
	6	Soaking pit addition	–	○	○	○	○	○
	7	Charging machine replacing	–	○	○	○	○	○

6.2 Equipment cost of each alternative

Results of reviewing the equipment cost estimate of each of the 5 alternatives are shown in Table II.2. in terms of each equipment unit. The following findings are obtained from these results:

a) Naturally, as far as the equipment cost is concerned, Alternative 2 (B) is the most inexpensive.

b) Alternative 1 has the highest equipment cost, because costs of the continuous casting machine and the engineering and erection equipment are high.

c) Alternatives 2 (A) and 3, which propose remodeling of the existing Tomas Plant, requires the equipment cost, which is not greatly reduced from that of Alternatives 4 and 5.

Table II.2. List of the equipment cost of each alternative

Unit: US$1,000

	Alternative 1			Alternative 2 (A)			Alternative 2 (B)			Alternative 3			Alternative 4			Alternative 5		
	Existing 80t LD x 2/3			Remodelled 17t OBM x 2/4			Remodelled 17t OBM x 2/4			Remodelled 17t LD x 2/3			Newly installed 36t LD x 1/2			Newly installed 36t OBM x 1/2		
	Purchasing cost	Work cost	Total	Purchasing cost	Work cost	Total	Purchasing cost	Work cost	Total	Purchasing cost	Work cost	Total	Purchasing cost	Work cost	Total	Purchasing cost	Work cost	Total
① Furnace proper-related equipment	—	—	—	872	266	1,138	872	266	1,138	610	197	807	2,976	486	3,462	3,255	555	3,810
② Raw material-related equipment	1,814	335	2,149	1,735	337	2,072	1,238	259	1,497	1,742	337	2,079	2,593	490	3,083	2,845	542	3,387
③ Ingot making-related equipment	8,021	1,466	9,487	217	31	248	217	31	248	217	31	248	697	76	773	697	76	773
④ Waste gas cleaning apparatus	—	—	—	7,128	1,190	8,318	—	—	—	7,128	1,190	8,318	5,390	924	6,314	5,390	924	6,314
⑤ Crane-related equipment	1,329	196	1,525	2,214	317	2,531	2,162	307	2,469	2,214	317	2,531	3,063	441	3,504	3,063	441	3,504
⑥ Electrical equipment	521	159	680	242	66	308	207	52	259	242	66	308	362	100	462	362	100	462
⑦ Waterworks	631	538	1,169	—	121	121	—	90	90	—	121	121	—	121	121	—	121	121
⑧ Civil Engineering equipment	—	2,435	2,435	—	448	448	—	328	328	—	517	517	—	1,379	1,379	—	1,310	1,310
⑨ Erection equipment	4,676	2,500	7,176	1,514	793	2,307	1,218	673	1,891	1,549	866	2,415	2,007	1,131	3,138	1,955	1,114	3,069
⑩ Blooming-related equipment	3,333	1,657	4,990	2,286	1,487	3,773	2,286	1,487	3,773	2,286	1,487	3,773	2,286	1,487	3,773	2,286	1,487	3,773
Total	20,325	9,286	29,611	16,208	5,056	21,264	8,200	3,493	11,693	16,140	5,146	21,117	19,384	6,635	26,009	19,853	6,670	26,523
Total excluding ⑩	16,992	7,629	24,621	13,922	3,569	17,491	5,914	2,006	7,920	13,702	3,642	17,344	17,088	5,148	22,236	17,567	5,183	22,750

a) Oxygen piping and holder between the oxygen plant and the steelmaking plant are outside the scope of estimate in each alternative.
b) Power source cable and installation cost between the transformer substation to the steelmaking plant in Alternatives 4 and 5 are outside the scope of estimate.
c) The primary side piping and installation cost of LPG, N_2 gas, argon, etc. in Alternative 2 (A), (B) and 5 are outside the scope of estimate.
d) The argon bubbling device, etc. in the steelmaking plant in Alternative 2 (A), (B) and 5 are outside the scope of estimate.
e) In regard to a proposal to reinforce or remodel the existing plant in Alternative 1, 2 (A), (B), and 3, it was examined on the assumption that the capacity of the power supply equipment at the existing steelmaking plant could be dealt with without reinforcement.
f) Spares of products purchased for each equipment are not taken into account.

Remarks

a) Work cost of each alternative in terms of equipment unit is on the basis of estimating in Japan.

b) Purchasing cost of each alternative in terms of equipment unit is based on the current estimating status in Japan, which is then converted to the CIF basis.

7. Production Capacity of Each Alternative

The production capacity and pre-requisites of each alternative are shown in Fig. II.1 and Table II.3.

Next, the underlying thinking of the production capacity of each alternative is explained as follows.

Alternative 1

In the Expansion Plan, the lining life of 200 heats (relining time 120 hours) and the down time of 1,456 hr/y due to a relining time extension are stated. Eliminating this down time due to the relining time extension is necessary for improving the availability.

Hence, efforts must be made to extend the lining life or to shorten the relining time.

In this study the lining life extension is to be used for meeting the requirement. The lining life required estimated as below.

(Relining time/tap to tap) x 2

= (120 hours x 60 min/hr ÷ 48 min/heat) x 2

= 300 heats

The lining life of approximately 300 heats will be needed.

Alternative 2

In order to secure a crude steel production of 330,000 t/y by remodelling only 3 Thomas converters, the following values will be needed for the lining life (wall and bottom).

Wall Lining Life (heat)	Bottom Lining Life (heat)	Capacity (1,000 T/y)
200	50	302
	70	313
	100	326
250	50	316
	65	327
	100	338
300	50	327
	75	346

However, accomplishing them will be rather difficult even when the present situation and improved results of the dolomite brick plant are taken into consideration. This means that 4 units will be required for remodelling. Even if remodelling of the 4 units should be carried out, only 2 units will be operating at all times due to layout restrictions (complications of scrap charging, hot metal charging, tapping, etc.)

Alternative 3

In order to secure the operation status of 2 units at all times by remodelling only 3 of the Thomas converters, a minimum of 170 heats will be necessary for the lining life judging from

$$(72 \text{ hours} \times 60 \text{ min/hr} \div 50.5 \text{ min/heat}) \times 2 = 170 \text{ heats}$$

the relining time (current records -- 72 hours). Accomplishing this will be difficult even if improvement of the dolomite brick plant is taken into consideration. Therefore, the 4 Thomas converters must be all remodelled. But, layout restrictions will enable only 2 units to be in constant operation.

Alternatives 4 and 5

From ingot arrangements (3 t/ingot x 12 ingots, 4 t/ingot x 9 ingots), the 36t is set as heat tonnage.

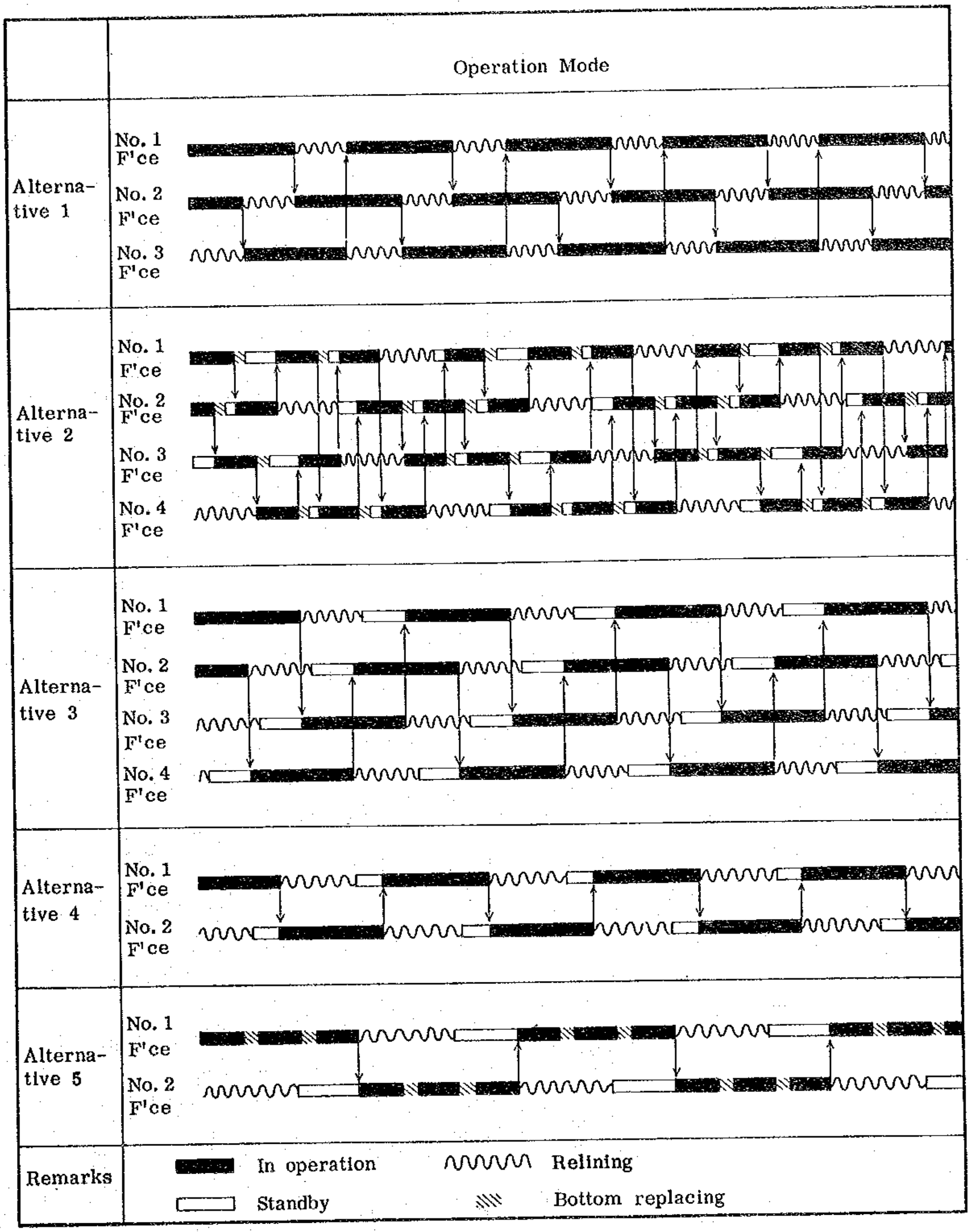


Fig. II.1 Furnace operation mode of each alternative

Table II-3 Summary of the production capacity

		Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5	
Production Capacity (x 1,000 t/y)		1,200 + 310		330		310		365		336	
Ton/Heat		76.4		16.0		16.0		36.0		36.0	
Steelmaking Time	Steel Grade	Rail	Other than rail	Rail	Other than rail	Rail	Other than rail	Rail	Other than rail	Rail	Other than rail
		Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes
	Charging	5	5	3	3	3	3	3	3	3	3
	Blowing I	13	10	12	9	13	10	13	10	12	9
	Slag-off	5	5	5	5	5	5	5	5	5	5
	Blowing II	13	13	12	9	13	10	13	10	12	9
	Temperature measuring, sampling	5	5	5	5	5	5	5	5	5	5
	Tapping	4	4	3	3	3	3	3	3	3	3
	Slag-off	1	1	2	2	1	1	1	1	1	1
	Re-blowing	2.5	2	2	1.5	2.5	2	2.5	2	2	1.5
	Subtotal	48.5 Minutes	42 Minutes	44 Minutes	37.5Minutes	46.5Minutes	40 Minutes	46.5Minutes	40 Minutes	44 Minutes	37.5 Minutes
	Percentage	5 %	95 %	20 %	80 %	20 %	80 %	20 %	80 %	20 %	80 %
	Average	42.5 Minutes		39.0 Minutes		41.5 Minutes		41.5 Minutes		39.0 Minutes	
Availability		53.3 %		38.2 %		38.2 %		40.0%		34.7 %	
Shut-down Time		hr/y		hr/y		hr/y		hr/y		hr/y	
	Shut-down maintenance	1,680		1,056		1,056		528		528	
	Shut-down due to breakdown, etc.	1,832		3,064		3,064		1,224		1,224	
	Bottom replacing	—		2,750		—		—		610	
	Relining, standby	8,760		14,770		17,520		8,760		8,760	
	Total	12,272 hr/y		21,640 hr/y		21,640 hr/y		10,512 hr/y		11,442 hr/y	
Relining Time		120 hr/furnace		72 hr/furnace		72 hr/furnace		96 hr/furnace		96 hr/furnace	
Bottom Replacing Time		—		10 hr/replacing		—		—		10 hr/replacing	
Remarks		Availability = Total steelmaking time / No. of vessels installed x calender hours									

$$\text{Availability} = \frac{\text{Total steelmaking time}}{\text{No. of vessels installed x calender hours}}$$

8. Comparison of the Alternatives

8.1 Technical comparison

Technical comparison of the alternatives is summarized in Table II.4. A summary of the major technical points is as follows.

Alternative 1

a) The biggest restriction is the one imposed by converter's lining life (minimum 300 heats required). If the current results of about 200 heats at the 80t LD plant is taken into consideration, it seems necessary to put into effect comprehensive countermeasures such as improvement of the manufacturing technique and qualities of refractories, the converter operational technique and shortening the relining time.

b) Converter's availability is a high 53.3%, and the high efficiency 2/3 vessel operation is needed. The past performance of the top-blown converter plants engaged in the 2/3 vessel operation in Japan shows that converter's availability at the highest efficient operation is about 56 to 57%.

c) What is proposed is reinforcement of the existing facilities, and the startup period will be shorter.

Alternative 2 (A)

a) The yield of steel produced is low.

b) Production decreases will be caused during the construction period.

c) In terms of a capacity of the equipment, the 2/4 vessel operation at all times is needed. This means that it will be necessary to operate the standby furnace at the time of bottom replacing, thus complicating co-ordination of operating furnaces.

d) The waiting period occurs after the furnace completes operation and this gives adverse affects on the lining life.

e) The number of ingots per heat does not balance with the number

of ingots to be charged into the soaking pit, thus increasing the rate of generating cold ingots.

f) In case of the melting of high carbon steel, because of the high hydrogen content in the steel, it is considered necessary to use an argon bubbling device or the like.

Alternative 2 (B)

a) Same as a) - f) of Alternative 2 (A)

b) With no waste gas treatment equipment provided, it may cause emission of red fume. All the greenfield steel-making plants in the world are equipped with waste gas treatment facilities without exception. Also, new introduction or expansion of these facilities is in progress in the existing steel-making plants as well to prevent emission of red fume. From these considerations, this is not recommendable as a permanent measure.

Alternative 3

a) Production decreases will be caused during the construction period.

b) In terms of the equipment capacity, the 3/4 vessel operation is necessary. But, this is considered to be infeasible in view of the layout and co-ordination of operating furnaces. Consequently, there will be a steelmaking capacity shortage totalling 20,000t/y.

c) The number of ingots per heat in steelmaking does not balance with the number of ingots to be charged in the soaking pit, thus raising the rate of generating cold ingots.

Alternative 4

a) Since there is already an 80t top-blown converter plant, education and training of workers will be made easier if another top-blown converter plant is built. This is a very important factor now at Helwan Works.

b) As a result of complete education and technical training, all the workers will possess improved technique so that startup of operations at the new plant will go smoothly, thus contributing

greatly to production.

c) The equipment capacity is 365,000t/y which is the highest, and there is a large flexibility in the production capacity.

d) The number of ingots per heat will be 12 in case of 3t ingots, which are roughly in balance with the capacity of the blooming mill soaking pit. Hence, an increase in the soaking pit capacity can be expected.

Alternative 5

a) In order to secure the equipment capacity, it is necessary to have the wall lining life of 200 heats and the bottom lining life of 70 heats.

b) In case of the melting of high carbon steel, devices such as argon bubbling device are considered to be necessary because of the high hydrogen content in the steel.

c) The converters will be of the 1/2 vessel operation, and the operation mode is simple (excepting the bottom replacing work).

d) In case of 3t ingots, the number of ingots per heat is 12, which are roughly in balance with the blooming mill capacity. Therefore, an increase in the soaking pit capacity can be expected.

Table II.4 List of results of technically reviewing each alternative

Notes: ○........ Technically superior items
△........ Items creating technical restrictions
×........ Items that will be in trouble technically

	Alternative 1 Existing 80t LD x 2/3	Alternative 2 (A) Remodelled 17t OBM x 2/4	Alternative 2 (B) Remodelled 17t OBM x 2/4	Alternative 3 Remodelled 17t LD x 2/4	Alternative 4 Newly installed 36 t LD x 1/2	Alternative 5 Newly installed 36t OBM x 1/2
1) Equipment capacity (1000 t/y)	1,200 + 310	330	330	310 × Annual capacity shortage of 20,000 t	365	336
1-1) Availability (%)	53.3	38.2	38.2	38.2	40.0	34.7
1-2) Average steelmaking time (min)	42.5	39.0	39.0	41.5	41.5	39.0
2) Lining life restriction	× Min. 300 heats	Wall .... 150 heats Bottom .... Min. 50 heats	Wall .... 150 heats Bottom .... Min. 50 heats	150 heats	150 heats	Wall .... Min. 200 heats Bottom .... Min. 70 heats
3) Steel quality	———	△ In case of the melting of high carbon steel, the high H content in the steel is considered to require use of the argon bubbling device.	△ Same as Alternative 2(A)	———	———	△ Same as Alternative 2 (A)
4) Mode of operation	× Highly efficient 2/3 vessel operation necessary	× At the time of bottom replacing, the standby furnace will be made to operate, thus complicating coordination of furnaces. × In securing the 2-vessel operation at all times, the standby furnace is created, thus affecting lining life adversely.	× Same as Alternative 2 (A) × Same as Alternative 2 (A)	× The 2/4 vessel operation necessary in terms of equipment capacity	○ This is the 1/2 vessel operation, and the operation mode is the simplest.	○ Same as Alternative 4 △ The 0/2 vessel operation at the time of bottom replacing (10 hr/replacing)
5) Problems in construction	———	× Production decreases due to construction will be caused × Environments in carrying out construction are bad.	△ Restrictions will occur at the time of remodelling the hopper above furnace	× Same as Alternative 2 (A) × Same as Alternative 2 (A)	———	———
6) Layout problems	———	× The tilting device is diverted from the existing furnace and its renovation will be needed in the near future. △ Scrap handling will be complicated.	× Same as Alternative 2 (A) △ Same as Alternative 2 (A)	× Same as Alternative 2 (A) △ Same as Alternative 2 (A)	———	———
7) Effects on the blooming mill soaking pit	———	△ The number of ingots per heat in steelmaking is not in balance with the number of ingots to be charged in the soaking pit, thus increasing the rate of creating cold ingots.	△ Same as Alternative 2 (A)	△ Same as Alternative 2 (A)	○ The number of ingots per heat in steelmaking becomes 14 roughly in balance with the soaking pit capacity. As a result, increases in the soaking pit capacity can be expected.	○ Same as Alternative 4
8) Red fume	———	———	× Generation of red fume	———	———	———

8.2 Comparison of economical advantages

In regard to the equipment cost and items considered to vary in the operating condition of the steelmaking and blooming processes of each alternative, calculations were made on the Japanese basis, and their comparison and review were made.

8.2.1 Preconditions

Preconditions for making a comparison in terms of economy are shown in Table II.5. Differences of each alternative with respect to each item of operating conditions are calculated on the basis of the following thinking.

(1) Yield of steel produced

Alternatives 1 & 4

In Alternative 4, which proposes an addition, the tap hole will also be equiped and the inner volume index (tonnage of heat/ inner volume) will be the same value as the existing 80t LD converters. Therefore, it is considered that the same level of performance as the existing 80t LD plant can be achieved.

Alternatives 2 (A) & (B)

The 73% yield of the existing Thomas converters is extremely low. But, a 10% rise of that is taken into account in expectations of improved levels of operation.

It must be added that the lowest yield of all alternatives is assumed, because the tap hole cannot be equiped.

Alternatives 3

The tap hole will be equiped, and yet, because charging and tapping are performed on the same side, wall lining will be damaged. A 2% decrease in yields due to this adverse effect as compared with Alternatives 1 and 4 is considered.

Alternative 5

Decreases in dust amount in the waste gas and reduction of total Fe in slag were taken into account based on the result of various studies, and a 1.3% increase in yields as compared with Alternatives 1 and 4 is estimated.

(2) Fluorspar

Alternatives 1, 3 & 4

It was considered on the same level of performance at the existing 80t LD plant.

Alternatives 2 (A), (B) & 5

Since available studies on the subject shows that fluorspar is not needed, no fluorspar is used.

(3) Lining material

Fettling materials for repair during operation is not included in each alternative. For the unit consumption of lining material, the estimated values for wear lining only are used. The bottom-blown method includes the bottom brick tonnage at the time of bottom repalacing.

(4) Oxygen

Alternatives 1, 3 & 4

The same level of performance at the existing 80t LD plant is suggested.

Alternatives 2 (A), (B) & 5

A value 10% less than the top-blown converter method is presented in consultation with the data available.

(5) LPG

Alternatives 2 (A), (B) & 5

9% of the unit consumption of oxygen is proposed in consultation with the data available.

(6) N_2

Alternatives 2 (A), (B) & 5

10% of the unit consumption of oxygen is offered in consultation with the data available.

(7) Burnt lime crushing cost

Alternatives 2 (A), (B) & 5

Existing records in Japan were used for reference.

8.2.2 Results of economical comparison

Study results for comparative economy are provided in Table II-6.

(1) Overall comparison

a) As for cost increases derived from capital investment required, Alternative 2 (B) represents the lowest figure, US $ 2,771,000 per annum. On the other hand, Alternative 5 represents the highest figure, US $ 6,488,000 annually, US $ 3,717,000 more than Alternative 2 (B).

b) For the cost differential due to the difference in operating conditions, a discrepancy as wide as US $ 4,463,000 per annum exists between two extremes - Alternative 1 (lowest) and Alternatives 2 (A) and (B) (highest).

c) As obvious from the above paragraphs a) and b), the comparative economy of each alternative is influenced more by the cost differential due to the difference in operating conditions rather than by the size of added costs for equipment addition or revamping.

d) Viewing from this, it can be said that the comparative economy of each alternative must be judged from not only the comparative size of the required capital investment but also the comparative characteristics of operating conditions.

(2) Comparative cost of each alternative

a) As for cost increases derived from additional capital investment plus cost differentials due to the difference in operating conditions, Alternative 1 provides the largest economy.
The cost discrepancy between Alternative 1 and Alternative 4 is not so significant, US $ 19,000 annually.

b) Alternative 2 (A) shows the greatest deviation, US $ 3,365,000, from Alternative 1.

c) Alternative 2 (B) will cost 850,000 dollars more than Alternative 1

annually.

e) The cost disparity between Alternative 1 and Alternative 3 is 741,000 dollars per annum.

f) The cost differential between Alternative 1 and Alternative 5 is US $ 403,000 a year.

(3) Conclusion

a) Alternative 1 provides the greatest economy, though its cost advantage over Alternative 4 is not so significant.

b) Alternative 2, though most advantageous in capital cost, is inferior in overall economy to Alternatives 1 and 4 because of the difference in operating conditions, particularly of a lower yield of steel.

c) In view of inferior operating conditions, or operational results, Alternatives 2 and 3, both consisting essentially of revamping of the Thomas plant, we are afraid, cannot be a longrange way of rehabilitation.

Notes: What is meant by the Japanese basis

a) Principal factors for trial cost calculations are established by using the data of the 80t LD converter plant at Helwan Works and of literature. As for the unit cost of each factor, the current value in Japan is ultilized for computation.

b) For computation of the equipment cost interest, maintenance cost, depreciation, and the like, methods currently in use in Japan are used.

		Alternative 1 Existing 80t LD x 2/3	Alternative 2 (A) Remodelled 17t OBM x 2/4	Alternative 2 (B) Remodelled 17t OBM x 2/4	Alternative 3 Remodelled 17t LD x 2/4	Alternative 4 Newly installed 36t LD x 1/2	Alternative 5 Newly installed 36t OBM x 1/2
Production quantity (t-bloom/y)		290,000	290,000	290,000	290,000	290,000	290,000
Equipment cost (US$1,000)		Steelmaking 24,621 Blooming 4,990 Total 29,611	17,491 3,773 21,264	7,920 3,773 11,693	17,344 3,773 21,117	22,236 3,773 26,009	22,750 3,773 26,523
Steelmaking	(1) Yields						
	Yields of steel produced	90. 0 %	83. 0 %	83. 0 %	88. 0 %	90. 0 %	91. 3 %
	CC or ingot making yields	95. 0 %	98. 0 %	98. 0 %	98. 0 %	98. 0 %	98. 0 %
	(2) Flux unit consumption						
	Burnt lime	85. 5 kg/t-main raw material	85. 5 kg/t-main raw material	85. 5 kg/t-main raw material	85. 5 kg/t-main raw material	85. 5 kg/t-main raw material	85. 5 kg/t-main raw material
	Fluorspar	3. 4 kg/t-main raw material	0	0	3. 4 kg/t-main raw material	3. 4 kg/t-main raw material	0
	(3) Lining material unit consumption	12. 7 kg/t-bloom	25. 0 kg/t-main raw material	25. 0 kg/t-ingot	20. 0 kg/t-ingot	12. 0 kg/t-ingot	15. 0 kg/t-ingot
	(4) Fuel unit consumption (for blowing)						
	Oxygen	46. 2 Nm^3/t-main raw material	41. 6 Nm^3/t-main raw material	41. 6 Nm^3/t-main raw material	46. 2 Nm^3/t-main raw material	46. 2 Nm^3/t-main raw material	41. 6 Nm^3/t-main raw material
	LPG	0	3. 8 Nm^3/t-main raw material	3. 8 Nm^3/t-main raw material	0	0	3. 8 Nm^3/t-main raw material
	N_2	0	4. 1 Nm^3/t-main raw material	4. 1 Nm^3/t-main raw material	0	0	4. 1 Nm^3/t-main raw material
	(5) Others						
	Burnt lime crushing cost	0	6. 9 US$/t-burnt lime	6. 9 US$/t-burnt lime	0	0	6. 9 US$/t-burnt lime
Blooming		60,000 t/y | 250,000 t/y					
	(1) Fuel unit consumption	0 | kcal/t-bloom 400,000	300,000 kcal/t-ingot	300,000 kcal/t-ingot	300,000 kcal/t-ingot	300,000 kcal/t-ingot	300,000 kcal/t-ingot
	(2) Yields	100 % | 92. 0 %	88. 0 %	88. 0 %	88. 0 %	88. 0 %	88. 0 %
Remarks		a) Alternative 2 (A), (B) assumes generation of 46. 0 kg/t-ingot of steel shop scrap (compared with Alternatives 1,4 & 5). b) Alternative 3 assumes generation of 13. 0 kg/t-ingot of steel shop scrap (as compared with Alternatives 1, 4 & 5).					

Table II.6. List of results of reviewing each alternative in terms of economy

unit : 1,000 US$/y

		Alternative 1 Existing 80t LD x 2/3	Alternative (A) Remodelled 17t OBM x 2/4	Alternative (B) Remodelled 17t OBM - 2/4	Alternative 3 Remodelled 17t LD x 2/3	Alternative 4 Newly installed 36t LD x 1/2	Alternative 5 Newly installed 36t OBM x 1/2	Remarks
	Principal raw material cost	36,824	41,200	41,200	38,859	37,945	37,435	
By-products	Steelshop scrap		-1,321	-1,321	-352			
	Ingotmaking scrap		-600	-600	-600	-600	-600	
	Bloom scrap	-3,786	-4,207	-4,207	-4,207	-4,207	-4,207	
	Subtotal	-3,786	-6,128	-6,128	-5,159	-4,807	-4,807	
Flux	Burnt lime	1,176	1,314	1,314	1,242	1,210	1,197	
	Fluorspar	73	—	—	76	76		
	Subtotal	1,249	1,314	1,314	1,318	1,286	1,197	
Variable parts of the operation cost	Oxygen	721	728	728	762	742	659	
	LPG	—	200	200	—	—	186	
	Nitrogen	—	11	11	—	—	11	
	Lining material	1,721	3,662	3,662	2,914	1,721	2,207	
	Others (converter)	424	476	476	448	438	431	
	Others (ingot casting)	—	1,739	1,739	1,739	1,739	1,739	
	Others (CC)	1,631	—	—	—	—	—	
	Soaking pit or heating furnace fuel	1,497	1,197	1,197	1,197	1,197	1,197	
	Others (blooming)	338	445	445	445	445	445	
	Subtotal	6,332	8,458	8,458	7,505	6,282	6,875	
	Burnt lime crushing cost	—	238	238	—	—	217	
	Equipment cost interest	2,961	2,126	1,169	2,112	2,601	2,652	
	Equipment maintenance cost	1,804	1,787	887	1,754	2,081	2,155	
	Depreciation	1,619	1,373	715	1,355	1,634	1,682	
Total		47,003	50,368	47,853	47,744	47,022	47,406	
Differences (Alternative 1) - (each Alternative)		± 0	⊕ 3,365	⊕ 850	⊕ 741	⊕ 19	⊕ 403	⊕ Represents more than the alternative 1. ⊖ Represents less than the alternative 1.

8.3 Results of comparative review

Comparative review has been conducted of each alternative in terms of technique and economy. For the following reasons, Alternative 4, namely, an addition of a top-blown converter plant around the existing Thomas Plant, is recommended.

a) Economically, it is advantageous.

b) It has large flexibility of production capacity.

c) Training of personnel for operation is easy.

d) The mode of operation is simple.

e) No production decrease is caused during construction.

9. Basic Conditions of the Recommended Alternative's Equipment Plan

9.1 Raw materials and utility

9.1.1 Principal raw materials

(1) Hot metal composition

Si	Mn	P	S
0.4/0.8	0.6/1.2	0.45	0.04

(2) Unit consumption of the principal raw materials

Hot metal .... 1,054.0 kg/t-good ingot (Hot metal ratio 93%)

Scrap .... 79.3 kg/t-good ingot

9.1.2 Flux

(1) Burnt lime composition

CaO .... 90 %

SiO_2 .... 2 %

S .... 0.08 %

(2) Burnt lime size

5 - 50 mm

*Note The current size of burnt lime, 50 - 70 mm, is too big as the particle size. Therefore, alteration of the limestone size is considered necessary.

(3) Iron ore size

5 - 15 mm

(4) Fluorspar size

5 - 30 mm

(5) Unit consumption of flux

Burnt lime .... 100 kg/t-HM   HM = Hot Metal

Iron ore .... 15 kg/t-HM

Fluorspar .... 4 kg/t-HM

Note Current capacity of the shaft kiln for burnt lime -- 25 - 35 t/d -- may result in a capacity shortage so that it will be necessary to review the shaft kiln capacity.

9.1.3 Utility

(1) Oxygen

Purity .... 99.6 %

Condition .... Dry

Pressure .... 17 - 35 kg/cm^2 G

(2) Unit consumption

Oxygen .... 55.0 Nm^3/t-good ingot

Air .... 2.0 Nm^3/t-good ingot

Gas .... 7.0 Nm^3/t-good ingot

Electricity .... 23.0 KWH/t-good ingot

Water .... 0.8 m^3/t-good ingot

9.2 Converter equipment

See SPECIFICATION, IV Vol.1

9.3 Material flow sheet

Conceptions illustrated in Fig. II.2 form the basis for the material flow in the converter plant, which is necessary for examining the equipment plan of the recommended alternative (Alternative 4) in concrete terms.

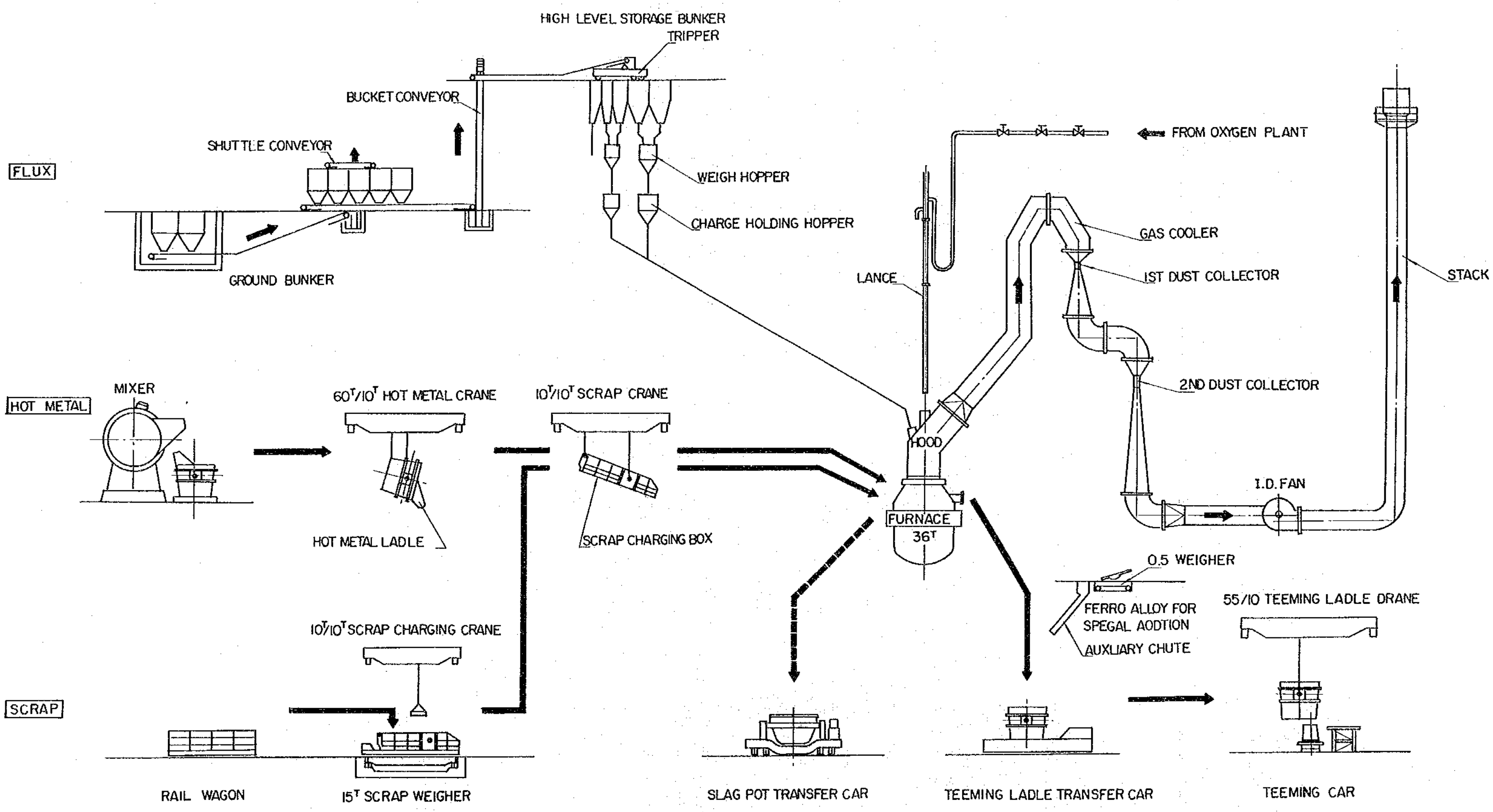


Fig. II-2 Material Flow

10. Outlines of the Equipment in the Recommended Alternative

10.1. Principal raw material equipment

10.1.1 Hot metal mixer

An addition of a 600T hot metal mixer is proposed.

10.1.2 Hot metal ladle capacity

The hot metal ladle capacity will be 40 t to enable operation of the 100% hot metal ratio.

$$QHM = QBOF \times \frac{HMR\ max}{YLS} = 40.8t \longrightarrow 41t$$

QHM: Maximum hot metal amount

QBOF: Maximum heat size (36.0t)

HMR max: Maximum hot metal ratio (100%)

YLS: good ingot yield (88.2%)

10.1.3 Hot metal weigher capacity

A fixed type weigher is installed in location under the hot metal mixer tap hole. The weigher capacity will be 60t.

Hot metal ladel		Hot metal		Reserve	
17t	+	41t	+	2t	= 60t

10.1.4 Capacity inside the scrap chute

It will be 7t to enable operation of the maximum scrap ratio of 15%.

10.1.5 Scrap weigher capacity

Chute's tare weight		Scrap		Reserve	
6t	+	7t	+	2t	= 15t

10.2 Converter equipment

10.2.1 Vessel profile

The vessel profile is shown in DWG 16. The inner volume inside the shell is 104 m^3, and the inner volume after lining is set at 37.6 m^3. The brick thickness is about the same as that of the existing 80t LD converter.

Permanent lining .... 114 mm

Wear lining .... 750 mm

For the vessel, either the conventional vessel or the bottom removable vessel can be used.

10.2.2 Tilting device

Tilting is performed electrically by use of a DC motor, and the tilting speed will be 0.1 ~ 1.0 rpm.

10.2.3 Oxygen blowing device

In accordance with good ingots 36.0 t/heat, unit consumption of oxygen 55.0 Nm^3/t-a good ingot, blowing time 20 minutes, the oxygen blowing volume of 6,000 Nm^3/hr is calculated as follows.

$$55.0\ Nm^3/t\text{-good ingot} \times 36.0\ t \times \frac{60}{20} = 5{,}940\ Nm^3/hr$$

$$\longrightarrow 6{,}000\ Nm^3/hr$$

This means that the equipment will be capable of the maximum oxygen blowing volume of 7,500 Nm^3/hr. The blowing pressure will be 9 - 12 kg/cm^2G with the maximum capability of up to 15 kg/cm^2.

10.2.4 Lance lift

The method of lance lifting will be by a fixed winch along the lance guide. Lance replacing work is to be performed by the service crane installed in the top section.

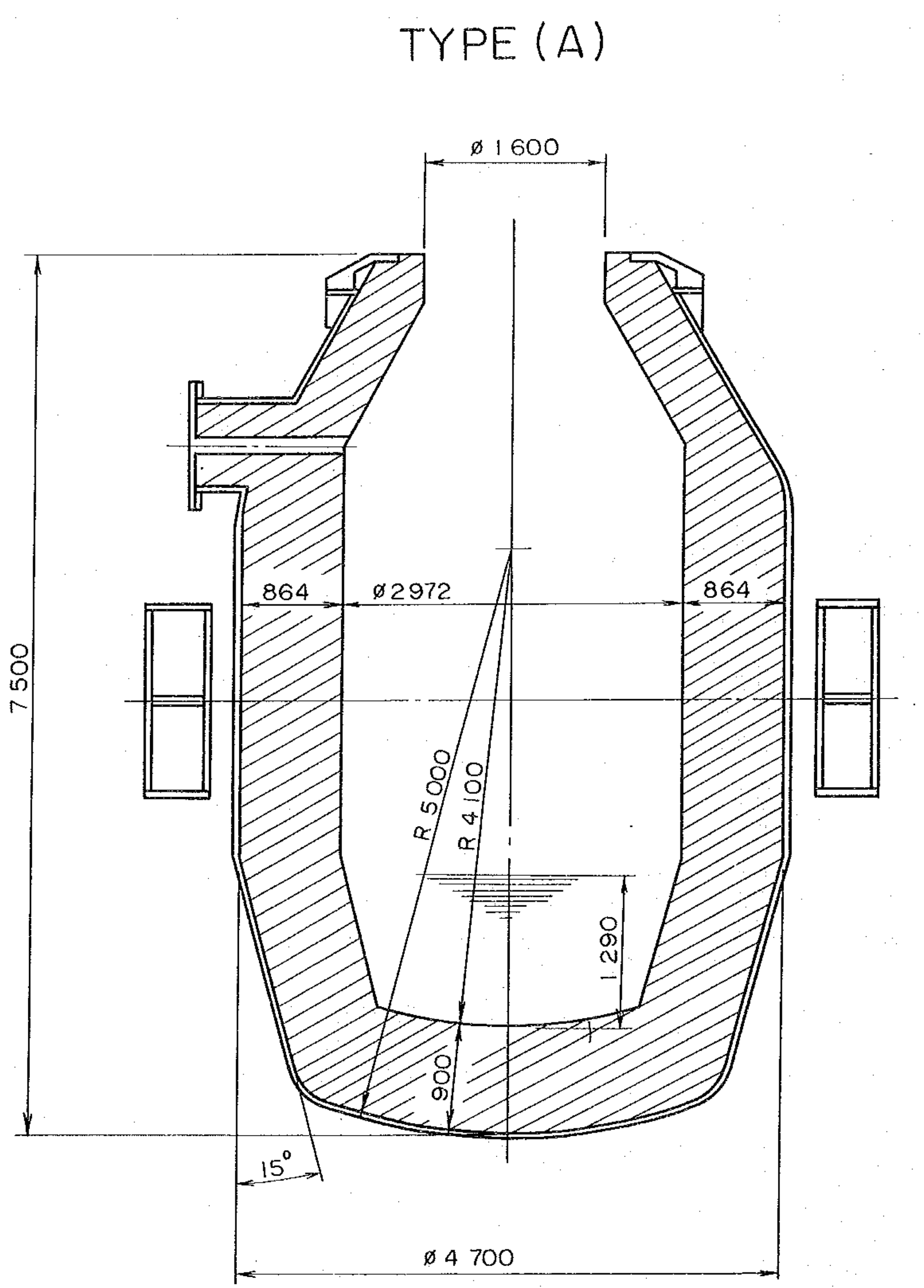
10.2.5 Oxygen blowing pressure control

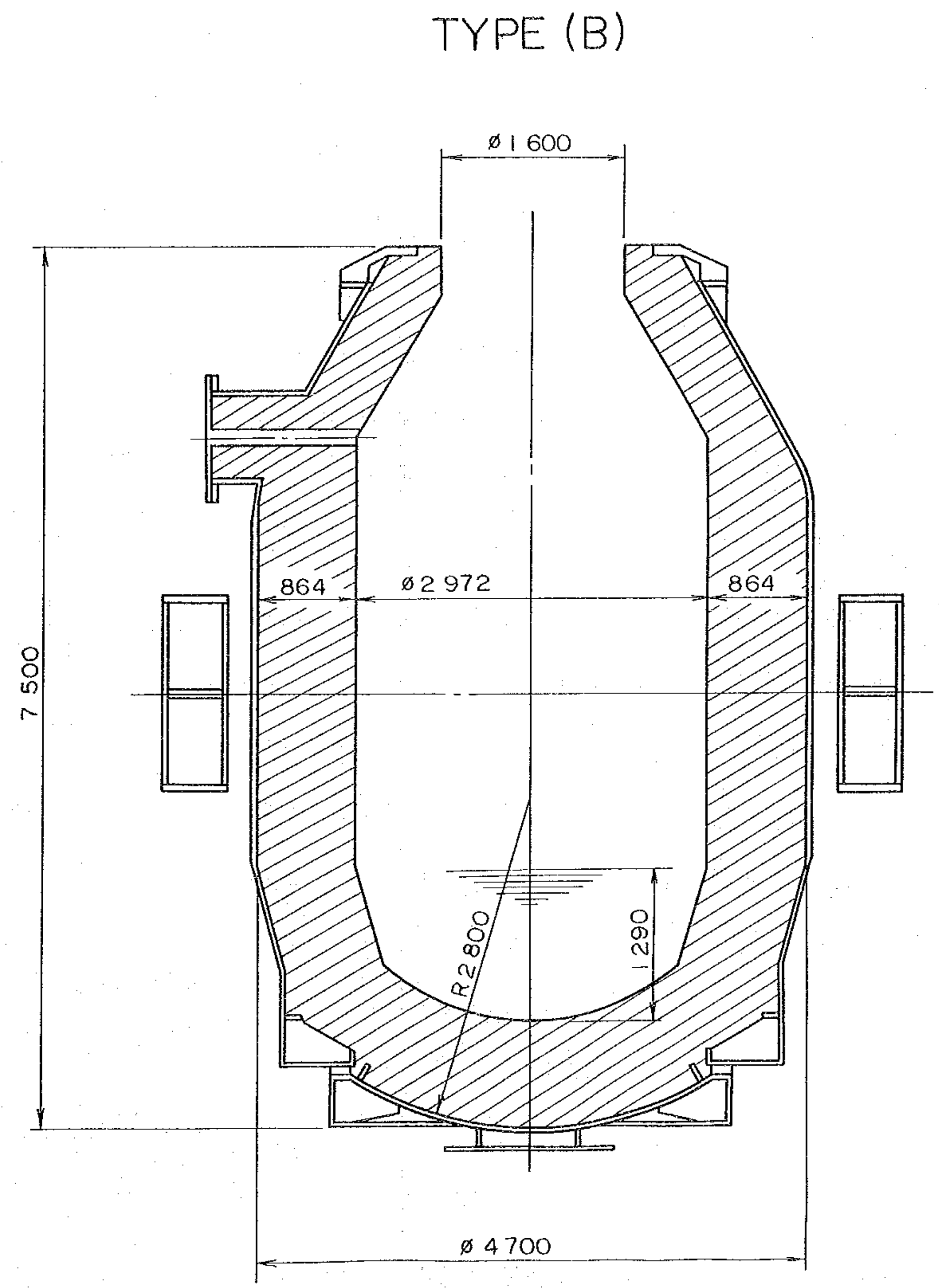
Pressure reduction of oxygen during oxygen blowing will be the 2-step pressure reduction method.

1st step .... 35 kg/cm^2G ⟶ 17 kg/cm^2G

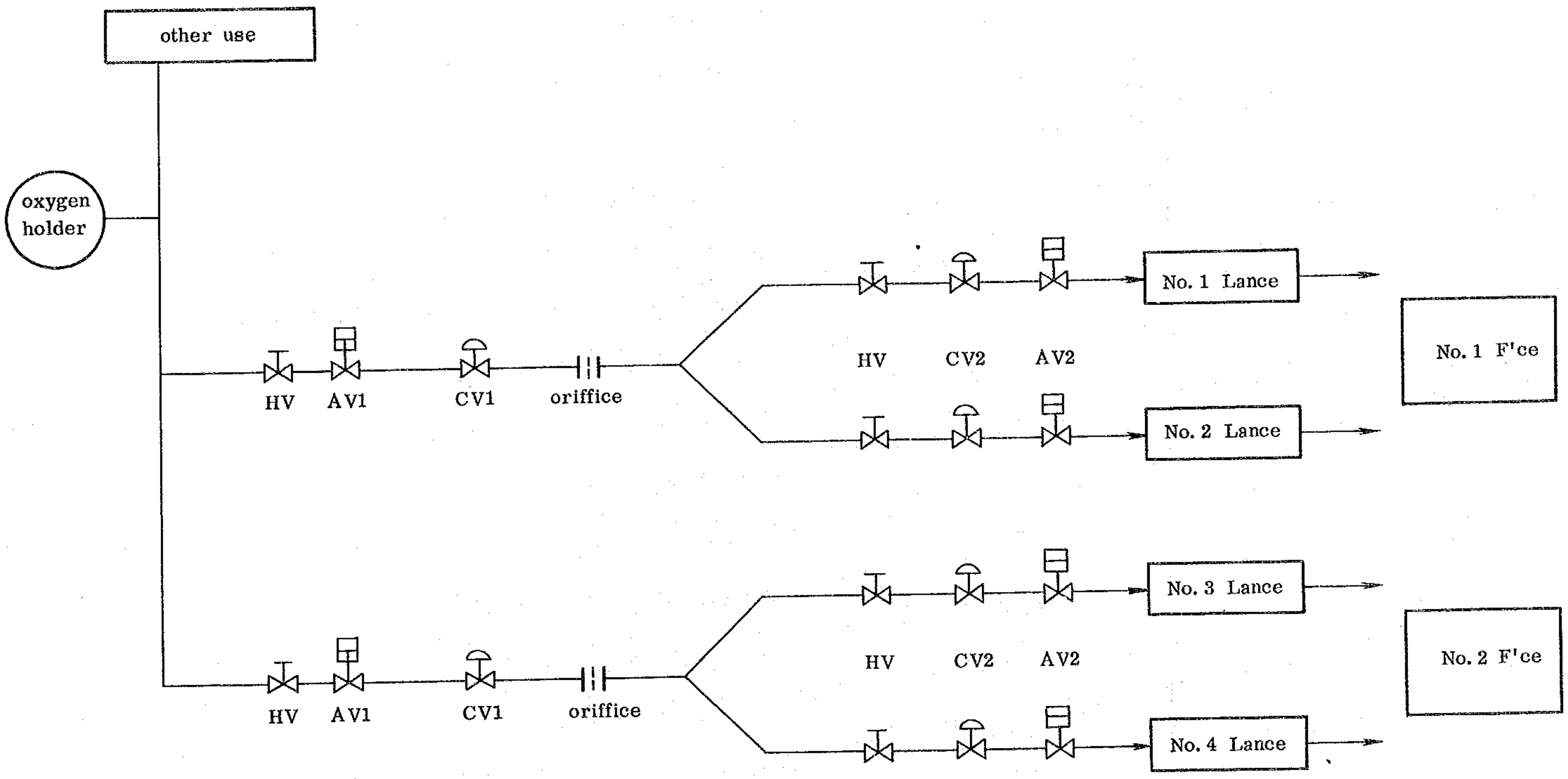
2nd step .... 17 kg/cm^2G ⟶ oxygen blowing pressure

The oxygen piping flow sheet is available in Fig. II.3.





HADISOLB'S HELWAN WORKS (STEEL MAKING PLANT)	
36 t/heat CONVERTER PROFILE	
DWG. NO.	16



HV	:	Hand operation valve
AV1, AV2	:	Pneumatic operation valve
CV1	:	Control valve (Pressure Control)
CV2	:	Control valve (Flow control)

Fig. II.3. Oxygen Flow Sheet

10.2.6 Lance cooling water

A cooling tower will be set up for lance cooling, and the lance cooling water will be used in circulation. For the cooling water volume, about 100 t/hr is needed.

10.2.7 Relining

The waste gas cleaning apparatus hood is moved, and bricks are brought in from the operation floor by crane. For brick laying inside the furnace, scaffolding is utilized.

10.3 Flux equipment

The facilities from receiving flux by freight car or truck to charging into the converter can be divided into the following 3 systems.

10.3.1 Receiving system

By freight car or truck, flux is delivered to the underground receiving hopper, on the bottom of which a feeder is set up. Through this feeder, flux is released to the belt conveyor, carried, and then rolled up vertically by pocket elevator. The brought up flux is transported by the shuttle conveyor over the ground bunker to the ground hopper for each material.

10.3.2 Transport system

Flux is released to the conveyor by the feeder set up on the bottom of each bin of the ground bunker. The flux released to the conveyor is rolled up by the pocket elevator in the plant and moved, again, to the belt conveyor installed above the furnace. Then, the flux moved to the belt conveyor is stored in the bunker above the furnace by the tripper for each material

10.3.3 Charging system

The bunker above the furnace consists of 6 bins, and the feeder installed on the bottom of each bin will release a required amount of each material to the weigher for weighing. The flux thus weighed is held in the charging relay hopper of the furnace in operation by means of the reversible belt conveyor installed on the lower section of

the weigher. When the time comes for charging into the furnace, the discharge gate is opened.

10.4 Ferro alloy equipment

Ferro alloy carried to the operation floor of the converter plant is stored in the bunker installed between No. 1 and No. 2 Furnaces. Necessary ferro alloy will be released by bunker's feeder into a wheel barrow and weighed by the weigher on the operation floor. Then, it is charged into the teeming ladle through the charging chute.

10.5 Waste gas cleaning apparatus

The CO gas generated by blowing from the top-blown converter (36 t/heat) is indirectly cooled in the gas cooling equipment, and the dust in the gas is eliminated in the wet dust collector. Clean air is, then, emitted by the induced draft fan through stack to the atmosphere.

10.5.1 Gas cooling equipment

The gas cooling equipment is made up of the hood and gas cooler. CO gas generated during blowing is caught by the hood, mixed with air sucked in through the gap between the furnace and the hood, fully burnt in the hood and inside the gas cooler, indirectly cooled to about 1,200°C, and led to the dust collector. The hood and gas cooler are of the double jacket structure. To facilitate brick laying of the furnace at the time of relining, only the hood is designed to move horizontally. Commonly called the evaporation cooling system, the hood-and-gas-cooler cooling system functions in such a way that the cooling water is supplied from the flush tank on top of the hood to the hood and gas cooler by the circulating pump. Part of that cooling water evaporates inside the double-jacket, and it is again returned to the flush tank while in the state of steam-and-water mixture. Steam is separated from water in the flush tank and emitted in the atmosphere. Water that becomes short as steam is evaporated is replenished with water by a pump from the alkali-removing water softening device to the flush tank.

10.5.2 Dust collector

The dust collector consists of the washer, whose purposes are to direct cool high temperature gas from the gas cooler and to catch coarse dust, and the venturi scrubber, whose purpose is to finally catch fine dust.

Available after the venturi scrubber is the mist separator, where water droplets collecting dust are separated. The amount of dust contained in the clean gas is less than 0. 3 gr/Nm^3. The dust collecting water is supplied to the washer and venturi scrubber in parallel. Drainage from each source is sent to the thickner, where dust particles are precipitated for separation. Clean water after the dust-removing process at the thickner is returned to the dust collecting water tank and recirculated at the dust collector.

10.5.3 Iuduced draft fan

The gas cleaned at the dust collector is burnt and emitted by the induced draft fan through the stack to the atmosphere.

Main specifications of the induced draft fan are as follows.

Volume of gas sucked	:	2,450 Bm^3/min (saturated)
Total blowing pressure	:	1,300 mmAq at 73°C
Motor capacity	:	900 KW

10.6 Water supply and drainage treatment facilities

As explained in 10.5, in the gas cooling equipment, part of the cooling water becomes steam during blowing and emitted to the atmosphere. As a result, it is necessary to replenish this system with water. If industrial water should be used as it is for this replenishment, scale may be formed in the hood and gas cooler. Hence, soft water obtained by treating it in the alkali-removing water softening device is utiilized.

This alkali-removing water softening device eliminates the hardness ingredients and alkalinity through the ion exchange resin is conducted by caustic soda and hydrochloric acid.

Drainage from the dust collector contains a large quantity of dust, and the thickner is available for precipitating the dust. The supernatant liquid of the thickner contains about 200 ppm suspended solids, but it is coolected in the dust collecting water tank to be supplied, again, to the dust collector by the pump.

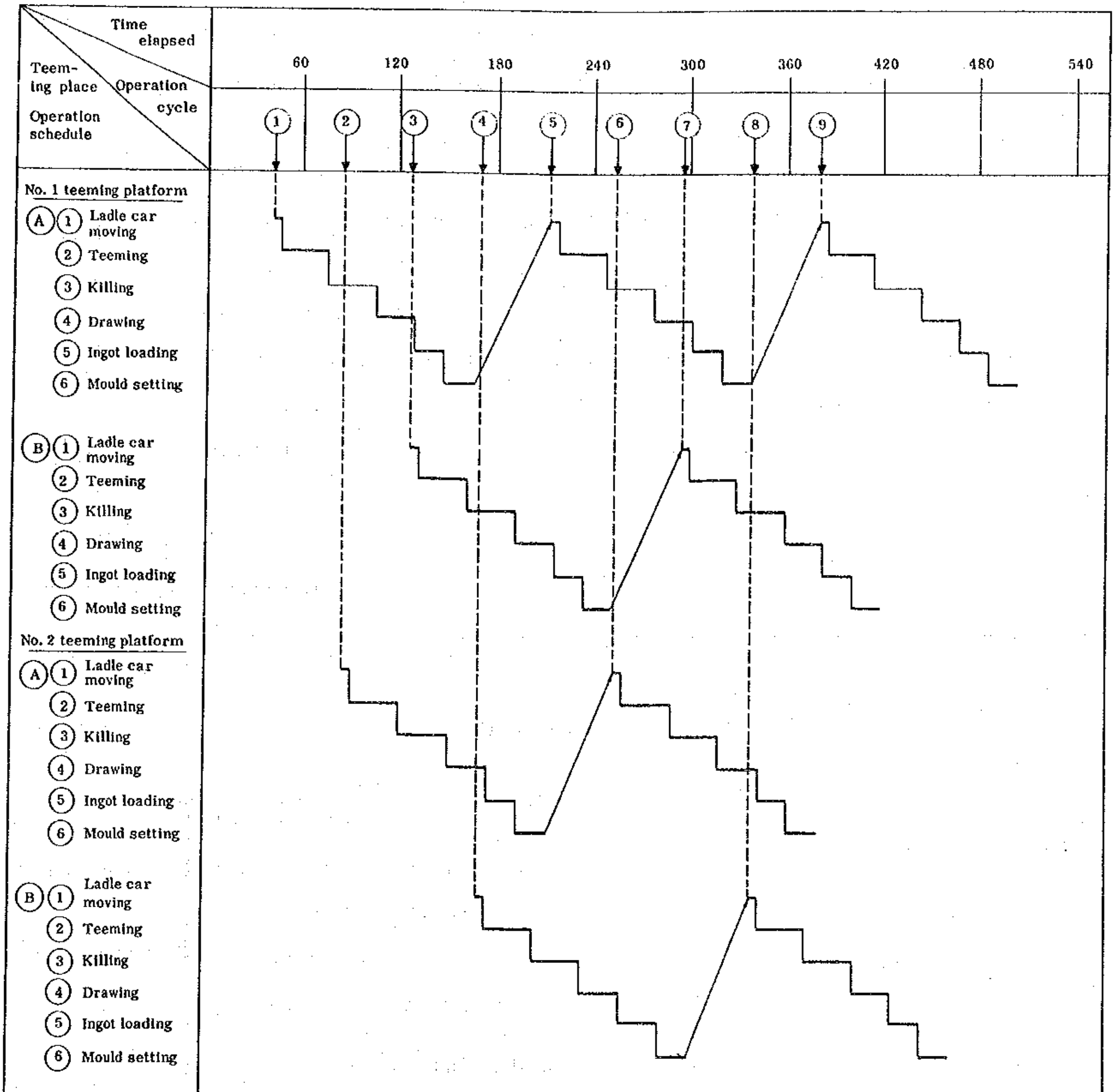
Dust particles settled in the thickner are gathered by the rake in the thickner's bottom and pumped to the sludge hydroextractor by the slurry pump. The sludge hydroextractor is of the pressurizing type, which discharges dust as cake with some 30 % water content.

10.7 Ventilation, dust collector

Red smoke generated when hot metal is taken from or poured into the hot metal mixer, and smoke generated at the time of charging into the converter are sucked by the induced draft fan through the hood and ducts, and dust is eliminated by the bag filter of this equipment

Main specifications are as follows.

Bag filter capacity	:	4,000 m^3/min, at 130°C
Induced draft fan	:	4,000 m^3/min, 400 mmAq
Induced draft fan motor capacity	:	500 KW



Conditions

a) The operation cycle is worked out on the basis of continuous operation with an average steelmaking time of 41.5 minutes in consideration of the operation peak.

b) A total of 4 teeming areas are assumed -- No. 1 teeming platform and No. 2 teeming platform, 2 areas for each platform.

Fig. II.4 Simulation results of the ingot making operation

10.8 Ingot making facilities

10.8.1 Teeming platform

The teeming platform is designed to be available in 2 areas so that basically, there will be no disorder in the sequential operation of each element such as teeming, drawing, ingot handling and mould setting even when the operation peak from the converter continues at the rate of an average steelmaking time of 41.5 minutes. Moreover, at one teeming platform, a sufficient space is allotted to enable teeming of 2 heats.

Results of hand simulation under conditions above are shown in Fig. II.4. The simulation results proved that no problems would be encountered, and that the operation peak of the converter could be adequately dealt with.

10.8.2 Mould cooling floor

(1) Mould use cycle

Item	Time (minutes)
(1) End of tapping - start of teeming	5
(2) Teeming	30
(3) End of teeming - start of mould stripping	30
(4) Mould stripping	24
(5) Cooling of mould	600
(6) Mould setting	24
(7) Waiting for teeming	30
Cycle Time	743
Turnover rate of mold use in a day	1.94 → 2.0

The mould turnover rate is set at 2.0.

(2) Required area of the mould cooling floor

A study was conducted in accordance with moulds for 3 t ingots.

1,525 mm x 1,025 mm = 1.56 m^2/mould * See Fig. II.5

1.56 m^2/mould x 12 moulds = 18.72 m^2/heat

18.72 m^2/heat x 15 heats = 280.8 m^2 .... (1)

Assuming that reserve moulds on hand (including space for taking out and bringing in new and obsolete moulds) are for 5 heats, an additional area is needed as follows.

18.72 m^2/heat x 5 heats = 93.6 m^2 .... (2)

Therefore, some 374 m^2 will be needed for the mould cooling floor.
Accordingly, the cooling floor of 184 m^2 (8 m x 23 m) x 2 places is arranged in front of each teeming platform.

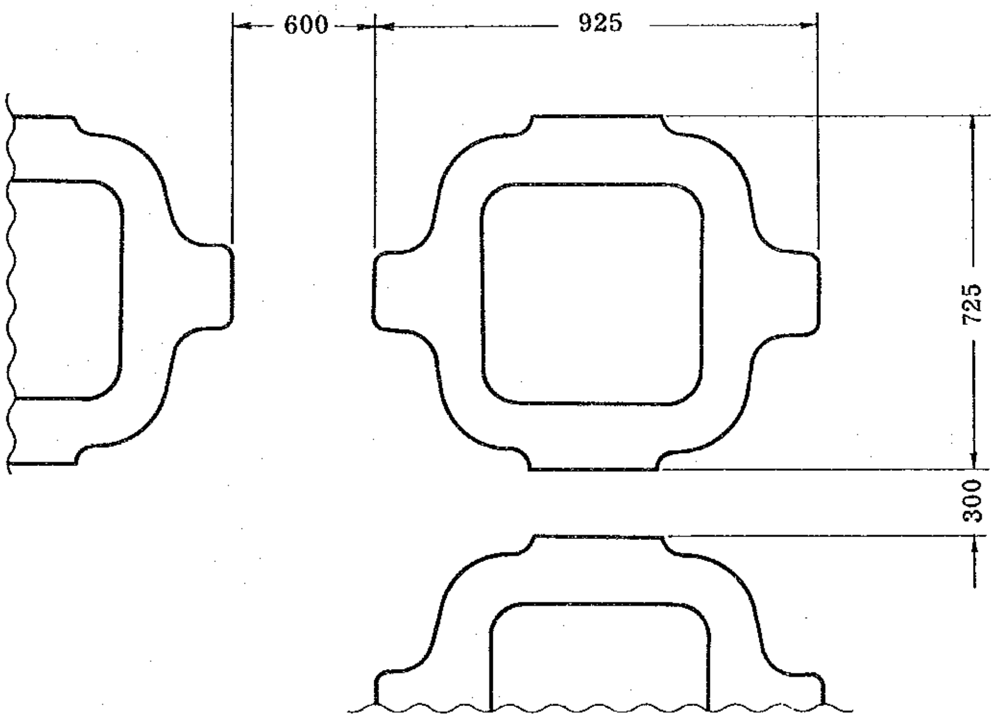


Fig. II.5 Criterion for calculating the mould cooling floor

10.8.3 Required number of teeming ladles

(1) 27,500t/m ..... 764 heats/m   Steelmaking time 41.5 min/heat

(2) Ladle lining life 8 heats ...... Steelmaking time 0.692 hr x 8 = 5.53 hr/cycle

(It is assumed that no intermediate or minor repair will be done.)

(3) Ladle relining time

* hr/cycle

Cooling	Wrecking	Brick-laying	Drying	Total
7	5	12	12	36

(4) Required number of ladles

a) Number of ladle in fulltime service

= (36 hr + 5.53 hr)/ 5.53 hr = 7.5 ladles

b) Standby ladles = 1 ladle

c) Standby ladle with skull deposits, etc. = 1 ladle

Total 9.5 ⟶ 10 ladles

11 Outlines of the Principal Equipment Specifications

	Principal Equipment	Equipment Specifications	Quantity	Remarks
①	Hot metal, scrap equipment			
	1) Hot metal mixer	Capacity : 600 t	1	
	2) Hot metal weighter	Capacity : 60 t	1	
	3) Hot metal ladle	Capacity : 43 t	4	
	4) Scrap chute	Capacity : 7 t	3	
	5) Scrap weigher	Capacity : 15 t	1	
	6) Hot metal ladle drier		1	
②	Flux, ferro alloy equipment			
	1) Receiving bunker	Capacity:: 30 m^3	2	
	2) Ground bunker	Capacity : 45 m^3	5	
	3) Conveyor's conveying capacity	Capacity : 60 t/hr	1	
	4)	Capacity : CaO 24 m^3 x 2, Ore 5 m^3 x 1, CaF_2 5 m^3 x 1, Spar 5 m^3 x 1	5	
	5) Weigher	Capacity : 2t x 1, 0.5 t x 1	2	
	6) Shuttle conveyor	Capacity : 150 t/hr	1	
	7) Additives hopper	Capacity : 3 m^3	2	
	8) Ferro alloy storage bunker	Capacity : 1 m^3	3	
	9) Ferro alloy weigher	Capacity : 0.5 t	1	
	10) Ferro alloy charging equipment		2	

	Principal Equipment	Equipment Specifications	Quantity	Remarks
③	Converter equipment			
	1) Furnace shell	Capacity : 36 t Shell height 7,500 mm Shell diameter 4,700 mm	2	Shell volume 104 m^3 Inner volume after lining 37.6 m^3
	2) Tilting device	Tilting speed: 0.1 ~ 1.0 rpm	2	
	3) Lance winch & lance guide	Capacity : 10 t	2	
			2	
	4) Lance		4	
	5) Flexible hose for lance cooling water	Water volume : 100 t/hr	4	
	6) Flexible hose for oxygen	Oxygen volume supplied : 7,500 Nm^3/hr	2	
	7) Indoor oxygen piping	Oxygen volume supplied : 7,500 Nm^3/hr	2	
	8) Indoor piping for lance cooling water	Water volume : 100 t/hr	2	
	9) Furnace proper lining breaker		1	
④	Waste gas cleaning apparatus	Waste gas volume : 61,300 Nm^3/hr	2	Slag pot transfer car
⑤	Ingot-making equipment			
	1) Ladle car	Capacity : 55 t	2	
	2) Teeming ladle	Capacity : 36 t	9	
	3) Slag pot	Capacity : 6 m^3	5	
	4) Slag pot transfer car	Capacity : 20 t	3	
	5) Ladle drier		2	

	Principal Equipment	Equipment Specifications	Quantity	Remarks
⑥	Crane equipment			
	1) Hot metal receiving crane	Capacity : 50/10 t	1	
	2) Hot metal charging crane	Capacity : 60/10 t	1	Hot metal 41 t, Hot metal ladle steel mantle 9 t, Bricks 7 t, Total 57 t
	3) Scrap charging crane	Capacity : 10/10 t	1	Scrap 7 t, Scrap chute tare weight 6 t, Total 13 t
	4) Teeming crane	Capacity : 55/10 t	2	Molten steel 36.9 t, Molten steel ladle steel mantle 9 t, Bricks 8 t, Total 53.9 t
	5) Stripper crane	Capacity : 10 t	2	
	6) Converter bay service crane	Capacity : 15 t	1	
	7) Hoist crane for brick-carrying	Capacity : 3 t	2	
	8) Wall crane for repairing ladle	Capacity : 3 t	2	
⑦	Water treatment equipment for the waste gas cleaning apparatus			
	1) Water softening device	Capacity : 15 t	1	
	2) Thickner	Capacity : 250 t/hr	1	
	3) Hydroextractor	Capacity : 0.5 t/hr		
⑧	Ventilation, dust collector	Capacity : 4,000 m^3/min	1	

12. Countermeasures for Improvement at the Thomas Plant

As for the problems pointed out in 1, there are those that ought to be coped with by executing the rehabilitation plan, and those that ought to be handled at present. Countermeasures for the latter problems should be put into effect at the earliest opportunity. Main items of such countermeasures are as follows.

a) Restoration of the hot metal weigher, its maintenance and control should be made.

b) The temperature measurement system should be established.

c) The ingot transport lot should be changed to a maximum of 2-heat lot in conformity with the blooming/soaking cycle.

Along with these remedial measures, it seems worthwhile to study the possibility of instituting oxygen enrichment for the improvement of productivity of the Thomas Plant and quality of steel produced therefrom. In this study, due considerations should be given to the effect of oxygen enrichment on the lining life, particularly bottom linings.

III. ROLLING

1. Blooming Mill

In this rehabilitation plan, the following two alternative bloom and slab manufacturing methods in the blooming mill are considered.

a) To manufacture all blooms and slabs from ingots.

b) To manufacture a part of blooms and slabs by rolling large CC blooms.

Table III.1 Comparision of all ingot method and CC-breakdown method

		All ingot method	CC-breakdown method
Input		375,000 t/y	295,000 t/y (CC: 250,000, Ingot: 45,000)
Equipment remodelling cost		$3,773,000	$4,900,000
Major equipment to be remodelled		Addition of 4 soaking pits	Installation of 1 reheating furnace (70 t/hr)
		Addition of 1 soaking pit crane	Installation of 1 charging crane
		Addition of 1 cover crane	Remodelling of receiving table
Working conditions	Rolling	68.1 t/hr	79.6 t/hr (CC blooms: 81.6, ingots: 70.4)
	Fuel consumption	300,000 kcal/t	385,000 kcal/t
	Shearing yield	88.0 %	91.5 %
Remarks			4 soaking pits are sufficient for the purpose. A reheating furnace will be installed in the place of No. 5 and 6 soaking pits.

These two alternatives should be carefully compared and studied to attain a good coordination between steelmaking and blooming departments, taking into consideration the rehabilitation of the Thomas plant. The comparison of them, which have been described in detail in II. STEELMAKING, indicates that the All ingot method has the advantage over the CC breakdown method. Therefore, the following rehabilitation plan of the blooming mill is based on the All ingot method.

1.1 Improvement of operation

1.1.1 Ingots

The size and weight of ingots have an important effect on the soaking pits operation, rolling capacity, shearing yield and products quality. The present mould dimensions are as follows.

Table III.2 Present mould dimensions

Mould	Top (mm)	Bottom (mm)	Hight (mm)
K33	445 x 445	510 x 510	2,150
K40	445 x 565	510 x 630	2,150

As for K40, there is no room for changing its casting ingot weight of approximately 4,000 kg because of the limitation of the lifting capacity (3.3 tons) of the soaking pit crane. On the other hand, K33 moulds, from which ingots of approximately 1,850 mm in height and approximately 2,800 kg in weight are produced, are used only for rimmed steel. Therefore, ingots of 2,000 mm and 3,100 kg in weight will be able to be cast at the permissible top level tolerance of 150 mm. The reason why smaller ingots have been manufactured seems to be the limitation of the width of the reheating furnace in the heavy section mill. In the rehabilitation of the Thomas plant, it is advisable to reexamine bloom dimensions

and to establish a system in which ingots of 2,000 mm in height and 3,100 kg in weight can be produced.

1.1.2 Soaking pits

(1) Heating rate of soaking pits

Since the heating rate of soaking pits usually depends on the track time, charging tonnage of ingots and the furnace operating method, it is necessary to take measures for these.

1) Track time

It is desirable to minimize the track time of ingots for the improvement of fuel consumption and heating rate, and to prevent the cold ingots. It is said that fuel consumption can generally be reduced by 8,000 kcal/t, heating time by 10 ~ 15 minutes by reducing the track time by 10 minutes. The track time which would be achieved in actual operations in Helwan Works is estimated as follows.

Time for solidification: rimmed, semi-killed steel 25 min.
killed steel 90 min.

Percentage of killed steel: 2% of the total (estimated from the result in Nov. 1976)

Transport time: 1.0 km/5 km/hr = 0.20 hr → 15 min.

Track time

Teeming end	Time for solidification	Waiting for stripping	Stripping	Loading	Waiting for transport	Transport	Waiting for charging	Charging	Charging end
	25'(90)	4'	2'xN	1.5'xN	8'	15'	10'	1.5'xN	

*N: number of ingots

*Waiting time: based on the Nippon Steel

Table III.3 Calculations of track time

LD rimmed, semi-killed steel		122'
EF	Rimmed, semi-killed steel	77'
	Killed steel	142'
Average		112'

* Number of ingots: LD 12 ingots, EF 3 ingots.

The actual hours of track time in Helwan Works are as follows.

Actual hours of track time (Nov. 1976)

(Thomas + EF)

< 2 hr	:	300 heats
2 ~ 3	:	206 "
3 ~ 4	:	109 "
4 ~ 5	:	45 "
> 5	:	72 "

The shortest track time of heats from the newly planned LD plant is expected 95 min. In view of the fact that heats with track time of less than 112 min. account for 41% at present, it may be not impossible to achieve the average track time of 120 min. if only proper measures are taken. Track time may vary depending on the distance between steelmaking and blooming plants and operating conditions, but there are some steel works treating 5-ton ingots, whose average track time for rimmed steel is approximately 100 min..

The number of locomotives required for transporting hot ingots in Helwan Works is estimated as follows.

Number of heats to be transported.

EF steel: 45,000 t/y/325 d/y x 12 t/heat = 11.5 heats/d

LD steel: 330,000 t/y/325 d/y x 36 t/heat = 28.2 heats/d

If all EF heats are transported together with LD heats, the number of transport services is 28.2 times/d, and if each heat of EF and LD heats are transported separately, the number of transport services is 39.7 times/d.

Transporting time is

Switching at the steelmaking plant	5'	50 min./cycle
Transporting ingots	15'	
Switching at the blooming mill	5'	
Transporting of empty transfer cars	15'	
Waiting time for crossing	10'	

Assuming that the time required for inspecting locomotives is 0.5 hr/shift and working rate is 75%, working time is

(24 hr - 0.5 hr/shift x 3 shifts) x 0.75 = 16.9 hr/day, thus the number of transport services of a locomotive per day is 20.3 times/d.

Table III.4 Required number of locomotives

Transporting method	Number of locomotives
Separate transport of EF and LD heats	2.0
Transport of 50 % of EF heats together with LD heats	1.7
Transport of 100 % of EF heats together with LD heats	1.4

Therefore, in order to handle ingots in a short track time, two units of locomotives specially used for transporting hot ingots are required. In addition, it is necessary to strengthen management of daily works, such as mould stripping in the steelmaking plant, ingot charging in the blooming mill and

coordination between the steelmaking plant and the blooming mill. In Helwan Works, the necessity is reduction of track time in order to improve soaking pit capacity. In Japan, too, various attempts have been made in recent years to reduce track time with a view to energy conservation, and as a result, fuel consumption of 100,000 kcal/t, or even 70,000 kcal/t in some cases, has been recorded.

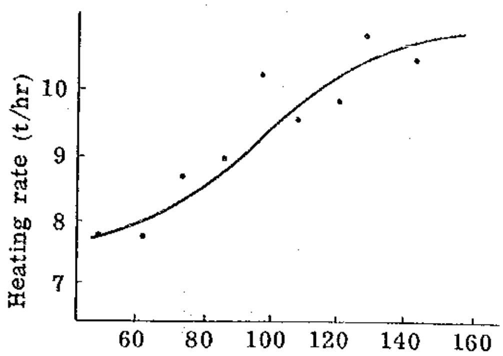
Next, another problem in blooming mill of Helwan Works is an abnormally high level of cold ingot generation. Generation of cold ingots is generally attributable to the following factors.

a) The difference of periodical maintenance days between the steelmaking plant and the blooming mill.
b) A long-time failure and annual repair in the blooming mill.
c) Extraodinariness in steelmaking, such as steel of unexpected composition.

Cold ingot rate in Nippon Steel is generally 2 ~ 6 %, and even in Nippon Steel's Kamaishi Works which has only one blooming mill, the cold ingot rate is approximately 6 %. The cold ingot rate of 42% experienced by Helwan Works in Nov. 1976 is quite extraodinary, so adequate measures, including performing periodical maintenance in steelmaking and blooming departments on the same day, should be taken as soon as possible to reduce the cold ingot rate to at least under 10 %.

2) Ingot charging method

In charging ingots into soaking pits, there is a close relationship between the cover ratio and the heating rate of soaking pits, fuel consumption. That is, within a certain cover ratio, both the heating rate of soaking pits and fuel consumption are improved by increasing the total weight of ingots to be charged. In general, the cover ratio of 35 45 % is considered optimum.



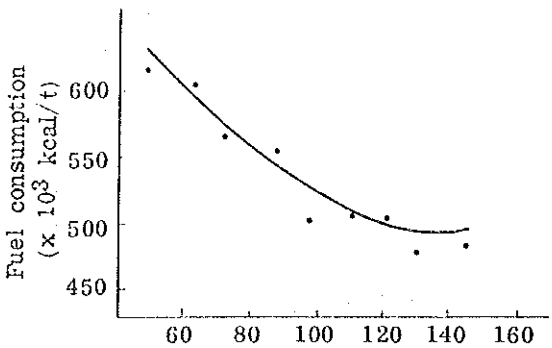


Fig. III.1 The relation between the total weight of ingots to be charged and heating rate, fuel consumption

The relation between the total weight of EF and LD ingots to be charged and the cover ratio in Helwan Works is as follows.

Table III.5 The ralation between charging method and cover ratio in Helwan Works

	Charging 2 charges of EF ingots	Charging 1 charge of LD ingots	Charging EF and LD ingots in combination
	6 ingots	12 ingots	15 ingots
Cover ratio	14.0 %	22.7 %	29.6 %

Since EF steels are tapped at the rate of 12 t/heat in the intervals of approximately 2 hours, when two heats of EF are to be charged, the preceding heat has to be placed in the soaking pit or left out of the soaking pit until the succeeding heat arrives. This is a very ineffective practice. Therefore, it is recommendable to investigate whether the following charging method is possible or not.

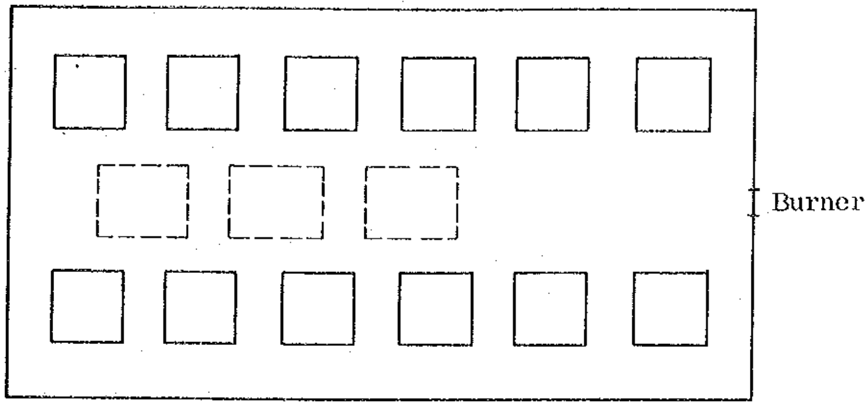


Fig. III.2 Proposed charging method

Solid line - LD ingots, dotted line - EF ingots

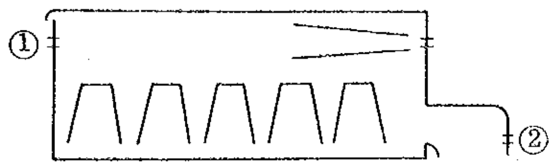
That is, when a total of two heats, 1 heat of EF and another of LD heats, are charged, heating capacity is imporved by approximately 40 % on calculation, compared with the charging of two heats of EF ingots.

In this case, the desirable charging method is three-row charging, as shown in Fig. III.2. This charging method seems to have no problems since the cover ratio is 29.6 %. Alghough Nippon Steel has experience in the 3-row charging method used in the 2-burner soaking pits which are a little wider, but has no experience in soaking pits of such a 1-burner type as installed in Helwan Works. Therefore, it is recommendable to study this charging method and to establish a proper working method.

3) Operation of soaking pits

(a) Control of internal temperature of soaking pits

The internal temperature control system of soaking pits in the blooming mill of Helwan Works is one in which temperature is detected at two points to control the flow of gas and air.



After the heating starts and the point ② reaches the predetermined temperature, gas and oil flow is decreased and then the point ① reaches the predetermined temperature, initiating the on-off operation of oil flow.

In Japan, satisfactory results have been obtained with the 1-point temperature control at the point ① or a opposite point. It cannot be hastily determined which of the two control systems is better, but the 1-point temperature control is advantageous at least in the following two points.

a) Temperature in the hole can be rapidly raised, thus improving heating rate.

b) The flow control system can be simplified.

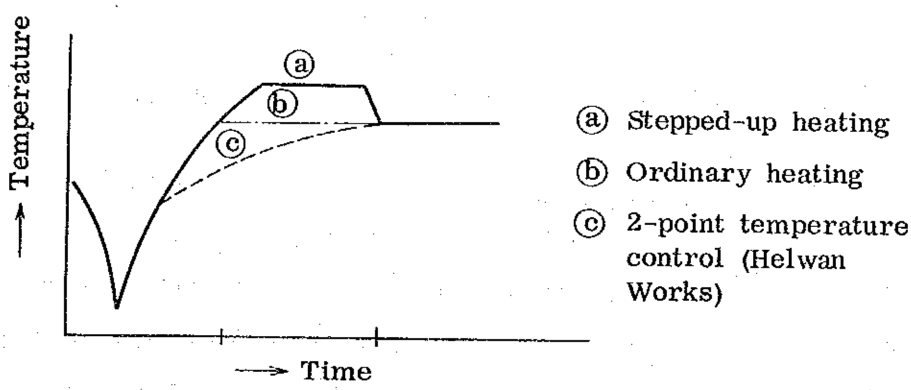


Fig. III.3 Comparison of heating methods

Fig. III.3 shows temperature changes at the point ① of a soaking pit. The 2-point temperature control system has the adverse effect on that of the stepped-up operation, which is generally employed to improve the heating rate of the

soaking pit. This 2-point system leads to delay in temperature rise of ingots in the hole. Consequently, it is necessary to study the possibility of 1-point temperature control system. Fig. III.4 shows a typical instrumentation flow for a gas-fired soaking pit. The instrumentation of oil/gas-fired soaking pit is the same in principle as that of gas firing soaking pit.

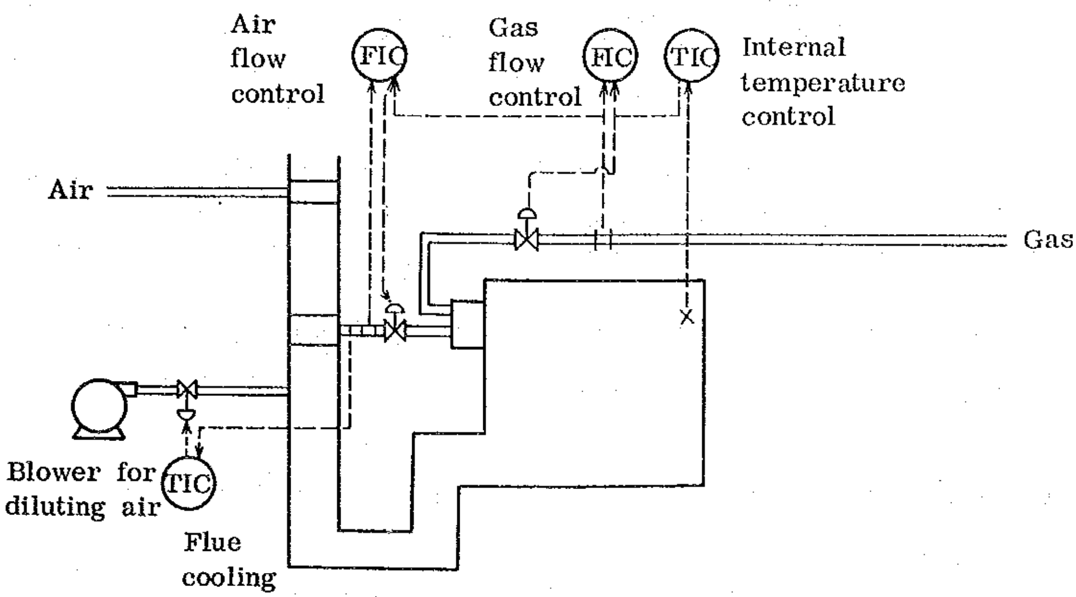


Fig. III.4 A typical flow of soaking pit instrumentation

(b) Recuperators

Recuperators in the blooming mill of Helwan Works are not well maintained. It is said that recuperators have an effect to improve fuel consumption and heating rate by approximately 20 % each. In Helwan Works, recuperators are reportedly often burned to damage, so measures to prevent such damages should be taken.

Table III.6 Materials of metallic recuperators and preheating temperature

Type		Materials		Preheating temperature (°C)
Finned tube type		28Cr - 1Ni, 30Cr - 10Ni		500 - 600
Herzen type		External tube 25Cr - 12Ni	Internal tube 18Cr	450 - 500
Stack type	Shack type	High temp. zone 20Cr - 10Ni	Low temp. zone 18Cr - 8Ni	550 - 600
	Escher type	High temp. zone 25Cr - 20Ni	Low temp. zone 18Cr - 10Ni - Ti	550 - 600

The air preheating temperature of the metallic recuperators is limited by the type of metal materials, which are used up to the maximum preheating temperature of approximately 600°C. One of the commonly used means to protect recuperators is to measure combustion gas temperature and air preheat temperature and to adjust the combustion gas temperature by blowing diluting air to the entry side of the recuperator, as shown in Fig. III.4. It is necessary to prevent abnormal temperature rise and to perform routine maintenance so that the protecting device can be properly operated in case of abnormal temperature rise.

(2) Operating rate of soaking pits

Soaking pits in the blooming mill have 8 holes, but their operating rate is extremely low. The cause for low operating rate is shutdown of the holes due to replacement of hole covers, repair of the holes, slag off operations, etc.

Table III.7 Shutdown of soaking pits in Helwan Works (day)

Month \ Hole		1	2	3	4	5	6	7	8
1976	6	0	18	2	11	3	11	2	8
	7	23	7	8	2	11	2	4	0
	8	3	17	14	9	6	0	17	0
	9	6	8	8	21	0	2	0	22
	10	14	15	17	8	0	20	11	6
	11	12	15	13	0	18	3	1	0
Total		58	80	64	51	32	38	35	36

The table indicates that only 5.8 holes out of 8 holes have been operated on an average. In order to improve the operating rate of soaking pits, extension of hole life and mechanization of slag off operations should be needed.

1) Extension of hole life

(a) Refractories

The following types of refractories are used for soaking pits in Japan.

Table III.8 Refractories for soaking pits

	Type of refractories
Hole bottom	Chrome-magnesite bricks, chamotte bricks, insulation fire bricks
Hole wall	Upper and middle parts: silica bricks, plastic refractories Lower part: chrome-magnesite bricks, insulation fire bricks
Seal, burner port	High-alumina refractories, plastic refractories, castables
Flue	Chamotte bricks, insulation fire bricks
Hole cover	High-alumina bricks, plastic refractories, castables, insulation fire bricks
Gas exhaust port	Silica bricks, high-alumina bricks, chrome-magnesite bricks

In constructing soaking pits, care should be exercised on the following points.

a) Selection of refractories best suited to the conditions of soaking pits.

b) Provision of expansion joints (size, location)

c) The selection of proper brickwork

d) The method of zoned lining

(b) Hole covers

The practice of Helwan Works blooming mill to replace hole covers every month is quite abnormal. Nippon Steel also uses high alumina bricks (Al_3O_2 50 %, SK35) of the same shape and quality as used in Helwan blooming mill, but they last over ten years only with partial repairs.

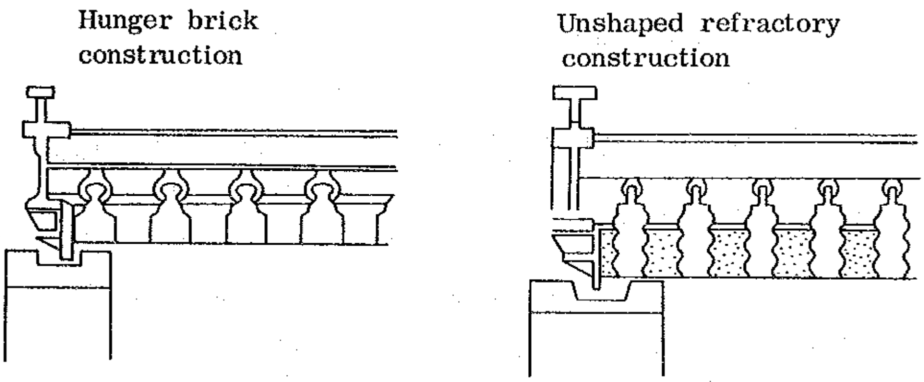


Fig. III.5 Shapes of hole covers

As measures to lengthen the hole life,

a) The shape of hanging portion of bricks should be reexamined.

b) The strength of metal hangers and insulation should be reinforced.

c) Hole covers should be dried before use.

- Allow them to stand after repair to dry naturally.
- Dry them forcibly in a simple dryer placed outside the hole.

d) Dry hole covers with heat in the hole immediately after replacement.

- Replace them with new ones at the time of periodical repair and dry completely at low temperatures in the hole.

Particularly, c) and d) seem to prove effective measures.

(c) Hole walls

The repair cycle of Nippon Steel's soaking pits which are in the same operating conditions as in Helwan blooming mill is 25 ~ 30 months. Bimonthly repairs of every surface of pit walls practiced in Halwan Works blooming mill is a very unique repairing method, and dry time after repair seems to be too short. Convex deformation of hole walls is attributable to frequent cooling of the hole, in addition to the problem associated with hole construction.

The possible measures for lengthening the hole life are

a) Use of proper refractories

In recent years, unshaped refractories have been used in some soaking pits in Japan, but more commonly, silica bricks are used in the upper and middle parts of the hole and chrome-magnesite bricks in the lower part.

b) Improvement of hole construction technique

The following values are generally used as expansion and joint allowances.

Joint allowances

Ordinary refractories:	2 ~ 3 mm
Red bricks:	7 ~ 8 mm

Table III.9 Expansion allowances of fire bricks

Type of brick	Expansion allowances
Silica	13 ~ 15 mm/m
Chamotte	6 ~ 8 "
High alumina	8 "
Cr-Mg (fired)	11 "

c) Extension of dry time after repair

Typical temperature rise curves are shown in Fig. III.6. Sharp temperature rise causes spalling, leading to shortened hole life.

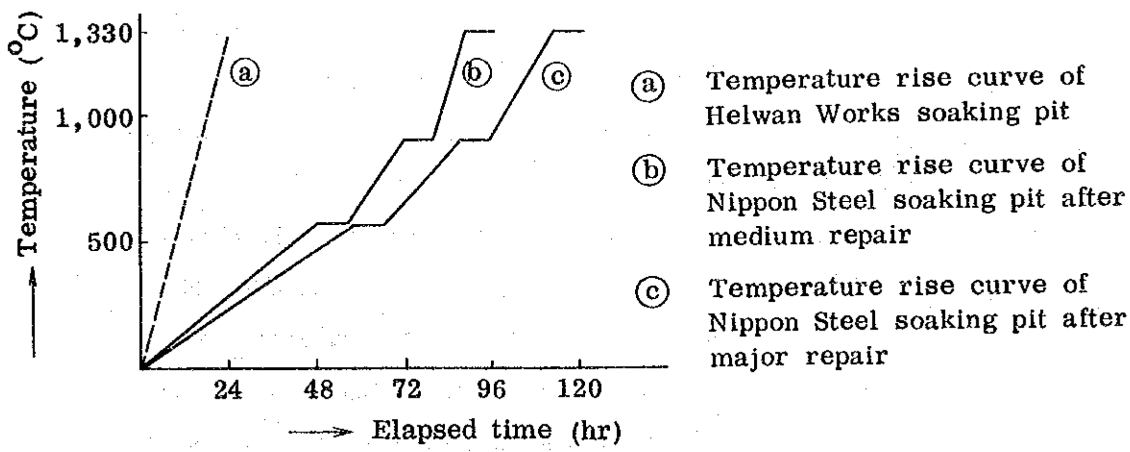


Fig. III.6 Temperature rise curves after repair

d) Prevention of intermittent hole operation

Concave deformation of hole walls seems to be attributed to the intermittent operation of soaking pits.

Repair of hole walls should be performed simultaneously on four surfaces. It is necessary to completely perform the repair of soaking pits, and at the same time, to maintain control of daily operations, such as prevention of damage to the holes during ingot charging and discharging operation and control of sand seal.

2) Mechanization of slag off operation

In Helwan Works blooming mill, slag off operation is performed once every two months after cooling the hole, and at the same time, hole walls are also repaired. There is no blooming mill in Japan which cools the soaking pits for slag off operation. In some soaking pits of new type, slags are scraped off to the bucket under the holes by a scraper inserted by the soaking pit crane through the cinder hole provided on the hole bottom. In soaking pits of the older type having no cinder hole, slag are scrapped together at the center of the hole by a scraper operated by the soaking pit crane and discharged outside the hole using a special bucket. With this method, operations ranging from slag off to bottom-making with fine coke can be completed in an hour.
To attain this, a soaking pit crane of the construction that is capable of scraping slags by a scraper is needed.
It is desirable that slag off operation be performed immediately after discharging of ingots, when the hole temperature remains high. Solidification of slags experienced in Helwan Works seems to be due to low hole temperature during slag off operation. In case the hole temperature drops, we recommend to perform slag off work after softening slags by raising the temperature in the empty hole. On the other hand, combustion control should be carefully performed to prevent slag troubles due to washing.

An example of hole bottom control

Bottom-making material:	very fine coke
Replenishment of fine coke:	once every 3 days
Slag off operation:	once a month

(3) Capacity of soaking pits

The capacity of soaking pits is calculated from the following equation.

$$Ph = \frac{1}{24} \times \frac{24 - (Tb + Te)}{T_P + T_O + T_C + Td} \times Wt \qquad \text{t/hr, hole}$$

$$T_P = C_1 \times \frac{(Wt)^{0.8} \times (TT)^{0.62}}{(Qp)^{0.50}} + C_2 \qquad \text{hr/cycle, hole}$$

$$Te = \frac{Wt}{W} \times t_u$$

$$T_d = \frac{Wt}{Pr}$$

P_h	:	Capacity of soaking pit per hole	t/hr
T_P	:	Heating time	hr/hole cycle
TO	:	Over soaking time	"
T_c	:	Ingot charging time	"
Td	:	Ingot discharging time	"
Tb	:	Bottom making time	hr/d
Te	:	Idle time of soaking pit	"
Wt	:	Total weight of ingots to be charged	t/hole cycle
TT	:	Track time	hr
Qp	:	Maximum heat input	10^4 kcal/hole-hr
W	:	Unit weight of ingot	t/ingot
tu	:	Time required to charge one ingot	hr/ingot
Pr	:	Rolling rate	t/hr
C_1	:	Constant	
C_2	:	"	

Values

T_o	T_b	T_e	Q_p	t_u	P_r
1.00	0.15	3.00	364	0.025	68.1

Constants

	Rimmed, semi-killed steel	Killed steel
C_1	0.71	0.52
C_2	2.85	5.90

Prerequisites

a) For TT, a value 1.20 times the value given in Table III.3 is used to provide some allowance.

b) Cold ingot rate is set at 10 % of total ingots.

c) Total weight of ingots to be charged is assumed to be LD ingots 3 t x 12 pcs. = 36 t, EF ingots 4 t x 3 pcs. = 12 t.

d) In separate charging, LD ingots 36 t, EF ingots 12 t x 2 = 24 t, cold ingots 30 t are assumed to be charged, and in combined charging, LD ingots 36 t + EF ingots 12 t = 48 t are assumed to be charged.

The conditions required for heating 375,000 t/y of ingots under the above-mentioned prerequisites are given in Table III.10.

Table III.10 Required heating time (hole-hr)

			Steel ingots t/y	Separate charging			Combined charging *		
				T_p	P_h	Hole-hr	T_p	P_h	Hole-hr
Hot ingots	LD	Rimmed steel	297,000	3.99	5.31	55,932	3.99	5.31	33,032
	EF	Rimmed steel	33,750	3.47	3.35	10,075	4.28	6.46	25,093
		Killed steel	6,750	6.56	2.24	3,013			
Cold ingots			37,500	8.00	2.67	14,045	8.00	2.67	14,045
Total			375,000			83,065			72,170

* In combined charging, all EF heats are charged with LD heats.

(Note) In two-heat charging of EF ingots, it is assumed that the second heat arrives 2 hours later and can be discharged after a heating time 30 minutes shorter than T_p in the case of charging two heats simultaneously.

If the above-mentioned measures for improving the operation rate of soaking pits are taken, the annual heating time per hole can be increased to 7,000 hr/y.

Total calender hours : 24 hr x 365 day = 8,760 hr

Pit repair: 24 hr x 30 d/y = 720 hr
Annual repair: 24 hr x 10 d/y = 240 hr
Periodical repair: 48 hr/m x 11.5 m/y = 552
Other down time: 248 hr

} Downtime

Therefore the heating time for 8 holes is 8 x 7,000 = 56,000 hr/y and the soaking pit capacity is

In separate charging, $375{,}000 \text{ t} \times \frac{56{,}000}{83{,}633} = 251{,}000$ t/y

In combined charging, $375{,}000 \text{ t} \times \frac{56{,}000}{72{,}169} = 291{,}000$ t/y

1.1.3 Rolling

(1) Rolling rate (t/hr)

The rolling rate of Helwan blooming mill is low with the operation during the period between Jan. ~ Oct., 1976 being 31.7 ~48.2 t/hr averaging 42.0 t/hr. The low rolling rate is attributable not only to operating problems such as misrolling of blooms due to low ingot temperature, small rolling reduction, etc. but also to the fact that the net rolling time are not accurately recorded because short down time is included in rolling time.

An estimate of rolling rate in t/hr under normal conditions is given in Table III.11. Assuming the percentages of each bloom for heavy section mill and each slab for plate mill are equal, then the average rolling rate is 68.1 t/hr.

To accomplish the rolling rate of 68.1 t/hr, the following measures should be taken.

a) To increase the rolling temperature of ingots

Short heating time of ingots may result in bend or camber of blooms due to uneven heating and low rolling reduction. Although values given in Table III.10. Required heating time are of considerably high accuracy, the heating time best suited to the hole type, ingots and other operating conditions in the blooming mill has to be determined by careful study of the actual conditions.

Table III.11 Rolling rate (t/hr) by cross section

Application	Cross section	No. of passes	Calculated rolling rate (t/hr)
Light section and for sale	140 x 140	25	53.6
Heavy section	140 x 160	25	54.2
	140 x 200	25	55.0
	140 x 280	21	72.5
	160 x 180	23	62.9
	160 x 220	21	72.2
	160 x 240	21	72.5
	200 x 200	21	73.4
Plates	140 x 450	15	126 (136)
	170 x 450	15	127 (137)

Note 1: The t/hr values above are calculated based on the rolling time and idle time measured on a rolling mill of the same type in Helwan Works.

Note 2: The t/hr values in brackets for slabs for plates are ones for rolling on a rolling mill having no bottlenecks in discharging.

One of the criteria for judging whether or not heating time is proper is the finishing temperature of rolling. In general, the heating time is determined so that the average value of the finishing temperature of rolling falls within 1,100 ± 10°C.
In determining the heating time in Helwan Works, not only the rolling rate but also the rolling without further conditioning in subsequent processes should be taken into consideration. In addition to the above, the rolling temperature of ingots is required to be increased to reduce surface defects on slabs and blooms.

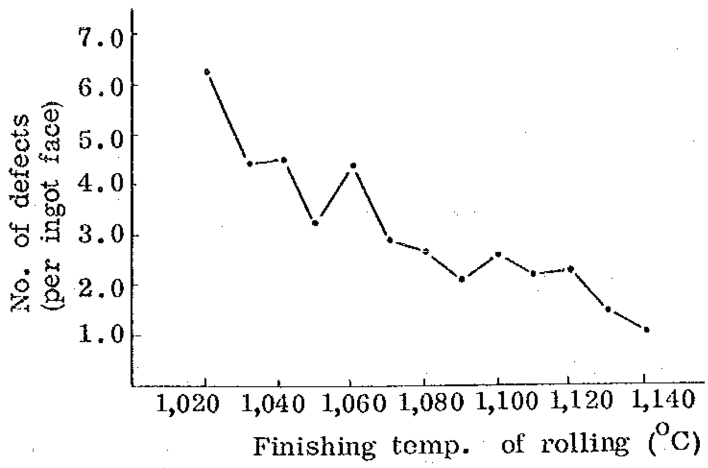


Fig. III.7 Finishing temperature in blooming and surface cracks

At the rolling temperature of over 1,050°C, rolling reduction of 40 ~ 50 mm in flat pass, or of 60 ~ 80 mm in edging pass is possible on the rolling mill in Helwan Works, and bend and camber of blooms would be reduced.

b) To reduce delay in discharging ingots

Charging and discharging of ingots in same hole, which appear to be the prime cause for delay in ingot discharging. It should be discontinued. Charging and discharging operations cause not only a drop in rolling rate due to delay in ingot discharging but also a decrease in the temperature of discharging ingots.

c) To prepare the pass schedule of rolling

It is necessary to prepare the standard pass schedule and to let all operators fully understand the pass schedule. At the same time, rolling skills should be trained. An example of a pass schedule is shown below. In Helwan Works blooming mill, over filling is very large at edging pass after flat pass, which seems

to be a cause for misrolling. In the pass schedule shown, flattening processes of over filling are included in 13th and 14th passes. It is advisable to prepare such a standard pass schedule that is most suitable in terms of rolling rate and quality.

A pass schedule for blooms of cross section, 140 x 140

1	470	13	260
2	450 (T)	14	240 (T)
3	450	15	300
4	410	16	240 (T)
5	370	17	240
6	330	18	180 (T)
7	290	19	240
8	240 (T)	20	180 (T)
9	530	21	180
10	470	22	140 (T)
11	410	23	190
12	350 (T)	24	140 (T)
		25	140

d) To reexamine the shape and dimensions of roll caliber
The taper of roll caliber in Helwan blooming mill is too small. In general, the taper of 25 % is desirable for calibers of 285 mm and 220 mm in width, and that of 15 % for calibers of 150 mm in width.

e) To control rolling rate, t/hr
Rolling rate, t/hr is dependent not only on equipment but also technical consciousness of rolling operators, probably to a larger extent. It is necessary, therefore, to give close attention to rolling rate by day, shift and cross section, and to trace human factors causing low rolling rate.

The rolling rate of Japanese blooming mills of the similar size to that of Helwan mill is as follows.

Plant	Weight of ingots	Capacity of mill motor	Rolling rate, t/hr
A plant	3.2, 3.8 t	2,620 KW	85.1
B plant	3.3, 4.1 t	3,500 KW	90.2

(2) Rolling capacity

Rolling capacity is equal to rolling rate, t/hr x rolling time, and the value of 6,000 hr/y is commonly used as rolling time in calculating plant capacity.

Table III.12 Operating conditions of a typical blooming mill

Annual calendar hours		8,760 hr	
Planned shutdown	Check and adjustment	255 hr	0.25 hr/s x 3 s x (365 - 10) day - 11 hr
	Roll changing	0	Rolls are changed in periodical repair
	Periodical repair	736 hr	16 hr x 4 times/m x 11 m + 16 hr x 2 times/m x 1 m
	Annual repair	246 hr	24 hr x 10 days
	Total	1,231 hr	
Hours to be worked		7,529 hr	
Annual rolling time		6,000 hr	
Operating rate		68.5 %	
Work rate		79.7 %	

Major causes for rolling shutdown in hours to be worked in Helwan Works blooming mill, are waiting for heating and failures.

Down time due to failures (Jan. ~ Oct., 1976)

Mechanical failures:	73.6 hr/m
Electrical failures:	72.5 hr/m
Other failures:	27.5 hr/m

Total down time in Helwan Works blooming mill during the period between Jan. ~ Oct., 1976 is as much as 173.6 hr/m. Therefore down time due to failures should be substantially reduced through strengthening of preventive maintenance. Failure rate in Nippon Steel's mills is generally kept within the range of 2 ~ 4 %, and rolling shutdown due to failures is 20 ~ 30 hr/m.
In palnned shutdown, on the other hand, periodical repair of 16 hr x 4 times/m seems to be too frequent. In Nippon Steel, standard periodical repair is generally 10 ~ 12 hr/repair, and 1 ~ 2 times/m.
Thus, measures should be taken to imporve rolling time so that rolling time of 6,000 hr/y would be achieved.
In such a case, rolling capacity should be as follows.

Rolling capacity = 68.1 t/hr x 6,000 hr/y = 408,600 t/y.

Rolling time required for rolling 375,000 t/y of the input amount to the blooming mill is 5,507 hr/y (monthly average 472 hr/y), a valeu not unattainable for Helwan blooming mill.

1.1.4 Shearing

Shearing work does not cause a bottleneck in the production of Helwan Work mill. However, shearing yield rate is extremely low. For example, the shearing rate of blooms in Nippon Steel is 92.2 % for rimmed steel, 92.5 % for semi-killed steel and 85.0 % for killed steel, and scrap generation rate due to misrolling is 0.02 %.

Table III.13 Shearing yield

Application	Type of steel	Current yield	Planned yield	Target yield
Light section and for sale	Rimmed, semi-killed	85.0	89.0	91.0
	Killed		83.0	84.0
Heavy section	Rimmed, semi-killed		89.0	91.0
	Killed		83.0	84.0
Plate	Rimmed, semi-killed		85.0	86.0
	Killed		80.0	81.0
Overall yield rate		85.0	88.0	89.9

Current yield: Average yield in Jan. ~Oct., 1976.

Planned yield: Yield used in this plan.

Target yield: Yield estimated to be attainable in the future.

Assuming that shearing yield is improved from 85% to 90% the production of billets for slae can be increased by 7,500 t/y in the case of 375,000 t/y of input, or 8,300 t/y of ingot input can be saved to cater for an output of 330,000 t/y.

The following measures should be taken to imporve yield.

(1) To reduce scrap generation due to misrolling

Raising ingot temperature, as described earlier in the item of Measures to imporve rolling rate, also helps to prevent misrolling. Overfills produced with III caliber, should be flattened by rolling in a flat pass. Since the shape of blooms which are likely to casue misrolling can be easily identified by mill operators, they should be trained to take adequate measures to prevent misrolling, for example, by changing pass schedule in advance.

The loss of yield rate due to misrolling has not been exactly known, but is estimated to be 3 ~ 5 %. Although the loss of 3 ~ 5 %. Although the loss of 3 ~ 5 % itself is extraordinaly, still there is no exact figure abnormal despite of such a large amount of scrap produced.

It is necessary to collect accurate data such as mill operators, the cross section of bloom and the operating state at the time, as well as the quantity of misrolling.

(2) To reduce cutting-off of non-defective parts

Shearing standards should be established. Some standards would be established based on quality requirements, for example, a standard which permits pipes left in blooms.

In shearing operation, it is necessary to reduce cutting-off of non-defective parts by piecemeal shearing in which the top and bottom of a bloom are sheared not at a time but piece by piece.

1.2 Improvement of equipment

1.2.1 Addition of soaking pits

As described in 1.1.4, the existing soaking pits have a capacity of only 250,000 t/y even after various improvement measures are taken, so addition of soaking pits with 4 holes is required so as to heat 375,000 t/y of ingots.

$$\text{Required number of holes for separate charging} = \frac{83{,}065}{7{,}000} = 11.9 \text{ holes}$$

$$\text{Required number of holes for combined charging} = \frac{72{,}170}{7{,}000} = 10.3 \text{ holes}$$

The positions of 4 holes shall be on the east side of No.5 and 6 holes and on the west side of No.7 and 8 holes.

It is difficult to show why a large space is provided on the receiving table side of No. 5 and 6 holes because the latest survey did not cover that point, but, if soaking pits cannot be installed on the

east side of No. 5 and 6 holes, two pits shall be installed on the east side of No. 1 and 2 holes.

Dimensions of new soaking pits shall be the same as those of the existing holes so that the existing cover cranes can be used.

An additional unit of cover crane shall be installed by the side of No. 5 and 6 holes.

In view of the fact that the heating of EF ingots show poor performance in terms of both thermal efficiency and fuel consumption, it is advisable to consider the introduction of soaking pits of such a type that is 4 m in width and has two burners and an independent cover crane, on the assumption that both EF and LD ingots are charged into No. 9 through 12 holes.

1.2.2 Addition of soaking pit crane

If soaking pits are added and ingots are transported to the receiving table with a soaking pit crane, the ingot discharging cycle comes into question in relation to rolling rate, t/hr.

Although the discharging cycle of all holes is adequate for blooms for light and heavy sections when compared with rolling rate, t/hr, the discharging cycle of holes farther than No. 7 and 8 holes tends to be longer than the rolling cycle for slabs for plates. It results in a decrease in the rolling rate t/hr of slabs for plates by 10 t/hr on an average. This brings about a decrease of 0.5 t/hr in the overall rolling rate.

The existing 8-hole soaking pits on the west side of the receiving table may cause an increase in mutual interference of charging and discharging operations, but it is difficult to theoretically estimate such a possibility. Judging from the experience in Nippon Steel's blooming mills operating under the similar conditions to Helwan Works mill, down time in rolling due to mutual interference of charging and discharging operations is estimated to be in the neighborhood of 20 hr/m.

In view of the prerequisite for this rehabilitation plan to minimize capital investment, it is recommended to use soaking pit crane for transportation of ingots, but it is necessary to study the possibility to install buggies in the future to reduce failures of soaking pit crane and mutual interference of charging and discharging operations. The existing soaking pit crane are outdated and frequently cause troubles. In order to meet the increase of travelling distance due to the addition of 4-hole soaking pits, and to facilities the handling of 4-ton ingots and slag off operations by soaking pit crane, it is necessary to add one soaking pit crane.

By doing this, 2 units shall be used for ordinary operations and the remaining one shall be either used for some extraordinary operations or subjected to maintenance with scrupulous care.

The soaking pit crane to be added shall have a capacity larger than that of the existing one and be installed between the two existing ones. To cope with increased weight of the new soaking pit crane, proior consideration should be given to the structural strength of the building.

Table III. 14 Discharging cycle by hole

Hole No.	Travelling - downstream	Grabbing	Travelling - upstream	Release	Discharging cycle
1	36	5	36	16	104
2	30	5	30	16	90
3	20	5	20	16	68
4	20	5	20	16	68
11	20	5	20	16	68
12	20	5	20	16	68
5	36	5	36	16	104
6	34	5	34	16	99
7	45	5	45	16	124
8	43	5	43	16	119
9	53	5	53	16	142
10	50	5	50	16	134

Discharging time = Total of 4 processes/0.9

1.2.3 Bloom handling crane

The existing claw crane performs the handling of sheared materials and the charging of blooms into the reheating furnace of the heavy section mill.

Other than this, two more cranes are stationed in the same bag. The operating state of these three cranes has not been investigated in detail in this survey, but it is, necessary to take another look at the optimum number of cranes to be stationed in this bay and how to use them after taking into account expected increases in the operating rates and productivity of blooming, heavy-section and plate mills. This issue will be discussed again in the subsequent section for heavy section mill.

1.2.4 Preventive measures against equipment trouble

For main production equipments in the blooming mill, preventive maintenance should be intensified further. For the equipments with more troubles in particular, redesigning, revamping, reconsideration of materials and/or intensified control of inventory of their spare parts will be essentially required.

It would be necessary to direct further efforts toward better maintenance and, if required to do so, to study the possibility of revamping or replacement for those equipments in the blooming mill, important but highly susceptible to failures, such as manipulators, rear and front tables of the mill and mill main motors other than soaking pit cranes, soaking pits and soaking pit covers which were already discussed in this report.

Referring to the front and rear tables of the mill, one or two rollers located close to the mill should preferably be driven independent of the other rollers driven by the line shaft.

Obviously, the mill main motor, inclusive of its controls, must be maintained with adequate care. What is more important is that the motor room be ventilated fully with air filtered by the air cleaner and be maintained at controlled temperatures since electrical equipment are very sensitive to dust.

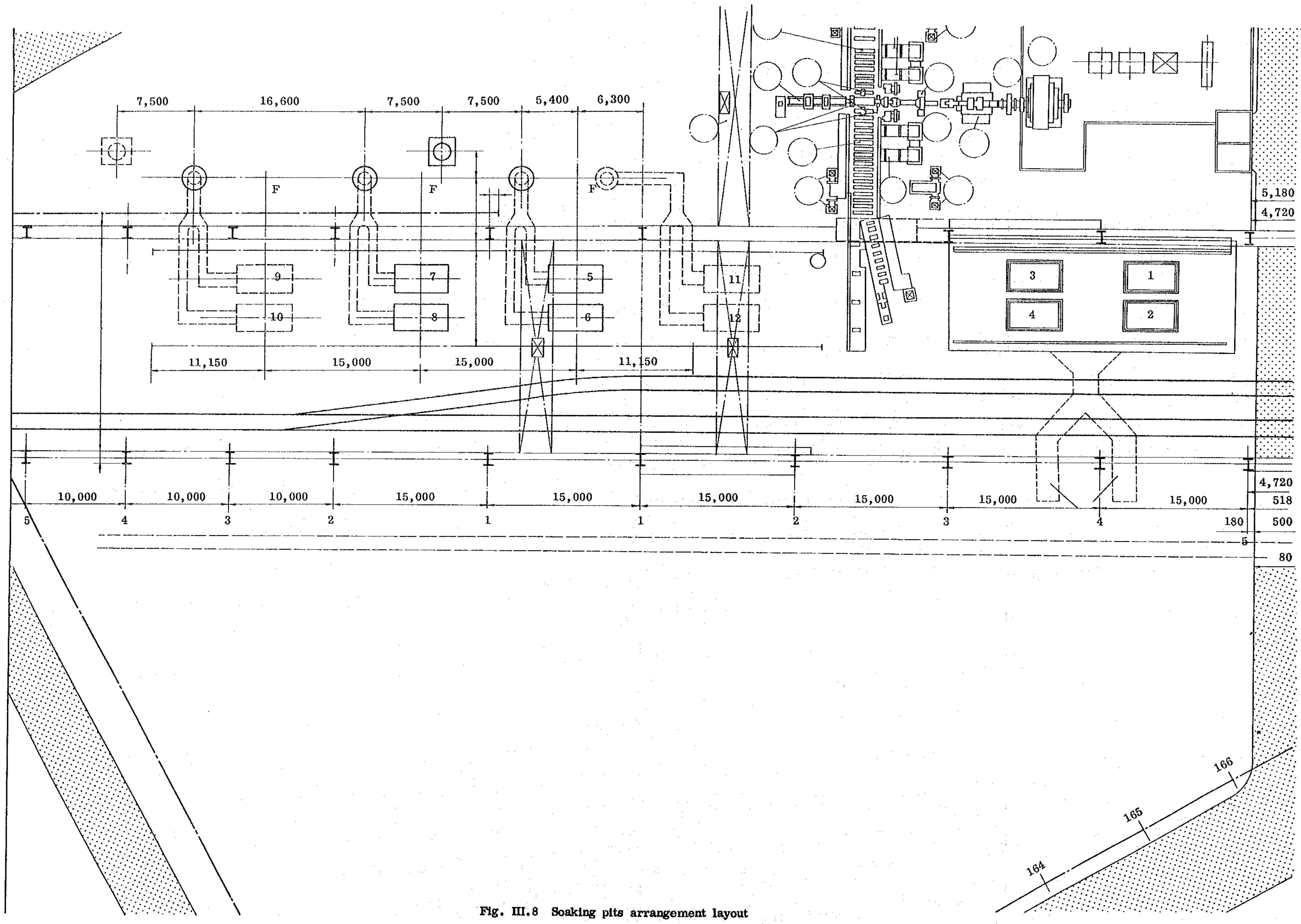


Fig. III.8 Soaking pits arrangement layout

2. Heavy Section Mill

2.1 Problems

The designed capacity of this mill is 180,000 t/y (15,000 t/m), whereas the average production (t/m) from January to October 1976 reached only about 1/3 of that capacity as shown in Table III.15. Assuming that the rolling time is 500 hr/m and rolling rate is 30 t/hr to obtain designed capacity of this mill, there is big difference between actual operation records and assumption values. The most serious problem in increasing the production capacity is the shortage of the reheating furnace capacity, which is directly shown as the time of waiting for reheating (average 54 hr/m) or charging for furnace (average 10 hr/m). Moreover, this shortage causes indirectly, product stoppage, which is the biggest down time at the mill (average 99 hr/m). Although details of this product stoppage are not clear, it is presumed to consist of such factors as waiting due to poor timing at the direct rolling or hot charging, occurrence of mis-rolling due to rolling of poorly reheated steel, roll breakage, and adjustment of guides and rolls. Naturally, rolling of poorly reheated material causes decrease of the rolling t/hr.

Many hours of stoppage due to the equipment trouble can be cited as the second factor. Despite 78 hr/m for planned maintenance, there are a total of additional 76 hr/m for mechanical stoppage (31 hr/m) and electrical

Table III.15 Operation records

	Jan. ~ Oct. 1976 Average	Max. *3	Min. *3
Production quantity	4,790 t/m	6,040	3,445
Scheduled shutdown*1	128 hr/m	171	71
Stoppage due to trouble *2	175 hr/m	202	112
Rolling time	302 hr/m	442	226
Rolling t/hr	16.8 t/hr	20.3	11.8
Yield	82.0 %	83.9	79.2

*1 Planned maintenance + shutdown

*2 Mechanical + electrical + product stoppage

*3 Maximum or minimum value of these months

stoppage (45 hr/m). As a result, the actual rolling time is shortened. As for the rolling t/hr, which is another factor determining the production capacity, those steel products with low t/hr will be transferred to the new medium section mill, and after improvement of the capacity of the reheating furnace, this heavy section mill will be able to produce the remaining products with enough rolling t/hr to realize the designed capacity.

Concerning the mill's future, there are two problems of the finishing line and quality. As for the finishing line, under the plan to increase the production of heavy rails in the future, installation of the finishing line exclusively for rails will be needed. It is also considered that replacement of the current roller straightener will be needed.

In regard to quality, there are questionable points as follows: no tracing of the Heat No. after blooming mill is performed; the bloom yard is too narrow to allow adequate and effective material stock under good control; and no surface conditioning of blooms is conducted. These points may, naturally, become problems as quality requirements become higher and as steel grades become more varied in the future. It is necessary to start making arrangements now for such possibilities and to take them into consideration in remodelling or newly installing the equipment. The first prerequisite for increasing the production capacity is reinforcing the reheating capacity as well as maintaining the facilities, equipment and apparatus in such a way, namely, that the reheating furnaces as well as the rolling stands would be constantly kept ready for operation whenever the materials are available.

2.2 Reinforcement in the reheating furnace capacity

2.2.1 Mill layout

The layout of this heavy section mill is designed so that installation of the reheating furnace permit a free selection of the three processes as shown in Fig. III.9, direct rolling hot charging to the furnace, and cold charging to the furnace. Although the designed capacity of the furnace is 30 t/hr by hot charge and 20 t/hr by cold charge, these capacities are rather small to obtain the designed capacity of 15,000 t/m.

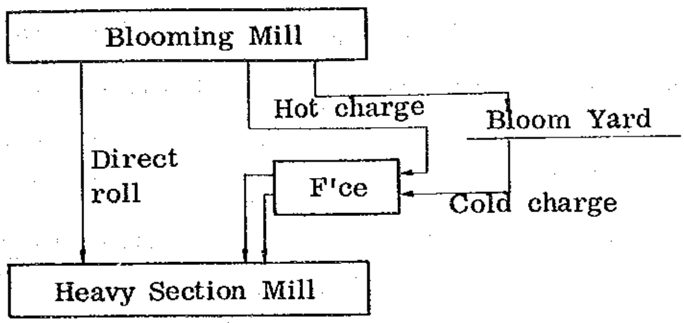


Fig. III.9 Bloom flow

2.2.2 Material flow

If the blooming mill is nearly exclusive for the heavy section mill, this layout is desirable from the standpoint of productivity and fuel saving. In the initial plan, the production flow was, as shown in Fig. III.10, such that 76.6% or 196,000 tons of the 256,000 tons of materials produced at the blooming mill was for the heavy section mill.

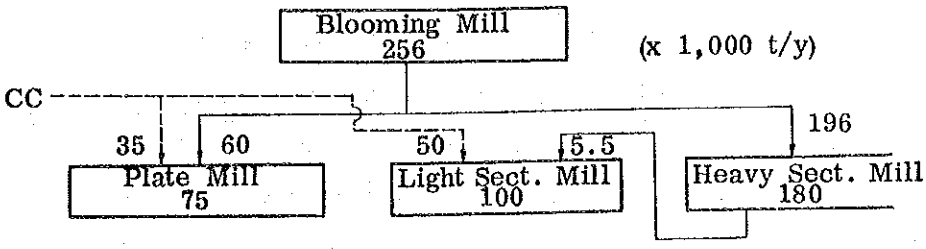


Fig. III.10 The production flow (planned) between the blooming mill and rolling mills

However, at present, the 140 mm bloom for the light section mill can be rolled at the blooming mill, and so the blooming mill must roll materials for the three mills of heavy section, plate and light section, thus reducing the ratio for the heavy section mill.

Furthermore, there are many hours troubles at the blooming mill so that smooth blooming operation cannot be accomplished. Thus, direct rolling and hot charging operation are difficult to be done smoothly. Under such circumstances, the actual operation between the blooming mill and heavy section mill is roughly in the ratios shown in Fig. III.11.

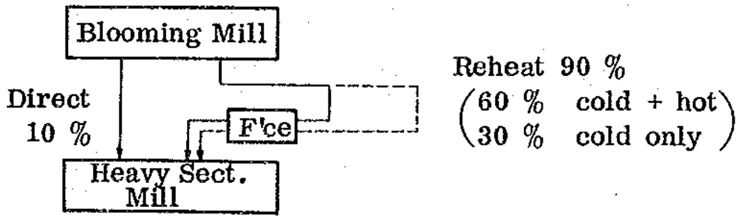


Fig. III.11 Actual production flow between the blooming mill and heavy section mill

Hot and cold charging operations are carried out at any time when the material dimensions and the steel grade are suitable. In this case, because of the pusher type furnace, hot blooms and cold blooms are charged side by side in contact. And when a cold charged blooms are discharged with insufficient heat, the operation takes the form of waiting for heating. Conceptions of the material flow should be as follows. What is needed most, at present, for Helwan is to get the full capacity of each mill in order to increase the production output. Therefore, it is important not to cause stoppage of each mill on account of the trouble of other mills. Hence, the reheating furnace of the heavy section mill should have the capacity necessary for the designed production capacity at cold charging.

But, the fact that direct rolling and hot charging can be performed offers advantages such as less reduction in production at the time of repairing the reheating furnace or less fuel consumption. Therefore, in terms of layout, it should be arranged so that the mill is capable of these operations, and that these operations should be positively undertaken when the rolling timing of the blooming mill corresponds to that of the heavy section mill. At the same time, adoption of the walking beam type furnace, which permits selection of a distance between materials, would be better, since it prevents hot blooms from contacting with cold blooms.

2.2.3 Reheating furnace capacity

Although the designed capacity of the reheating furnace is, as previously explained, 20 t/hr for cold bloom charging and 30 t/hr for hot bloom charging, actual reheating capacity for cold bloom charging is said to be only 8 to 13 t/hr.

The results of the Nippon Steel's review of this heating furnace capacity are as follows. Note that preconditions for this calculation include:

a) Brick damage, etc. are not taken into account.

b) Values used for the calculation are as below.

Helwan's data; Furnace type, furnace dimensions, burner capacity, calorific values of fuels

Estimates ; Other items necessary for computation

Results of calculations are shown in Fig. III.12 (cold charge) and Table III.16.

Table III.16 Reheating furnace capacity

Charging method	Charging temperature	Air temperature	Heating capacity	Remarks
Cold Charge	20 °C	30 °C	14 t/hr	Limited by the capacity of the heating zone burner.
		300	18	Limited by the capacity of the preheating zone burner.
Hot Charge	850	30	40	Limited by the capacity of the heating zone burner
		300	45	Limited by the furnace length

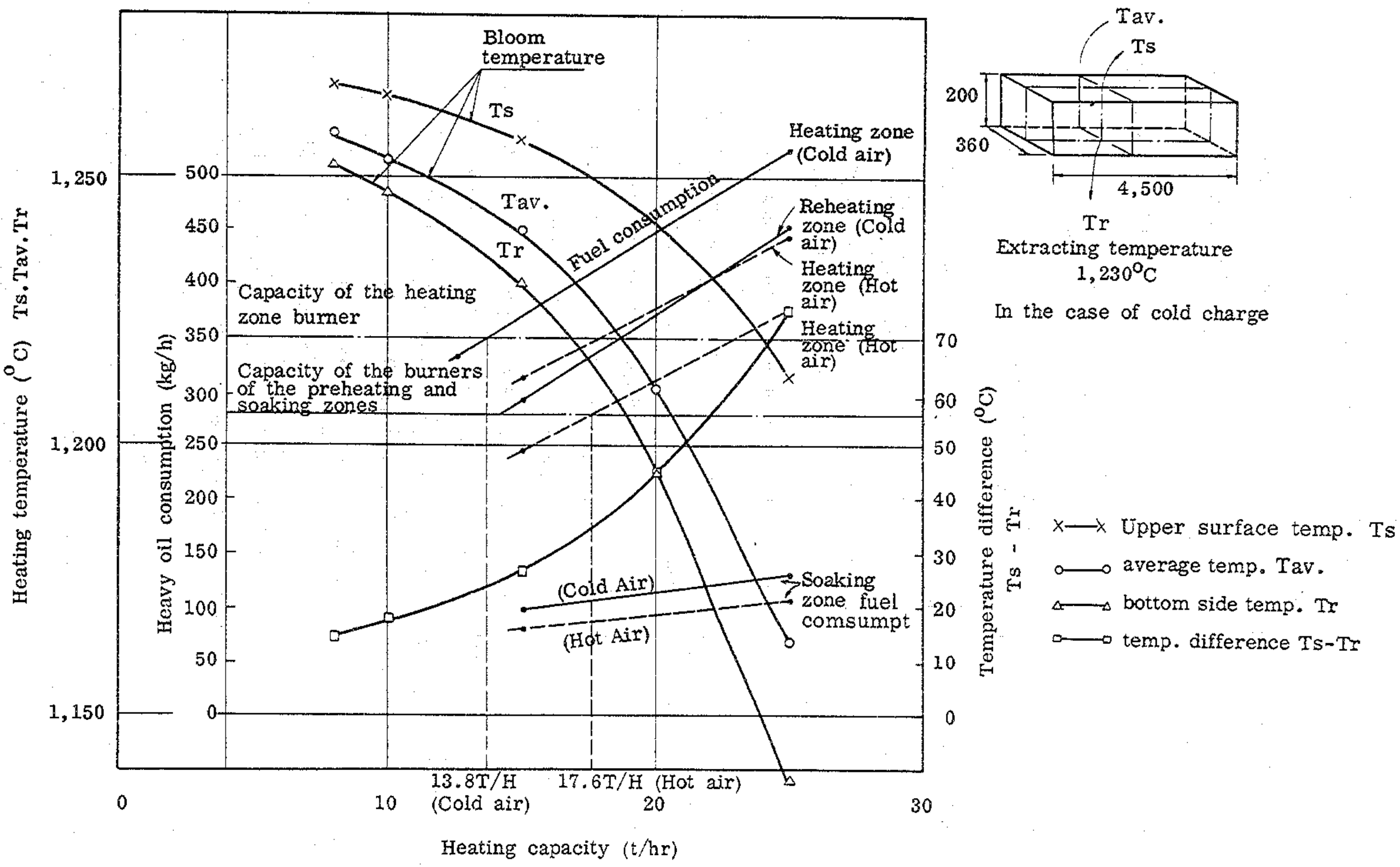


Fig. III.12 Reheating furnace capacity

In this calculation, heavy oil only is to be used for the burners. As clear from Fig. III.12, suppose the maximum burning of oil and gas is possible, the reheating capacity will increase to some extent. Maximum burner capacities are as follows.

Preheating zone, soaking zone burners

4 burners x 55 kg/hr + 4 burners x 225 Nm^3/hr

Soaking zone burners

5 burners x 55 kg/hr + 5 burners x 225 Nm^3/hr

In the case of cold charging, such increase will be as follows.

14 t/hr ⟶ 16 t/hr and 18 t/hr ⟶ 20 t/hr

The reheating furnace capacity necessary for achieving the designed production capacity of the mill is roughly 40 t/hr (by cold charging), although it varies with the product mix.

2.2.4 Methods of increasing the reheating capacity

The following 4 alternatives can be considered for inproving the reheating furnace capacity.

(1) Remodelling the existing reheating furnace

Inasmuch as the reheating capacity for cold charging must be more than two times of existing capacity, this method will require large-scale working including the furnace length extension, complete change of the shape of the combustion chamber of each zone, and an increase of the burner capacity. This means that the remodelling work will be very close to removing the existing furnace and installing a new one.

Its advantage is that the best location of the reheating furnace can be secured for the rolling mill of the heavy section mill. But, the

period of production stoppage is the longest of all methods, and the remodelling cost is high. These drawbacks are the basis for not recommending this method.

(2) Installation of a preheating furnace

A preheating furnace is installed in front of the existing reheating furnace. For cold charging, materials are heated to 800 ~ 850°C through this preheating furnace and transferred to the existing reheating furnace. In the case of hot charging from the blooming mill, materials are directly charged into the existing reheating furnace without going through the preheating furnace. For the method of installation, an arrangement as shown in Fig. III.13 can be considered.

For advantages, this method offers a short period of production stoppage due to construction, cheaper construction cost than other methods, utilization of the existing reheating furnace, etc. The drawbacks are, since the preheating furnace is set up in an narrow area, the bloom yard becomes even narrower, fuel consumption is large, and the heating furnace is used with the existing width of 4.5 m, while countermeasures against the existing furnace trouble must be taken.

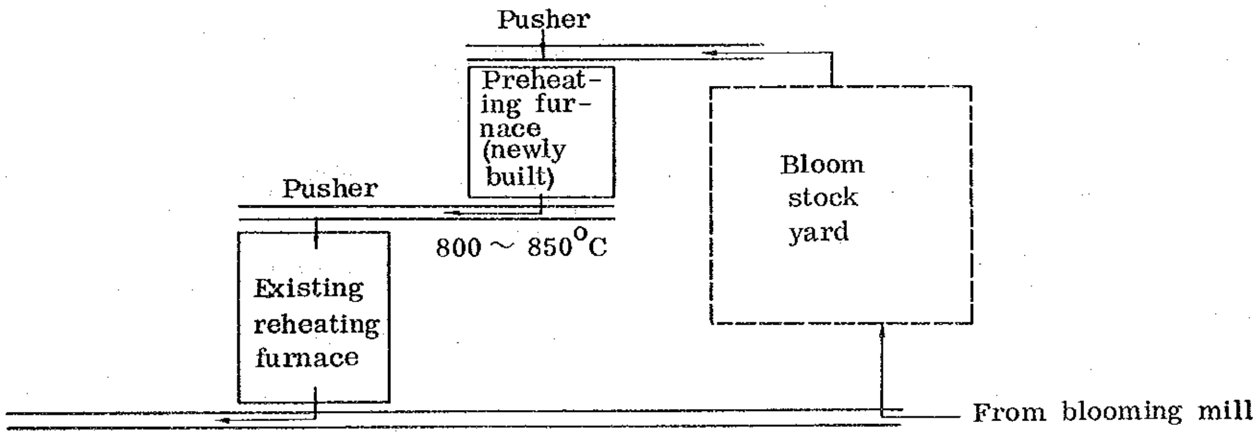


Fig. III.13 Preheating furnace arrangement

(3) Addition of a reheating furnace

This method proposes installation of a new reheating furnace having the same degree of capacity as the existing reheating furnace in order to carry out operations with two 20 t/hr furnaces. Effective utilization of the existing reheating furnace and flexibility in operations are merits of this method, while difficulty in selecting a place for its installation is its disadvantage.

(4) Installation of a new reheating furnace

A new reheating furnace with the required capacity is installed, whereas the existing reheating furnace is used as stand-by. Difficult as selection of the place for its installation is, the furnace type, furnace dimension, capacity, etc. can be chosen freely. In addition, the latest type furnace that also excels in fuel consumption can be installed. Proposed sites are shown in Fig. III.14 (A, B & C).

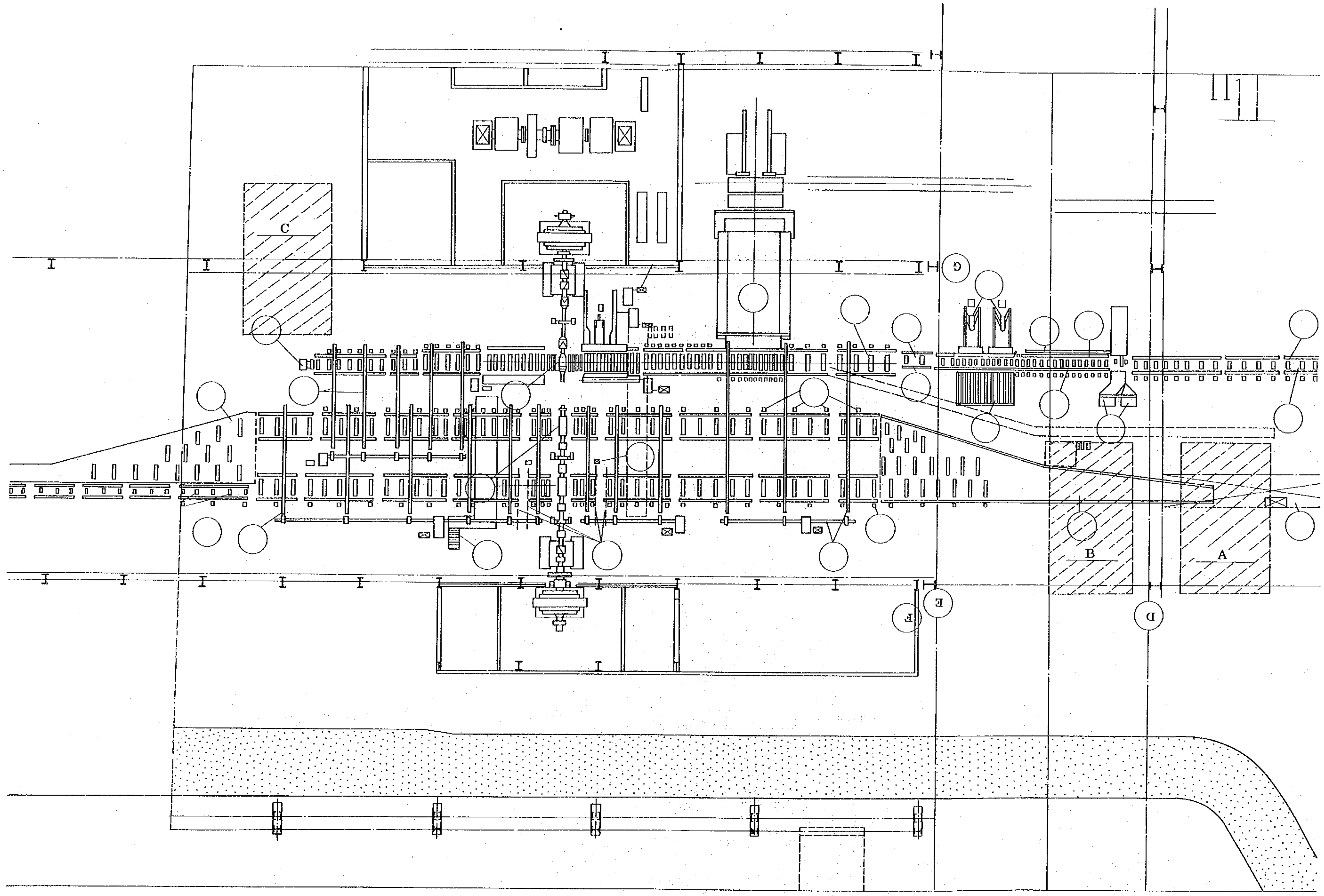


Fig. III. 14 Layout for installation of a newly installed reheating furnace

In the foregoing explanation, four alternatives of improving the reheating capacity have beeb presented. Evaluation in accordance with the following items should be made to make an overall judgement of which method to adopt.

a) Is the material flow smooth with no difficulty? Can hot charging be done smoothly, too?

b) Is the period of production stoppage due to construction short?

c) How much is the construction cost?

d) How much is fuel consumption?

e) Is maintenance easy to provide?

f) Is there any room to meet the future requirements for quality and production increase?

g) Is there free selection of the furnace type, furnace capacity and dimension?

h) Is the effective utilization of the existing furnace possible?

One example of evaluation is provided in Table III.17

Table III.17 Evaluation example

	① Remodelling existing furnace	② Installation of preheating furnace	③ Addition of reheating furnace	④ Installation of reheating furnace
a	◎	○	○	○
b	×	○	○	○
c	×	◎	○	△
d	○	×	×	◎
e	○	△	△	○
f	×	×	×	○
g	○	×	△	◎
h	×	○	○	△

Notes: ◎Excellent ○ Good △ Fair × Poor

In this case, the position of the new reheating furnace of alternative ④ is to be shown Fig. III. 14-A.

As obvious from this table, the most recommendable is alternative (4) for installation of a new reheating furnace at position A.

2.2.5 Details of alternative 4 A

The plant layout under alternative 4 A is shown in Fig. III-15. To be newly installed are the walking-beam type reheating furnace, charging bed, materials handling crane and table rollers. Inclined table needs to be remodelled to some extent.

(1) Main specifications for recommended reheating furnace

Capacity	: 40 t/hr
Type	: walking-beam type
Dimensions	: 6.0 m wide (max. length of charged material 5.5m)
	x 14 m long (effective length 12.5 m)
Floor load	: 580 kg/m^2 hr

The above furnace width assumes the max. length of charged material as 5.5 m, from which 18 m x 3 rails of 52 kg/m will be obtained. The cross-section of the material is to be the same as the present size, 200 x 360.

The furnace capacity, 40 t/hr, is a required minimum, though it varies with the dimension of charged material.

(2) Materials flow

1) For cold charges

Bloom from the blooming mill will be transported to the cooling yard, where it will be cooled, as is so at present.

Bloom thus cooled will be carried by the new crane to the bloom yard, where the cold bloom will be conditioned to remove surface defects if necessary. The bloom will then be converyed by the new crane to the charging bed and charged into the reheating furnace.

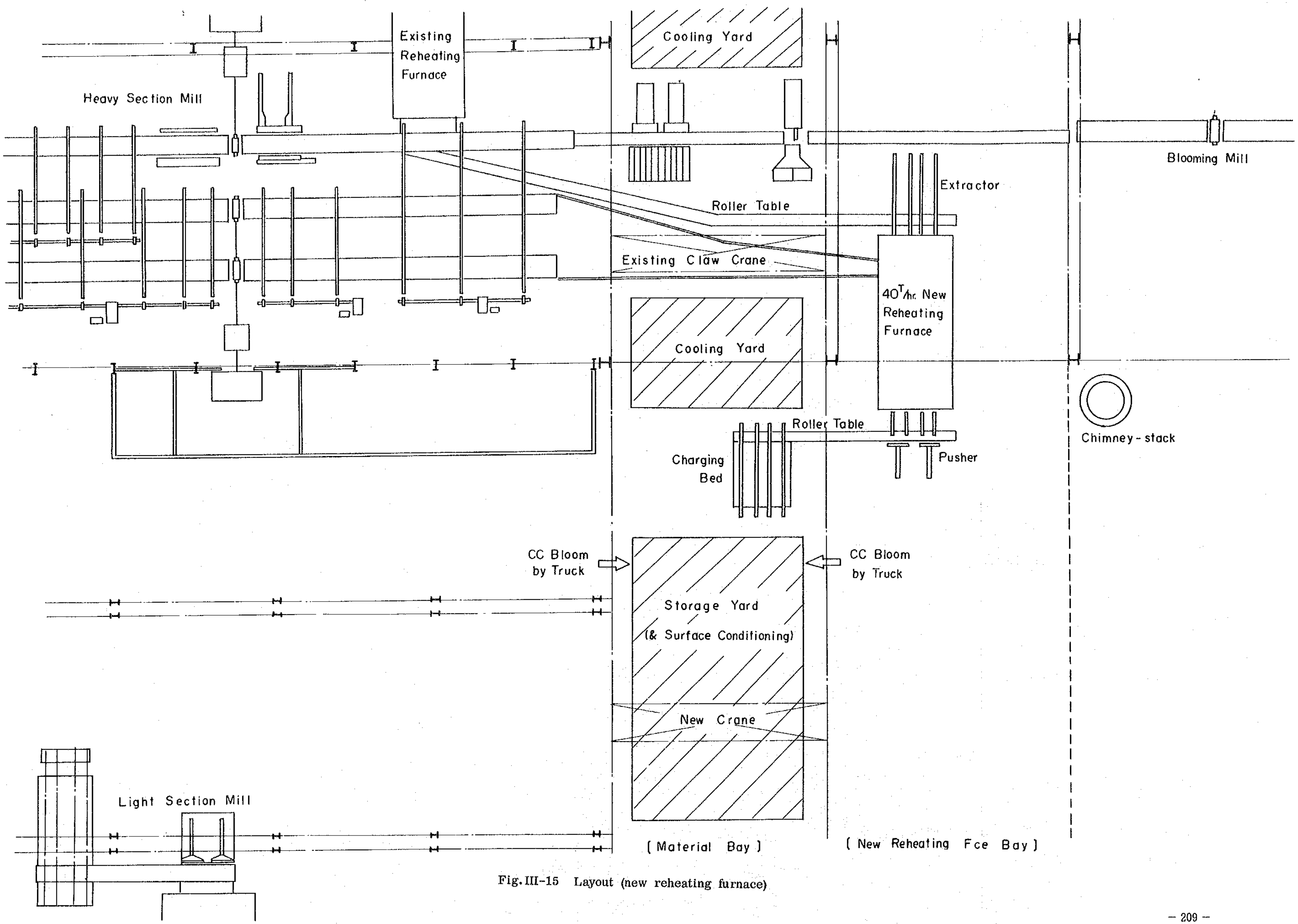


Fig. III-15 Layout (new reheating furnace)

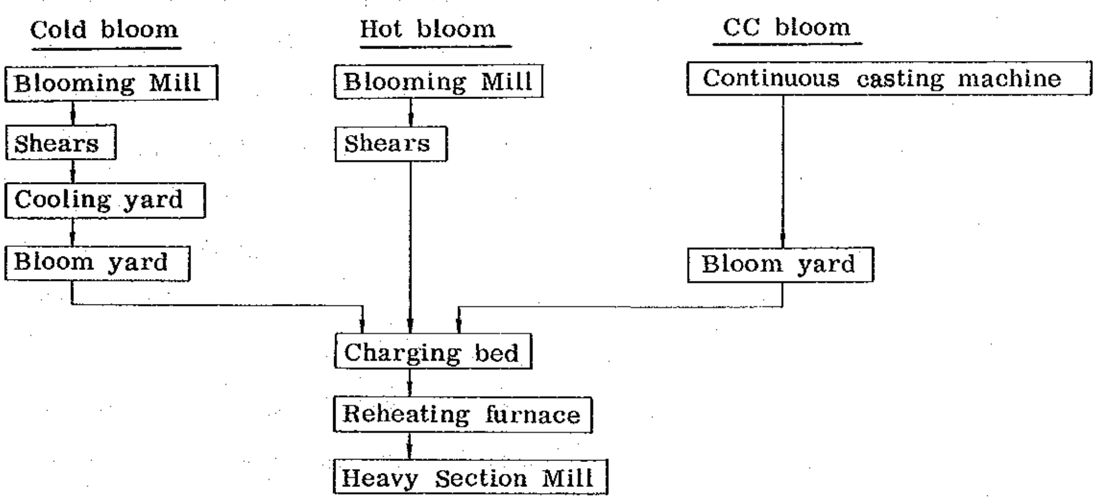
2) For hot charges

Hot bloom from the blooming mill will be transported by the existing claw crane directly to the charging bed and charged into the reheating furnace.

3) For continuous-casting bloom

Continuous-casting bloom will be transported by truck directly to the bloom yard. For rolling, CC bloom will be carried by the new crane to the charging bed for charging into the reheating furnace, as is the case with the cold bloom from the blooming mill.

The above three routes cab be summarized as a flow of materials shown below.



(3) Disposal of bloom crops

Crops sheared from bloom will be directed into the bucket placed in the bloom shear pit. The crop-filled bucket will be carried by crane to a wagon on which it will be transported to the scrap yard.

(4) Necessity of a new crane

In this bloom yard bay, most of material handling operations will be performed by crane. In other words, bloom handling will account for a predominant portion of the jobs to be done there. Furthermore, other relevant jobs such as receiving CC bloom, removing crops and surface conditioning will also have to depend on the crane power. It is self-evident that the existing claw crane alone cannot

perform all of these jobs, and one additional crane will become necessary.

There are two ordinary cranes other than the claw crane in this bay, on the plate mill side. If permissible judging from the operating rate and severity of deterioration, one of them may be removed to the new reheating furnace side with the claw crane arranged between the two ordinary cranes.

It is desired that this crane, newly added or removed from the plate mill side, can operate both on a wire and a lifting magnet.

As for the equipment cost, the estimate assumes installation of a new crane.

(5) Reuse of existing reheating furnace

The existing reheating furnace should desirably be laid aside for reuse as a stand-by unit. By doing so, it can be utilized effectively when a large-scale repair of the new reheating furnace or increased production of steel becomes necessary.

If the existing furnace is to be utilized in this way, countermeasures against soaking-zone brick troubles should be taken, inculding: a) Changing the direction of the soaking-zone burners, namely, adopting either side burners or roof burners.

b) Changing the shape the combustion chamber in the soaking zone.

An example of the remodelling idea is shown in Fig. III-16.

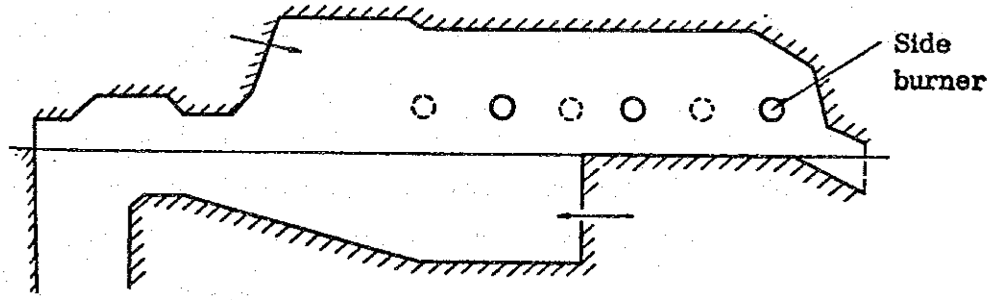


Fig. III.16 Shape of the combustion chamber of the remodelled reheating furnace

(6) Others

With the new layout, the new reheating furnace will be located about 60 meters apart from the rollong mill, a distance relatively long but not to the extent detrimental to a smooth flow of mill operations. In fact, heavy section rolling mills at Nippon Steel's Yawata and Kamaishi works are situated over 60 m distant from their reheating furnaces and satisfactorily in operation with no problems derived from it. By installing the new reheating furnace as shown in Fig. III-15, expansion of the materials yard and conditioning yard will be made possible without difficulty when increased production or improved product quality becomes necessary.

2.2.6 Use of natural gas in reheating furance

The conversion of reheating furnace fuel from heavy oil into natural gas can be made without particular problems by remodeling or changing the equipment into natural gas-fired equipment. This equipment remodeling or change involves burners, fuel piping and instrumentation, etc. This applies not only to heavy section mill but also to light section mill (reheating furnace) and blooming mill (soaking pit).

The fuel conversion, however, presupposes that the furnace or pit to be remodeled is operating well on a heavy oil.

Nippon Steel has experience with fuel conversion in two of its slabbing mills. The conversion, which invariably involved soaking pits, was from fuel oil to LNG in one instance and to LPG in the other.

Nippon Steel checked their specific fuel consumption, heating time, qualities and yield, etc., and found no large differences with the case of oilfired counterparts. The natural gas-fired soaking pits are now running smoothly.

2.3 Countermeasures against the equipment trouble

Common as this problems is in other mills and plants, there are very many hours of stoppage due to the equipment trouble. Despite the scheduled maintenance for an average of 78 hours per month at the heavy section mill, additional stoppage due to the mechanical and electrical failure averages 76 hours per month.

At the survey, what constituted troubles were unable to be checked. Normally, these troubles are caused by poor operations, natural deterioration of mechanical or electrical parts, poor specifications of the equipment and apparatus. For ways to consider countermeasures against these troubles, each equipment should be ranked according to its critical degree, and a transfer from the post maintenance to the preventive maintenance system should be made in regard to the critically important equipment. As for the details of the countermeasures against troubles, work standards should be formulated for operations, and such standards should be strictly observed. Regular inspection standards of the equipment and apparatus should be established and put into effect. Review of design and materials should be made with respect to the equipment and apparatus, which often have troubles, and efforts should be made to maintain good control of spares. In executing these countermeasure, make sure that the mill side discuss with the maintenance department and make a decision.

What is especially important to the preventive maintenance is the inspection of the equipment and apparatus. Startup inspection, daily inspection and routine inspection comprise the preventive inspection. The standard should be made, which determines the equipment and apparatus to be inspected, inspection frequency, inspection methods, etc. Check lists to put on such inspection results should be made and used effectively. On the basis of data gained in these inspections, repair should be applied before a trouble begins or in the early stage of the trouble so that occurrences of unforeseen accidents may be prevented, and that production stoppage time may be minimized.

The existing reheating furnace and mill motor seem most problematic among others. Problems relating to the existing reheating furnace were alrady discussed in paragraph 2-2-5. The motor room must be ventilated with air filtrated by the air cleaner and be maintained at controlled temperatures since the mill motor and its slectric controls are extremely sensitive to dust.

Also, attention should be apid to whether mill motor windings are poorly insulated particularly for mill motors in service over 20 years. At Nippon Steel windings of large mill motors are subjected to a careful diagnosis after 20 years of service and replaced if necessary.

2.4 Production capacity of the mill after countermeasures

2.4.1 Capacity of the reheating furnace

As previously explained, this capacity will be as below: This product heating capacity is 36 t/hr, as the material heating capacity is 40 t/hr and the yield 90 %.

2.4.2 Operating hours

First, two cases (Case I & II) of the operating hours after reinforcement of the reheating furnace capacity and execution of the countermeasures against the equipment trouble are estimated with respect to the average from January to October 1976, and the results are shown in Table III.18. Case I refers to the target of about 500 hours of actual rolling time, which is estimated to be accomplishable in the near future after taking the countermeasures. Case II is the advanced stage, where further efforts are taken into account in estimating accomplishable target.

Table III.18 Details of stoppage time

	Current	Case I	Case II
Maintenance (Planned)	78 hr	60 hr	30 hr
Mech. stoppage	31	50	40
Elect. "	45		
Product "	99	40	30
Wait for heating	54	0	0
Roll change & adjust	44	50	50
Furnace charging	10	0	0
Others	16	20	20
Total stoppage	377	220	170
Shut down	51	0	0
Rolling time	302	500	550
Calendar time	720, 744	720	720

The time that should be spent for rolling is defined that the shut-down, planned maintenance, and roll change time is subtracted from calendar time. The ratio of the actual rolling time to this time that should be spent for rolling comes to about 50 to 60 %, at present. In Case I after the countermeasures, this will be 82 %, and in Case II, this will be 84.4 %. Records at heavy section mills in Japan show that this is 88 to 95 % at new mills and 85 to 90 % even at old mills. Projected target for Case I and II at Helwan are not too high to be reached.

2.4.3 Rolling t/hr

Steel products at the heavy section mill are shown in Table III.19. As shown in this Table, after the new medium section mill is built, small steel products, which are rolled with smaller rolling t/hr at the heavy section mill, will be transferred to the new mill, and this transfer will be very advantageous in terms of rolling t/hr at the heavy section mill.

Table III.19 Rolling mill and product size

Steel product	Current	After Oct., 1977	
	Heavy section mill	Heavy section mill	New medium section mill
Billet	50 - 130	90 - 130	27 - 80
Round bar	45 - 125	90 - 130	30 - 80
Angle	70 - 150	100 - 150	50 - 90
I beam	100 - 260	140 - 260	80 - 120
Channel	80 - 260	140 - 260	50 - 120
Rail	8, 37, 52	37, 52	8 - 18
Sleeper	18, 52	52	18

Many steel products can be produced at the rolling t/hr requiring the full or more of the reheating furnace. As a result, it is considered that 30 t/hr necessary for achieving the mill's designed capacity of 180,000 t/y (15,000 t/m) can be attained without difficulty, although it depends on product mix. Confirmation is as follows.

(1) For calculating the rolling t/hr, the following formula is employed.

$$P_{Ri} = m \frac{3.6\,W \cdot \eta/100}{\dfrac{60\,\ell \cdot R_A^{\frac{1}{n}} (R_A - 1)}{\pi \cdot R \cdot D\,(R_A^{\frac{1}{n}} - 1)} + C_1(n - 1) + C_2}$$

where P_{Ri} = Rolling t/hr by products (t/hr)

W = Material weight (kg)

η = Yield (%)

ℓ = Material length (m)

R_A = Material-to-product ratio in terms of area

$$R_A = \frac{A}{a}$$

A: Material cross-sectional area (mm^2)

a: Prduct cross-sectional area (mm^2)

R = Motor revolutions .... in case of DC motor, base revolution (rpm)

D = Roll diameter

n = Number of pass

m = Number of pieces simultaneously passing

C_1 = Coefficient of the transfer time of pass to pass

In case of Helwan's arrangement = 6.0

C_2 = Coefficient of the transfer time from the reheating furnace to the rolling mill

(2) Preconditions in calculating the rolling t/hr at Helwan's heavy section mill

The yield η is set at 90 % for all products for the sake of brevity in calculation. The material length ℓ is the same as the current 4.5 m. As for the products whose R_A and n are unknown, these values are estimated. Motor rpm R is 89.5 rpm, and the roll diameter D is 750 mm.

Although the simultaneously-passing number of pieces m is usually larger than 1, m is set at 1.0 here. However, C_2 is set at 0, and 1 piece of material is being rolled at all times on one of 3 rolling stands. C_1 is set at 6.0 from the rolling mill arrangement.

(3) Results of calculation are shown in Table III.20

Table III.20 T/hr calculation results by products

Products	Product weight (kg/m)	Material cross section x length	Material unit weight (kg/m)	Material weight (kg/piece)	As roll length (m)	Number of pass	R_A	$R_A^{\frac{1}{n}}$	P_{RS} (t/hr.)	Rolling t/hr (t/hr.)
ф 90	63.6	200 x 200 x 4.5	310	1,395	22	11	4.87	1,155	47	36
ϕ 90	49.9	200 x 200 x 4.5	310	1,395	28	13	6.21	1,151	37	36
∠ 100 x 100 x 8	12.2	160 x 180 x 4.5	220	990	81	11	18.03	1,301	21	21
130 x 130 x 12	23.6	160 x 240 x 4.5	300	1,350	57	9	12.71	1,326	40	36
150 x 150 x 12	27.3	160 x 240 x 4.5	300	1,350	49	9	10.99	1,305	43	36
⊔ 140 x 60	16.0	140 x 240 x 4.5	260	1,170	73	13	16.25	1,239	22	22
180 x 70	22.0	160 x 240 x 4.5	300	1,350	61	13	13.64	1,223	27	27
220 x 80	29.4	160 x 240 x 4.5	300	1,350	46	11	10.20	1,235	36	36
260 x 90	37.9	(200 x 260 x 4.5)	400	1,800	47	13	10.55	1,199	40	36
I 140 x 66	14.3	140 x 240 x 4.5	260	1,170	82	13	18.18	1,250	21	21
180 x 82	21.9	160 x 240 x 4.5	300	1,350	62	13	13.70	1,223	27	27
220 x 98	31.1	160 x 240 x 4.5	300	1,350	43	11	9.65	1,229	37	36
260 x 113	41.9	(200 x 260 x 4.5)	400	1,800	43	13	9.55	1,190	41	36
⚲ 47	47	200 x 360 x 4.5	560	2,520	53	15	11.91	1,180	46	36
52	52	200 x 360 x 4.5	560	2,520	48	15	10.77	1,172	48	36
F.P. 47	16.2	160 x 180 x 4.5	220	990	61	13	13.58	1,222	20	20

2.4.4 Mill rolling t/hr in terms of product mix

The formula for calculation is as follows.

$$R = \frac{1}{\sum \frac{N_i}{100 \times R_i}}$$

where R = Overall rolling t/hr (t/hr)

N_i = Percentage of production by products (%)

R_i = Rolling t/hr by products (t/hr)

Results of calculation is shown in Table III.21.

Table III.21 Mill rolling t/hr

Products	Rolling t/hr	Case-A	Case-B	Case-C
⊿100 x 100 ⊔140 x 60 I 140 x 66 F.P.	t/hr 20	% 10	% 15	% 15
⊔180 x 70 I 180 x 82	27	10	10	15
Others	36	80	75	70
Mill rolling t/hr		32.3 t/hr	31.2 t/hr	30.8 t/hr

2.4.5 Other processes

As the bottleneck equipment, there are the hot saw, cooling bed, finishing line, etc. The capacity shortages of such equipment can be covered by the transfer equipment, extra space and manpower, and so they are not treated as the essential elements limiting production. For example, if as roll length is long while the products length is short, the hot saw capacity may not cover the rolling capacity even though 2 hot saw were available.