In this case, the as rolled material can be cut by the hot saw twice as product length, and after cooling, gas cutting can be applied at a different location. In regard to the capacity shortage of the 3 cooling beds, there is a cooling method by sprinkling water by a hose. Another method could be placing the product temporarily in extra space for natural cooling.

As far as these bottleneck equipment are concerned, it is not always economical to possess the equipment, which has a sufficient capacity under any condition. As to the bottleneck, solution is possible through a little improvement, ingenuity or combination of rolling plan.

This is also true of the finishing line, but rails require special processes such as finishing both ends, drilling, and special inspection. When the rail production ratio increases in the future, a finishing line exclusively for rails will become necessary. This will be explained later.

2.4.6 Production capacity of the mill

The formula for calculation is as follows.

Production capacity of the mill = Actual rolling time x Rolling t/hr.

If calculation is made with the operating hours in Case I and rolling t/hr in Case C,

Production capacity of the mill is as follow.

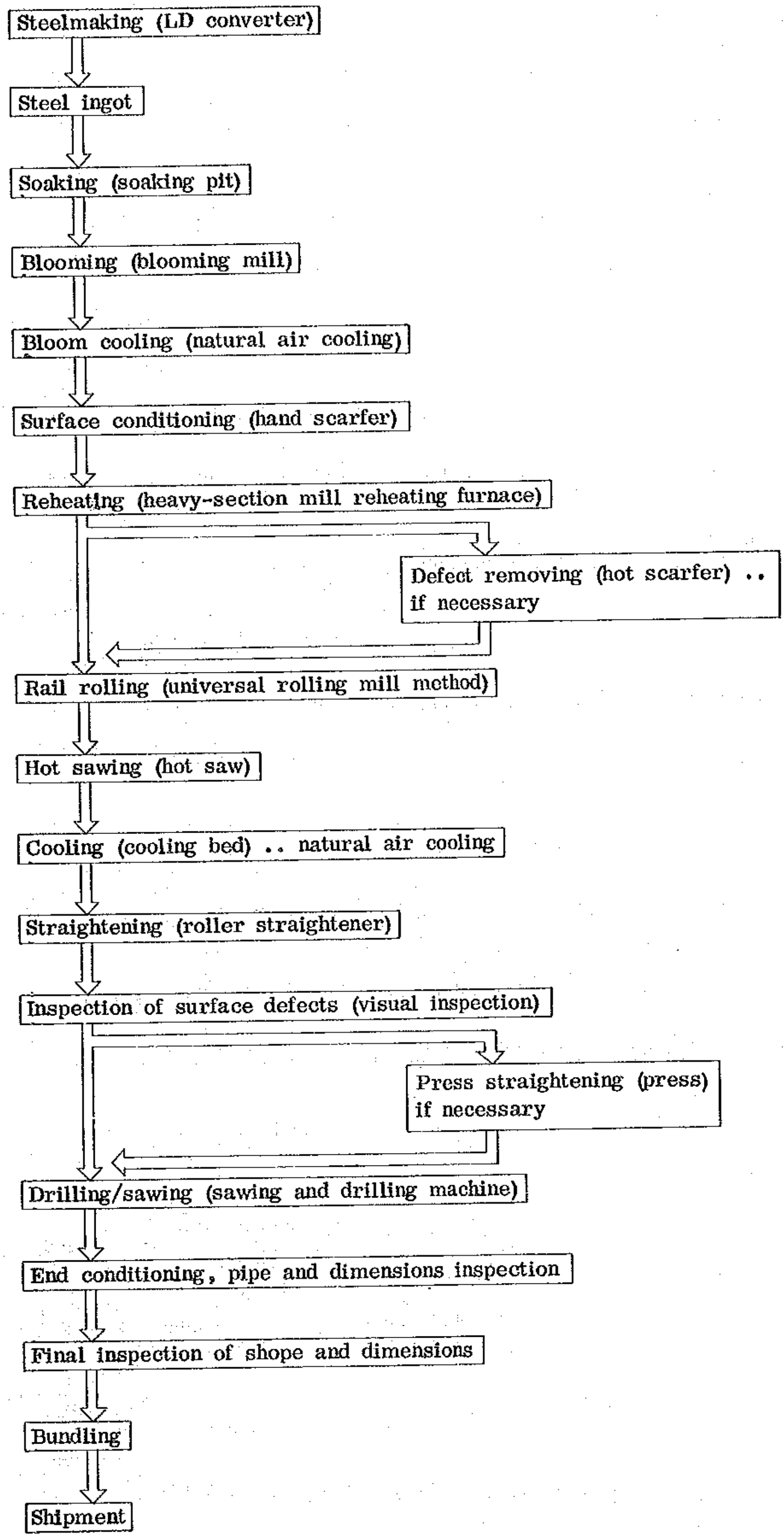
500 hr/m x 30.8 t/hr = 15,400 T/m

As for other cases, production in excess of this value is possible.

## 2.5 Reinforcing the finishing line

### 2.5.1 Production of rails

At Helwan, 60,000 tons of rails will be produced annually in the future. The following illustrates, for reference, a typical rail manufacturing process practised at Nippon Steel.


Steelmaking (LD converter)
Steel ingot
Soaking (soaking pit)
Blooming (blooming mill)
Bloom cooling (natural air cooling)
Surface conditioning (hand scarfer)
Reheating (heavy-section mill reheating furnace)
Defect removing (hot scarfer) .. if necessary
Rail rolling (universal rolling mill method)
Hot sawing (hot saw)
Cooling (cooling bed) .. natural air cooling
Straightening (roller straightener)
Inspection of surface defects (visual inspection)
Press straightening (press) if necessary
Drilling/sawing (sawing and drilling machine)
End conditioning, pipe and dimensions inspection
Final inspection of shope and dimensions
Bundling
Shipment

Slow cooling is not used to reduce the hydrogen content of rails. For the manufacture of rails, a well-planned quality control over the entire manufacturing steps, from steelmaking to shipment, is essentially required.

So far as the Helwan's heavy section mill is concerned, it does seem necessary to reinforce the finishing capacity.

However, reinforcing the finishing line should be considered separately from the current measures for immediate increase of the production capacity to the designed capacity.

## 2.5.2 Finishing line exclusively for rails

The rail finishing process includes the following work: cold sawing to finish the rail into a required length, drilling holes for joint, end conditioning, and the severe inspection process for bending, dimensions, surface defects, and pipe check, etc.

Two alternatives (Layouts A and B in Fig. III-17) can be conceived as a layout of the rail finishing line.

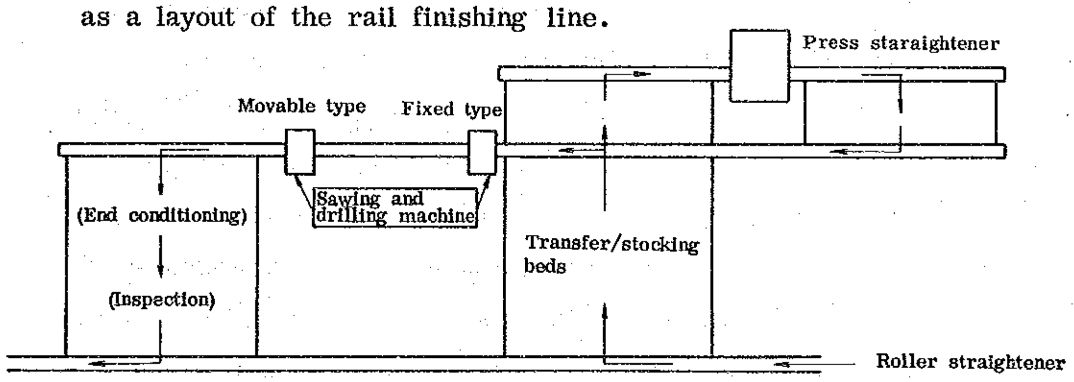



Fig. III−17 (A) Examples rail of finishing line

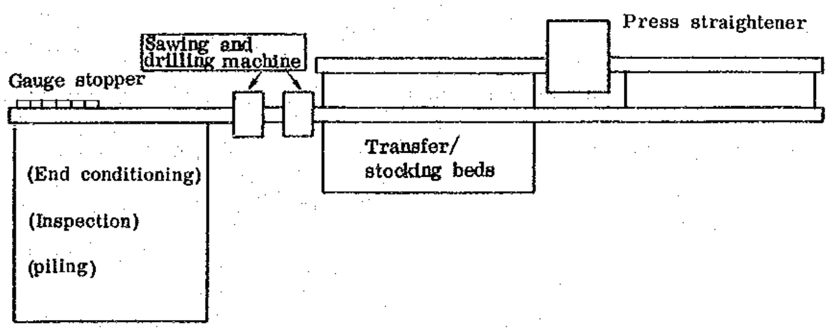



Fig. III−17 (B) Examples rail of finishing line

Rails from the straightening rollers will either be laid aside for a while or directed through the transfer bed to the sawing and drilling machine, where they will be cut to specified lenghts and drilled. After end condioning, rails will be sent finally to inspection beds.

Layout (A) is suitable for rails of constant length while Layout (B) for rails of varied lengths.

With Layout (A), the top and bottom of a rail can be drilled and sawed simutaneously, whereas with Layout (B), simultaneous drilling and sawing of the bottom of a preceding rail and the top of a succeeding rail is made possible.

In the meantime, rails which have not been straightened completely on the roller straightener are directed to the press for restraightening before being drilled and sawed.

This press traightener should desirably be of a dual-press type which is capable of pressing rails horizontally and vertically.

For the capacity of the sawing and drilling line, one line consiting of two sawing and drilling machines is considered to be sufficient to handle the planned output, 5,000 tons per month, of heavy rails (52 kg/m or 47 kg/m) each measuring 18 m long on an average.

The comparative equipment cost is estimated to be about US$1.87 million for layout (A) and about US$ 1.32 million for layout (B). Included in this estimate are roller tables, transfer beds, 2 units of sawing and drilling machines and a straightening press. The roller straightener is not included.

2.5.3 Roller straightener

Currently, there are two roller straighteners. One unit is ot the double hausing type, while the other is of the cantilever type. The double hausing type has a small capacity After Production

of small sizes at this mill is transferred to the new medium section mill, this straightener will not be needed. Generally speaking, the double hausing type takes time for roller change. Besides, the roller adjusting operation is difficult. Consequently, most manufacturers are switching to the cantilever type. As for the other cantilever type unit, it is necessary to check its straightening capacity for heavy rails, steel sheet piles, heavy section steel, etc., although it somewhat depends on the straightness of products required.

## 2.6 Pass schedule and pass design

### 2.6.1 Pass schedule

The pass schedule in section steel rolling should be examined mainly in terms of rolling capacity, since it stands for pass distribution at each roll stand, in this instance. Small sizes such as channels or I beams present problems especially at the heavy section mill. Number of passes of these products at finishing stand is too many to roll with average rolling t/hr, while this contributes to reducing the number of roll.

But these small products will be transferred to the new medium section mill. As for large sizes remained in this mill, as explained in 4-3 ~ 4-6, an estimate is made, in such a way that one piece of material is being rolled on one of 3 roll stands at all times. With this calculation, the results indicate that the designed production capacity is possible.

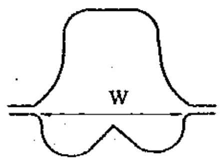
### 2.6.2 Pass design

The quality of roll pass design directly affects the quality and shape of products as well as easiness and stability of the rolling operation, and rolling t/hr. It is of vital importance in section rolling.

Designed of roll pass judgment on its quality and its improvement calls for technique, experience and skill of exceptional levels. Improvement of the roll pass requires an investigation of the actual rolling circumstance and survey to check the actual filling degree of the materials to the roll grooves.

Always in search of better pass design to the mill, improvement should be made, and it is absolutely necessary to train engineers engaged in this special technology. In the following are presented pass design problems and suggestions for improvement with respect to 3 steel products.

(1) Rail 52 kg/m : The problem in the web off-center to the rail base. Assume that Pass-1 is as shown in the right illustration, where rolling is performed by the top and bottom rolls, size of the material rolled in being 190 mm(H) x 160 mm(W),




1) Then, the material width 160 mm to the bottom roll's groove width w = 180 ~ 185 mm is too small with too much allowance. On the other hand, the material width 160 mm is too large for the top roll groove width about 160 mm, and this may cause unstable rolling especially at bite to the rolls.

2) In the pass of forming the base in Pass-1, 2 & 3, it is necessary to check by making cobble-prints whether a sufficient base width is secured.

From the material dimensions (190 x 160) and pass design, it seemed that the base width in Pass 3 tends to be insufficient for the base width in Pass 4.

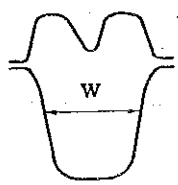
For measures to improve it, the following steps are available.

(a) By means of the entrance guide of Pass-1, holding the material is made completely with good centering.

(b) Another forming pass is set up before Pass-1 to facilitate getting more base width and, at the same time, to make the material in trapezoidal shape that can be stably bitten in Pass-1.

At Nippon Steel, the universal rolling mill built with new technology is currently in use for rolling rails. With this method, much improvement has been gained in regard to dimensional accuracy, rolling capacity, roll consumption, and many other factors as compared with rolling by conventional 2-high reversing mills. Before adoption of this method, when Nippon Steel utilized the Thyssen type pass design, 4 passes for the base forming were used in contrast to Helwan's 3 passes (Pass 1 ~ 3).

As shown in the right illustration, in the forming pass 1, the top and bottom rolls were reverse to Helwan's. Material width was determined by w so that the material could be rolled in the bottom roll stably.




Material height was made higher than Helwan's to secure base width.

(2) ⊔ 200 x 75 : Poor yield due to much cropping of the top and bottom is the problem. In this pass desing, Gr. 9 ~ 6 are used for both I beam and channel, and Gr. 5 ~ 1 is only for channels. There are two problems on design as follows.

1) Width widening quantity of the web is generally too large. This tends to cause shortage of the flange width.

2) As for Gr. 5 ~ 2 exclusively for channels, distribution of the draft of the top and bottom flanges is unbalanced. For improvement, one pass for channels can be added, and this can eliminate overstrain, thus resulting in good products and good yields.

At Nippon Steel, ⊔ 250 x 90 has a similar pass design. But, the pass exclusively for channels is Gr. 6 ~ 1, wereby good products and good yields are obtained.

(3) Sheet pile Larssen 1A type

Since this is under test rolling, measures for improvement are explained as follows.

1) Finishing Pass 9 had better be altered to what is illustrated in Fig. III.18. This makes it possible to form the interlocking part without the bending roller guide. However, design alteration of the interlocking part of Pass 8 is necessary in this case.

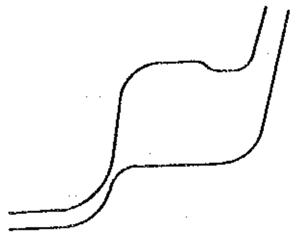


Fig. III.18 Design of finishing Pass 9

2) The interlocking part of the products is as shown in Fig. III.19, but it is better to alter this as shown in Fig. III.20. (In Fig. III.19, the t section is slanted.) By this alteration, improvement in executing the sheet pile construction work will be made.


Fig. III.19 Pass design of the current interlock

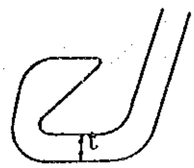



Fig. III.20 Pass design of the improved interlock

3) Cracks generated in the outside of interlock can be greatly reduced by making good ingots at steelmaking and performing surface conditioning of bloom with carefully.

In the section steel rolling, use of rolling oil often contributes like good roll pass design, to facilitating the rolling operations and to getting superior quality products.

(4) Rolling oil

Effects of appropriate use of rolling oil are as follows.

a) Roll wear is alleviated, thus reducing the roll cost.

b) Material sticking to the roll is prevented.

c) Flange width is secured.

d) Forming complex shapes such as the sheet pile interlock is made easy.

Tar was used as lubricant initially at Nippon Steel. A tank filled with tar was placed above the roll stand, and from the tank, tar was dropped in driplets through the pipe. Although good effects were obtained, there was considerable smoke generated. Besides, the rolling mill area was made dirty. No tar is used now. At present, newly-developed rolling oil, mixed water is sprayed to the roll groove. Inasmuch as this is highly effective for rails, I beams, channels, sheet piles, etc., its use should be reviewed at Helwan.

## 3 Light Section Mill

### 3.1 Introduction

Mainly small size round bars (over ø13 mm) and a small quantity of angles are manufactured at this mill. It seems that wire rods of 6 ~ 10 mm and bar-in coils used to be produced. But, there were many problems, and their production is currently stopped with the equipment partially removed.

Actual production is 45,000 to 55,000 t/y against the designed production capacity of the mill, 100,000 t/y. Due to problems in iron-making and steelmaking, stoppage caused by a lock of materials amount to 130 hours per month on the average. Recent operating status is shown in Table III.22.

Table III.22 Operation record

| Items | Jan. ~ Oct. 1976 Average | Max. *3 | Min. *3 |
|---|---|---|---|
| Production output | 3,690 t | 4,473 t | 2,836 t |
| Schedule shutdown*1 | 85 hr | 93 hr | 35 hr |
| Stoppage due to material shortage | 130 hr | 270 hr | 38 hr |
| Stoppage due to trouble *2 | 141 hr | 225 hr | 92 hr |
| Rolling time | 352 hr | 428 hr | 289 hr |
| t/hr | 10.5 | 11.7 | 9.2 |
| Yield | 80.3 % | 84.4 % | 75.2 % |

*1 Planned maintenance + Shutdown

*2 Mechanical + Electrical + Product stoppage

*3 Maximum and minimum values of these months

Should the sufficient material be given and rolling be performed during the stoppage hours due to the lack of material, the production output would rise up to 65,000 to 70,000 t/y.

3.2 Problems

There are two principles in increasing production of the rolling mill -- elongation of actual rolling time and increase of rolling t/hr within this period. The current practice at this mill is against these two principles. Due to many hours of stoppage by trouble, actual rolling hours have been decreased and rolling t/hr has been also lowered by almost one rolling and low rolling speed. Let us first take a look at the operating hours. The operation records from January to October 1976 show the following facts. Of the total stoppage averaging 365 hours per month, 93 hours per month of product stoppage occupy a very large ratio, even putting aside 130 hours per month of stoppage due to the lack of material, which could be coped with the future. This product stoppage is 25.5 % of the total stoppage and 66 % of the total time 141 hr/m of mechanical, electrical and product stoppages. The main causes for this product stoppage consist of various misrolls and the adjusting time for coping with them. The yields as low as 79 to 84 % (averaging about 80 %) also indicates many occurrences of misrolls.

Such being the case, the first-step solution to the problems of this mill is prevention from misroll occurrence to increase the yield. Then, after rolling operations could be smoothly and stably performed, improvement of rolling t/hr should be attempted as the second step.

3.3 Prevention of misrolls and improvement of yields

The misroll occurrence rate at this mill can be estimated from yields as follows, as its actual data are not available. According to the operation record from January to October 1976, a monthly average yield

will be 80.3 %.

$$\left(\text{Yield} = \frac{\text{Product wt.}}{\text{Material wt.}} \times 100\ (\%)\right)$$

Assuming, Scale (Furnace, secondary scale) : 2 %

Crop cut of materials after 3 High-Rougher rolling : 3～4 %

Crop cut of products : 3～4 %

Approximately 10 % misrolls must be occurred. Reduction of these misroll to 1 to 2 % will increase production by 8 to 9 %. At the same time, the reduced misroll handling time will be substituted by the rolling time, thus contributing immensely to the production increase. As the current survey period is too short, causes of those misrolls occurrences could not be well clarified. However, it should be noted that, general causes of misroll occurrences at a small bar mill include the following: defective material (pipe, surface defects, sheared sectional defects, etc.), poor adjustment of roll setting (improper spacing, poor thrust adjustment, profile sabnormalities due to heavy wear, large jumping, etc.), poor adjustment of guide setting (poor material holding and twisting, repeater trouble, etc.), temperature decrease of steel materials, and poor pass design.

In the event that a misroll has occurred, it is necessary exactly to judge which of these causes brought about the misroll and if the cause was exercised directly or indirectly, before proper action must be taken. This calls for improvement of worker's operational skill. Especially when production is carried out by an old rolling mill as in the case of this mill, prevention of misrolls depends heavily on workers' positive attitued against misroll and the elevation of their technical level.

The following are some examples of how high levels of technical and operational skill are needed to the worker of this mill.

a) The worker should be capable of operating easily any roller guide (entrance guides, exit twisting guides) which are in use at bar mills

in any countory. This high skill will contribute to reducing faulty feeding at the entrance, thus decreasing misrolls. This high skill of roller guide operation is indispensable for performing stable repeater rolling at finisher.

b) The worker should be competent enough to take preventive action (such as roll and guide adjustment) by inspecting or checking the status of steel materials during rolling before actual misroll occurs. For example, the worker should have careful watch at abnormal looping, looping size, and roll clearance changes due to the deposit of secondary scale on the side of materials rolled, or the worker should be careful at any change of steel material profile (overfill, underfill) by pressing a wooden board to the hot material rolled.

c) The worker should be competent enough to discover any fault of the rolling mill and its auxiliary equipment to improve them and perform proper actions. In the case of old roll-stand clearance of the sliding part, roll thrust adjusting device, wear of fabric bearing, etc. should be given priority for checking in order to prevent rolls and roll chock from getting loose, and measures for improvement should be worked out.

As an example of measures to improve workers' technical skill level, the voluntary control activity in Japan is explained below. There is an activity by workers to decrease misrolls. In this voluntary campaign, workers establish the target for the misroll occurrence rate, and to accomplish that target, they gather various data, discuss the causes among themselves, set up countermeasures, and put them into effect. As a result, the misroll occurrence rate is less than 1 % at most mills. Such activity has brought about great improvement in workers' technical capability and a decrease in the misroll occurrence rate.

As for the phase of yields, it seems that corp ends of the top and bottom of ø13 mm materials after 3-high mill rolling have been generated far more than required. Also, finishing bars to be transferred to the cooling bed should be made the full length of the cooling bed.

3.4 Improvement of rolling t/hr

Only the case of rolling the main size ø 13 mm will be considered here. Even if the misroll occurrence rate should decrease so that the actual rolling time per month may reach 500 hr, it will be difficult to accomplish the designed capacity of 8,300 t/m (100,000 t/y).

Reasons are:

a) Because the existing finishing roll (No. 8 stand) speed is as slow as 3.5 m/sec. This is caused by the fact that the entrance operation of the finishing roll is manually done.

b) Although only the finishing roll (No. 8 stand) is possible to make two strands rolling, the rate of actually performing that operation is very low.

There are two countermeasures for improving t/hr as follows.

Therefore, there are 2 countermeasures for improving t/hr as follows.

a) Two strands rolling should be performed as far as No. 8 stand of the continuous roll and finishing roll is concerned.

b) A repeater should be set up in between the finishing stand No. 7 and No. 8, so that manual operation may be eliminated to increase the finishing roll speed.

Of these two countermeasures, the most effective is the first step of two strands rolling, which will contribute to raising rolling t/hr as well as decreasing misrolls. This is because even if a trouble occurs in one of the two strands, the other strand can perform rolling without misrolling the succeeding materials. What should be particularly heeded in two strands rolling are the following two points:

a) Shape of the two loops through the repeater of the finishing parallel stand should be able to develop normally and hold itself.

b) Two loops are not to interfere with each other.

These points can be easily solved through some contrivance on the loop channel exclusively for each loop.

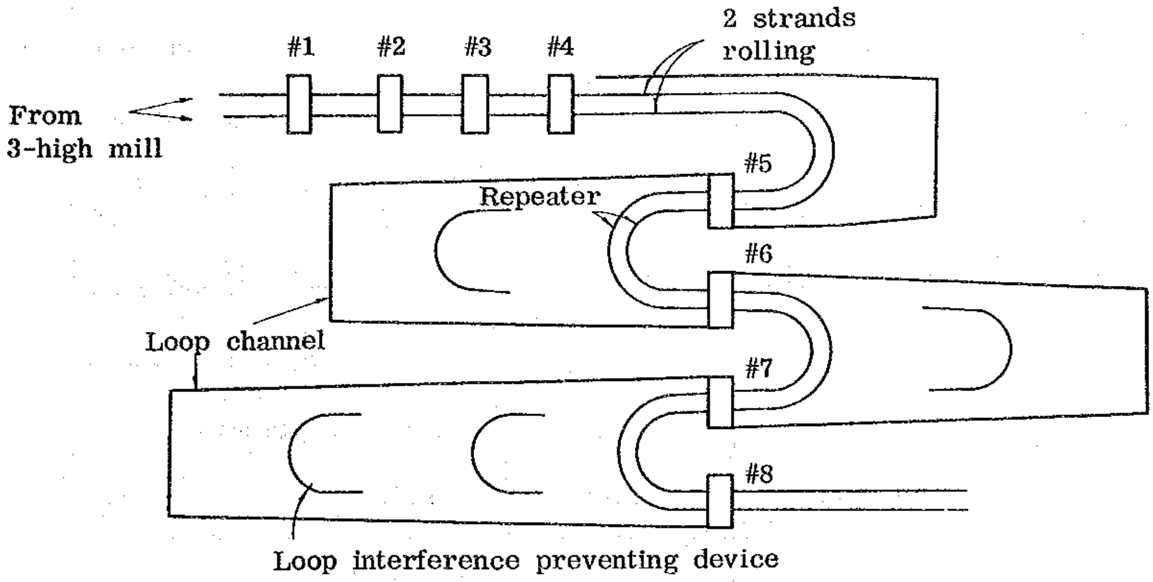



Fig. III.21 Two strands rolling

Improved rolling t/hr due to these countermeasures will be as shown in Table III.23.

Table III.23 Comparison of rolling t/hr

| | Existing-I | Existing-II | Finishing speed increase | 2 Strands |
|---|---|---|---|---|
| Number of strand | 1 | 1*1 | 1 | 2 |
| Finishing No. 8 roll speed (m/s) | 3.5 | 3.5 | 5.6 | 3.5 |
| Finishing No. 8 roll rolling pitch (sec.) | 78 | 68 | 49 | 44 |
| Number of pieces rolled per hour (pc/hr) | 46 | 53 | 73 | 82 |
| t/hr *2 | 12.4 | 14.3 | 19.7 | 22.1 |

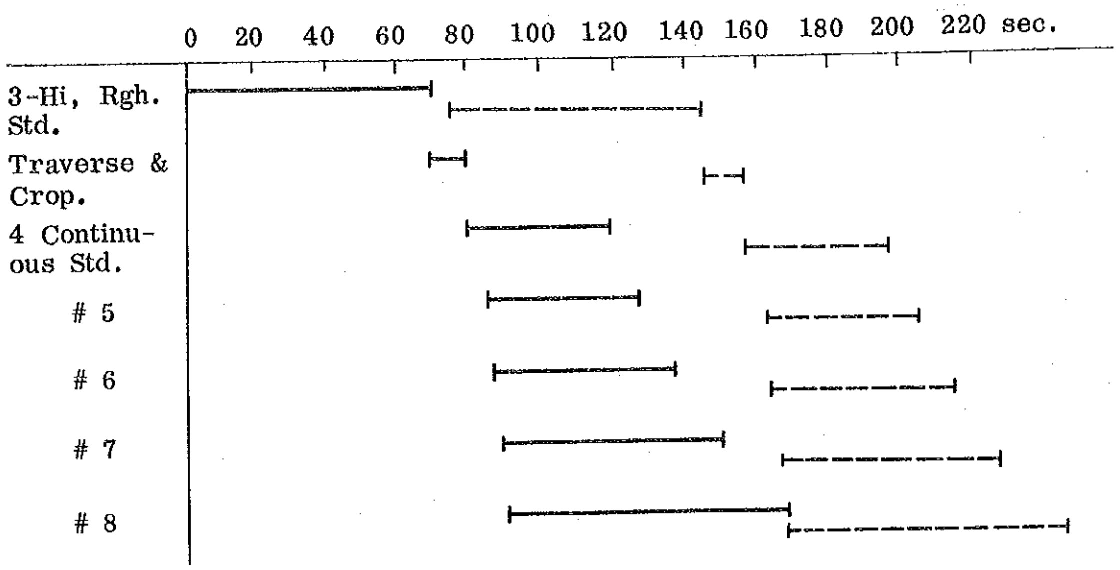
*1 2 strands rolling for 10 sec. lap only at finishing No. 8 stand

*2 Product t/hr (1 piece of material 300 kg, yield 90 %)

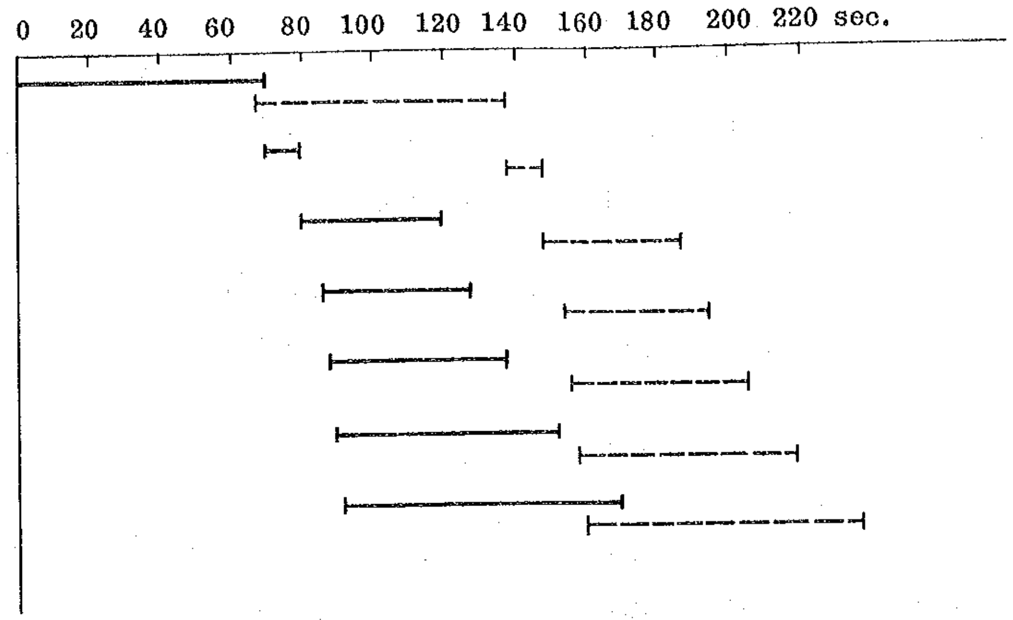
An example of the rolling time schedule in the case of current rolling and two strands rolling is shown in Fig. III.22.

According to Fig. III.22, in two strands rolling, it is not necessary to roll two pieces of steel material simultaneously at the continuous roll. Be that as it may, for the purpose of decreasing misroll as previously explained, it is desirable to make the continuous roll capable of two strands rolling and to roll on these strands alternately. The rotary shear after finish rolling and the inlet runway of the cooling bed are capable of two strands rolling. At present, one strand portion of those equipment is in use. When two strands rolling becomes part of normal operations in the future, it is desirable that this section is used for two strands.

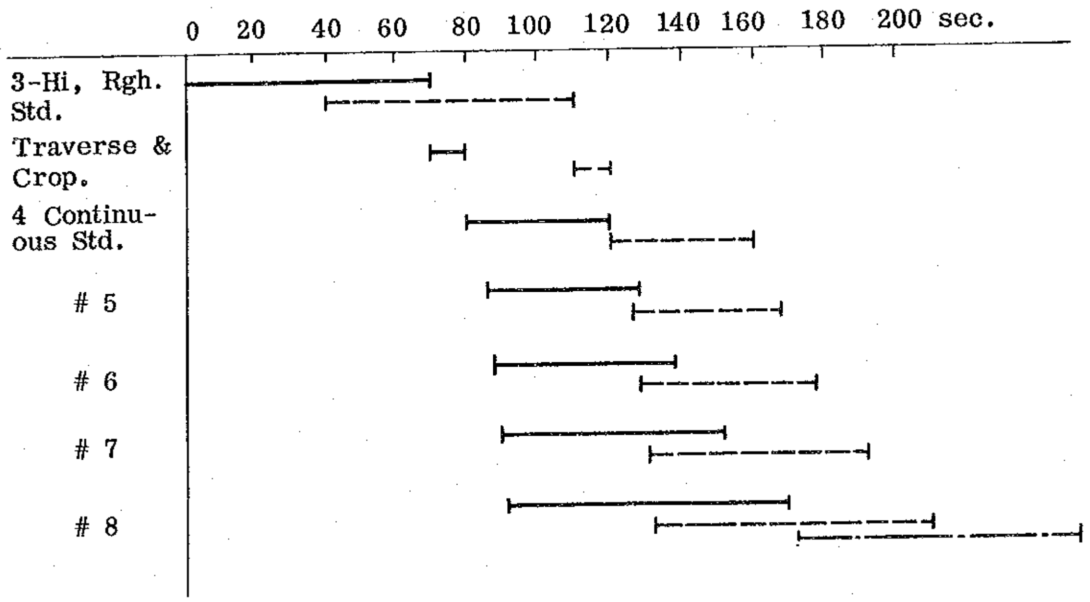
Existing I (Finishing No. 8 stand, no lap)



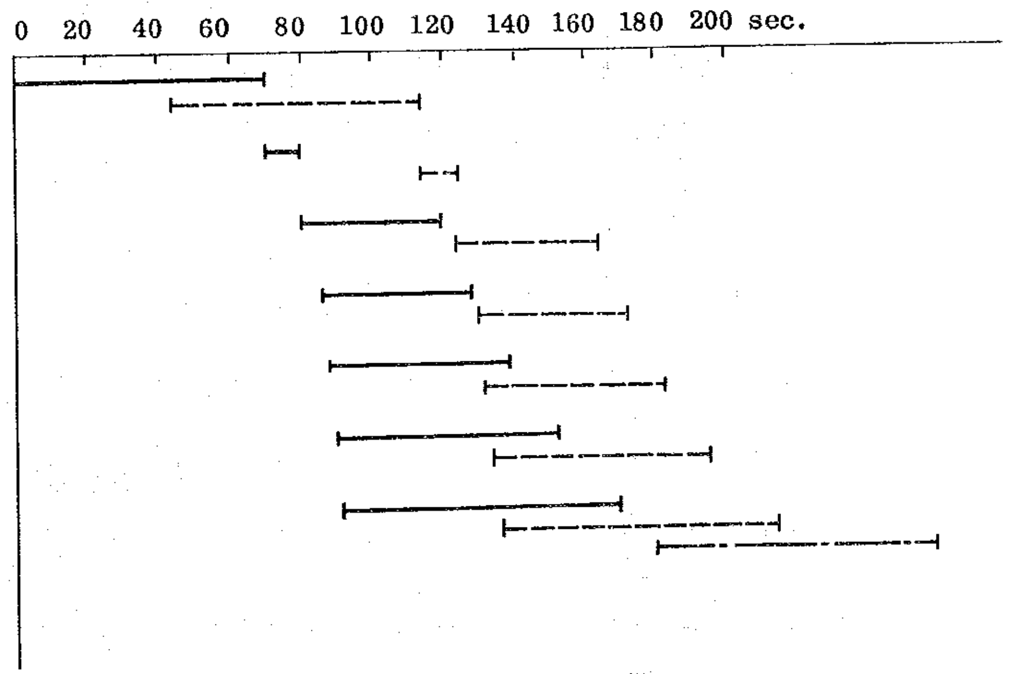

Existing II (Finishing No. 8 stand, 10 sec. lap)




two strands rolling (Finishing No. 8 stand, rolling pitch 40 sec.)




two strands rolling (Finishing No. 8 stand, rolling pitch 44 sec.)




Note: 1. Rolling time

| | | |
|---|---|---|
| 3-Hi, Rgh. Std. | : | 70 sec. |
| Cont. Std. #1～4 | : | 40 |
| Fin. Std. #5 | : | 42 |
| 6 | : | 50 |
| 7 | : | 62 |
| 8 | : | 78 |
| Transfer, crop cutting | : | 10 |

2. Legend

|—————| 1st piece

|- - - - -| 2nd piece

|-·-·-·-| 3rd piece

Fig. III.22 Rolling time schedule

## 3.5 Mill's production capacity after countermeasures

### 3.5.1 Capacity of the heating furnace

As in the case of the heavy section mill, sources of data in calculating the heating furnace capacity are as follows.

Helwan data: Furnace type, dimension, burner capacity, calorific value of fuel

Data speculated by Nippon Steel: Necessary data for calculation in addition to the above

Results of calculating the capacity are shown in Fig. III.23. From Fig. III.23 we learn that the furnace capacity is limited by the capacity of the preheating zone burners, and that mixed burning of heavy oil and blast furnace gas by the preheating zone burners is needed. These findings are summarized in Table III.24.

Table III. 24 Reheating furnace capacity

| Combustion method | Air temperature | Heating capacity | Remarks |
|---|---|---|---|
| Heavy oil burning | 30 °C | 19 t/hr | Limited by the capacity of the preheating zone burners |
| | 300 | 20.5 | ditto |
| Heavy oil + blast furnace gas mixed burning | 30 | 25 | *1 |
| | 300 | 25 | *2 |

*1 Heavy oil 88.5 kg/hr x 5 burners = 442.5 kg/hr
Blast furnace gas 475 $Nm^3$/hr x 5 burners = 2,375 $Nm^3$/hr
Mixed burning of the above ratio is necessary using the preheating zone burners.

*2 Heavy oil 88.5 kg/hr x 5 burners = 442.5 kg/hr
Blast furnace gas 285 $Nm^3$/hr x 5 burners = 1,425 $Nm^3$/hr
Mixed burning of the above ratio is, likewise, necessary.

Note that these represent the required quantities of blast furnace gas in terms of calorie. In actuality, since blast furnace gas contains a large quantity of waste gas, more than these blast furnace gas quantities will be needed.

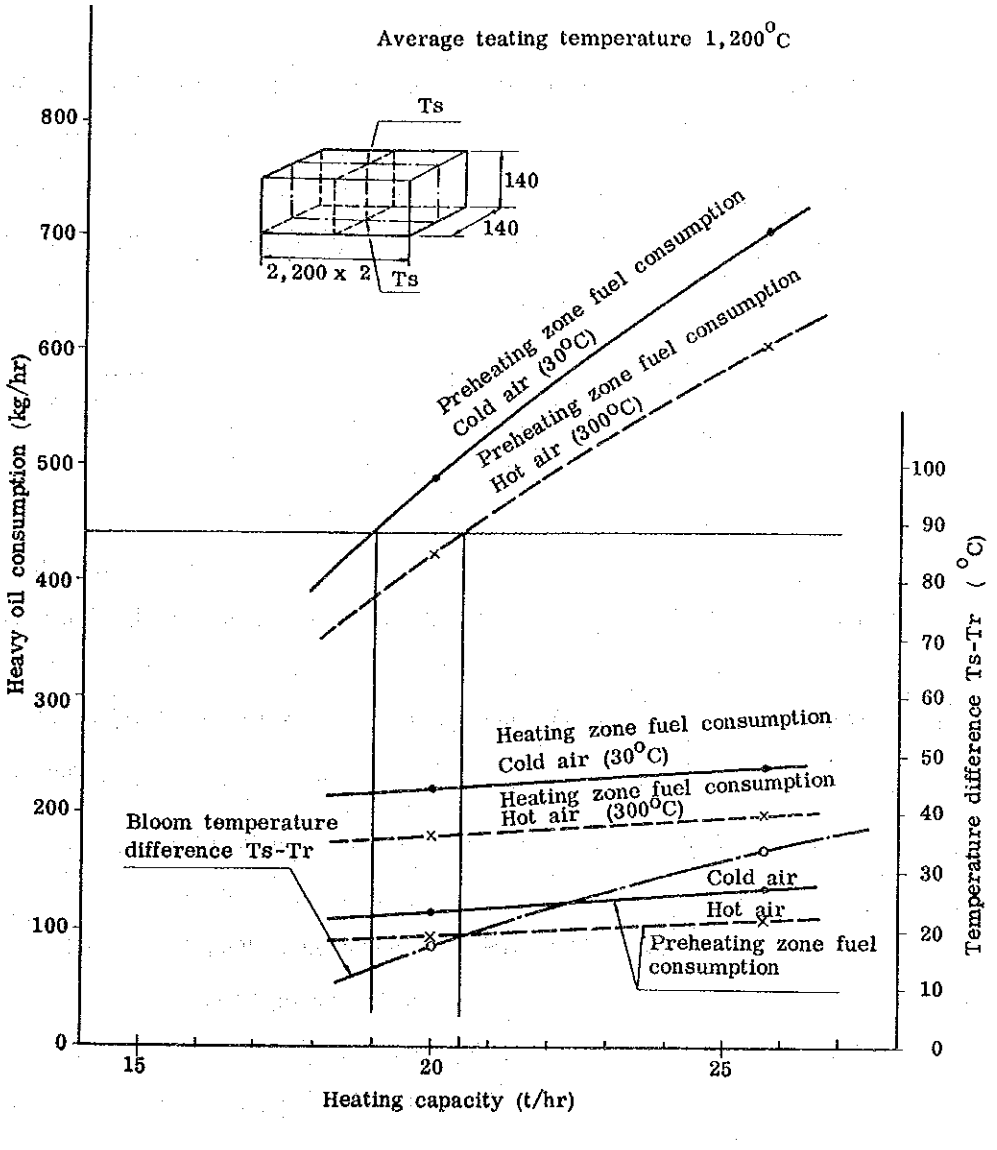



Fig. III.23 Reheating furnace capacity

Since there are no data on the possible limit of mixed burning, no clear statement can be made about the capacity of this heating furnace. However, if the burner capacity is to be increased in order to raise the capacity, the following items need to be investigated.

a) Combustion air blower capacity
b) Air pipe diameter, fuel pipe diameter, and steam pipe diameter
c) Exhaust equipment such as flue ducts and stack
d) Recuperator capacity
e) Fuel supply facilities (oil pumps, heaters, strainers, oil tanks, gas blowers, etc.)
f) Energy balance of the mill as a whole (oil, gas, steam)

The capacity of the heating furnace in calculating the mill capacity is as follows.

(Material heating t/hr = 25
Product heating t/hr = 22 (≑ 25 t/hr x 0.9))

3.5.2 Rolling capacity

(1) Operating hours

On the basis of actual records from January to October 1976, one month operation (30 days base) was assumed for 4 cases as shown in Table III.25, and the rolling time was computed. No shutdown was assumed.

| | | |
|---|---|---|
| Case I | : | Current operation, roughly Jan. ~ Oct. actual performance base |
| Case II | : | Assuming current levels of operation with no shortage of materials |
| Case III | : | After countermeasures, rolling operations fairly stabilized with a resultant decrease in product stoppage |
| Case IV | : | Working time ratio to be achieved in the future 554 hours of the rolling time are 77 % of the calendar time. |

Table III.25 Details of stoppage time

| | Current levels | | After countermeasures | |
|---|---|---|---|---|
| | Case I | Case II | Case III | Case IV |
| Maintenance (Planned) | 70 hr | 80 hr | 80 hr | 46 hr |
| Mech. stoppage | 25 | 30 | 25 | 20 |
| Elect. stoppage | 22 | 27 | 25 | 20 |
| Product stoppage | 92 | 107 | 40 | 30 |
| Wait for heating | 4 | 4 | 10 | 10 |
| Roll change & adjust | 9 | 11 | 25 | 25 |
| Lack of material | 130 | 0 | 0 | 0 |
| Others | 7 | 8 | 15 | 15 |
| Total stoppage | 359 | 267 | 220 | 166 |
| Rolling time | 361 | 453 | 500 | 554 |
| Calendar | 720 | 720 | 720 | 720 |

Notes: Details of the 46 hours of planned maintenance in Case IV are

2 shifts x 2 time/m = 4 shift/m (= 32 hr/m)

0.5 hr x 28 d/m = 14 hr/m .... every morning maintenance

(2) Rolling t/hr

1) Rolling t/hr of ø13 mm

As the measure for improving t/hr, two strands rolling is too be performed, and the finish roll speed is the same as the current speed of 3.5 m/sec, with the ratio of two strands rolling time at 70 %, and the remaining 30 % for one strand rolling. The total t/hr in this case is shown in Table III.26.

Table III.26 Rolling t/hr of ϕ 13mm

| Number of strand | Bottleneck | t/hr | Time ratio | Total t/hr |
|---|---|---|---|---|
| 1 (no lap) | Finish roll speed | 12.4 | 30 % | 19 |
| 2 | Heating furnace | 22 | 70 % | |

2) Rolling t/hr of ∠ 30 x 30 x 4 and ∠ 40 x 40 x 4

Material is 300 kg/pc, the same as ϕ 13 mm, and rolling yield is 90 %. The finish roll speed is 3.5 m/sec. Rolling is one strand rolling. The bar rolling interval at the finish roll is 5 sec. Total t/hr in this case is shown in Table III.27.

Table III.27 Angle rolling t/hr

| | t/hr | Bottleneck |
|---|---|---|
| ∠ 30 x 30 x 4 | 18.5 T | Finish roll speed |
| ∠ 40 x 40 x 4 | 22 | Heating furnace |

(3) Equipment capacity after rolling

This can be handled with considerable flexibility as long as there are transfer equipment, extra place and manpower in the finishing line. Hence, its review has not been made at this time, and there is supposed to be no bottleneck in process.

(4) Rolling t/hr by products

This rolling t/hr is given by the following formula.

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

where $R$ : Rolling t/hr

$N_i$ : Production percentage by steel products (%)

$R_i$ : Rolling t/hr by steel products

For product mix, the cases, A, B and C are assumed, and the rolling t/hr for these cases is obtained as in Table III.28.

Table III.28 Total rolling t/hr of the mill

| | Case A | Case B | Case C |
|---|---|---|---|
| ø 13 | 80 % | 70 % | 90 % |
| L 30 x 30 x 4 | 10 | 15 | 5 |
| L 40 x 40 x 4 | 10 | 15 | 5 |
| Total rolling efficiency of the mill | 19.2 T/Hr. | 19.3 T/Hr. | 19.1 T/Hr. |

5) Total production capacity of the mill

When this is calculated in the case of Case III for the operating hours and Case C for product mix, we obtain

| Production capacity P = 500 hr x 19.1 t/hr ≑ 9,500 t |
|---|

For other cases, production in excess of this is possible.

## 3.6 Pass design

Upon checking pass design of the main size, ø 13 mm, various problems were discovered. The original pass design itself is problematical in draft distribution of each pass and determination of roll clearance. It seemed that actual rolling operations are performed under conditions considerably different from designed values.

Actual circumstance of current rolling operations, namely, roll clearance and the profile of materials at each pass (overfill or underfill), must be

closely examined before any steps are taken to improve the roll pass design.

The continuous roll does not have much flexibility in altering pass design, because the roll rpm is fixed for each stand.

Reduction is extremely large (24.5 ~ 39 %) here, thus resulting in substantial roll wear. If the normal condition is to be maintained, frequent roll adjustment is necessary. However, making materials with correct square profile at this continuous No.4 stand and forwarding them to the finishing No. 5 stand constitute one condition for stable and smooth rolling at the finishing four stands.

A recommended modification plan on the pass design of ø 13 mm is shown in Table III.29.

Continuous rolls (No. 1 ~ 4) at this pass design are governed by the fixed rate of rpm so that reduction cannot be independently determined. The range of selection is determined by the roll diameter and rpm.

Since there are no data on the diameter of rolls now in use, no modification plan can be shown. But, as indicated in Table III.29, distribution of reduction at each pass of continuous rolls for ø 13 mm is not good. Also, note that in the same continuous rolls, distribution of reduction for each size of ø 13, 16 and 19 differs as in Table III.30. These should be modified after the actual situation is carefully checked.

Table III.29 Current pass design of $\phi$ 13 mm and the modification plan

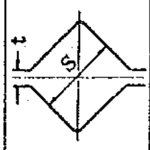
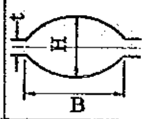
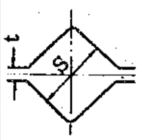
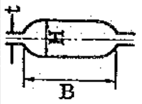
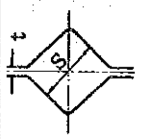
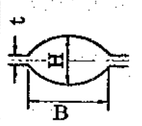
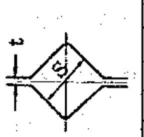
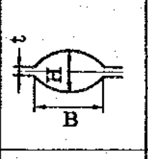
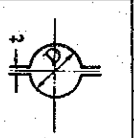
| Stand | | | Current situation<br>Helwan | Modification plan | Remarks |
|---|---|---|---|---|---|
| 0 |  | S | 37 | | |
| | | H | 46.4 | | |
| | | t | 6 | | |
| | | F | 1,326 | | |
| | | Red. | | | |
| 1 |  | H | 21 | | Red. large<br>Roll clearance large |
| | | B | 51.2 | | |
| | | t | 6.4 | | |
| | | F | 827 | | |
| | | Red. | 37.6% | | |
| 2 |  | S | 25.2 | | Roll clearance large |
| | | H | 32.2 | | |
| | | t | 4.5 | | |
| | | F | 624 | | |
| | | Red. | 24.5% | | |
| 3 |  | H | 12 | | Red. large |
| | | B | 40.6 | | |
| | | t | 4.5 | | |
| | | F | 380 | | |
| | | Red. | 39.1% | | |
| 4 |  | S | 16.6 | | |
| | | H | 20.7 | | |
| | | t | 2.9 | | |
| | | F | 270 | | |
| | | Red. | 28.9% | | |
| 5 |  | H | 11.5 | t = 2.5<br>Red. : 21 ~ 24% | Red. small |
| | | B | 26 | | |
| | | t | 3.5 | | |
| | | F | 230 | | |
| | | Red. | 14.8% | | |
| 6 |  | S | 14.0 | t : 2.5<br>Red. : 18 ~ 21% | Roll clearance too large |
| | | H | 17.7 | | |
| | | t | 3.7 | | |
| | | F | 190 | | |
| | | Red. | 17.4% | | |
| 7 |  | H | 11.0 | $\frac{B}{H-t}$ (=2.10) 2.4<br>2.9<br>t : 2.0<br>Red. : 20 ~ 22% | Red. small<br>Roll clearance small and amount of adjustment small<br>$\frac{B}{H-t}$ : be made larger to facilitate twisting |
| | | B | 20.2 | | |
| | | t | 1.4 | | |
| | | F | 167 | | |
| | | Red. | 12.1% | | |
| 8 |  | D | 12.9 | Red. : 15 ~ 18% | Red. too large<br>Possibility of overfill |
| | | t | 2 | | |
| | | F | 132.7 | | |
| | | Red. | 20.5% | | |

Table III.30 Distribution of reduction at continuous stands

| | ∅ 13 | | ∅ 16 | | ∅ 19 | |
|---|---|---|---|---|---|---|
| | Area | Red. | Area | Red. | Area | Red. |
| # 0 (Square) | 1,326 | | 2,330 | | 3,290 | |
| 1 (Oval) | 827 | 37.6% | 1,570 | 32.6% | 2,210 | 32.8 |
| 2 (Sq.) | 624 | 24.5 | 1,118 | 28.8 | 1,560 | 29.4 |
| 3 (Oval) | 380 | 39.1 | 719 | 35.7 | 1,070 | 31.4 |
| 4 (Sq.) | 270 | 28.9 | 498 | 30.7 | 760 | 30.0 |

What is important about the pass design of 3-high roughing stand rolls is, as previously discussed, whether the 37 mm square can be correctly produced at the final pass. Unless this square is accurately produced, materials tend to enter the rolls of No. 1 continuos stand while twisting, and this may cause trouble. It is possible to form into a round shape, which is easy to be rolled, instead of this square, and good results are mostly obtained at the No. 1 continuous stand. It often happens that at the 3-high roughing mill, the screw up device of the bottom roll does not work due to scale and dust. The bottom roll should be properly maintained at all times just like the top roll so that adjustment can be made.

At present, production wire rods and BIC by using the finish stand No. 9 ~ 12 is stopped. The smallest size by using up to No. 8 finish stand is the main size, ∅ 13 mm. In this case, the average draft can be obtained by the next formula.

$$R = (1 - \sqrt[n]{\frac{A}{A_o}}) \times 100,$$

where $R$ : Average draft (%)

$n$ : Number of passes

$A$ : Product cross sectional area ($mm^2$)

$A_o$ : Material cross sectional area ($mm^2$)

The average draft for rolling the 140 x 140 material into ∅ 13 mm through 17 passes is R = 25.5 %. Generally, values of this average draft are as follows.

| | |
|---|---|
| Round bars of ordinary steel | R = 23 ~ 27 % |
| Round bars of high grade steel | R = 20 ~ 23 % |

Therefore, under the current method of rolling at Helwan, ∅ 13 mm becomes the smallest size, and rolling of round bars in sizes less than this will be extremely difficult.

For example, in case of rolling ∅10 mm by 17 passes R is 27.7 %, which is too large. This means that the number of passes must be increased. For increasing the number of passes, there are two method: one is using the 3-high roughing stand to make 9 passes into 11 passes; the other is illustrated in Fig. III.24 by passing the finishing No. 5 and No. 6 stands twice.

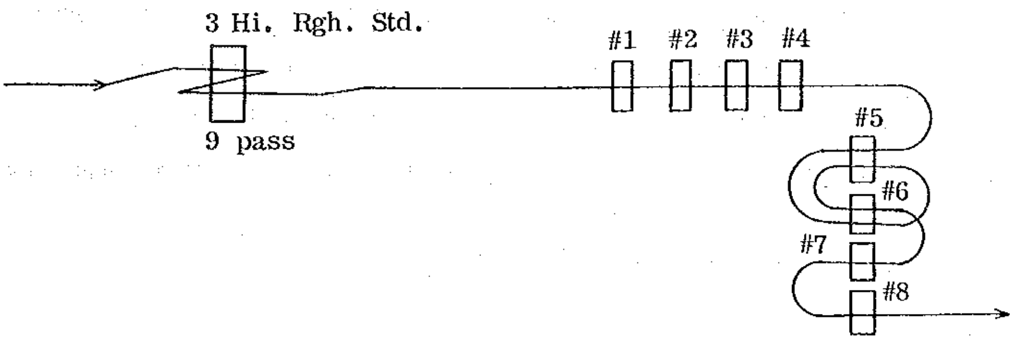



Fig. III.24 Rolling schedule of smaller size

Regardless of which method is used, rolling operations are not free from extreme difficulty. Production of round bars less than ∅ 13 mm is no desirable in that t/hr becomes less.

As in the heavy section mill, it is necessary to train engineers at the light section mill, who can take charge of roll pass design.

## 3-7 Equipment improvement

So far as the operational results achieved between January and October of 1976 are concerned, the frequency of mechanical and electrical troubles was not unusually high.

It is of course necessary, however, to make further efforts to reduce as much as possible the equipment downtime caused by mechanical and electrical failures. Basic considerations that should be taken in this maintenance were already pointed out in the subsection 2-3 of section 2 for heavy section mill.

Particularly problematic for the light section mill are mill motors and rolling stands.

As for mill motors, problems are just the same as those for the heavy section mill. For rolling stands, on the other hand, both the four continuous rolling stands and the four finishing stands are old-fashioned and poorly maintained. Particularly careful maintenance of these will therefore be necessary.

It would be also desired to study the possibility of replacing these stands with prestressed ones equipped with roller bearings in order to perform rolling operations on a more consistent basis and produce bars and light sections of higher quality.

## IV. AUXILIARY SECTOR

### 1. Refractories

#### 1.1 General

Helwan Works is confronted with refractories problems throughout its processes ranging from iron-making through steelmaking to rolling. To solve these, a basic approach to the solution must be established in advance. To this end, due considerations should be given to a variety of relevant factors including the present situation of the local refractories industry. As a conclusion of the studies on this issue, the following recommendations are given:

a) To prefer imported refractories for construction use,

b) To employ, in principle, locally-produced refractories for relining, and

c) To improve technical standards for the overall control of the refractories quality, brick-laying work and the furnace operation.

As for refractories for construction uses (those refractories that are used in blast furnaces, for example, over an extended period), it is of course advisable to import them when required in order to obtain high-quality refractories at lower costs since the demand for such refractories is more or less intermittent. For refractories for relining applications, on the other hand, a continued supply from domestic sources must be maintained. If domestic products cannot meet the quality requirements, however, continued dependence on imports would be unavoidable at least for the time being. Also, there may be cases that some special refractories which must be imported in the future as well will be used as a temporary substitute of relining refractories.

If refractories are to function satisfactorily in practical service, quality alone cannot meet the requirement. In addition to that, intensified brick-laying control for the improved lining performance and appropriate furnace operation techniques based on the considerations

of effects of the operating conditions on the life of the refractory linings are essential. To this effect, it is necessary to establish an improved comprehensive control system which will encompass the quality control of refractories at the time of manufacture or purchase, performance control of brick-laying work and furnace operation and application data control.

As a result of the present study, the overall refractories consumption at Helwan Works is estimated to be 150 to 170 kg/t-steel. It can be broken down as follows:

Table VI-1 Typical lining life and refractories consumption

| | | Lining life (heats) | Refractories consumption (kg/t-metal) |
|---|---|---|---|
| Blast furnace | Taphole mix | - | 4.0 |
| | Trough & runner | - | 2.0 |
| Thomas converter | Wall | 110 ~ 130 | 120.0 |
| | Bottom | 20 ~ 22 | |
| Electric furnace | Roof | 50 ~ 70 | 12.0 |
| | Wall & bottom | - | 49.0 |
| Ladle | BF ladle | 8 ~ 10 | 7.4 |
| | Mixer ladle | 60 ~ 90 | 2.8 |
| | Conv. ladle | 5 ~ 8 | 36.0 |
| | EF ladle | 8 ~ 11 | 32.5 |

## 1.2 Dolomite plant

### 1.2.1 Problems with the existing dolomite plant ancillary to Thomas Plant

At the dolomite plant which is ancillary to the Thomas Converter Plant, tar dolomite brick and tar dolomite mix are manufactured mainly for use in the Thomas converter, part of the output being directed also to the electric furnace. This dolomite plant has such problems as follows:

a) The plant equipment are inadequately spaced and generally obsolete.

b) Shaft kilns are used to fire dolomite. As associated with this type of kiln, operation control is rather difficult and the quality of clinker product is very uneven. Further, some flux components, $SiO_2$, $Al_2O_3$, etc., derived from coke fuel also exist.

c) There are also many problems to overcome in the operating practices and equipment used for crushing, mixing and forming processes.

It seems very hard to solve these problems unless drastic modification of the existing plant is made.

### 1.2.2 Remedial measures

Under the Rehabilitation Plan, the dolomite plant ancillary to the Thomas Converter Plant shall be shut down and the manufacture of tar dolomite brick and tar dolomite mix shall be taken over by the new dolomite plant of the new LD Plant already in operation, where all the dolomite refractories for captive use shall be produced. Both improved quality and production efficiency can be expected from this centralization.

The new dolomite plant is estimated to be capable of producing a total of 19,400 tons of refractories (brick: 16,300 tons; mix: 3,100 tons) annually.

It is expected, on the other hand, that when the Rehabilitation Plan is realized (Steelmaking Plant alternative No. 4), the overall

tar dolomite consumption by the both LD plants will be 12 kg/t-steel. Currently, the new LD Plant reportedly consumes 15 to 18 kg/t-steel of tar dolomite, but the figure will decline down to the level of 12 kg/t-steel thanks to improvements expected in the future in the quality of brick and operational techniques.

Assuming that the tar dolomite consumption by the electric furnace will also be reduced to 20 kg/t-steel under the Rehabilitation Plan, the annual consumption of tar dolomite refractories required to produce 1,530,000 tons of steel by LD converters and 45,000 tons by the electric furnace annually will be:

For LD converters: 12 kg/t x 1,530,000 tons = 18,360 tons

For EF: 20 kg/t x 45,000 tons = 900 tons

Total 19,260 tons (including about 3,100 tons of tar dolomite mix)

Hence, it is considered possible to centralize the entire production of dolomite refractories on the new dolomite plant.

Technical improvements, especially in operational techniques, expected in the future are reflected in the specific consumptions on which the above required production is calculated.

If it proves unrealistic to achieve those specific consumptions, the resulting situation may be improved to a certain degree by adopting a 3-shift system, instead of a 2-shift one, for the dolomite plant and employing chrome-magnesia brick and magnesia brick as refractories for the wall and bottom of the electric furnace, respectively. But essentially utmost efforts should be exerted to attain the projected specific consumption of refractories.

Should shutdown of the existing dolomite plant prove impossible for some reason or other, it may be used to manufacture dolomite refractories specifically for use in the electric furnace. In this case, however, it is desired to devote the plant only to the

manufacture of tar dolomite mix (mass).

### 1.2.3 Extension of service life of LD converter

Extension of the lining life of LD converters to achieve the refractories consumption below 12 kg/t-steel will be possible mainly by (a) improved operating conditions of converters and (b) improved quality of brick linings.

Many approaches are thinkable to the improved operating conditions. The first consideration, however, should be given to an intensified control of the end-point temperature. Also important is to maintain the Si content of hot metal as low as possible. (Refer to Table IV.2.)

Table IV.2 Effects of operational conditions on converter lining life

| Operational factors | | Effects on life |
|---|---|---|
| Hot metal | [Si] | - - |
| | [Mn] | + |
| Slag | Total Fe | - - |
| | $CaO/SiO_2$ | + |
| | MgO | + + |
| | $CaF_2$ | - |
| Operation | Temperature | --- |
| | Holding time | - - |
| | Heats/Day | + |

Many studies have been reported on the effects of the end-point temperature on the wear rate of refractory linings of a LD converter. According to these studies, the effects vary depending on the quality of brick linings and the converter operating practice employed.

Here is quantitatively shown as a reference an example of the relation which we have confirmed with a tar-impregnated burnt mag-dolo brick lining with an MgO content of about 70 %.
The relation between the end-point temperature (X $^{\circ}C$) and the coefficient of lining wear rate (Y) is as follows:

$$Y = 0.022 X - 34.0$$

Assuming that the lining wear rate is 1.0 at 1,590°C of the end-point temperature, the lining wear rate at the end-point temperature of 1,680°C is approximately 3.0, or thrice the wear rate at 1,590°C of the end-point temperature.
This indicates clearly the importance of end-point temperature control for the extended lining life.
Improvement in the brick quality can be achieved also through various means, including appropriate selection of raw materials, improvement of the manufacturing process and intensified control of production process. What are considered particularly effective include:

a) Making the bulk density as high as possible (This necessitates reconsideration of the grain size distribution and tar addition rate, mixing practice, and forming temperature.)
b) Increasing the residual carbon content of brick by changing the composition of tar or adding carbon (natural graphite) to the mix.
c) Increasing the MgO content of brick
   The noticeable effect of the increased MgO content, among others, has been fully proven to date, though the measure of the favorable effect varies to a certain extent with the manufacturing conditions and properties of raw materials of brick and operating conditions of the LD converter.

Fig. IV.1 indicates an example of the relation between the MgO content of brick and the lining life.
Addition of magnesia clinker becomes necessary to increase the MgO content of brick lining. As to the procurement of clinker, due consideration will be necessary.

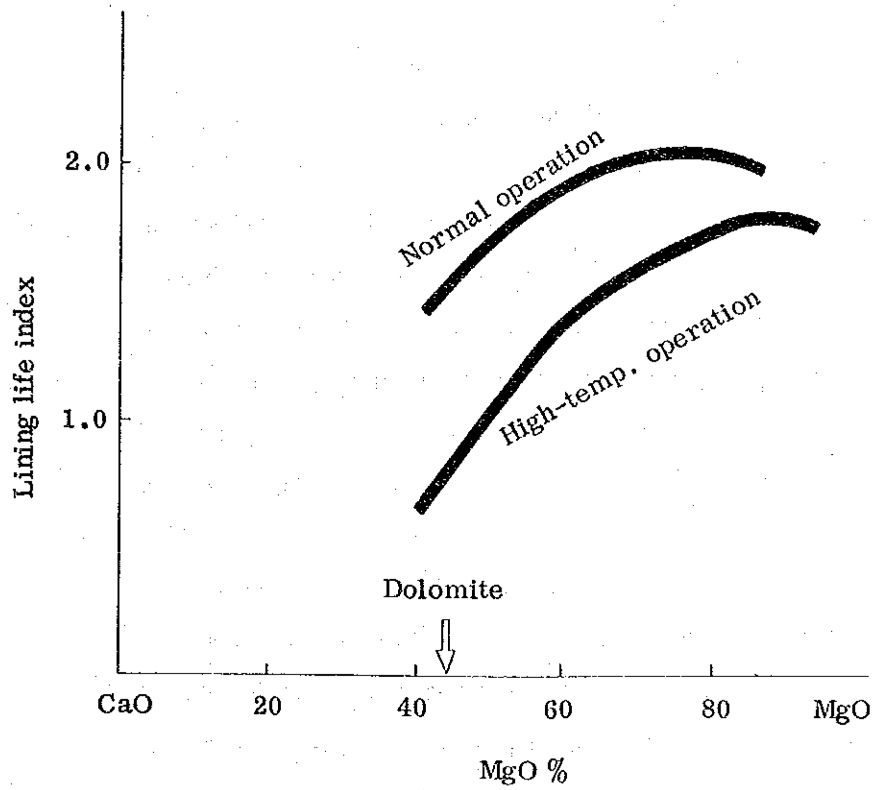



Fig. IV.1 Relation between MgO content of brick and lining life (typical example)

d) Other measures for extended furnace life

Other than the above measures, the following can be cited as promissing measures for prolonging furnace life, though for measures excepting repair by gunning, prior study should be made fully on their practicability and economic advantages or disadvantages.

① Repair by gunning

② Baking (tempering) of tar-bonded dolomite brick

③ Utilization of burnt dolomite brick

④ Slag control

Gunning, or repair by gunning, is already used in many countries the world over, and various types of gunning machines and gun mixes are commercially available. These are selectively used to meet particular requirements. The gunning repair is especially useful for repair of locally eroded parts, thus enabling a furnace at the end of its campaign to survive to the projected lining life. In practical application of this repairing method, however, due consideration should be given to its comparative economy and the time loss due to repair work. Currently, however, some gunning repair can be completed in no more than 10 minutes.
Baking tar-bonded dolomite brick also favors a longer lining life by improving the hot strength and slaking resistance of brick.
Generally, 300 to 350 C is cited as the most suitable range of baking temperature. Problem is its comparative economy derived from added costs of equipment and baking treatment.
It can generally be said that application of this method can be justified generally in the case that the brick-making plant is situated in high-humidity climate and geographically distant from the steelmaking plant.

Use of burnt dolomite brick would be impracticable in economy far through the future. Tar-bonded magnesia brick seems more promising, but this may be regarded as an extreme version of the afore-said measure of increasing the magnesia content of tar-bonded dolomite brick.
Slag control consists of a way of reducing lining wear by increasing the MgO content of converter slag.

If this is to be adopted at Helwan, full study should be made in advance on the expected effects of increased MgO content of slag on dephosphorization of steel.

e) Improving productivity of dolomite brick manufacturing plant

If the dolomite brick manufacturing plant affiliated to the existing new LD converter plant is to be loaded with the entire production of tar-bonded dolomite brick and its productivity is to be realized as planned, a good harmonization of productivities at various manufacturing steps must be assured. It can be assumed that for Helwan the forming process would be most problematic in productivity. If so, measures conceivable to overcome this include:

① Intesifying maintenance of presses

② Employing the warm-forming process

To maintain the operating rate of forming presses at high levels, well-planned maintenance of them, inclusive of securing a sufficient inventory of spare parts such as press molds, will be essential.

Helwan presently depends upon a low-efficiency manufacturing process wherein hot-kneaded tar-dolomite mix is, after being cooled, formed into brick. This is undesirable also from the viewpoint of the bulk density of formed brick. The low efficiency seems to come primarily from the necessity to cool the mix before forming.

These problems can be solved by the use of warm-forming process in which the tar-dolomite mix as heated can be formed directly into brick. In adopting this method, however, reviewing the properties and the blend ratio of tar will become necessary.

Whether to add to the existing capacity of the forming press or others should be studied at the next step depending on the results of operational measures thus taken.

1.3 Ladle liming

The unsatisfactory service life of the ladle lining at Helwan Works might be due mainly to the following causes:

a) Inadequacy in the quality of brick (shape and quality)

b) Improper workmanship in brick-laying work

c) Improper operational practice (occurrence of heavy skull)

Improvement of the brick quality can be accomplished by, for example, substituting siliceous fireclay brick of bloating type (porosity: 10 ~ 15 %) for the currently used brick (porosity: 20 ~ 23 %; $Fe_2O_3$ content: 2 ~ 4 %). For this quality conversion, conversion of clay raw materials will be required first. At the same time, improved accuracy in the shape and dimension of brick will also be needed. If this geometry control is properly performed, the result will be a substantial reduction in the rates of joint erosion and skull formation. Obviously, intensified control of brick laying and actual operation (for the prevention of skull formation in particular) will provide an added benefit.

These remedial measures will in combination make it possible to extend the lining life from 5 to 8 heats currently to 10 to 15 heats. These measures, however, must be accompanied with sincere efforts on the part of refractories manufacturers as well for the improved brick quality as part of the overall movement toward domestic production of quality refractories, including the proper selection of raw materials.

## 2. Utilities

### 2.1 Utilization of BFG and capacity of BFG holder

#### 2.1.1 BFG supply and demand

(1) Present state

Table IV.3 shows the relation between supply and demand of blast furnace gas for August, 1976, a month when production activities at Helwan Works were relatively stable.

As obvious from the table, the BFG supply from No. 3 BF is exactly balanced with the BFG consumption, whereas the BFG supply from Nos. 1 and 2 BFs is not balanced with the consumption. As large as 40 % of the total BFG production from the two blast furnaces, or 16 % of the aggregate BFG production, is discharged as waste. Naturally, this discharged BFG could be absorbed by EL-TABBIN, but actually it is not utilized there because the surplus varies to a large extent in quantity.

(2) After rehabilitation

The BFG supply/demand expected to come at the final stage after implementation of the Rehabilitation Plan for the existing steelworks is shown in Table IV.4. As seen in the table, the BFG supply/demand pattern will essentially remain unchanged at the final stage with surplus of BFG from Nos. 1 and 2 BFs expected to increase to 66,000 $Nm^3/h$. In order to make use of this surplus BFG at EL-TABBIN, a closer cooperation between the power plant and Helwan Works will be required.

#### 2.1.2 BFG holder capacity and emergency BFG availability

In the event of accidental blowing down of blast furnaces, all the gas line should be cut off immediately. Hence, the optimum capacity of the BFG holder should be a) that enough to make up for the shortage in the BFG supply that may arise before the completion of cutting off of the gas consumption when one of the largest blast furnaces (Nos. 3

and 4 BFs with BFG production of 166,000 $Nm^3/h$ per furnace) is accidentally blown down, plus b) that which will permit adjustment of imbalanced supply and consumption of BFG so as to enable utilization of surplus gas.

Described hereunder is the result of the study made for the effective use of the existing 30,000 $Wm^3$ gas holder (effective capacity: 30,000 x 0.9 = 27,000 $Wm^3$).

The time required to cut off the gas supply at Helwan Works ranges from 5 to 15 minutes. The required BFG capacity for emergency can be reduced to 15,000 $Wm^3$ by reducing the time to 2.5 minutes each for the hot blast stove and Turbo-blower station and to 5 minutes for others. In other words, the gas holder should maintain 15,000 $Wm^3$ of BFG at all times and, in the event of accidental blow-down, cutting-off of the gas consumption must be completed in a time span during which the gas holder can afford to make up for the resulting shortage in gas supply.

In addition, 12,000 $Wm^3$ shall be assigned as a capacity for the adjustment of the imbalanced supply and consumption of BFG to level off the amount of surplus gas.

If the time required to cut off the gas consumption is to be reduced, the current procedures for the utilization of BF gas must be reviewed in advance for all the blast furnaces, Nos. 1 to 4. The result of the review may justify the addition of a BFG holder. In the forthcoming study of the overall instrumentation system, it should be studied whether to equip the No. 2 Blast Furnace with a BFG measuring instrument.

Table IV 3 BFG supply and consumption

(Aug. '76)

| | | Monthly output ton | Average BFG supply and consumption ($Nm^3/h$) | | |
|---|---|---|---|---|---|
| | | | Total | BFG (No.1, 2) | BFG (No.3) |
| Supply | | | | | |
| | No. 1, 2 B.F. | 16,191 | 76,000 | 76,000 | |
| | No. 3 B.F. | 30,734 | 116,000 | | 116,000 |
| | Total | 46,925 | 192,000 | | |
| Consumption | | | | | |
| Existing plant | Hot stoves for No. 1, 2 B.F. | | 27,000 | 27,000 | |
| Existing plant | Blooming mill | 11,181 | 8,000 | 8,000 | |
| Existing plant | Heavy sec. mill | | | | |
| Existing plant | Light sec. mill | 3,251 | 4,000 | 4,000 | |
| Existing plant | Lime calcination plant | | 3,000 | 3,000 | |
| Existing plant | Existing steel melting shop | 7,311 | 4,000 | 4,000 | |
| Existing plant | Sub. Total | | 46,000 | 46,000 | |
| Expanded plant | Hot stoves for No. 3 B.F. | | 34,000 | | 34,000 |
| Expanded plant | Hot rolling mill | 15,195 | 24,000 | | 24,000 |
| Expanded plant | Cold rolling mill | | 4,000 | | 4,000 |
| Expanded plant | Lime shaft kilns | | 8,000 | | 8,000 |
| Expanded plant | Others | | 10,000 | | 10,000 |
| Expanded plant | T.B.S. | | 36,000 | | 36,000 |
| Expanded plant | Sub. Total | | 116,000 | | 116,000 |
| | Discharge | | 30,000 | 30,000 | |
| | Total | | 192,000 | 76,000 | 116,000 |

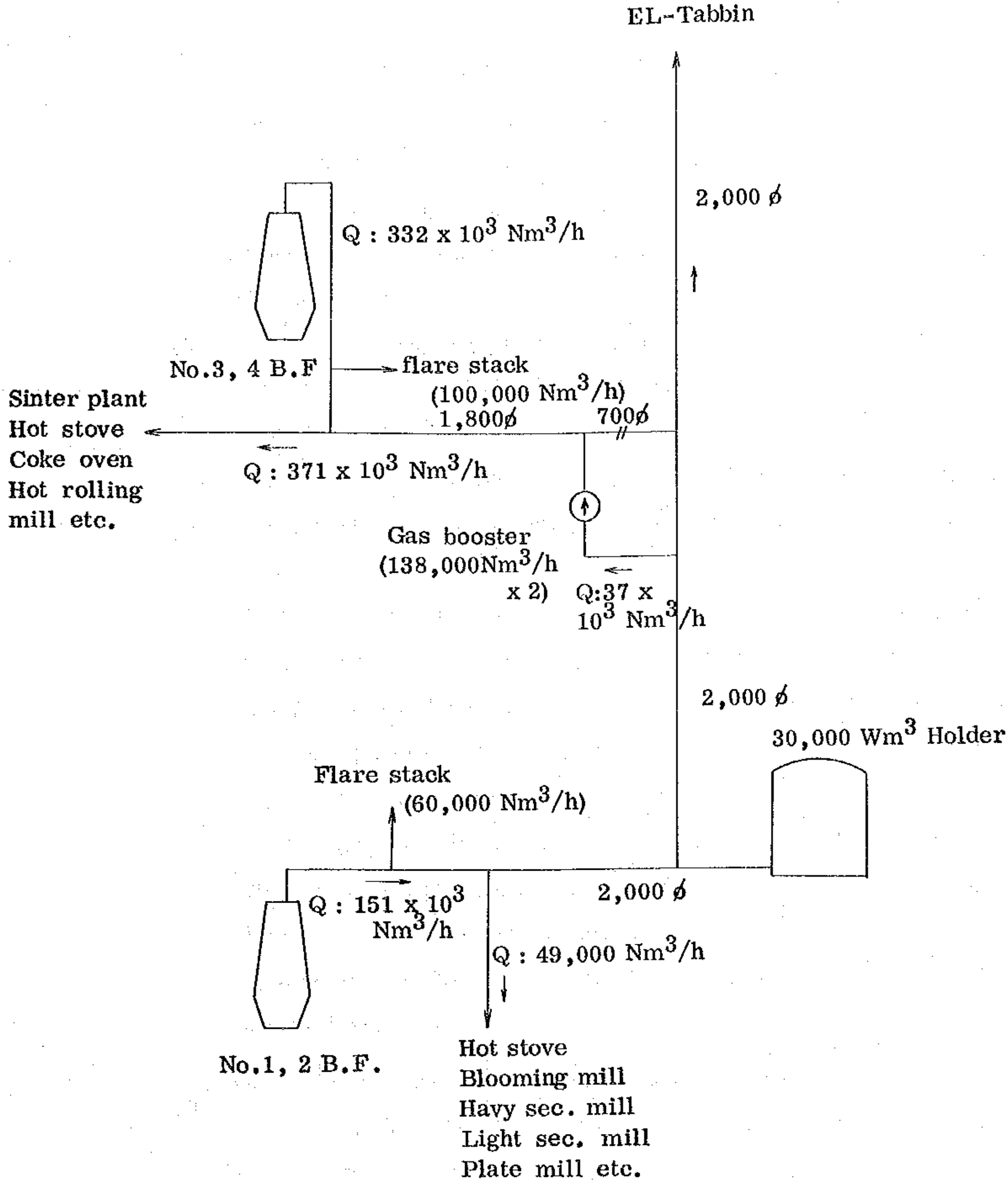



Fig. IV.2 Blast furnace gas piping system (at final stage)
Figures in parentheses represent installed capacity.

## 2.2 Security of power source

### 2.2.1 Problems .... Power failure

Total and partial power failures have occurred frequently at Helwan Works, causing damages on plant and equipment to the detriment of the production efficiency.

Particularly noteworthy is occurrence of power failures in the power receiving system at an unusually high frequency. Power failure sometimes continues for up to 75 minutes.

(1) Failure of power receiving system

Main causes of the failure of the power receiving system include:

a) As power is received through an aerial line, the reliability of the power receiving system tends to be deteriorated by the severe climate.

b) Receiving substations are installed at as many as four locations, thereby making the power receiving network very complicated. What is worse, the protective relay system is poorly equipped for this network; power failure of one substation may cause power failure of all the remaining substations. Since these receiving substations are owned and operated by an electricity utility company, it is easily imaginable that Helwan Works has thus far encountered difficulties in taking measures against power failure or remedial measures in the event of power failure.

(2) Power failure caused by deterioration of power equipment

Many power failures have been reported which have taken place due to deterioration or damage of power equipment. These are attributable mainly to the following facts:

1) The power cable has degraded parts here and there and is improperly laid. Laid 800 mm under the ground level and overlaid with brick, the cable cannot withstand the traffic load and many damages are found on the cable around the Thomas

Converter Plant. Also frequently seen are failures due to water peneration through cable joints.

2) Substation equipment are all of an open construction not protected from dust. Degradation in insulation due to dust build-up has led to power failure.

(3) Throubles caused by deterioration of electricity-consuming equipment

Many troubles are reported that are caused by deterioration of electricity-consuming equipment due to the rise in ambient temperatures. These troubles may lead to a large-scale power failure.

(4) Inadequate measures in the event of power failure

1) As a precautionary measure against power failure, elevated water tanks are maintained to secure supply of furnace cooling water for emergency. (Some furnaces are equipped with emergency diesel pumps.) Actually, however, there are cases that power failure continues for a long period of time beyond the capacity of these elevated tanks. Judging also from the fact that no power supply equipment is provided for production protection in an emergency, it can be said that protective measures taken at Helwan Works against power failure are quite insufficient.

2) Some of the distributing substations are unattended without provision of a remote control system, one of factors contributing to expansion of power accidents.

2.2.2 Measures from equipment side

All of the measures to be taken against power failure are in essence those from equipment side. The necessary measures can be shown as follows:

- Improving reliability of power supply system
  - Improving reliability of power receiving system
  - Addition of internal power source
    - Installation of emergency diesel generator at some critical locations
    - Installation of in-plant generator
- **Improving reliability of electric power equipment**
  - Improving reliability of power transmission equipment
  - Expansion of protective relay system and network
- **Improving reliability of electricity-consuming equipment**

(1) For higher reliability of power source

1) In-plant generator

The first consideration must be given to a higher reliability of purchased electricity supply. In view of the fact that all the existing power source equipment including receiving substations are under the control of an electricity utility company, however, improved reliability of the purchased power supply system cannot be expected immediately.

Installation of diesel generators for emergency use, if limited to the minimum necessary for securing power source for the protection of equipment in an emergency, will incur minimum costs.

Installation of an in-plant generator, on the other hand, will make it possible, though at high costs, to secure not only power supply for equipment protection but that for production protection with improved reliability of power source. This approach seems timely and justifiable in the light of the fact that the current level of power consumption in Egypt requires increased capacity of power supply. Indeed, installation of a power plant within Helwan Works will serve a double purpose. Thus, it is considered desirable to install such an in-plant generator.

2) Type of in-plant generator

A gas turbine type is most recommendable in that it is easy to operate, costs less for construction and requires a shorter term of construction.

3) Suitable scale of in-plant generator

For the purpose of installation, the suitable scale of the proposed in-plant generator will depend on the overall size of the entire power system. Here, the necessary minimum capacity of the independent power plant is planned based on the required emergency power supply, or the sum of the emergency power requirements for equipment protection and production protection. When estimating the emergency power requirement for Helwan Works from that for Nippon Steel on the assumption that the emergency power requirement is proportional to the production size, the emergency power requirement for Helwan Works will be approximately 20 MW. If the suitable size of the required emergency power supply is twice the size of the emergency power requirement, though the relation varies in a great measure with the structure of the network, the required capacity of the in-plant generator will be around 40 MW.

4) Considerations required when installing an in-plant generator

When constructing an in-plant generator at Helwan Works, a comprehensive prior study should be made with particular emphasis on a) the countermeasures for increasing the interrupting capacity to cope with the proposed installation of a turbine generator and b) how to rearrange the network in order to supply the emergency electric power effectively, as well as on the possibility of placing the receiving substations under the control of Helwan Works. (Refer to Fig. IV.3.)

5) Fuel

The gas turbine generator shall be fuelled by natural gas. For the natural gas balance, refer to Table IV.4. And for the piping system, refer to Fig. IV.6.

A gas turbine power plant is to be installed at site adjacent to the Helwan Works by the electric utility company. If Helwan works is to use this power plant as a stable power source, it is required to study the possibility of installing a high-reliability power-receiving cable and power-receiving network.

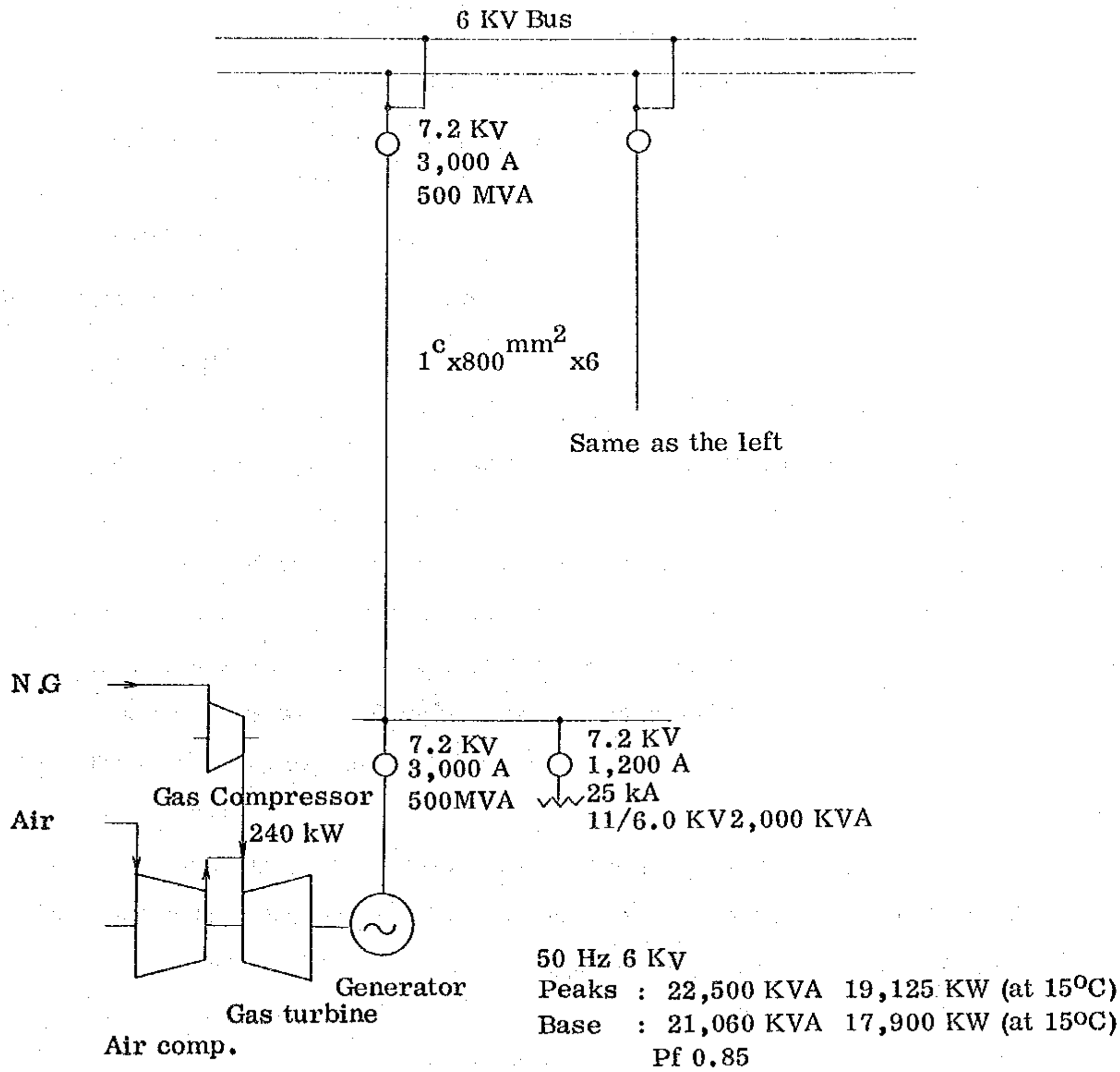



Fig. IV 3 Gas turbine generator system

(2) Countermeasures against deterioration of equipment

Deteriorated equipment should be replaced according to the severity of deterioration in due consideration of the preset schedule for the replacement or revamping of plant equipment. In doing so, improvement of the cable laying method (by laying cables down to 1,200 mm under surface and housing them in a rigid trough), dust control measures (such as adoption of a fully closed construction) and preventive measures against temperature rise (by improving layout and ventilation) will become necessary.

## 2.3 Natural gas and other utilities

### 2.3.1 Natural gas

HADISOLB is planning to switch the source of fuel from heavy oil to natural gas. When considering the likelihood of stoppage of natural gas supply, however, it seems necessary to continue to use the existing heavy oil facilities particularly for those equipment where security and productivity are critical.

If a new equipment on a dual-fuel (heavy oil and natural gas) system is to be employed, detailed engineering will be necessary for each of equipment.

### 2.3.2 Other utilities

There can be seen no problems particularly to be noted about compressed air and steam. In pursuing the optimum rehabilitation of Helwan Works as a whole, however, these should also be restudied in the future.

## 2.4 Improvement of recirculating water quality

### 2.4.1 Addition of a cooling tower

It is planned that when all the Helwan plants associated with Nos. 1 & 2 BFs are operated to capacity, the recirculating water requirement will be 5,000 $m^3/hr$ as shown in Fig. IV.4. The installed capacity of feed pumps, piping, etc. is well balanced with this projected requirement. As seen also in the figure, however, Helwan Works maintains a cooling tower with the capacity of only 3,000 $m^3/hr$, a capacity insufficient to control effectively the temperature of feed water with the projected flow rate.

It seems therefore necessary to add to the existing capacity a cooling tower with a capacity of 2,000 $m^3/hr$.

### 2.4.2 Installation of oil separator

A considerable amount of lubrication oil and grease discharged mainly from rolling mills comes into recirculating water. Some of these oil and grease in recirculating water stay afloat in the settling basin to form an oil film and others become emulsified in the recirculating water. Part of the emulsified oil can be entrapped by the filtration media in the filter to be installed under the rehabilitation plan and removed from recirculating water, but the rest, passing through the filter, forms a slime at each user point together with suspended solids and micro-organisms, thereby reducing the heat-exchange efficiency of cooling water or causing a choke-up of nozzles. Also, presence of oil affects adversely the life of filtration media in the filter by forming slime mud balls in the media.

To overcome these troubles, it is necessary to provide an oil skimming belt to remove oil afloat in the settling basin. Emulsified oil, on the other hand, can be prevented from getting concentrated by continuously treating 20% of the recirculating water in a dissolved-air floatation system containing coagulant.

2.4.3 Installation of filtration facilities

Since only a gravity settling basin is maintained at Helwan Works as water treatment facilities to control the quality of recirculating water, the Helwan recirculating water has a high concentration of suspended solids, 72 ppm, for example, according to the data furnished by Helwan Works. When direct and indirect cooling water for ironmaking, steelmaking and various rolling mills is fed by a single recirculation system, the concentration of suspended solids of the feed water should desirably be 20 ppm or so. Higher contamination than this level may result in reducing cooling effect, clogging nozzles and choking cooling pipes.

To avoid these, it is desired to direct effluent from the settling basin to filtration facilities.

The arrangement of the filtration facilities is shown schematically in Fig. IV.5 (lower).

2.4.4 Independent water recirculation system for BFG cleaning

At present, waste water from the blast furnace gas cleaning equipment is, after being treated in the settling basin (Small settler), directed to a water recirculation system common to the blast furnace plant, steelmaking plant and other various plants. Such a configuration of the water recirculation system makes it inevitable to transfer ions of chlorine, calcium, zinc and so on from BF gas to recirculating water, thus deteriorating the overall quality of the recirculating water.

Since the BF gas cleaning equipment itself does not require high quality and low temperature of feed water, it is permissible to have an independent water recirculation system for BF gas cleaning like the water treatment facilities shown in Fig. IV.5 (Upper). Installation of such water recirculation facilities will make it possible to reduce the quantity of the feed water to the BFG cleaning equipment, 750 $m^3$/hr currently, to less than a tenth. Further, the surplus water thus produced can be used as supplement to the cooling water for blast furnaces.

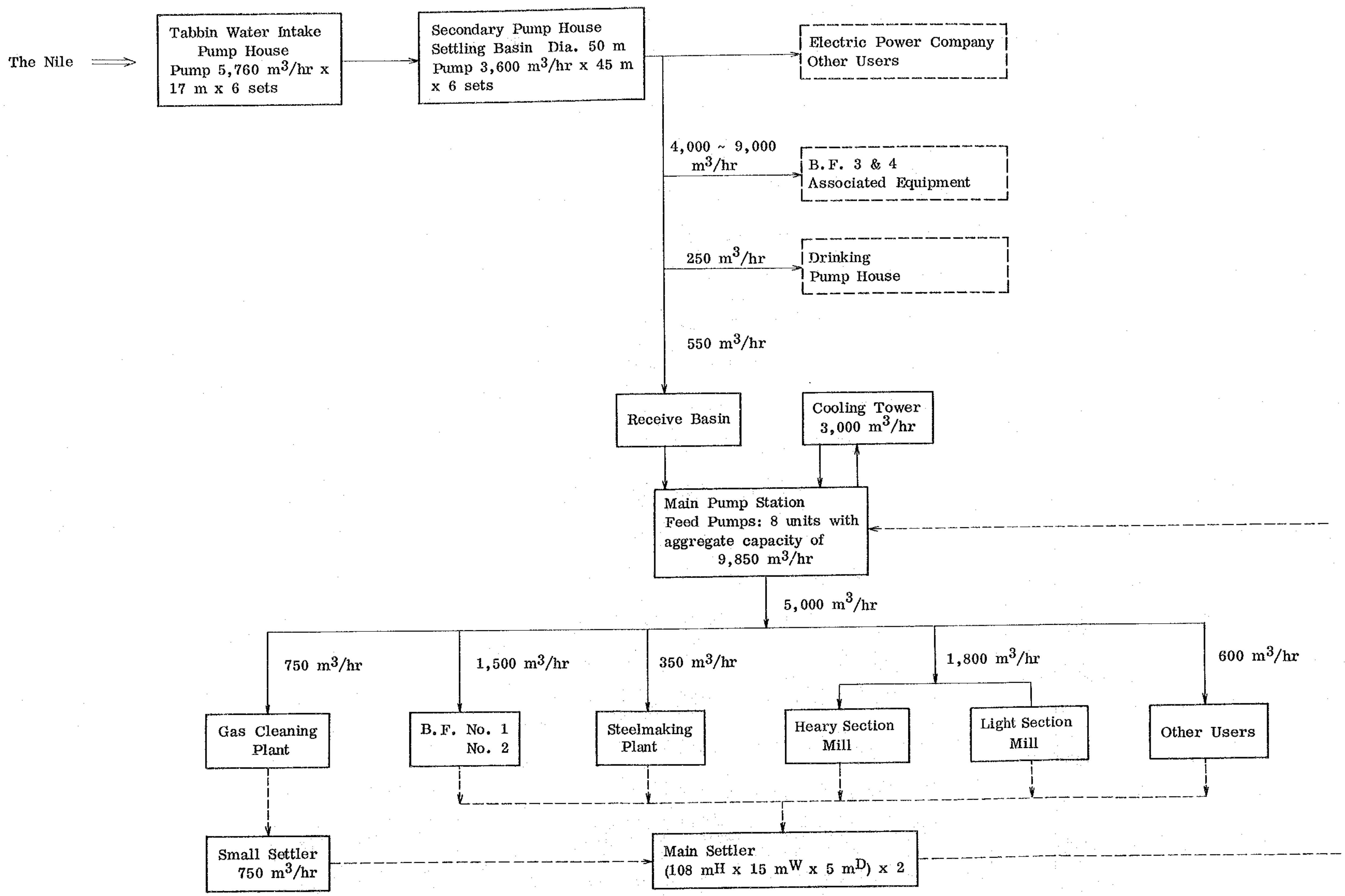
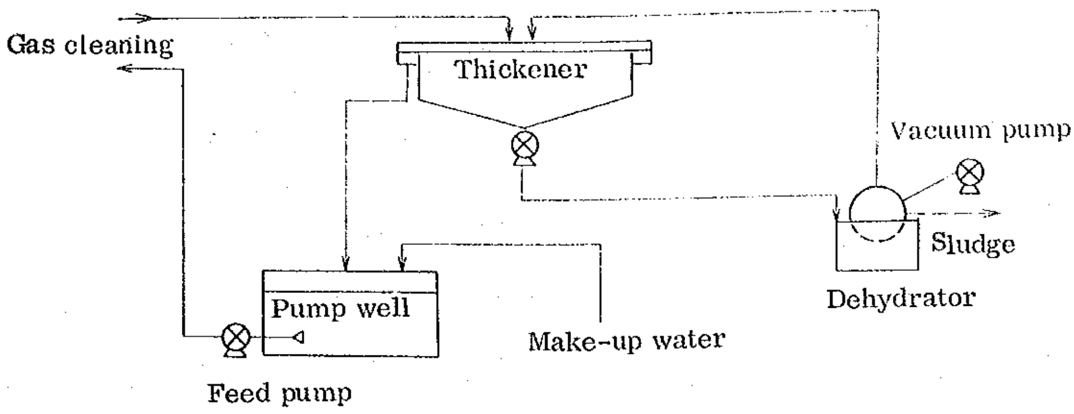
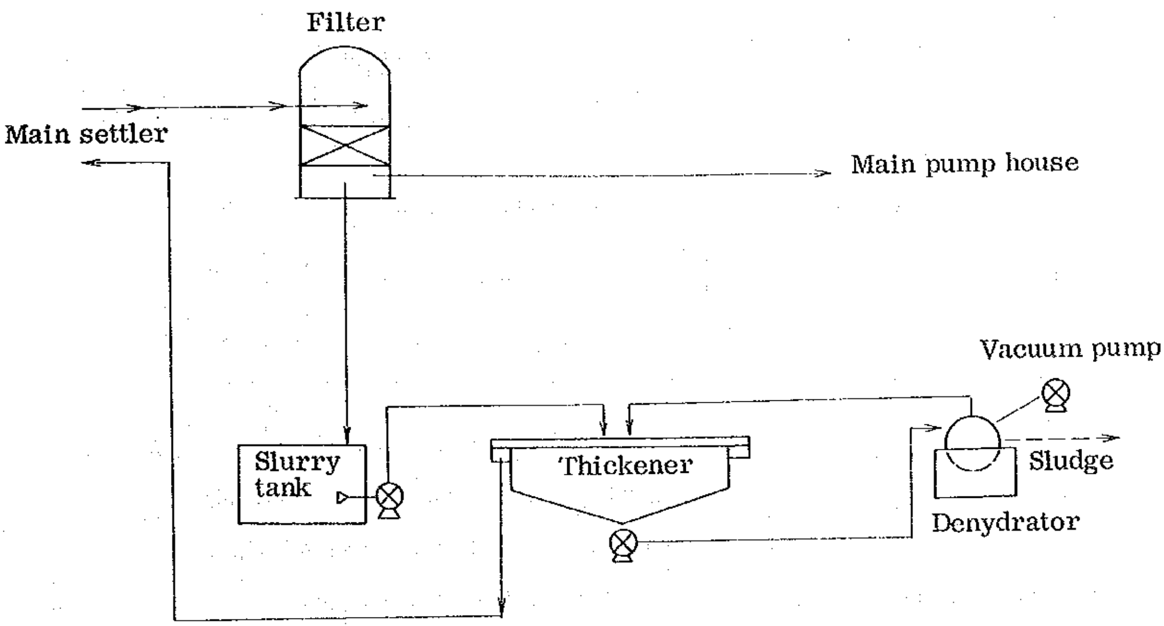



Fig. IV.4 Water Supply System & Flow Balance




Water recirculation facilities for B.F gas cleaning




Filtration facilities

Fig. IV.5 Schematic diagram of water treatment facilities

## 2.5 Expansion of utilities under Rehabilitation Plan

### 2.5.1 Expansion of utilities for the modified Nos. 1 and 2 BFs

Under the Rehabilitation Plan, the blast furnace operating conditions shall be as follows:

| Item | |
|---|---|
| Pig iron production (Pmax) | 600 t/d |
| Pig iron production (Po) | 540 t/d |
| Coke rate | 765 kg/t-p |
| Oil rate | - |
| Natural gas rate | 80 $Nm^3$/t-p |
| Blast requirement | 1,961 $Nm^3$/t-p |
| Oxygen enrichment | 3 % |
| Air leak | 10 % |
| Total natural gas requirement | 2,000 $Nm^3$/h x 2 |
| Total blast requirement | 910 $Nm^3$/h x 2 |
| Total oxygen requirement | 2,150 $Nm^3$/h x 2 |

(1) NG supply equipment

Natural gas, taken at 6 atg in the vicinity of No. 4 G.R.P., shall be fed through a pressure regulator to blast furnaces. For more details, refer to Fig. IV.6. The natural gas balance is indicated in Table IV.4.

(2) Oxygen supply equipment

Oxygen shall be pumped at 2 atg from No. 2 Oxygen Plant to blast furnaces through an oxygen enrichment equipment. Refer to Table IV.5 and Fig. IV.7.

## Table IV.4 Energy supply and consumption

| | Annual output x $10^3$t | Specific heat consumption x $10^6$ Kcal/t | Gas calorific value Kcal/$Nm^3$ | Annual total x $10^9$kcal | Including: BFG (No.1) | Including: BFG (No.3,4) | Including: N.G. | Annual oil consumption x $10^3$ t | Hours of operation per year | Gas supply and consumption x $10^6$ Kcal/hr: Total | Including: BFG (No.2) | Including: BFG (No.3,4) | Including: N.G. | Oil consumption (t/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Supply | | | | | | | | | | | | | | |
| No.1, 2 B.F. | 394 | 3.1 | 1,025 | 1,220 | 1,220 | | | | 8760x0.9 | 155 | 155 | | | |
| No.3, 4 B.F. | 1,340 | 1.86 | 894 | 2,494 | | 2,494 | | | 8,400 | 297 | | 297 | | |
| N.G. | | | 9,000 | 2,398 | | | 2,398 | | | 296 | | | 425 | |
| Oil | | | 10,054 | | | | | 249.4 | | | | | | 33.2 |
| Total | | | | 6,112 | 1,220 | 2,494 | 2,398 | 249.4 | | 748 | 155 | 297 | 425 | 33.2 |
| Consumption | | | | | | | | | | | | | | |
| No.1, 2 B.F. | 394 | | | | | | 284 | | | 36 | | | 36 | |
| Hot stoves for No.1, 2 B.F. | | | 1,025 | 217 | 217 | | | | 0760x0.9 | 28 | 28 | | | |
| Existing steel melting shop | 330 | | | | | | | | | | | | | |
| Blooming mill | 330 | 0.3 | 1,025 | 50 | 50 | | | 4.9 | 8760x0.89 | 6 | 6 | | | 0.6 |
| Heavy sec. mill | 180 | 0.4 | 1,025 | 22 | 22 | | | 5.0 | 8760x0.6 | 4 | 4 | | | 1.0 |
| Light sec. mill | 100 | 0.5 | 1,025 | 15 | 15 | | | 3.5 | 8760x0.6 | 3 | 3 | | | 0.7 |
| Plate mill | 75 | 1.17 | 1,025 | 88 | 88 | | | | 8,000 | 11 | 11 | | | |
| Lime calcination plant | | | 1,025 | 48 | 48 | | | | 8,000 | 6 | 6 | | | |
| Gas turbine | | | | 904 | | | 904 | | 8760x0.8 | 129 | | | 129 | |
| Sub. Total | | | | 1,628 | 440 | | 1,472 | 13.4 | | 223 | 58 | | 165 | 2.3 |
| Sintering plant No.1 | | | | | | | | 15 | | | | | | 1.9 |
| Sintering plant No.2 | | | | | | | | 48.2 | | | | | | 6.1 |
| No.3, 4 B.F. | 1,340 | | | | | | | 116.8 | | | | | | 13.9 |
| Hot stoves for No.3, 4 B.F. | | 0.71 | 1,170 | 955 | | 670 | 285 | | 8,400 | 114 | | 80 | 34 | |
| Coke oven and by-product plant | 1,616 | 0.62 | 1,000 | 990 | | 490 | 500 | | 8,760 | 115 | | 57 | 58 | |
| Mixer dep. and other minor-consumers | | | 4,390 | 100 | | | 100 | | 8,000 | 13 | | | 13 | |
| Converter shop firing of boilers | 1,200 | | 1,500 | 150 | | 72 | 78 | | 8,760 | 17 | | 8 | 9 | |
| Hot rolling mill | 560 | 0.7 | 894 | 392 | | 392 | | | 6,000 | 67 | | 67 | | |
| Cold rolling mill | 290 | 0.3 | 1,600 | 57 | | 38 | 19 | | 6,000 | 11 | | 5 | 6 | |
| Merchant shapes mill | 215 | 0.6 | 1,600 | 129 | | 57 | 72 | | 6,000 | 21 | | 9 | 12 | |
| Repair shops | | | 4,390 | 6 | | | 6 | 53.2 | 3,000 | 2 | | | 2 | 9.0 |
| Others | | | 4,390 | 1,297 | | 243 | 1,054 | | | 155 | | 29 | 126 | |
| T.B.S. | | | | 718 | | 718 | | 2.8 | | 82 | | 82 | | |
| Sub. Total | | | | 4,794 | | | 2,114 | 236 | | 597 | | 337 | 260 | 30.9 |
| EL-TABBIN or Discharge | | | | 594 (=66x$10^3$ $Nm^3$/hr) | 780 | 186 | | | | 57 (=56x$10^3$ $Nm^3$/hr) | 97 | -40 (=39x$10^3$ $Nm^3$/hr) | | |
| Total | | | | 7,005 | 1,220 (=130x$10^3$ $Nm^3$/hr) | 2,494 (=318x$10^3$ $Nm^3$/hr) | 3,302 | 249.4 | | 877 | 155 (=151x$10^3$ $Nm^3$/hr) | 297 (=332x$10^3$ $Nm^3$/hr) | 425 (=47.2x$10^3$ $Nm^3$/hr) | 33.2 (=37.1x$10^3$ $Nm^3$/hr-NG) |

Notes:

(1) Data for Nos. 1 and 2 BFs, hot stoves for Nos. 1 and 2 BFs, blooming mill, gas turbine, heavy section mill and light section mill are based on the study this time, whilst data for other facilities are sited from D.P.R., USSR.

(2) The BFG consumption by T.B.S. is estimated to be equal to the capacity of the BFG burners (11,000 $Nm^3$/h x 4 x 2).

(3) COG given in D.P.R. is converted into N.G.

(4) As for oil, N.G. equivalents are shown on the assumption that oil will be replaced completely by N.G. in the future.

Table IV.5 Oxygen balance

| | | At normal operation | | | At periodic maintenance of one unit (4,200 $Nm^3/hr$) | | |
|---|---|---|---|---|---|---|---|
| | | No.1 oxygen plant | No.2 oxygen plant | | No.1 oxygen plant | No.2 oxygen plant | |
| Equipment | Capacity | $Nm^3/hr$ 4,200 x 4 | $Nm^3/hr$ 10,000 x 2 | $Nm^3/hr$ 3,500 x 2 | $Nm^3/hr$ 4,200 x 3 | $Nm^3/hr$ 10,000 x 2 | $Nm^3/hr$ 3,500 x 2 |
| | Purity of oxygen | 99.5% | 95% | 99.5% | 99.5% | 95% | 99.5% |
| | | DRY | 30% WET | DRY | DRY | 30% WET | DRY |
| Generation | Quantity | $Nm^3/hr$ 16,800 | $Nm^3/hr$ 20,000 | $Nm^3/hr$ 2,000 | $Nm^3/hr$ 12,600 | $Nm^3/hr$ 20,000 | $Nm^3/hr$ 9,000 |
| Consumption | Nos.1 & 2 BFs | | | 4,300 | | | 4,300 |
| | Nos.3 & 4 BFs | | 18,100 | | | 18,100 | |
| | New converter | 8,630 | | | 8,630 | | |
| | Projected converter | 3,000 | | | 2,120 | | 880 |
| | Others | 1,850 | | | 1,850 | | |
| Total | | $Nm^3/hr$ 13,480 | $Nm^3/hr$ 18,100 | $Nm^3/hr$ 4,300 | $Nm^3/hr$ 12,600 | $Nm^3/hr$ 18,100 | $Nm^3/hr$ 5,180 |
| Balance | | $Nm^3/hr$ 3,320 | $Nm^3/hr$ 1,900 | $Nm^3/hr$ 3,600 | $Nm^3/hr$ 0 | $Nm^3/hr$ 1,900 | $Nm^3/hr$ 1,820 |

Remarks:

(1) All of the above data except for the oxygen consumption at Nos. 1 and 2 BFs and projected converters are cited from D.P.R. Expansion Plan.

(2) Periodic maintenance of Nos. 1 and 2 Oxygen Plants shall not coincide.

(3) When one of the installed oxygen generators of No. 2 Oxygen Plant is shut down for periodic maintenance, oxygen supply to blast furnaces shall be reduced.

2.4.2 Expansion of utilities for projected converter plant

(1) Oxygen supply equipment

Under the Rehabilitation Plan, the converter operating conditions shall be as follows:

| Item | |
|---|---|
| Heat size | 36 t/heat |
| Tapping yield | 90 % |
| Hot metal ratio | 85 % |
| Steelmaking time | 40 minutes |
| Blowing time (Total) | 22 minutes |
| Steelmaking time (minimum) | 40 minutes |
| Oxygen consumption | 55 $Nm^3$/t-steel |
| Oxygen consumption per heat | 2,000 $Nm^3$ |
| Oxygen flow rate | 3,000 $Nm^3$/hr |
| Oxygen consumption during blowing | 5,400 $Nm^3$/hr |

As for No. 1 Oxygen Plant, 4 units of oxygen generators shall be operated and one 2.200 $Nm^3$/hr and 34 atg oxygen compressor shall be added to the existing capacity. When one of the four units is shut down for periodic maintenance, the oxygen compressor (2,200 $Nm^3$/hr and 34 atg) which will be added to No. 2 Oxygen Plant shall take over it, offsetting the reduction in oxygen supply from No. 1 Oxygen Plant.

The Converter Plant shall be supplied with oxygen through two oxygen holders each having capacity of 150 $Wm^3$ which will be installed in the plant.

Basic considerations underlying the calculation of the required capacity of each oxygen holder are:

Holder capacity = oxygen requirement needed to level off the oxygen feed rate + oxygen stock (for 1 heat) against power failure ≑ 300 = 150 x 2

Refer to Table IV-5 and Fig. IV-7.

the substation itself is situated in the very dusty environment. In line with the modification of the Converter Plant, the substation for the old steel melting shop shall be relocated and the power equipment therein shall be replaced with an enclosed, outdoor type one. The heavily deteriorated power cable shall also be replaced.

Furthermore, the old steel melting shop substation shall be remotely controlled from M.S.D.S.-1.

The capacity of the substation, wiring method and number of feeders installed shall remain unchanged. Refer to Fig. IV.8.

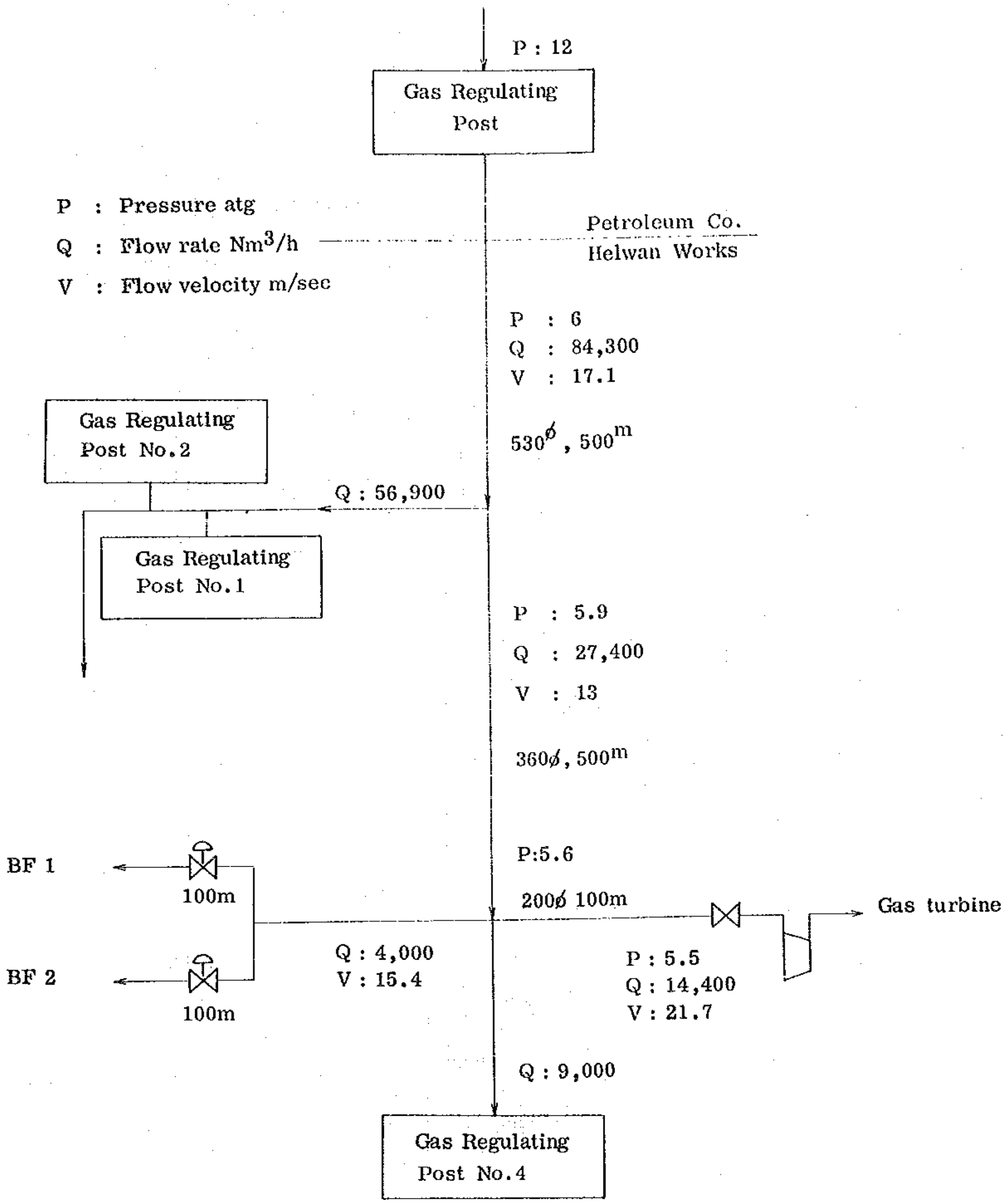



Fig. IV.6 Natural gas piping skelton

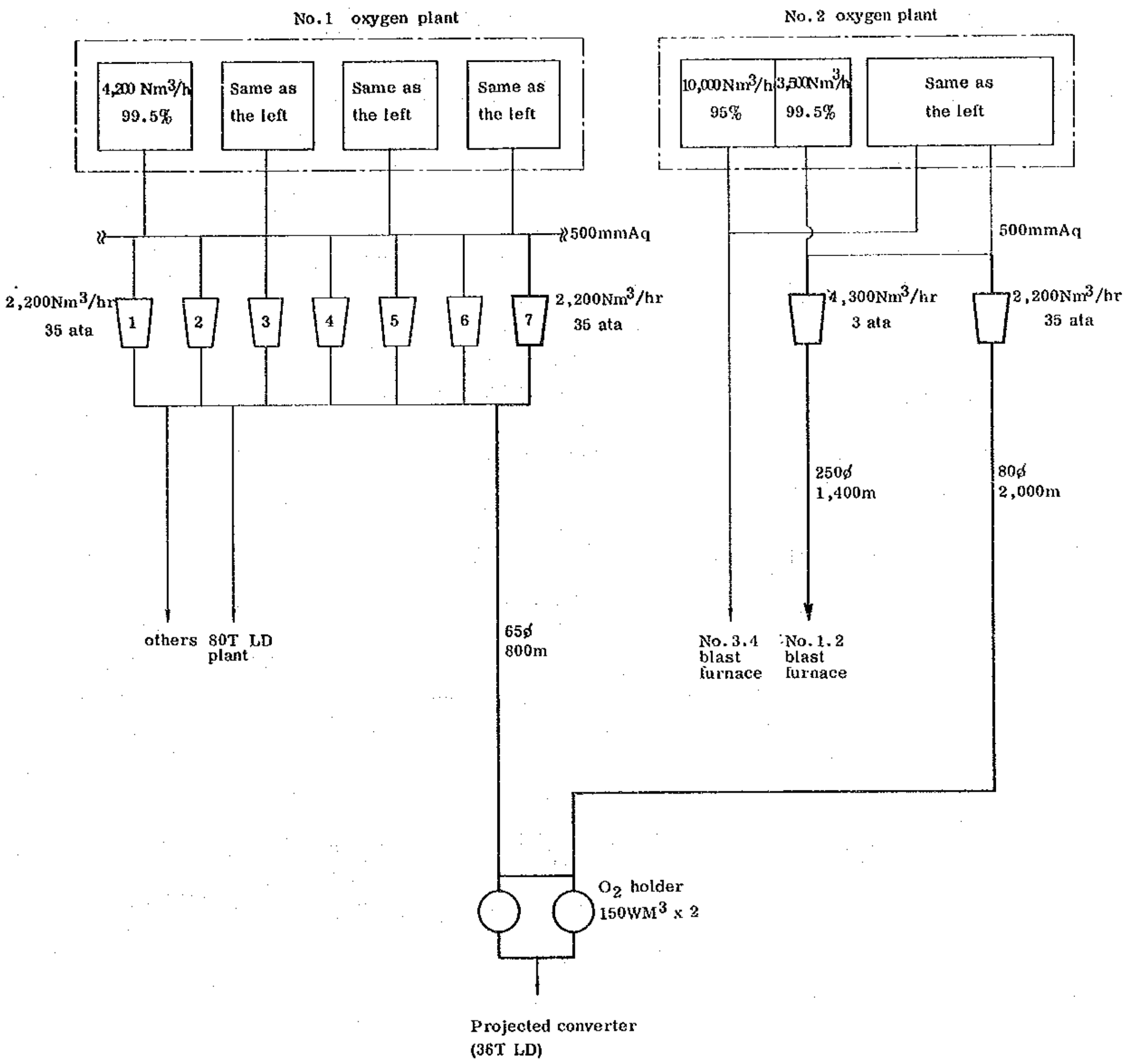



Fig.IV-7 Oxygen piping skelton

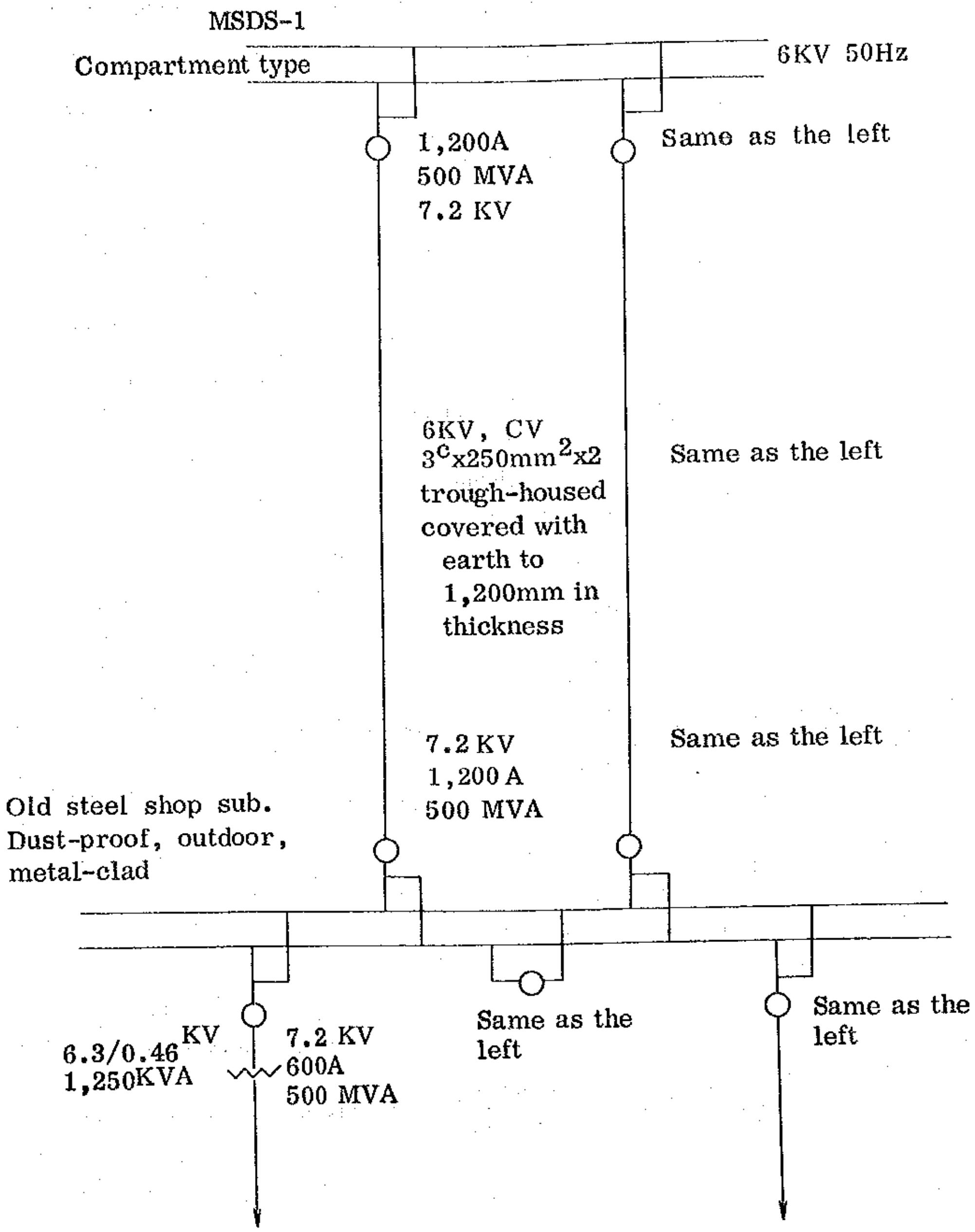



Fig. IV.8 Steel shop power system

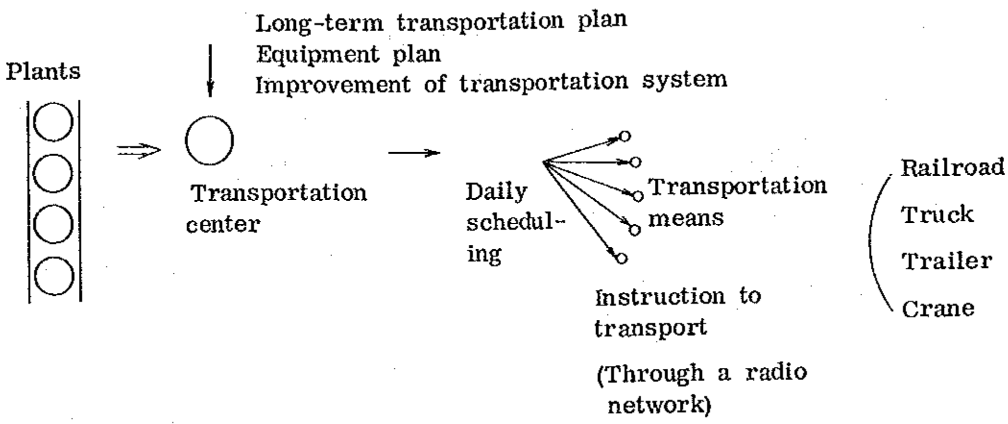
3. Transportation

Given hereunder as a reference is an example of the transportation control at Nippon Steel as a typical practice at average Steelworks in Japan.

(1) Maintenance rate = $1 - \frac{\text{Number of units under repair}}{\text{Total number of units maintained}}$

| | |
|---|---|
| Locomotives | 0.85 |
| Open ladles | 0.7 |
| Slag cars | 0.8 |
| General freight cars | 0.9 |

(2) Operation control system




(3) Transportation factor

Transportation factor = $\frac{\text{Total tonnage transported}}{\text{Tonnage of crude steel produced}}$

| | |
|---|---|
| Yawata Works | : 9.4 |
| Kamaishi Works | : 7.5 |
| Muroran Works | : 7.5 |
| Oita Works | : 5.3 |
| Kimitsu Works | : 5.1 |

It can generally be said that the transportation efficiency and the quality of the layout of transportation facilities are inversely proportional to the transportation factor. The relatively high transportation factor of Yawata Works, whose layout of transportation facilities is similar to that of Helwan Works, can be attributed to the existence of the railway connecting the Yawata Area with the Tobata Area. Oita Works and Kimitsu Works, both being modern steelworks with a good plant layout and geographical condition, show lower transportation factors.

Existing old-type steelworks have a transportation factor usually 7 to 8.

4. Machine shop

The Helwan Works has a machine shop as shown in Table IV-6, and it is essential to raise the self-supply rate of spare parts and others by making use of this machine shop. The current situation of manufacture and repair of spare parts and others for blast furnace and steelmaking equipment of the Muroran Works of Nippon Steel Corporation which has a machine shop similar to that of the Helwan Works is shown for reference. In utilizing the machine shop, elevation of designing and drafting capacity is necessary.

Table IV-6 Principal Equipment of the Machine Shop of Helwan Works

| Shops | Equipment capacity | Production | Principal equipment |
|---|---|---|---|
| Mechanical work shop | 7,000 t/Y | 5,000 t/Y | · Planing machine (6m)<br>· Boring machine & lathes<br>· Milling machine<br>· Gear cutter (max. 3 m)<br>· Grinder<br>· Frice · Drill |
| Steel structure shop | 460 t/M | July 169 t<br>Aug. 61 t<br>Sept. 188 t<br>Oct. 208 t | · Cutting machine (25 mm)<br>· Roll bending machine |
| Forging shop | 400 t/M | July 82 t<br>Aug. 66 t<br>Sept. 66 t<br>Oct. 48 t | · 2 t press (with manipulator)<br>· 3 t " ( " ) |
| Foundry shop | Cast iron 408 t/M<br>Steel 480 t/M<br>Non-ferros 29 t/M | BF (sinter)<br>20 t (16,000 MH)<br>Steel<br>61 t (14,000 " )<br>Rolling<br>23 t (15,000 " )<br>Erection<br>42 t (16,000 " ) | · 30 t crane<br>· Cupola 5 t<br>· Electric furnace 6 t<br>· High frequency induction furnace 1 set<br>· Annealing furnace 2 sets |
| Demag old general shop | 200 t/Y | 150 t/Y | No remark (Many repairs of small articles) |
| Electrical maintenance shop | · Motors A.C. up to 250kW 112 sets/M<br>· Motors D.C. up to 250kW 16 sets/M<br>· Motors D.C. up to 250kW 4 sets/M | Sept. 135 units<br>Oct. 143 "<br>Nov. 152 "<br>(Remark) Many are considered to be of small type. | · Drying furnace<br>· Cleaning furnace<br>· Winding machine (5 sets)<br>· Balancing machine |

Table IV-7 Principal Equipment of the Machine Shop of NSC's Muroran Works

| Shops | Furnace | | | | | | | | | Machine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | For casting | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Heat treatment furnace | Electric furnace | Reverberating furnace | Melting furnace | Crucible | Coal furnace | Gas furnace | Drying furnace | Annealing furnace | Roll grinder | Lathe (incl. turning) | Drilling machine | Boring machine | Planor, planing machine | Shaper shaping machine | Fluting cutter | Milling machine | Gear cutting machine | Grinding machine | Press | Wood working machine | Others incl. balancing machine | Blanking machine | Plate shear | Pneumatic press | Steam hammer | Air hammer | Air compressor | High speed cutter | Emery band machine | Sand slinger | Hydraulic press | Band sawing machine | Oil hydraulic machine | Dynamic balancing machine | Slotting machine | Marking off | Electroslag welder | Heliarc welder | Plasma arc cutting machine | Semi-automatic welder |
| Machining | | | | | | | | | | | 18 | 3 | 4 | 2 | 2 | | 4 | 2 | 7 | | | 3 | | | | | | | | | | | | | | 3 | 1 | | | | |
| Roll grinding | | | | | | | | | | 19 | | 1 | | | | 2 | 1 | | 1 | | | 4 | | | | | | | | | | | | | | | | | | | |
| Casting | | | 1 | 3 | 4 | | | 4 | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| Cast steel | | 2 | | | | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wood mould | | | | | | | | | | | | | | | | | | | | | 3 | 4 | | | | | | | | | | | 2 | | | | | | | | |
| Fabrication & welding | | | | | | | | | | | | 3 | | | | | | | | 2 | | | 1 | 1 | 2 | | | 1 | | | | | | | | | | 1 | 1 | 1 | 10 |
| Machine repair | | | | | | | | | | | | 1 | | | | | | | | | | | | | 2 | | | | | | | | | | 1 | | | | | | |

Table IV-8 Example of actual manufacture and repair of parts for blast furnace

| Equipment | Parts | Specification | Manufacture | | Repair | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Self-manufacture | Contractor | Self-manufacture | Contractor | |
| Raw material feeding equipment | Screen (Metal net for grizzley) | RSH-260B 2 stage type KHI | | ○ | | ○ | Manufactured by specialized maker |
| | Screen (Driving portion) | | ○ | | ○ | | |
| | Each conveyor, belt | | Conveyor ○ | Belt ○ | | ○ | Experienced specific maker |
| | (Each hopper / Each chute) liner | Cix-2, NCx-90 | ○ | ○ | | ○ | Liner of SS grade is manufactured and replaced by contractor |
| | Skip, wheel | SCMn2B | ○ | ○ | Maintenance ○ | Replacement ○ | Circulating parts for maintenance |
| | Skip, wire | 44ø x 200m x 4 | | Purchase ○ | | ○ | |
| | Each reducer driving portion | | ○ | | ○ | | |
| Top charging equipment | Pressure equalizing valves etc. | Eccentric type Inside operating swing type | | ○ | Maintenance ○ | Replacement ○ | Circulating parts for maintenance |
| | (Bleeder, seal valve) Packings, etc. | Silicon rubber | | ○ | | ○ | |
| | Large and small bells | | | ○ | | ○ | |
| | Wire ropes of various types | | | ○ | | ○ | |
| | Hydraulic equipment | | | ○ | Complicated ○ | Simple ○ | |
| | (Each hopper / Each chute) liner | Cix-2 | ○ | ○ | | ○ | |
| Furnace proper and accessories | Detectors of various type | | ○ | ○ | | ○ | |
| | Shell | SM41B SM50B | ○ | | ○ | ○ | |
| | Mud gun | Mitsubishi Heavy Industry Full hydraulic type | | | Complicated ○ | Simple ○ | |
| | Tap hole opener, air motor | TYTD type | Simple ○ | ○ | Maintenance ○ | Replacement ○ | Circulating parts for maintenance |
| | Attaching and detaching equipment of large trough covers | | ○ | | | ○ | |
| | Pipings for cooling water | | ○ | | | ○ | |
| | Tuyere, inner and outer cooling | | | ○ | Tuyere, inner cooling ○ | Outer cooling ○ | Replacement of tuyere and inner cooling is by operation side, and that of external by operation side ~~and contractor~~ |
| | Pump | Volute type of suction at both ends | | ○ | ○ | | |
| Hot stoves and gas cleaner | Hot blast valve, valves of various type | Kubota's vertical sluice | | | ○ | | Dia. 1,000 - 1,300ø |
| | Shell | SS41 | ○ | | ○ | Simple ○ | |
| | Pump | Volute type of suction at both ends | | ○ | ○ | Small type ○ | |
| | Pipings of water | | ○ | | | ○ | |
| Dust collector (Bag filter) | Main blower | | | ○ | ○ | | |
| | Filter cloth Flow conveyor | | ○ | ○ | | ○ | |
| Other ancillary equipment | Gas compressor | | | | | ○ | Specialized contractor |
| | C gas booster | | | | ○ | | |
| | Parts for each driving portion | | ○ | ○ | | ○ | |

Table IV-9 Example of actual manufacture and repair of parts for converter

| Equipment | Parts | Specification | Manufacture | | Repair | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Self-manufacture | Contractor | Self-manufacture | Contractor | |
| Hot metal and molten steel crane | Wheels | SSW-Q1 | ○ | ○ | | | Use of standard articles in conditional from the time of designing. |
| Other general crane | Brake wheels | FCD | ○ | ○ | | | Manufacture is possible in the foundry plants around. |
| | Gears with shaft | | Simple ○ | Complicated ○ | | | |
| | Ladle hook | SM50A | ○ | ○ | | ○ | Both manufacture and repair are by specialized maker. |
| | Wire sieve | SS or FC | ○ | ○ | | | |
| | Hook | SF | | ○ | | | Specialized maker of metal hooks (Often purchased in sets). |
| Converter | Furnace mouth metal | FCD | | ○ | | | |
| | Trunnion bearing | | | Purchase ○ | | | |
| | Lance hole jacket | SS | ○ | ○ | ○ | | Repair of detachable goods for reuse. |
| | Flux chute | SS | ○ | ○ | ○ | | Same as above. |
| | Shell at inclined portion | SM50A | ○ | | | ○ | Total replacement of inclined portion due to large deformation. |
| | Parts for cooling & dust collecting pumps for various portions | | | Purchase ○ | ○ | ○ | Parts are ordered to specialized maker. |
| | Lower skirt | STB | | ○ | (Partial ○ | repair) ○ | |
| | IDF runner and shaft | Assembly parts | | ○ | | (Sent to maker) ○ | Self-repair is conducted for unexpected necessity. |
| | Pneumatic and hydraulic cylinder of various types | | | ○ | ○ | | Repair and manufacture of individual part inclusive will be self-conducted. |
| | Mechanical parts for tilting reducers | | ○ | ○ | | | |
| | Main lance pipe | STPT | | ○ | ○ | ○ | Daily repair. |
| | Lance nozzle | CU | | ○ | | | Manufactured by specialized maker. No repair is made. |
| | Probe | | | ○ | | | Manufactured by specialized maker. |
| | $O_2$ and water hoses for lance | | | ○ | | | Specialized maker. |
| Ventilator and dust collector | Filter cloth | | | ○ | | | Repaired goods have short life. |
| Belt conveyor | Carry roller | | ○ | ○ | | | Manufacture = specialized maker<br>Repair = subcontracting around the works. |
| | Head, tail pulley | | ○ | ○ | ○ | ○ | Can be anywhere as long as the drawings are available. |
| Hot metal ladle and steel ladle transfer car | Wheels | SSW-Q1 | ○ | ○ | | | Use of standard articles is conditional from the time of designing. |
| | Brake lining | | | ○ | | | Specialized maker. |
| Others | Valves for various utilities | | (Parts) ○ | (Assembly parts) ○ | ○ | ○ | |
| | Belt for conveyor | | | ○ | | ○ | Both manufacture and repair are by specialized maker. |
| | Gear coupling | | | ○ | | | Specialized maker. |
| | Metal (BC family) | | ○ | | ○ | | |
| | " (WJ family) | | ○ | | ○ | | |