REPORT
ON
REHABILITATION
OF
EGYPTIAN IRON AND STEEL COMPANY IN HELWAN
ARAB REPUBLIC OF EGYPT

OCTOBER, 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

Japan International Cooperation Agency was entrusted by the Japanese Government with the duty of executing studies on the planned rehabilitation of Egyptian Iron and Steel Company in Helwan for the Government of Arab Republic of Egypt.

With the cooperation of governmental organizations concerned and Japan Iron and Steel Federation, the Agency organized a study mission and sent it to Egypt for the on-site study of the steel complex from November 22 to December 16 of 1976. In Egypt, the Japanese mission composed of 15 experts and headed by Shigeru Maehara, deputy director of Overseas Technical Cooperation Div. of Engineering Divisions Group, Nippon Steel Corporation made a full inspection of the company, held discussions on a group-by-group basis and was provided by the Egyptian company with a multiplicity of data necessary for clearer understanding of problems the company faced. In addition, the mission also had the opportunities to visit the Baharia Mine and steel-related industries there. Beside these on-site survey efforts, careful analysis of the data obtained and extensive studies made on both technical and economic aspects have been crystallized into this final report.

We sincerely hope that this will prove a help to the prosperity of the Egyptian steel industry and, at the same time, to the further promotion of friendly relations between both countries.

Finally, I wish to take this opportunity to express my hearty gratitude to the Government of Arab Republic of Egypt and other authorities concerned for their kind cooperation and assistance extended to the team, without which the survey work could not have been carried out so successfully.

Shinsaku Hogen
President
Japan International Cooperation Agency

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	MR. TAKUJI MITSUYASU Nippon Steel Corporation	(ironmaking; equipment)
	MR. YOSHIAKI SAIMEN Nippon Steel Corporation	(steelmaking; operation)
	MR. HARUO ANAN Nippon Steel Corporation	(steelmaking; equipment)
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	MR. HISAO MINAMI Nippon Steel Corporation	(section rolling)
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	MR. KIICHI YOSHIDA The Japan Iron and Steel Federation	(maintenance)
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	MR. AKIRA KOJIMA Ministry of International Trade and Industry	(planning of equipment rehabilitation; planning and organization)
	MR. MICHIO OKUBO Nippon Steel Corporation	(planning of equipment rehabilitation; production process control)
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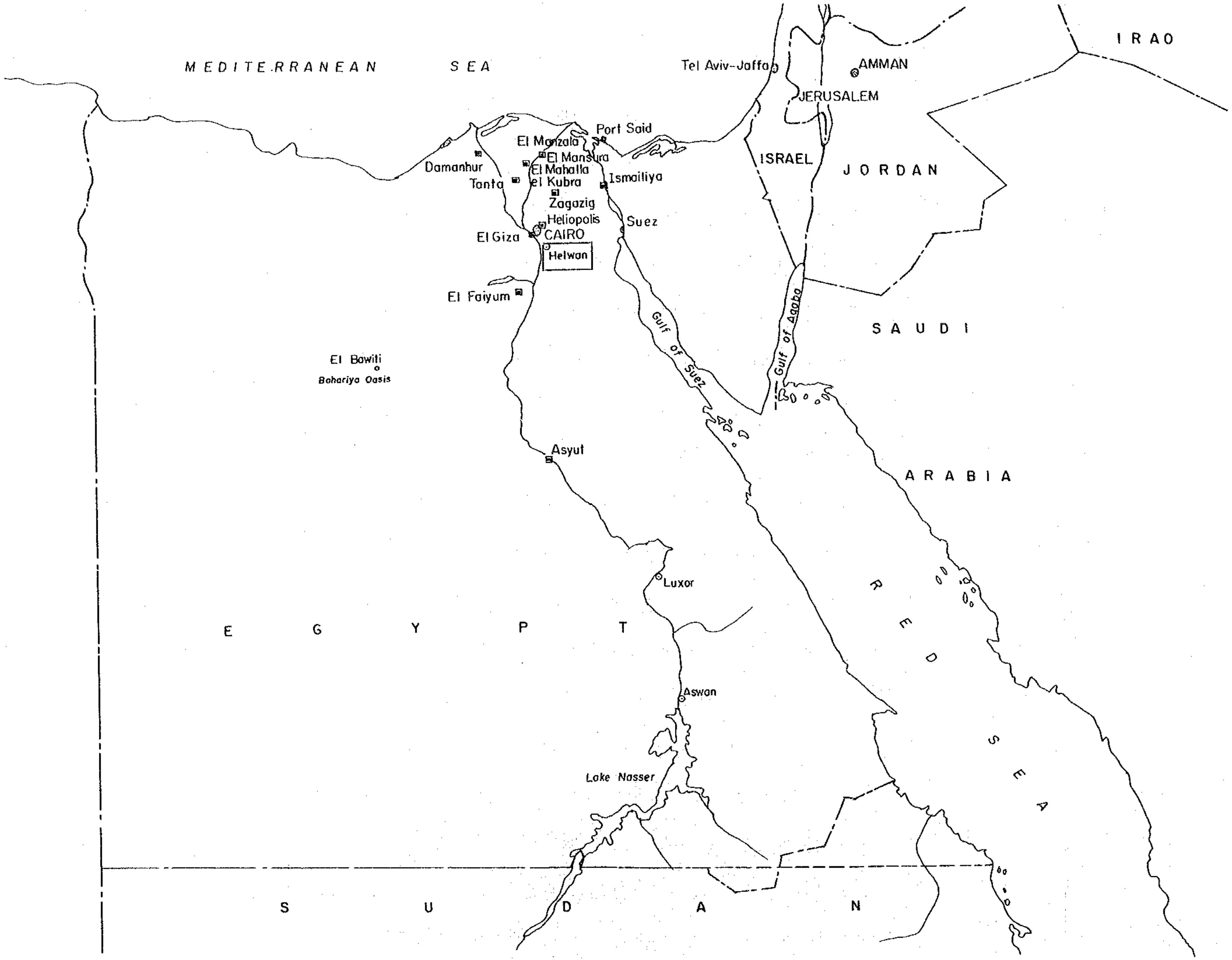
	Eng. FATH-ALL-KAMAL	(coordination group)
	Eng. MOHAB EL-MASRY	(coordination group)
	Eng. GAMAL HASSAN AFIFY	(coordination group)
	Chemist MOFID AMIN ANTON	(coordination group)

Itinerary of Japanese Study Team for the Rehabilitation of the Egyptian Iron and Steel Co., Helwan, Egypt

November 23, - December 15, 1976

November	23 (Tue.)	Arrival at Cairo Courtesy call on the Japanese Ambassador Team meeting
	24 (Wed.)	Preliminary meeting with the Egyptian counterpart group
	25 (Thu.)	General observation of Helwan works
	26 (Fri.)	Team meeting
	27 (Sat.)	First meeting with the Egyptian counterpart group
	28 (Sun.)	Second meeting, in groups (cordination; ironmaking; steelmaking; rolling; auxiliaries)
	29 (Mon.)	Site survey of Helwan works, in groups
	30 (Tue.)	Site survey of Helwan works, in groups Observation of Delta Steel Mill and National Metal industries (coordination group)
December	1 (Wed.)	Survey of Alexandria portfacilities
	2 (Thu.)	Same as above
	3 (Fri.)	Observation of Suez canal
	4 (Sat.)	Site survey of Helwan works and discussion with Egyptian counterparts, in groups Survey of Baharia mine (ironmaking group)
	5 (Sun.)	Same as above
	6 (Mon.)	Third meeting
	7 (Tue.)	Preparation of Interim Report
	8 (Wed.)	Same as above

December	9 (Thu.)	Same as above
	10 (Fri.)	Team meeting for completion of Interim Report
	11 (Sat.)	Fourth meeting; presentation and explanation of Interim Report
	12 (Sun.)	Meeting with Japanese Embassy staff Discussion with Egyptian counterparts (in groups)
	13 (Mon.)	Coutesy call on the Ministry of Economy and Economic Cooperation Team meeting
	14 (Tue.)	Team meeting
	15 (Wed.)	Departure from Cairo.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SAUDI
ARABIA
El Bawiti
Bahariya Oasis
Asyut
Luxor
EGYPT
RED SEA
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SUDAN

SUMMARY

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I. BASIC POLICIES FOR THE STUDY OF THE REHABILITATION PLAN

1. Basic Approach

This plan covers the older line built in 1958 by West German Demag at Helwan Works and which has been operating ever since.

The rehabilitation plan involves both operational and equipment sectors and therefore characteristically differs from the construction and operation of a greenfield complex. Moreover, the difference between Egypt and Japan in raw material situation and peripheral environment cannot be neglected. In studying and preparing the present plan, the following points have been considered.

a) The results of the field study and the requests from the Egyptian side must be reflected in the plan as much as possible.

b) The peripheral environment of Helwan Works must be taken into account in order to make the plan as applicable and practical as possible in Egypt.

c) Existing equipment in operation must be fully utilized, such that the continuance of production is not hampered.

d) The plan must not end up as a temporary emergency measure but must advantageously evolve in a long-range perspective.

e) Expected improvement in technology and skills at Helwan Works and in their control and management setup must be taken into considerations.

2. Basic Items of Investigation

The basic items of investigation to be conducted by Japan International Cooperation Agency under an agreement between the Egyptian Government and the Japanese counterpart, are as follows.

a) An investigation into the current status of operation and equipment at the Demag plant plus the isolation of problems and finding of solutions on the basis of the investigation results.

b) Technoeconomic studies to help Egypt choose between the two following alternatives basic to the promotion of the present rehabilitation plan, and the preparation of a master plan based on the study results.

Case A: The attainment of the design capacity of a rolling mill and measures to achieve the iron- and steelmaking capacity compatible with the above attainment

Case B: The attainment of the design capacity of a rolling mill; studies into the maximization of ironmaking capacity; and measures to achieve the steelmaking capacity corresponding to the above maximization.

3. Prerequisites to Investigation

The present investigation is aimed at the preparation of measures to improve the production capacity of the Demag plant from both operational and equipment standpoints. Needless to say, the plan to be devised must be such that upon its execution the intended results can be obtained.
In order that productive activities are realized as planned, however, a range of related conditions such as raw materials, energy, labor, and control setup must be perforce maintained in excess of certain levels.
In making this plan, expected improvements in a variety of conditions as aforementioned are considerably taken into account. Described below are some of the major considerations indispensable to the execution of the plan.

a) Control system for the management of the steelworks (labor, production, quality, maintenance, raw materials, and utilities, etc.) must be further improved to attain higher levels of control than at present.

b) Operational and maintenance technique and skills must be improved and for that purpose, orientations and trainings should be substantiated accordingly.

c) The raw materials, and comsumables and parts for operations and maintenance must be procured stably and smoothly on a planned purchase basis.

II. CONCLUSIONS AND RECOMMENDATIONS

Recently, we conducted a series of studies into a rehabilitation plan for the Demag plant, Helwan Wroks, Egypt, by taking account of various Egyptian requests as much as possible. The conclusions reached on the basis of the study are as follows.

1. The proposed improvements of operation and of equipment, if realized, will ensure the Demag plant the following.
   (1) Ironmaking capacity : 394,000 t/y (currently 240,000 t/y)
   (2) Steelmaking capacity : 375,000 t/y (currently 165,000 t/y)
   (3) Rolling capacity : Heavy section 180,000 t/y; Light section 100,000 t/y (currently: Heavy section 60,000 t/y; Light section 55,000 t/y)
2. With a change in ore brand, a corresponding change in steelmaking process is required. To meet this situation, it is advisable to discontinue the use of existing Thomas converter plant and to install a new oxygen top-blown converter plant.
3. Modifications to the equipment will require total investments of US$50,707,000 (US$ 242/ton-steel/year) (on Japanese basis).
4. This amount of investment is lower than the case where a 10,000,000 t/y steelmaking plant is built in Japan, which will require an investment of approximately US$485/ton-steel/year.
5. The term of works on equipment remodeling will complete in 34 months after order receipt. This takes into account the longest term of works required on the construction of an oxygen top-blown converter.

In order to attain the rehabilitation plan as efficiently as possible, this plan must parallel the effective effort at the improvement of technological levels, for the realization of which the following items must be practised along with the study into the introduction of operational guidance by steelmakers of an advanced steelmaking country.

1. In order to improve techniques and skills in operation and maintenance sectors, more substantial orientations and training must be carried out.
2. Control and management systems must be further substantiated. The raw materials and parts needed must be procured smoothly.
3. The acquisition of technical and engineering workers must be further studied.

These conclusions have been drawn from the present studies of a rehabilitation plan covering part of Helwan Works. The rehabilitation plan must be executed in a long-range perspective involving the entire steelworks. In its execution, therefore, the plan for equipment remodeling must be checked on a long-term, steelworks-wide basis.

In carrying out the rehabilitation plan, problems may be encountered which are characteristically different from those experienced with the construction of a greenfield plant.

It is strongly expected that the indigenous enthusism which was felt during the visit to Egypt will overcome these difficulties and carry the rehabilitation plan through to an end.

III. PRODUCTION FLOW

1. Basic Concept

The production balance basic to the discussion of the present investigation has been studied in line with the following fundamental concept.

a) Production balance should be considered in relation to not only the equipment involved but also to Helwan Works as a whole.

b) As regards the equipment outside the scope of this study, the planned values adopted in the Expansion Plan by the Egyptian side will be assumed to be achieved.

c) For a basic production flow, a plan used in the Expansion Plan is employed. As regards the equipment covered by this investigation, the values used therefor have been reviewed.

2. Prerequisites

In studying a production balance, the following prerequisites have been set.

a) The scrap for use in the steelmaking plant must not be purchased from the outside. Instead the home scrap generated entirely in Helwan Works should be used.

b) For yield in each plant, the values given in Table 1 are used. As regards the yield for the plants covered under the current study, expected post-improvement values are employed.

Concerning the plants outside the scope of this study, the numerical values adopted in the Expansion Plan are assumed to be attained.

c) The production of pig iron (248,000 t/y) and billets (340,000 t/y) for sale outside under the Expansion Plan must be secured with utmost efforts. Billets for sale will be considered in preference to pig iron for sale.

Table 1 Yields in each plant

Plant \ Item		Expansion Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Converter	Tapped steel yield	92.4	90.0	83.0	88.0	90.0	91.3
	Ingotmaking yield	93.9	95.0	98.0	98.0	98.0	98.0
	Good ingot yield	86.8	85.5	81.3	86.2	88.2	89.5
Blooming	Production yield	-	92.0	88.0			
Electric furnace	Tapped steel yield	-	89.3				
	Ingotmaking yield	-	98.5				
	Good steel yield	-	88.0				
Heavy sect.	Production yield	-	87.9				
Light sect.	"	-	87.7				
Medium sect.	"	93.0	-				
Plate	"	78.9	-				
Hot strip	"	96.8	-				
Cold strip	"	86.1	-				

3. Production Balance

Production balance has been studied in terms of the two following cases based upon the basic concept and prerequisites described in II. 1 and 2.

Case A: Iron- and steelmaking capacity compatible with planned rolling capacity

A study concerning the steelmaking capacity compatible with the production capacity of each rolling mill (including 340,000 t/y billets for sale) and as regards the ironmaking capacity required for the production of the molten iron for the aforesaid steelmaking and 248,000 t/y pig iron for sale.

Case B: Maximization of iron- and steelmaking capacity independently of planned rolling capacity

A study into a production balance in cases where iron output is maximized in excess of molten iron requirements compatible with rolling capacity (including 340,000 t/y billets for sale) combined with 248,000 t/y pig iron for sale. In this case, all iron output except the pig iron for sale will be supplied to the steelmaking plant. Ingots produced in excess of rolling capacity (including 340,000 t/y billets for sale) will be sold.

Five alternatives are considered pertaining to the Thomas converter rehabilitation plan.

Alternative 1: The existing Thomas Plant will be closed, while the 80t LD Plant will be reinforced.

Alternative 2: The Thomas Plant will be remodelled into OBM plant.

Alternative 3: The Thomas Plant will be remodelled into the LD plant.

Alternative 4: A new LD plant will be added near the Thomas Plant.

Alternative 5: A new OBM plant will be added near the Thomas plant.

The amount of molten iron required differs with each alternative. With alternative 1, in which the amount of molten iron required is the smallest of the five alternatives, the required ironmaking capacity and steelmaking capacity in case A will be as in Table 2. Accordingly the required steelmaking capacity in older line is 355,000 t/y and required ironmaking capacity is 457,000 t/y.

Table 2 Iron-and steelmaking capacity in equilibrium with rolling capacity

	Steelmaking concentrated on new line (1,000 t/y)
Order line capacity (Nos. 1 and 2 BF's)	457
New line capacity (Nos. 3 and 4 BF's)	1,340
Ironmaking capacity totals	1,797
Older line capacity (EF + Converter)	45 (EF only)
New line capacity (LD)	1,200 + 310
Steelmaking capacity	1,555

Our studies revealed, however, that even after their operational and equipment improvements, the Nos. 1 and 2 blast furnaces can turn out only a maximum of 600 t/d/unit of iron, or an average of 540 t/d/unit or 394,000 t/y. The manufacture of ingots in agreement with rolling capacity (including billets for sale) will leave 185,000 t/y of molten iron, i.e. pig iron for sale, an amount far short of meeting the Expansion Plan requirements of 248,000 t/y of pig iron for sale. Accordingly there is no need of discussing case B.

In this investigation, the production flow has therefore been studied on the understanding that iron- and steelmaking capacity be as follows.

a) Ironmaking capacity : Maximum ironmaking capacity

b) Steelmaking capacity: Steelmaking capacity compatible with rolling capacity (residual molten iron is to be used for pig iron for sale)

Fig. 1 and 2 show the production flow corresponding to each alternative of the Thomas plant rehabilitation plan.

Fig. 3 shows the production flow corresponding to the idea recommended in this study.

Unit : 1,000 t/y

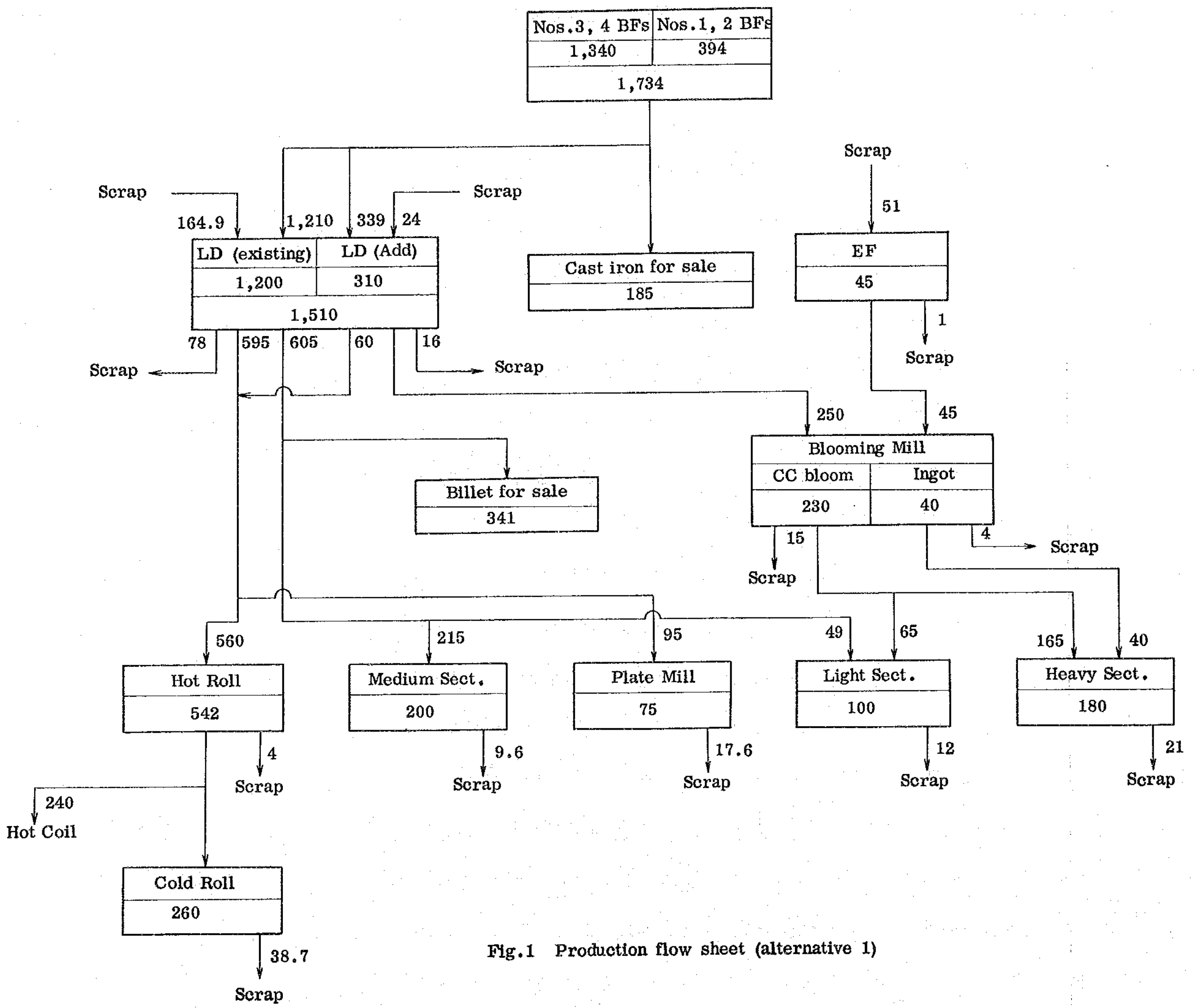


Fig.1 Production flow sheet (alternative 1)

Unit : 1,000 t/y

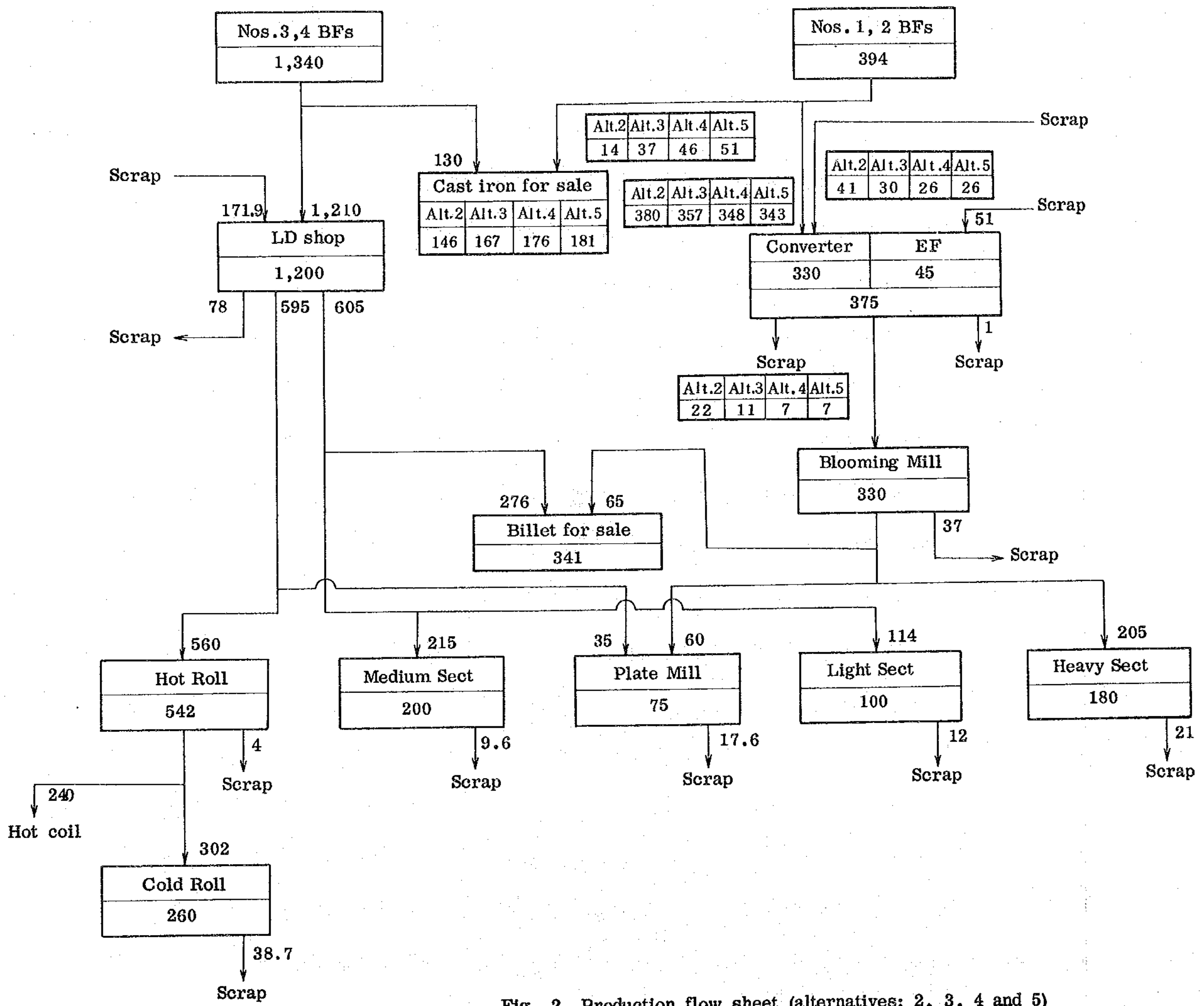


Fig. 2 Production flow sheet (alternatives: 2, 3, 4 and 5)

Unit: 1,000 t/y

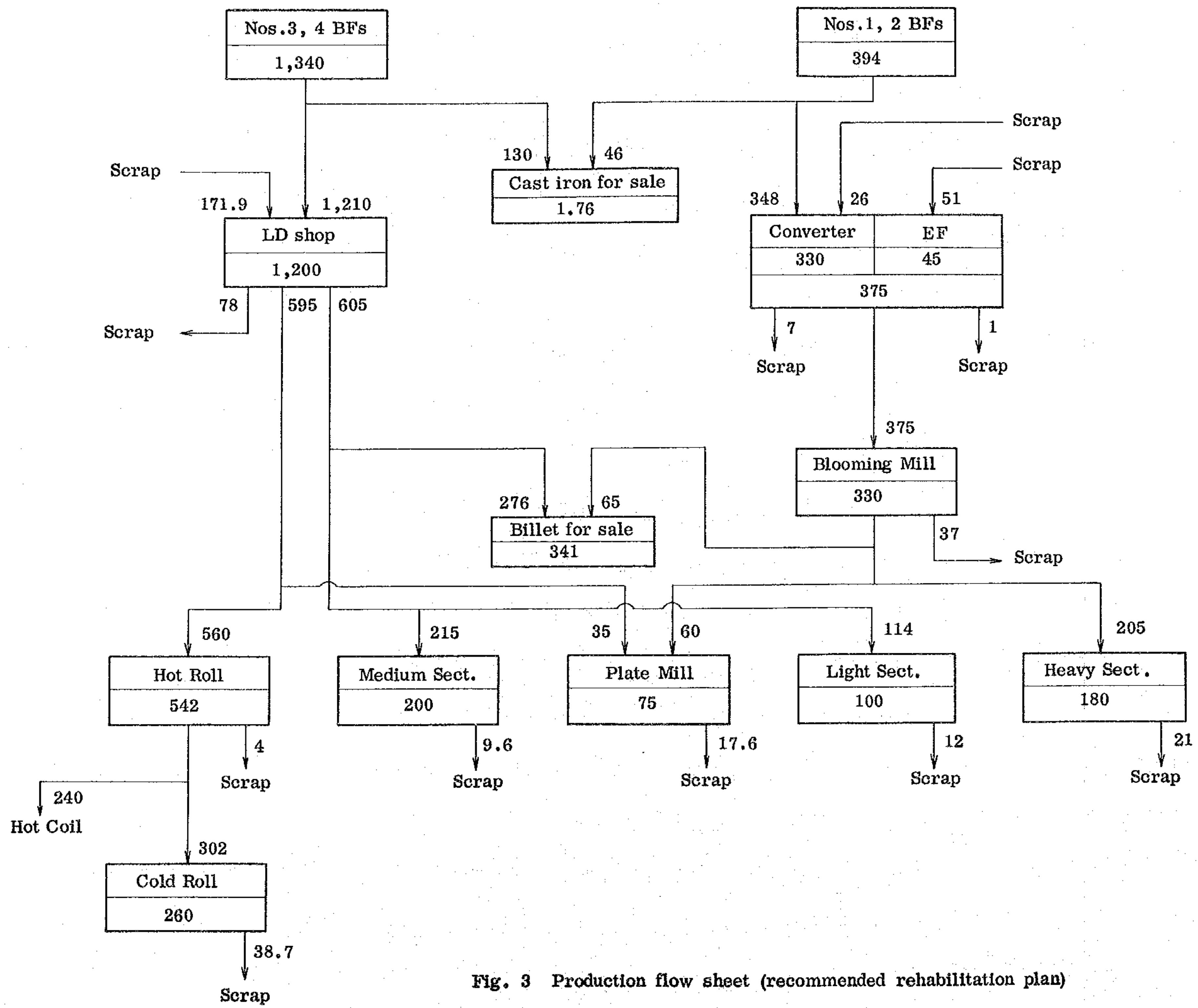


Fig. 3 Production flow sheet (recommended rehabilitation plan)

IV. OPERATIONAL AND EQUIPMENT IMPROVEMENTS

1. Ironmaking

1.1 Sintering

The factors adversely affecting production and qualities in a sintering plant can be summarized as follows.

(1) Troubles arising from the inherent nature of ores

a) Occurrence of equipment troubles due to high Na and Cl contents

b) Bad sinterability due to the ore being hematitic and goethitic with much fines

(2) Poor maintenance

a) Low availability of plant

b) Bad state of maintenance (poor sealing etc.)

(3) Insufficient operational control

Raw material and fuel quality improvements and their stable supplies play a very important role in blast furnace production increases and operational stability. Solutions to these problems, therefore, are of immediate importance. Despite the solutions given below, complete elimination of troubles is difficult with regard to problems attributable to the intrinsic nature of the ore concerned, unless drastic measures are taken to beneficiate the ore. The study on ore benefication therefore should be done in parellel.

1.1.1 Operational improvements

(1) Raw materials and fuels for sintering

a) Reinforce the treatment of fine ore on a closed circuit basis.

b) As concerns return fines, study the screen mesh and try to recover + 5mm particles.

c) As regards limestone grain size, endeavor to decrease + 3mm particles.

d) Coke pulverization should be reinforced.

(2) Sintering operations

a) Pay attention to the control of return fines blending.

b) Check and see if moisture is controled at a proper level.

c) Better use a hearth layer.

d) Strengthen charging controls.

e) Positively exercise a temperature control of the ignition furnace.

f) Substantiate the quality control setup in order to grasp the physical and chemical properties of sinter.

(3) Production increase

a) Preferably, add a binder to strengthen the quasi-particle forming.

b) To improve permeability, slit bars should advisably be installed.

c) It is advised that suction pressure be changed from minus 760 mmAq (specification) to minus 1,200 mmAq.

d) Provide more screens to intensify screening.

e) Reinforce maintenance so as to raise the availability of equipment.

1.1.2 Equipment improvements

a) Change the exhauster capacity to 5,000 m^3/min at 150°C, at minus 1,200 mmAq.

b) Modify the present screening system. The hearth layer materials should be secured by a secondary screen.

c) Install a blending equipment unit for burnt lime as a binder.

d) Furnish a sinter stockyard to ensure stable sinter supply to blast furnaces.

1.2 Blast furnace

The results of the investigation undertaken with respect to Nos. 1 and 2 blast furnaces at Helwan Works reveal that a lack of fundamental control over raw materials and operation can be counted among the causes of productivity impairment.

a) Material balance is not well taken.

b) Control over material properties is insufficient.

c) Operational control (tapping and flushing, furnace temperature, permeability, flame temperature in front of tuyere, etc.) is not sufficiently exercised.

d) Poor maintenance (for example, blast leaks in a hot blast pipe line.)

e) Combustion control of hot blast stoves is poorly maintained, etc.

To raise productivity, improvements of the aforesaid problems are prerequisite. Table 3 gives the contents of specific improvements. Furthermore, the measures given in Table 4, if they are taken, will enhance the productivity of the Nos. 1 and 2 blast furnaces as follows.

Maximum iron output (P_M) = 600 t/d. BF

Average iron output (P) = 540 t/d. BF*

*At operation rate ($P/P_M \times 100$) = 90%

Incidentally, these measures are considered to be the most economical approach to productivity improvement.

Table 3. Basic improvement of operation

Item	Contents of improvement	Current status	Comments
1) Raw materials Sinter size	- Reinforce screening in a sintering plant, and control to not more than 5 percent the amount of -5mm particles in blast furnace charge materials. - At the sintering plant, sample two times per shift to check for grain size. - After sinter reclaiming at the sinter bin gate, conduct periodical checks for grain size.	- -5mm = 4 ~ 5% in post-screening sampling at sinter plant. - On account of degradation during transit, -5mm particles in blast furnace charge materials are estimated to account for 7 ~ 8 percent of the total. - Periodical check on grain size is not performed.	- At Nippon Steel, blast furnace charge materials are controlled such that a fines of -5mm accounts for not more than 2 percent.
Mechanical strength	- Control at SI ≧ 82%		
Basicity	- CaO/SiO_2 = 1.00 (It is desirable to reduce the amount of limestone charged into blast furnace by raising the sinter basicity, but it was given up because sinter with high SiO_2 results in drop of productivity or quality if its basicity was raised.)	- CaO/SiO_2 = 0.86 ~ 1.04	- Reduction in the SiO_2 contents (percentage) of Baharia ore through their beneficiation at a mine site will make it possible to increase CaO/SiO_2.
Reducibility (FeO%)	- Gradually reduce FeO contents (percentage) while paying heed to mechanical strength.	- Reducibility is considered to be inferior on account of FeO accounting for 9.5 ~ 13.5 percent.	
Coke Moisture content	- Control moisture at not more than 4%. (This is accomplished by adjusting the amount of water used for quenching at a coke plant.)	- Average 7.7 percent, σ = 1.5 percent	
Size	- Post-screening grain size should be controlled at -15mm ≦ 2% - Strengthen control of coke screens to prevent mesh clogging.		
Mechanical strength	- Control at M_{40} ≧ 77.7%.	- Controlled at M_{40} > 75 % M_{10} < 7.5 % Performance records: M_{40} = 73.2 ~ 75.8% M_{10} = 7.7 ~ 9.0 %	

Item	Contents of improvement	Current status	Comments
2) Operation			
Availability	- Attain availability ≥ 95 percent by the procurement of coke, and prevention of power failure and monkey failure, etc.	- Average 65.6% (Nov. '75 ~ Oct. '76.) (Average 89.1% when coke shortage-caused shutdown is excluded.)	- Nippon Steel performance record: 96 ~ 99%
Tapping and flushing	- Preclude delays in ladle transfer and provide conditions for timely tapping and flushing corresponding to hot metal and slag levels.	- Tapping is performed eight times/d. Owing to ladle transfer delays, tapping often becomes delayed.	
Flushing ratio at cinder notch	- Increase number of cinder notches to two, inject compressed air through cinder notch and bring the flushing ratio to 60 ~ 70 percent.	- Flushing ratio is as low as approximately 30 percent on account of provision of only one cinder notch and due to frequent monkey failures.	
Furnace temperature control	- Measure molten iron temperature.	- Molten iron temperatures are not measured.	
Permeability control	- On the basis of various parameters ($\Delta P/V$, K, number of hangings, etc.), keep permeability under good control, and if it becomes deteriorated, take actions to optimize raw materials, tapping and flushing.	- No control is exercised at all.	
Control of flame temperature in front of tuyere	- Raise flame temperature (Tf) by increasing blast temperature and enriching oxygen, etc.	- No control is maintained at all, with flame temperatures held at as low as 1,900 ~ 2,000°C.	
Control of blast velocity at the tuyere	- Change the tuyere diameter and control the blast velocity at 200 ~ 250 m/sec.	- Control is not exercised, blast velocity at the tuyere being at 110 ~ 180 m/sec.	- At low blast velocity at the tuyere, normal raceway profile cannot be attained.
Fuel injection	- Control Tf = 2,200 ~ 2,300°C and $\mu \geq 2.0$.		- μ : The ratio of oxygen content of blast relative to the amount of oxygen required for complete combustion of the fuel injected.
Combustion control in hot blast stove			
Dome temperature	- Control dome temperature at levels 50°C or more lower than those allowed for the brick used.	- 1,200 ~ 1,250°C	
Exhaust gas temperature	- Control at a maximum of 350°C.	- Controlled at the maximum of 400°C.	
Hot blast leakage	- Keep hot blast leakage to the minimum through good maintenance.	- 15 ~ 40% (Average 29%)	- Hot blast leakage cannot be tolerated in high balst temperature and oxygen enrichment operations.

Table 4 Measures to achieve the production of 600 t/d. BF

Item	Contents of improvement	Current status	Comments
1) Raw materials Production of sinter	- Secure 2,160 t/d on the average. (When av. iron production = 600 x 0.9 = 540 t/d)	- Av. 1,200 t/d	- The operation being on the basis of 100% sinter ratio, secure sinter in accordance with the amount of tapping.
Coke quantity to be purchased for Nos. 1 & 2 blast furnaces	- Secure 322,000 t/y of unscreened coke required for the two blast furnaces.	- Due to quantitative shortages of coke, blast furnaces are banked down.	When coke rate is 750 kg/t-pig, P_M 600 t/d, operation rate 90%, and coke breeze generation 8%.
2) Operation Operation rate	- Secure $P/P_M \geq 90\%$		- Even if P_M is raised, productivity does not improve unless operation rate (P/P_M) is increased.
Fuel rate	- Attain a fuel rate ≤ 850 kg/t-pig	- Fuel rate = 891~1,101 kg/t-pig (Av. 987 kg/t-pig)	- Fuel consumption capacity being limited, fuel rate should be lowered to secure production.
Blast temperature	- Raise to 1,000°C	- Approximately 700°C	
Oxygen enrichment	- Enrich oxygen by 2~3 percent (Max. 2,200 Nm^3/hr. BF) in order to raise Tf and to compensate for blower capacity shortage.	- None	
Operation of scale car	- Operate a scale car efficiently, which should be operated at a rate of 6.3 charges/hr or more.	- Max. 6 charges/hr	
3) Equipment Blast furnace	- Replace the shell and increase the hearth diameter to 5.7 m.	- Hearth diameter = 5.1 m	
Hot blast stove	- Control dome temperature at 1,250°C on the basis of three stove operation. Replace brickwork so as to attain an allowable dome temperature of 1,300°C.	- Two stove operation. Controlled at dome temperature of 1,200~1,250°C	
Hot blast pipe line	- Replace entirely so that an inner diameter of 1.0 m, lining thickness of 400 mm, and shell diameter of 1.8 m are achieved.	- Inner diameter 0.9 m, lining thickness 250 mm, shell diameter 1.4 m	

2. Steelmaking

With the existing Thomas plant, changes in iron ore brands from Aswan ore to Baharia ore necessitate corresponding changes in steelmaking processes. The study on the Thomas plant from the standpoint of this change in steelmaking processes has pin-pointed the following problematical points.

a) Major equipment items are superannuated needing replacement at an earliest opportunity.
b) The entire plant is narrow in layout.
c) Many apparatuses are in need of maintenance.
d) Instrumentation for operational control is almost nil.
e) The yield is exceedingly low.
f) Refractory performance is excessively poor.
g) Ingots are not sufficiently controlled after casting.

To add to solutions to these problems, measures to cope with a new steelmaking process accompanying the change in iron ore brands, must also be studied.

2.1 Measures for improvement

2.1.1 Rehabilitation plan

The five following alternatives have emerged from the consideration of measures to cope with the new steelmaking process as well as of solutions to the above-mentioned problems confronted by the Thomas plant.

Alternative 1 ... The Thomas plant will be closed, while the 80 t LD plant will be remforced

Alternative 2 ... The Thomas plant will be remodelled into the OBM plant

Alternative 3 ... The Thomas plant will be remodelled into the LD plant.

Alternative 4 ... A new LD plant will be added near the Thomas plant.

Alternative 5 ... A new OBM plant with will be added near the Thomas plant.

2.1.2 Equipment costs for each rehabilitation plan

Equipment costs for each rehabilitation plan is given in Table 5.

As is evident from Table 5.

a) The lowest in equipment investments is alternative 2 (B).

b) Remodeling of existing Thomas plant does not cost far less in investments than the installation of a new plant.

c) The plan to reinforce existing 80 t LD plant costs the highest in investments on account of high construction costs for continuous casting equipment.

Table 5 Equipment costs for each rehabilitation plan

(US$1,000)

	Alternative 1	Alternative 2(A)	Alternative 2(B)	Alternative 3	Alternative 4	Alternative 5
(1) Furnace related equipment	-	1,138	1,138	807	3,462	3,810
(2) Materials related equipment	2,149	2,072	1,497	2,079	3,083	3,387
(3) Ingot related equipment	9,487	248	248	248	773	773
(4) Waste gas treatment plant	-	8,318	-	8,318	6,314	6,314
(5) Crane related equipment	1,525	2,531	2,469	2,531	3,504	3,504
(6) Electrical equipment	680	308	259	308	462	462
(7) Waterworks related equipment	1,169	121	90	121	121	121
(8) Civil engineering equipment	2,435	448	328	517	1,379	1,310
(9) Construction equipment	7,176	2,307	1,891	2,415	3,138	3,069
(10) Blooming equipment	4,990	3,773	3,773	3,773	3,773	3,773
Totals	29,611	21,264	11,693	21,117	26,009	26,523
Totals excluding (10)	24,621	17,491	7,920	17,344	22,236	22,750
Remarks	a) Work execution costs are based on estimates made in terms of the situation in Japan. b) Costs for equipment purchases are based on estimates made in terms of the situation in Japan on a C.I.F. basis.					

2.1.3 Production capacity for each equipment plan

Production capacity for each rehabilitation plan is as shown in Table 6.

Table 6 Production capacity

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Production capacity	1,200,000 + 310,000t/y	330,000t/y	310,000t/y	365,000t/y	336,000t/y
Number of vessel	3	4	4	2	2
Ton/heat	76.4	16	16	36	36
Av. steelmaking time (min/heat)	42.5	39.0	41.5	41.5	39.0
Availability (%)	53.3	38.2	38.2	40.0	34.7
Remarks	Availability = $\frac{\text{Total steelmaking time}}{\text{Number of vessel x Calendar hours}}$ x 100 Production capacity = $\frac{\text{Number of BF's x Calendar hours x availability}}{\text{Av. steelmaking time}}$ x ton/heat				

In sum, production capacity can be explained as follows.

a) Alternative 3 cannot ensure a necessary annual crude steel output of 330,000 t/y.

b) Alternative 4 turns out crude steel in excess of an annual required amount of 330,000 t/y and is very flexible in its production capacity.

c) To fill the requirements for annual cast bloom production of 310,000 t/y, alternative 1 must maintain a high rate of operation.

2.2 Comparison between rehabilitation plans

2.2.1 Technical comparison

Technical comparisons between rehabilitation plan are synthetically shown in Table 7. Technical advantages and disadvantages of each rehabilitation plan can be summarized as follows.

Alternative 1:

a) This involves the reinforcement of existing equipment only and therefore a duration of time required for startup is short.

b) For the attainment of production capacity, limitations on converter life are the largest.

c) Availability is as high as 53 percent and accordingly calls for highly efficient 2/3 furnaces operation (2 in operation, 1 under maintenance)

Alternative 2 (A):

a) Yield is the lowest.

b) A drop in production occurs during a term of works.

c) Mode of operation becomes complicated.

d) An imbalance between the number of ingots per heat and the number of ingots placed in a soaking pit causes a high frequency of occurrence of cold ingots.

e) To make high carbon steel, Ar injection equipment is necessary in light of hydrogen content.

Alternative 2 (B):

a) Same as a) ~ d) of Alternative 2 (A),

b) This is not recommendable as a permanent measure due to the generation of red fume.

Alternative 3:

a) Production capacity is insufficient.

b) Production reduction ensues during a term of works.

c) An imbalance between the number of ingots per heat and the number of ingots placed in a soaking pit causes a high frequency of occurrence of cold ingots.

Alternative 4:

a) Flexibility relative to production capacity is the largest.

b) Training of operational personnel is easy.

c) Mode of operation is simple.

Alternative 5:

a) Mode of operation is simple.

b) During furnace bottom changing, O furnace operations occur.

c) To make high carbon steel, Ar injection equipment is necessary in light of hydrogen content.

Table 7 Technical comparison between rehabilitation plans

	Alternative 1	Alternative 2(A)	Alternative 2(B)	Alternative 3	Alternative 4	Alternative 5
(1) Flexibility to production capacity	△	○	○	×	◎	○
(2) Limitations on furnace life	×	○	○	○	◎	△
(3) Limitations on steel grades	○	△	△	○	○	△
(4) Limitations on works	○	×	△	×	○	○
(5) Limitations on layout	○	△	△	△	○	○
(6) Limitations on mode of operation	○	×	×	×	◎	○
(7) Others (a) Effects on soaking pit	◎	△	△	△	○	○
(b) Maintenance	○	△	△	△	○	○
(8) Red fume	○	○	×	○	○	○
General rating	△	△	×	×	◎	○
Remarks	◎ Advantageous ○ Without problems △ Somewhat problematical × Problematical					

2.2.2 Economic comparison

Prerequisites for economic comparison between rehabilitation plans, and the results of studies are given in Table 8.

In summary, the results of economic comparisons can be described as follows.

a) Economically, alternatives 1 and 4 is the most advantageous.

b) Despite its low equipment investments, a plan to remodel the Thomas plant is economically disadvantageous owing to the effects of low yield.

c) Because of its economic demerits, the plan to remodel the Thomas plant can hardly become a prospective scheme worthy of discussions.

Table 8 A list of economic comparisons

			Alternative 1	Alternative 2 (A)	Alternative 2 (B)	Alternative 3	Alternative 4	Alternative 5
Prerequisites		Blooms / Main materials x 100 (%)	±0	-8.5	-8.5	-4.1	-2.4	-1.3
Prerequisites	Sub materials	Specific burnt lime consumption (kg/t-bloom)	±0	+12.7	+12.7	+5.7	+3.3	+1.7
Prerequisites	Sub materials	Specific fluorspar consumption (kg/t-bloom)	±0	-4.3	-4.3	+0.2	+0.1	-4.3
Prerequisites	Energy	Specific oxygen consumption (Nm^3/t-bloom)	±0	+0.4	+0.4	+3.1	+1.7	-4.9
Prerequisites	Energy	Specific nitrogen consumption (Nm^3/t-bloom)	±0	+5.7	+5.7	0	0	+5.2
Prerequisites	Energy	Specific L.P.G. consumption (Nm^3/t-bloom)	±0	+5.3	+5.3	0	0	+4.8
Prerequisites		Refractories consumption (kg/t-bloom)	±0	+14.8	+14.8	+9.1	0	+3.4
Prerequisites		Blooming fuel consumption (Kcal/t-bloom)	±0	-4,000	-4,000	-4,000	-4,000	-4,000
Results		Main material cost ($/t-bloom)	±0	+15.1	+15.1	+7.0	+3.9	+2.1
Results		Byproducts cost ($/t-bloom)	±0	-8.1	-8.1	-4.7	-3.5	-3.5
Results		Subtotals ($/t-bloom)	±0	+7.0	+7.0	+2.3	+0.4	-1.4
Results		Submaterial cost ($/t-bloom)	±0	+6.7	+6.7	+4.1	0	+1.7
Results		Energy cost ($/t-bloom)	±0	-0.3	-0.3	-0.9	-1.0	-0.6
Results		Costs accompanying investments ($/t-bloom)	±0	-3.8	-12.5	-4.0	-0.2	+0.4
Results		Others ($/t-bloom)	±0	+1.8	+1.8	+0.9	+0.8	+1.5
Results		Total ($/t-bloom)	±0	+11.6	+2.9	+2.6	+0.1	+1.4

2.2.3. Results of comparative studies

As a result of technical and economic comparisons between rehabilitation plans, alternative 4, namely the provision of a top-blown converter, is recommended for the following reasons.

a) It is economically advantageous.

b) It is the most flexible in relation to production capacity.

c) Training of operating personnel is easy.

d) The mode of operation is simple.

e) No production reduction occurs during a term of works.

2.3. Improvements in the Thomas plant

The execution of a rehabilitation plan will provide a drastic solution to existing problems, but before the execution, the following improvements should be made.

(1) The hot metal weigher should be repaired and well maintained.

(2) The temperature measurement system should be established.

(3) The lot of ingot transportation should be changed to 2-heat-unit in conformity with the heating cycle of the soaking pits of the blooming mill.

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

3. Rolling Mill

3.1 Blooming mill

An examination of the recent operating state of the blooming mill for the period between January ~ October, 1976 reveals that its production was 13,650 t/m, rolling efficiency 42.0 t/hr, and shearing yield 85.0%.

The soaking pits frequently suffer shutdowns due to repairs of hole covers and walls, leading to low operating rate. In addition, because of long track time and high cold ingot generation, heating t/hr is so low that the present capacity of soaking pits is estimated to be as low as approximately 200,000 t/y.

Rolling efficiency (t/hr) is low because of low rolling reduction and occurance of camber or bending which are caused by lower rolling temperature of ingots. The present rolling capacity of the blooming mill is as low as approximately 210,000 t/y because of low rolling t/hr and frequent rolling shutdowns due to failures. Discarding of blooms due to misrolling substantially decreases shearing yield.

According to the rehabilitation plan, the ingot to be rolled is 375,000 t/y. Since the present soaking pit capacity is 250,000 t/y at most even when the soaking pit capacity is increased through improvement of operating rate by extension of soaking pit life and improvement of heating t/hr by reduction of track time, it is necessary to add 4 holes of soaking pits in order to heat 375,000 t/y of ingots. The rolling efficiency of 68.1 t/hr is possible by increasing ingot temperature and improving rolling techniques. At such a rolling efficiency, the rolling time required for rolling 375,000 t/y of ingots will be 5,507 hr/y. This rolling time can be easily attained by reducing failure rate through preventive maintenance.

The rolling time of 6,000 hr/y, which is generally used in equipment planning, leads to the rolling capacity of 408,600 t/y. Thus, the capacity of the blooming mill will be as follows.

Soaking pit capacity:	375,400 t/y	Production capacity of the blooming mill: 375,400 t/y
Rolling capacity:	408,600 t/y	

Extremely low shearing yield seems to be attributable to a large amount of discards due to misrolling. The shearing yield 88.0% can be easily achieved through the reduction of discarding by taking the same measures as in the improvement of rolling t/hr, as well as the reduction of the discarding amount of non-defective parts of blooms.

3.1.1 Improvement of operation

(1) Improvement of the operating rate of soaking pits

In order to increase the ingot heating time from 6,500 hr/y to 7,000 hr/y, the following measures for extending the life of soaking pits should be taken.

a) Use proper refractories.

b) Extend the hole drying time after repair from 1 day to 3 days minimum.

c) Dry the hole covers before use, after repairs.

(2) Improvement of heating t/hr of soaking pits

Measures for increasing rolling temperature of ingot, and at the same time, increasing heating efficiency to 4.47 t/hr/hole should be taken.

a) Transportation should be improved to reduce track time.

Two locomotives for transporting ingots should be furnished. Ingots shall be transported in each heat by a locomotive. Work control should be properly performed to prevent delay in stripping.

b) Cold ingot rate should be reduced from 42% to 10%.

Simultaneous periodical repairs in steelmaking plant and blooming mill and other measures should be taken.

c) It is desirable to introduce heavy charge heating

In the current practice, LD ingots of 36 t/hole, EF ingots of 2 heats, 24 t/hole are separately charged, but a heating method of 48 t/hole (LD ingots: 1 heat - 36 tons, EF ingots: 1 heat - 12 tons) should be experimented and its heating method should be established.

(3) Improvement of rolling t/hr

Measures for improving rolling efficiency from 42 t/hr to 68.1 t/hr should be taken.

a) Delay in discharging should be reduced.

Until discharging of all ingots in a hole is completed, the next charge should not be charged into the same hole.

b) Ingot heating temperature should be raised.

Standard heating time should be established so as to maintain the temperature at the end of rolling at 1,050°C or more.

c) Rolling techniques should be improved.

Standard pass schedule should be established and made fully known to rolling operators. Efforts should be made to raise the technical level of rolling operators.

(4) Improvement of shearing yield

Measures for improving shearing yield from 85.0% to 88.0% should be taken.

a) The discarding amount of blooms due to misrolling should be reduced from 3 4% to less than 1.0%.

Ingot rolling temperature should be raised, and at the same time, rolling methods should be established to prevent misrolling in case the shape of blooms is likely to cause misrolling.

b) The discarding amount of non-defective parts of blooms should be reduced.

Shearing standards should be established, and shearing techniques should be improved.

3.1.2 Improvement of equipment

(1) Improvement of soaking pit capacity

a) 4 holes of soaking pits should be added.

b) Cinder removal operations should be mechanized.

Removal of the cinder in the holes should be performed with soaking pit crane within 1 hour without cooling the holes.

c) Temperature control in the holes should be simplified.

Temperature control with 2-point temperature detection should be changed to that with 1-point temperature control.

d) Metallic recuperators should be installed on all holes.

Metallic recuperators should be installed on all holes and protection devices should be provided to protect the recuperators from abnormal temperature rise of exhaust gas.

(2) Addition of soaking pit crane

The existing soaking pit crane have been out-dated, causing troubles frequently. In view of the need to handle 4-ton ingots and remove the cinder with soaking pit crane, it is desirable to add 1 unit of soaking pit crane.

3.2 Heavy section mill

This mill manufactures round bars, billets, sections, rails, etc., with the design capacity of 180,000 t/y. However, the actual production in this mill remains only at 60,000 ~ 65,000 t/y. According to the recent operating records, the monthly average rolling time was approximately 300 hr/m and the rolling efficiency was approximately 17 t/hr. The values for these two factors affecting production were too low.

The prime factor hampering production is insufficient reheating capacity, which directly causes waiting time for heating, and indirectly causes product stoppage (99 hr/m) and a decrease in rolling t/hr.

The second factor is frequent shutdowns due to equipment failures. In addition to planned maintenance time of 78 hr/m, rolling down time due to mechanical and electrical failures is as much as 76 hr/m.

Furthermore, problems of product quality and the finishing line will have to be considered in the future.

3.2.1 Improvement of equipment

(1) The reheating furnace capacity should be increased by any means.

The existing reheating furnace capacity of 20 t/hr in cold charge should be increased to 40 t/hr. There are following four alternatives to increase the furnace capacity.

1) Remodelling of the existing furnace --- It will require a large scale remodelling work and much production down time.

2) Addition of a preheating furnace --- Heating operation will be carried out by both the existing furnace and the new preheating furnace.

3) Addition of another reheating furnace of 20 t/hr --- Heating operation will be carried out by both the existing furnace and the new furnace.

4) Addition of another reheating furnace of 40 t/hr, with the existing furnace being stand-by --- Heating operation will be performed by the newly built furnace.

As a result evaluation of these alternatives, afternative (4) is most recommedable.

(2) Addition of a bloom handling crane is needed for the installation of new reheating furnace.

(3) As a measure aginst equipment failures, equipment should be ranked in the order of importance, and the preventive maintenance system should be introduced for important equipment.

3.2.2 Improvement of operation

(1) Cold charge operation shall be introduced in reheating furnace as a general rule.
Hot charge operation or direct rolling shall be introduced as the occasion demands when the timing of operation in the blooming mill coincides with that in the heavy section mill.

(2) Production of sections of small size shall be shifted to the new medium section mill as planned.

(3) The roll pass designs for problematic products shall be reexamined.
For those products whose yields are poor or whose rolling operations are unstable, their roll pass designs should be reexamined.
Since roll pass design plays a very important role in the rolling of sections, it is necessary to train engineers equipped with this special technology.

3.2.3 Problems to be considered in the future

(1) When the production of rails is increased in the future, installation of a finishing line for the exclusive use of rails will be needed.

(2) When quality requirements become more stringent, introduction of materials surface conditioning and replacement of straighteners should be considered.

3.3 Light section mill

This mill mainly manufactures round bars of small size and a small quantity of small angles. Its actual production is 45,000 ~ 55,000 t/y compared with the design capacity of 100,000 t/y. However, the monthly average down time due to lack of materials resulting from ironmaking and steelmaking problems is as much as 130 hours. If a sufficient amount of materials is supplied and this time is used for rolling, production will be increased to 65,000 ~ 70,000 t/y. Production of wire rods and bars in coil has been discontinued.

Assuming that the problem of the shortage of materials is solved in the future, the prime cause obstructing production in this mill is that mis-rolling is frequently caused by unstable rolling operation (yield ≒ 80%) and the monthly average product stoppage mainly caused by this amounts to 93 hours. Another factor is that rolling t/hr is as low as 10.5 t/hr because of one strand rolling on the continuous and finshing stands and low rolling speed of 3.5 m/sec at the finishing stand resulting from the manual operation on the entry side of No. 8 finishing stand.

In view of out-dated rolling facilities, enhancement of morale or posture toward more production among operators and improvement of their technical capability are urgently needed for realizing the design capacity with those facilities. Possible measures for this include training of operating techniques and technical guidance in similar plants in advanced countries.

3.3.1 Improvement of operation

(1) What to do as a first step is to reduce misrolling to ensure stable rolling operation at all times. To attain this, the technical level should be raised to make following operations possible.

a) To enable rolling operators to have full command of roller guides at the entry and delivery sides of rolling mills.

b) To enable rolling operators to adjust rolls and guides by visual inspection and examination of materials in rolling.

c) To make it possible to maintain and improve roll stands and their auxiliary equipment within the mill.

(2) As a second step, rolling t/hr should be improved.

a) Two strands rolling on continuous finishing rolls is effective in improving rolling t/hr.

b) As a measure to further improve rolling t/hr, a repeater can be used between Nos. 7 and 8 stands to increase the speed of rolls.

(3) Roll pass designs should be reexamined.

In order to ensure stable rolling operation for 13 mm round bars, which are one of major products of the mill, it is desirable to prepare cobble prints of each pass and to improve the pass designs.

4. Auxiliary Sector

4.1 Refractories

In Helwan Works, production troubles are frequently caused by refractories in various parts of the works, and solving problems relating to refractories is one of important tasks in the implementation of this rehabilitation plan. These important problems relating to refractories can be summarized in the following three items.

a) Basic policy toward refractories as a whole and the control system of refractories.

b) Dolomite plant

c) Ladle bricks

Problems in these items will be pointed out and their solutions will be described in what follows. It should be noted that the solutions discussed in the following include those measures which, from their nature, should be taken independently of this rehabilitation plan.

The first task at the moment is to eliminate production troubles caused by refractories to achieve stable and smooth steel production. The second task is to improve the performance of refractories through further betterments. To implement this, however, time and efforts will be required including accumulation of operating experience. It should be emphasized that great hopes are placed on the improvement of operation since the performance of refractories is largely affected by operating conditions.

4.1.1 Problems and causes

(1) The life of refractories as a whole is too short, thus constituting a large obstacle to production, particularly in ladles, blast furnaces and soaking pits.

(2) The poor performance is largely attributable to improper quality of refractories, and partly to poor workmanship in bricklaying as well as inadequate operating conditions of furnaces.

(3) A lot of problems can be pointed out in the equipment and processes as a whole in the dolomite plant ancillary to the Thomas converter plant. Particularly, the burning of dolomite in the shaft kiln is undesirable.

(4) The prime cause for inadequate quality of indigenous ladle bricks lies in their raw materials.

(5) A consistent technical control should be strengthened on the manufacture and purchase of refractories, bricklaying works and the operation of furnaces.

4.1.2 Possible improvements and measures to be taken

(1) It is desirable to study the measures to be taken in the future by classifying refractories into those for construction (to be used for blast furnaces and other furnaces which are used for a long time) and those for relining (to be used for maintenance in steelmaking, etc.).

(2) It is desirable, from the technical and economical point of view, that refractories for construction be imported at the time of construction of furnaces.

(3) As for refractories for relining, the stable supply of indigenous products is desirable, so the future study should be directed to this possibility. However, the home production of these refractories should be gradually pushed forward, taking into consideration the present state of raw materials and the level of manufacturing techniques. It is considered that there are not a few refractories that have to rely on imports for the time being.

(4) As for the manufacturing plant of dolomite refractories for converters and electric furnaces, it is a good policy to abandon the dolomite plant ancillary to the Thomas plant, which is now in operation and to concentrate the production to the dolomite plant now in operation for the new LD plant as this rehabilitation plan proceeds. In the fourth remodelling plan of steelmaking plant (alternative 4), a lange scale addition or remodelling of dolomite plant facilities appears unnecessary for the time being.

(5) As for improvement of the quality of other indigenous refractories (ladle bricks, etc.) and expansion of the types of indigenous products, it is desirable that further study will be made on another occasion inviting refractory manufacturers.

(6) It is desirable to strengthen functions required for consistently performing the control of the quality of refractories, furnace construction works and furnace operation.

4.2 Power and water supply

To maintain and increase production, it is absolutely necessary to meet energy requirements, but no particular problems cannot be found in this respect. As for the maintenance of the quality of energy, there are some problems in electricity. It is generally difficult, however, to quantitatively evaluate the effect of quality. Consequently, measures for maintaining the quality of energy will inevitably be secondary ones, but a long-range and wide view will be required in deciding such measures.

4.2.1 Application of blast furnace gas and blast furnace gas holder capacity

The capacity of blast furnace gas holder should be such that the minimum safety requirement can be maintained. The safety requirement depends on the length of the time required for shutting off gas supply in the event of sudden off-blast of blast furnace. Therefore the existing holder of 30,000 Wm^3 is sufficient to meet the safety requirement. It is rather necessary to reduce the time for shutting off gas supply.

4.2.2 Security of power supply

(1) Power failure

Power failures frequently occur, causing damage to production equipment and deterioration of production. The causes for power failures are inadequate power supply equipment, troubles in power receiving facilities due to low reliability of aerial line owned by electric power compaines, inadequate power supply equipment within the works, and inadequate receiving and distributing networks. In addition, poor control system aggravates the damage.

(2) Installation of a in-plant generator

Defective electrical equipment should be gradually replaced with new one of higher reliability as the occasion calls. In view of the fact that improvement of reliability in the power supply by power companies cannot be expected for the moment, and that the demand and supply situation of electricity is tightened in Egypt as a whole, it is desirable to improve reliability in power supply, to secure power for emergency use and to relieve the tightened power supply by installing a power plant within the works. As to the type of power plant, the gas turbine power generating system is recommended.

To install power plant inside the works site is not indespensable, but, if not installed, the preferential supply of power to the work and the installation of highly reliable receiving cable and network must be ensured.

4.2.3 Improvement of quality and temperature of recirculating water

(1) Addition of a cooling tower

The existing cooling tower capacity of 3, 000 m^3/hr is too low to cool recirculating water, which is estimated to amount to 5,000 m^3/hr when each plant is in full operation. Therefore it is necessary to add a cooling tower.

(2) Installation of oil separator

An oil separator should be installed to remove oil from recirculating water

(3) Installation of filters

Since there is only a natural sedimentation basin as a treatment equipment of recirculating water, the concentration of suspended solid is high. Therefore installation of filters is needed as a post-treatment process of the natural sedimentation basin.

(4) Installation of an independent recirculating system for blast furnace gas cleaning water

As cleaning water in the blast furnace gas cleaning process is mixed with general recirculating water in the same system, chlorine ions, calcium ions, zinc ions, etc. transferred from blast furnace gas to

the cleaning water contaminate the quality of the whole recirculating water. Taking into consideration the need to increase the amount of furnace cooling water for improvement of blast furnace equipment, it is necessary to install an independent recirculating system for blast furnace gas cleaning water.

(5) Replacement of deteriorated pipes

For water pipelines installed in and out of the plant, appropriate maintenance measures shall be taken, such as replacing them as part of the overall maintenance program in a well-planned manner according to the severity of deteriration of each pipe.

4.2.4 Reinforcement of utility equipment accompanying the rehabilitation plan

(1) Reinforcement of utility equipment relating to remodelling of Nos. 1 and 2 blast furnaces

Natural gas piping from the vicinity of No.4 G.R.P. and oxygen piping from No.2 oxygen plant shall be installed. The existing blowers shall be used as they are.

(2) Reinforcement of utility equipment relating to remodelling of converter plant

One each oxygen compressor shall be added to the existing capacity of No. 1 Oxygen Plant and No. 2 Oxygen Plant. In addition, oxygen line pipes from these oxygen plants shall be laid and oxygen holders shall be installed in the neighborhood of the Converter Plant.

The plan for installation of a 4,200 Nm^3/hr oxygen generator in No. 1 Oxygen Plant seems economically prohibitive since it will cost about US$ 7,000,000.

4.3 Transportation

Since on-the-spot investigation on transportation has not been conducted by transportation experts, the following comments are based on Helwan Works's reply to the questionnaire sent to Helwan Works.

(1) Transportation of major raw materials, semi-products and finished products heavily relies on railway transportation. The product shipment

route intersects the transportation route of main raw materials and semi-products. In preparation for increased traffic of trains in the future, traffic control by means of signalling facilities should be introduced at locations where trains intersect or crowd to make operation of trains efficient and to prevent accidents.

(2) The supply of main raw materials (especially, iron ore) is subject to great seasonal fluctuations. To cope with this, the check of materials inventories is needed.

(3) To cope with increased production in the future, the traffic of trains should be reduced by increasing the size of freight cars and locomotives.

(4) By use of self-loading/unloading type road vehicles, efficient and labor-saving transportation of miscellaneous materials, scrap, scale, crops, bricks, etc. is made possible.

(5) A marshalling yard for product shipment will be needed at the final stage of the plan.

V. MAIN SPECIFICATIONS OF EQUIPMENT

1. Sintering

(———— : Same as those of the existing equipment)

No.	Equipment	Item	Specifications after improvement	Specifications of the existing equipment	Remarks
1	Storage bins				
		For ore fines	————	8 bins x 103 m^3	
		For limestone	————	3 bins x 103 m^3	
		For mill scale	————	1 bin x 3 m^3	
		For return fines	————	2 bins x 144 m^3 (Hot) 25 m^3 (Cold)	
		For coke	————	3 bins x 103 m^3	
2	Mixer				
		Primary mixer	————	112 ~ 225 t/hr 2.8 mø x 6 mL	
		Secondary mixer	————	112 ~ 225 t/hr 2.8 mø x 6 mL	
3	Sintering machine				
		Surge hopper	————	20 m^3 with 130 t/hr feeder	
		Ignition furnace	————	6,941 mmL x 2,200 mmH, with 10 burners	
		Sintering machine	Addition of hearth layer materials hopper and gate; approx. 30 m^3	2 mW x 25 mL = 50 m^2 70 pallets 1.1 ~ 4.36 m/min, standard 3.0 m/min 2 mW x 1 mL, bed depth 300 mm	
4	Exhauster		5,000 m^3/min -1,200 mmAq, 150°C	3,500 m^3/min -760 mmAq, 150°C	
5	Other equipment				
		Hot crusher	————	125 t/hr 1 mmø	
		Hot screen	————	2 mW x 5 mL, mesh 6 mm	
		Cooler	————	60 m^3	
		Cold screen			
		(Primary screen)	180 t/hr 1.83 mW x 3.1 mL, mesh 20 mm	1.5 mW x 3.0 mL x 1 unit, mesh 8 mm	
		(Secondary screen)	140 t/hr 1.83 mW x 4.96 mL mesh upper 10 mm lower 5 mm		

No.	Equipment	Item	Specifications after improvement	Specifications of the existing equipment	Remarks
	Other equipment (cont.)	Dust collector	To be reinforced due to increase of negative pressure		
		Load cell	———	25 t/hr 2.1 mø x 3.0 mL	
			———	16 t/hr 0.9 mø x 1.0 mL	
		Burnt line receiving equipment	$65\ m^3$ x 1 Tank lorry with compressor		
		Sinter storage equipment	Tripper 1 unit Screen 1 unit		

2. Blast Furnace

No	Equipment	Item	After improvement	Existing equipment	Remarks
1	Blast furnace				
		Inner volume	623 m^3	575 m^3	Mantle will be replaced.
		Hearth diameter	5.7 m	5.1 m	
		Pig iron production	P_M = 600 t/d	400 t/d	
		Fuel rate			
		Coke rate	743 kg/t-pig (765 kg/t-pig)	921 kg/t-pig	( ): when natural gas is used.
		Oil rate	80 " (80 Nm^3/t-pig = 67 kg/t-pig)	66 "	
		Tap hole	————	1	
		Cinder notch	2	1	
		No. of tuyeres	————	10	
		Furnace supporting structure	————	Free standing	
		Furnace cooling equipment	Bosh ~ shaft: cooling plate (closed type) Hearth: water spray	Belly ~ shaft: cooling plate (open type) Hearth ~ bosh: water spray	
		Furnace-top charging equipment	————	2-bell type (with revolving hopper)	The existing equipment will be used.
		Top pressure	————	Low pressure (50 g/cm^2)	
2	Hot blast stove				
		Type	————	Cowper	
		No. of units	3/3 unit operation	2/3 unit operation	
		Blast temperature	Max. 1,050°C, normal 1,000°C	Max. 800°C, normal 700°C	
		Dome temperature	————	Max. 1,250°C	
		Allowable temperature of brick	1,300°C		Brickwork will be replaced.
		Heating area	Approx. 15,000 m^2/unit	Approx. 13,000 m^2/unit	
		Blast flow	960 Nm^3/min (910 Nm^3/min)	1,150 Nm^3/min (15 ~ 40% leakage)	( ): when natural gas is used.

No.	Equipment	Item	After improvement	Existing equipment	Remarks
2	Hot blast stove (cont.)	Oxygen volume	1,500 Nm^3/min (2,100 Nm^3/min)	No oxygen is used.	
		Hot blast main			A complete set of hot blast main will be replaced.
		Inner diameter	1,000 mmø	900 mmø	
		Thick. of lining	400 mm	250 mm	
		Shell diameter	1,800 mmø	1,400 mmø	
		Burner capacity	————	20,000 Nm^3/hr	
		Burner fan capacity	————	20,000 Nm^3/hr	
3	Charging equipment				
		System	————	Scale car, skip car	The existing equipment will be used.
		Scale car	12 t/charge x 7 charge/hr	12 t/charge x 6 ch./hr	Weighing frequency will be increased from 6 ch/hr to 7 ch/hr through work improvement.
		Coke weigher	————	5 t/batch x 2	
		Coke screen	————	30 t/hr x 2 (1,450 mm x 1,750 mm x 2)	
		Skip car	————	6 t/skip, 5 m^3/skip	28 skips/hr is possible if weighing can keep pace with skip cars, according to operating results in Ruhr.
			28 skips/hr	24 skips/hr	
4	Gas cleaning equipment	System	————	Dust catcher cyclone - spray tower - Theisen washer	The existing equipment will be used.
		Gas flow	150,000 Nm^3/hr/2 BFs	120,000 Nm^3/hr/2 BFs	
		Cleaning water treatment	Independent recirculation	To be used as general service water after 2-stage treatment	
5	Blower				
		Capacity	————	1,200 Nm^3/min	The existing equipment will be used.
		Wind pressure	————	1,200 g/cm^2	

3. Steelmaking

No.	Equipment	Item	After improvement	Existing equipment	Remarks
1	Converter equipment				
		Capacity	36 t x 2 units 1/2-unit operation		The specification of the Alt. 4 in which a new converter plant is to be constructed.
		Steel production	27,500 t/m		
			330,000 t/y		
		Tapped steel Yield	90.0%		
		Good ingot Yield	85.5%		
		Hot metal ratio	Average 93.0%		
			Maximum 100.0%		
			Minimum 85.0%		
		Availabity of converter	40.0%		
		Steelmaking time	41.5 min.		
		Breakdown:			
		Scrap charging	2.0 min.		
		Hot metal charging	2.0 "		
		Blowing (1)	10.0 "		
		Slag off	5.0 "		
		Blowing (2)	10.0 "		
		Temperature measurement and sampling	6.0 "		
		Tapping	3.0 "		
		Slag off	1.0 "		
		After blow	2.5 "		
2	Ingot-making equipment	Ingots	3.0 t x 12 ingots		
			4.0 t x 9 ingots		

4. Blooming Mill

No.	Equipment	Item	After improvement	Existing equipment	Remarks
1	Soaking pit				
		Type	-	Top one way combustion	
		Soaking capacity	375,400 t/y	195,500 t/y	
		No. of holes	12	8	
		Dimensions of hole	-	2,700 mmW x 5,100 mmL x 3,600 mmH	
		Maximum heat input	-	364 x 10^4 Kcal/hr/hole	
		Fuel	-	Blast furnace gas + heavy oil	
		Average heating time	4.68 hr	3.78 hr *1	* 1 Estimated
		Average weight of ingots to be charged	33.5 t/hole	30 t/hole *1	"
		Cold ingot ratio	10%	42% *2	* 2 Actual results in Nov., 1976
2	Soaking pit crane		3.3 t x 2 unit, 4.0 t x 1	3.3 t x 2 units	One unit will be added.
3	Rolling mill				
		Rolling capacity	408,600 t/y	214,200 t/y	
		Rolling T/H	68.1 t/hr	42.0 t/hr	
		Mill motor	-	4,300 kW, 0 66 120 rpm	
		Dimensions of roll	-	900mmø x 2,200 mmL	
4	Shear	Shearing force	-	700 tons	
		Shearing yield rate	88.0%	85.0%	
5	Claw crane		-	10 t x 1 unit	

5. Heavy Section Mill

No.	Equipment	Item	After improvement	Existing equipment	Remarks
1	Reheating furnace	Cold bloom reheating capacity	40 t/hr	20 t/hr	
		No. of units	40 t/hr x 1 unit or 20 t/hr x 2 units	1 unit	
		Type		3-zone, pusher type	
2	Rolling mill				
		Type and No. of units	Walking beam (at new construction)	Open top type reversing 2 high x 3 units	One unit is capable of breakdown rolling
		Rolling capacity	Over 180,000 t/y	65,000 t/y	
		Rolling efficiency	Over 30 t/hr	17 t/hr	
		Yield	87.9%	82.0%	
		Mill motor	-	DC2,315 kW, 0~62.5~120 rpm x 1 unit	
			-	DC3,320 kW, 0~89.5~160 rpm x 1 unit	
3	Sawing machine				
		No. of units	-	2 units	One of the existing machines is not used.
		Motor	-	AC185 kW, 1,000 rpm	
		Stroke	-	900 mm	
4	Cooling bed				
		Width x length x No. of units	-	17 m x 12 m x 3 beds	One of the existing beds is not used.
5	Shearing machine				
		Capacity	-	150 t	
		Maximum shearing cross section	-	100 φ or 19 x 300	
		Shearing cycle	-	20 cuts/min	
6	Straightening machine				
		Type x No. of units x motor capacity	-	Double housing type x 1 unit, 28 kW x 2 Cantilever type x 1 unit, 125 kW	
7	Bloom handling crane		10^t x 1 unit	–	One unit will be added at bloom yard bay

6. Light Section Mill

No.	Equipment	Item	After improvement	Existing equipment			Remarks
1	Reheating furnace						
		Type	-	3-zone (upper heating zone only), pusher type			
		Reheating capacity	-	25 t/hr			
		No. of units	-	1 unit			
2	Rolling mill	Name of stands		Roughing	Continuous	Finishing	
		Type	-	Open top type 3 high	Closed top type 2 high	Open top type 2 high	
		No. of units	-	1	4	4	
			-		4	2 2	
		Motor capacity	-	AC 1,070 kW	AC 1,840 kW	AC 515 kW	
		Revolution of motor	-	370 rpm	990 rpm	985 rpm	
		Revolution of rolls	-	82 rpm	#1 58.1rpm #2 86.5 rpm #3 131rpm #4 200 rpm	#5 200 rpm #6 200 rpm #7 210rpm #8 210rpm	
		Rolling efficiency	19 t/hr	10.5 t/hr			
		No. of strands	2 strands	1 strand			
		Yield	87.7%	80%			
3	Shearing machine						
		Hot steel shear	-	1 unit, motor capacity AC 22 kW			Rear of rougher.
		Flying shear	-	1 unit " AC 47 kW			In front of continuous rolling mill.
		Hydraulic rotary shear	-	2 units, " DC 4.5 kW			In front of cooling bed.
		Cold steel shear	-	1 unit, " AC 15 kW			For shearing finished products, rear of cooling bed.
4	Cooling bed	Type	-	Shuffle notch type x 1 bed			
		Size	-	50 m x 7.4 m			
5	Straightening machine	Type and No. of units	-	Cantilever type, 9-roller 1 unit			
		Motor capacity	-	AC36 kW			

7. Auxiliary Sector

No.	Equipment	Item	After improvement	Existing equipment	Remarks
1	(BFG holder)	Capacity x No. of units Type Pressure	Addition 50,000 Wm^3 x 1 Dry type 600 mmAq	30,000 Wm^3 x 1 Dry type (DEMAG, DISC) 300 mm Aq	Expected deficiency in BFG supply is estimated assuming: gas cutting off time 10 min adjustment for variable consumption 33,800 Nm^3; surplus for emergency 1,000 Nm^3.
2	Gas turbine power plant Gas turbine				
		Type No. of units Rating	Outdoor, dust-proof, open cycle 2 units Output (at generator terminal) Peak load 19,100 kW Base load 17,790 kW Heat consumption rate (at generator terminal) Peak load 3,331 Kcal/kWH Base load 3,387 "		To be installed near M.S.D.I. - 1. Standard type of gas turbine varies with its manufacturer. An example is shown here for your reference. here for reference. Ambient temperature 15°C Atmospheric pressure 760 mmHg
	Generator				
		Type No. of units Voltage, frequency Rating	Outdoor, dust-proof type 2 units 6 kV, 50 Hz Peak load: 22,500 KVA (19,125 kW) Based load: 21,060 KVA (17,900 kW)		Ambient temperature 15°C Atmospheric pressure 760 mmHg
	Other equipment				
		Natural gas piping Power transmission line	6 atg 200 mmø x 100 m 6 kV 1 c x 800 mm^2 2 circuits		
3	Blast furnace oxygen supply equipment				
		Booster Oxygen piping Oxygen enrichment equipment	4,300 Nm^3/hr 3 ata (500 mmAq) 2 atg, 250 mmø, 1,600 m 2,200 Nm^3/hr x 2		

No.	Equipment	Item	After improvement	Existing equipment	Remarks
4	Blast furnace natural gas supply equipment	Oxygen piping	6 atg, 125 mmø x 400 m		
		Decompression device	2,000 Nm^3/hr x 2		
5	Converter oxygen supply equipment	Oxygen holder	34 atg; 150 Wm^3 x 2		These holders will be installed near the Converter Plant.
		Compressor	2,200 Nm^3/hr and 34 atg x 1		For No. 1 Oxygen Plant
		Oxygen piping	34 atg, 65ø x 800 m		"
		Compressor	2,200 Nm^3/hr and 34 atg x 1		For No. 2 Oxygen Plant
		Oxygen piping	34 atg, 80ø x 2000 m		For No. 2 Oxygen Plant (The pipe rest for oxygen line pipes to Nos. 1 and 2 BFs will be used also for supporting this line pipe for the length of 1600 m.)
6	Old steelmaking plant sub	Receiving line	-	2 circuits for receiving electricity	
			6 kV $CV3^c$ x 250 mm^2 x $2/1^{cct}$	6 kV 3^c x 150 mm^2 x $4/1^{cct}$	
			1,000 m	Approx. 1,000 m	
		Substation	Outdoor, dust-proof, metal clad	Indoor conpertment	
			-	Double bus	
			-	Feeder	
			-	5 for 6 kV	
			-	2 for transformer	
			-	1 for bus connection	
			-	Transformer, 6/0.46 kV, 1250 KVA x 2	
			Control system:	Control system:	Remote supervisory and controlling will be performed at M.S.D.S. - 1.
			Remote supervisory and controlling system by direct control	On-the-spot supervision	
7	Recirculating water system				
	Cooling tower	Capacity	5,000 m^3/hr	3,000 m^3/hr	
		Type	Mechanical draft type		
	Filtering equipment	Capacity	5,000 m^3/hr		
		Details of equipment			
		Pressurized extra rapid filter	11 m^3/min x 8 units		
		Thickener	22 mø x 1 unit		
		Vacuum dehydrator	30 m^2 x 1 unit		
		Filtering backwash pump	15 m^3/min x 20 m x 2 units		

No.	Equipment	Item	After improvement	Existing equipment	Remarks
	BFG cleaning water recirculating equipment	Capacity	750 m^3/hr		
		Details of equipment			
		Circular radial flow settling basin	20 mø x 1 unit		
		Vacuum dehydrator	18 m^2 x 1 unit		
		Water feed pump	6.5 m^3/min x 40 m x 3 units		

VI. EQUIPMENT REMODELLING COSTS

Estimated costs for equipment remodelling are shown in Table 9.

1. Prerequisites for Estimation

a) Cost estimates were based on the assumption that all the equipment and materials required for remodelling are imported from Japan. Construction costs were estimated based on the past construction results in Japan.

b) Prices of equipment and construction materials (CIF basis) were based on the recent purchase results.

c) CIF conversion coefficients

Machinery	1.226
Electrical equipment	1.202
Instrumentation	1.281
Brick (for BF)	1.315
Brick	2.401
Steel structures for buildings	1.320

2. Total Cost for Remodeling

Without construction of blast furnace gas holder; US$50,707,000

With construction of blast furnace gas holder; US$53,397,000

Conversion rate; 1 US$ = 290 yen

3. Other Cost

Specialists' cooperation will be necessary for the future works, namely detailed engineering, construction, start-up operation etc. to promote this rehabilitation plan effectively.

The consultant fee for these works are generally considered to account for about 7% of the total cost.

Consultant fee; US$ 3,500,000

4. Utilization of the Machine Shop

In the implementation of the Rehabilitation Plan, the machine shop must be made use of for minimizing the purchase of spare parts etc..

The improvement of designing and drafting capacity is essential for this purpose.

Table 9 Estimated costs for equipment remodelling

Unit ; US$1,000

Plant	No.	Equipment to be remodelled	Equipment & materials cost	Installation cost	Total	Remarks
Sintering plant	1	Measures for increasing negative pressure	321	621		
	2	Remodelling of screening system	755	474		
	3	Burnt lime adding equipment	154	127		
	4	Sinter storage equipment	200	91		
	5	Hearth layer materials hopper equipment	40	8		
		Subtotal	1,470	1,321	2,791	
Blast furnace plant	1	Blast furnace (2 units)				Scope of estimate
		Dissection	0	236		Blast furnace:
		Steel structure	1,732	556		Dissection
		Brick	2,558	664		Replacement of shell
		Instrumentation	36	14		Replacement of cooling equipment
	2	Hot blast stove (6 units)				Replacement of brickwork
		Stove brick (4 units)	2,342	1,782		Hot blast stove:
		Checker supporting hardware	254	104		Replacement of stove brickwork
		Hot blast pipeline : steel structure	230	150		Replacement of checker support
		" : brick	298	198		Replacement of hot blast pipeline (stove outlet - goose neck)
		Subtotal	7,450	3,704	11,154	Replacement of brickwork
Steelmaking plant	1	Converter	2,976	486		Replacement of pipes
(Prices for the Alt. 4)	2	Raw materials equipment	2,593	490		
	3	Ingot-making equipment	697	76		
	4	Exhaust gas treatment equipment	5,390	924		
	5	Cranes	3,063	441		
	6	Electrical equipment	362	100		
	7	Water supply facility	0	121		
	8	Civil work	0	1,379		
	9	Construction work	2,007	1,131		
		Subtotal	17,088	5,148	22,236	

Table 9 (cont.)

Plant	No.	Equipment to be remodelled	Equipment & materials cost	Installation cost	Total	Remarks
Blooming mill	1	Addition of soaking pits	2,100	1,449		
	2	Soaking pit crane	186	38		
		Subtotal	2,286	1,487	3,773	
Heavy section mill	1	Reheating furnace	2,340	814		
	2	Bloom handling crane	127	17		
		Subtotal	2,467	831	3,298	
Utilities	1	Blast furnace gas holder	1,825	865		
	2	Oxygen distribution equipment for blast furnace	507	514		
	3	Natural gas distribution equipment for blast furnace	25	111		{ Estimated cost required to construct
	4	Oxygen distribution equipment for converter	1,880	317		additionally a 4,200 Nm^3/hr oxgen
	5	Relocation of converter substation	403	176		plant : US$ 6,964,000
		Subtotal	4,640	1,983	6,623	( ) : When the blast furnace gas holder is
			(2,815)	(1,118)	(3,433)	not constructed.
Water supply	1	Cooling tower equipment	180	126		
	2	Oil separator	170	110		
	3	Filtering equipment	1,300	846		
	4	Recirculating equipment of blast furnace dust collecting water	420	370		
		Subtotal	2,070	1,452	3,522	
		Grand total (without the construction of blast furnace gas holder)	35,646	15,061	50,707	
		(with the construction of balst furnace gas holder)	37,471	15,926	53,397	

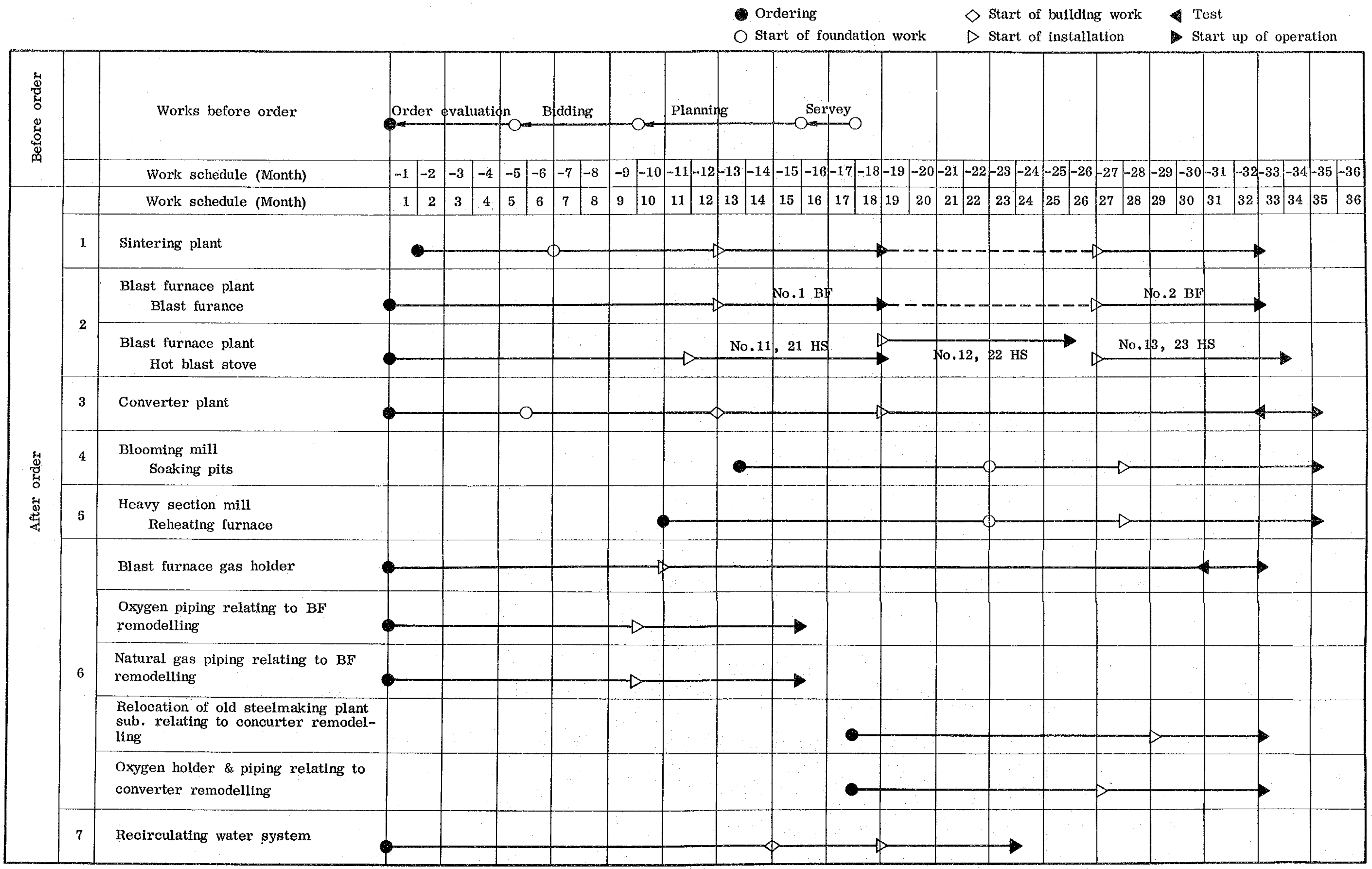
VII. EQUIPMENT REMODELING SCHEDULE

Table 10 shows the remodelling schedule for each equipment. Works before order are in accordance with the standard procedures in international biddings. As for works after order,

(1) Works relating to converter remodelling are scheduled to keep pace with the startup of the converter.

(2) Remodeling works to be carried out independently of converter remodeling are scheduled to their specific conditions.

Table 10. Equipment remodelling schedule



DETAIL

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IV. AUXILIARY SECTOR

I. IRONMAKING

1. Sintering

1.1 Improvement of operation

1.1.1 Raw materials and fuel for sintering

(1) Grain size of raw materials and fuel

1) Influence of grain size

Sintering is a process in which solid and liquid state reactions are induced through heat energy generated by the combustion of coke. For combustion of coke, it is desirable to keep the permeability of the sinter bed good, and in that sense, fine sized raw materials that impair permeability are undesirable. Conversely, for increased formation of bonding substances which serve to raise production yield and product strength, it is desirable that thermal reaction be great, or that there be numerous fine sizes to create a large specific surface area.

Thus, sintering involves in itself requirements regarding the size of feed ores conflicting with each other from considerations of permeability, on one hand, and yield and strength, on the other.

The "mixing and balling of materials" to be done prior to sintering is intended to satisfy these conflicting requirements simultaneously.

Generally, coaser materials produce higher permeability and higher rate at which coke is burnt, with the result of improved productivity of sinter at least up to a certain level. Beyond this marginal point, however, they rather produce reduced strength of product sinter because of reduction in the intergranular contact area and the relative shortage in the amount of melt produced. To overcome this, addition in increased amounts of coke, an increase of gangue components such as SiO_2, CaO, CaO/SiO_2 and FeO and an increased bed depth become necessary.

Fig. I.1 shows the effects of coarse particles on productivity and strength.

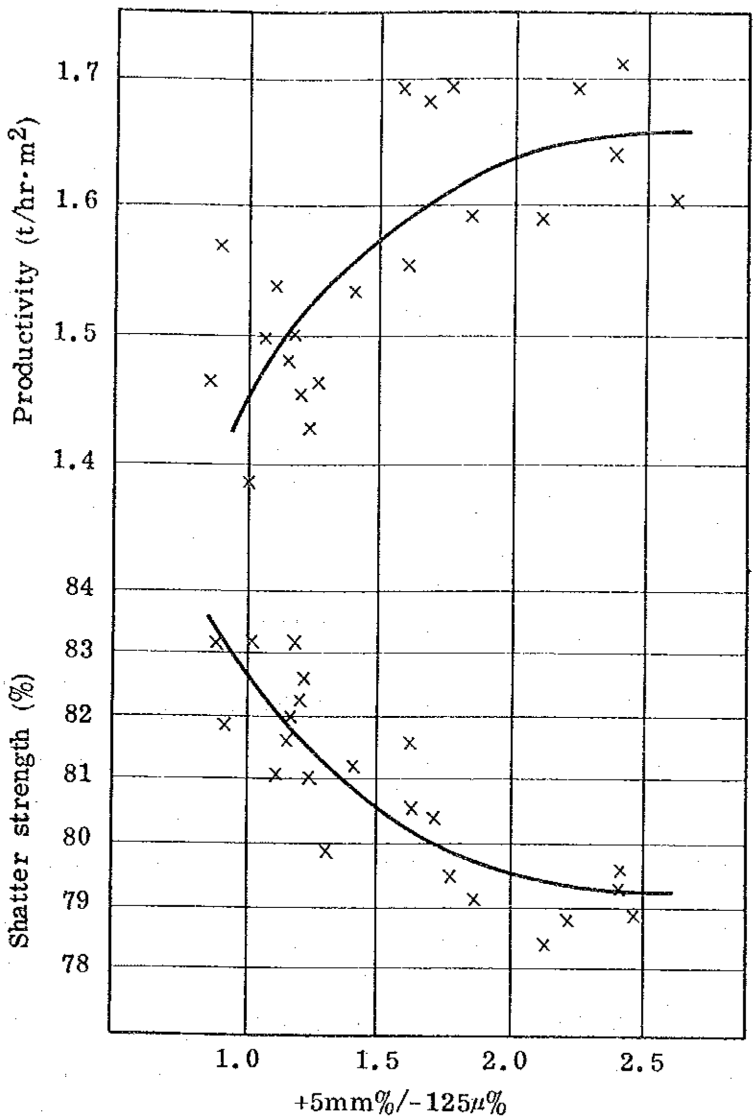


Fig. I.1 Effects of coarse particles on productivity and strength (Hirohata No.1 sintering machine)

Increased proportions of fine particles in the sinter mix, or the increase of specific surface area, on the other hand, lower the sinter productivity linearly as shown in Fig. I.2.

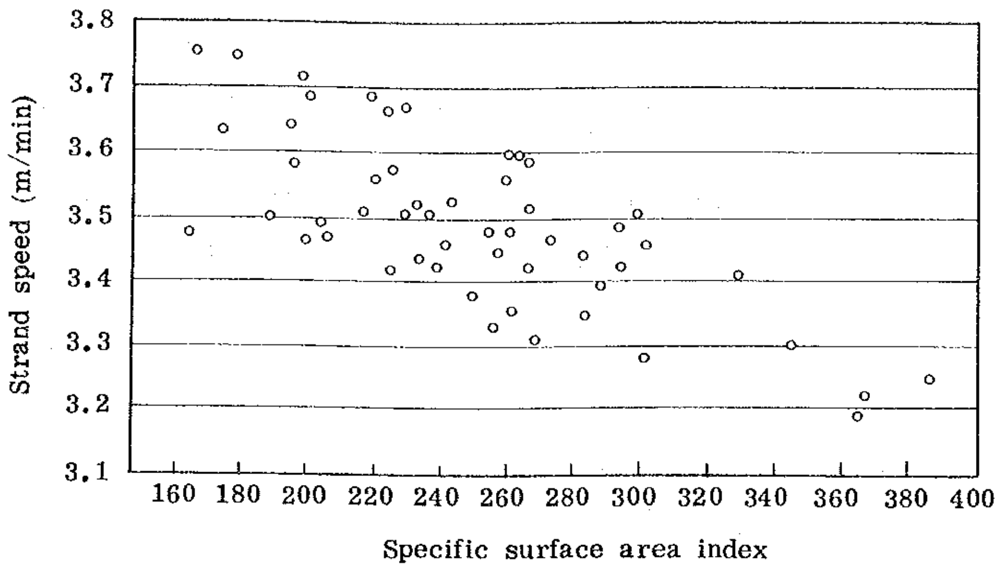


Fig. I.2 Relation between specific surface area index and strand speed

Fig. I.3 indicates a linkage of the sintering process factors occurring when the average grain size of sinter mix decreases. The cause and effect are:

a) Decrease in the average grain size of the sinter mix lowers the permeability of the sinter bed and results in not only lack of uniformity in air flow but reduced volume of air sucked down through the bed.

b) This, in turn, leads to increased generation of return fines and reduced flame front speed, thus reducing the productivity.

c) To overcome the resulting spotty burning, the bed depth needs to be decreased.

d) The decreased bed depth, however, means an increase in the relative proportion of the upper, brittle part of the bed, a factor for reduced strength and productivity of sinter.

e) To obtain improved sinter strength, it becomes necessary to increase the coke blending ratio.

f) The increased coke blending ratio raises the FeO content of sinter to the detriment of reducibility of sinter as blast furnace burden.

g) The increased coke blending ratio also causes further deterioration in the permeability of the sinter bed.

The above-mentioned vicious cycle can be reversed by increasing the average grain size of the sinter mix.

The above description may be somewhat circuitous. But the description was made from the judgment that the sinter feed available for use at Helwan Works have problems associated with both coarse and fine particles.

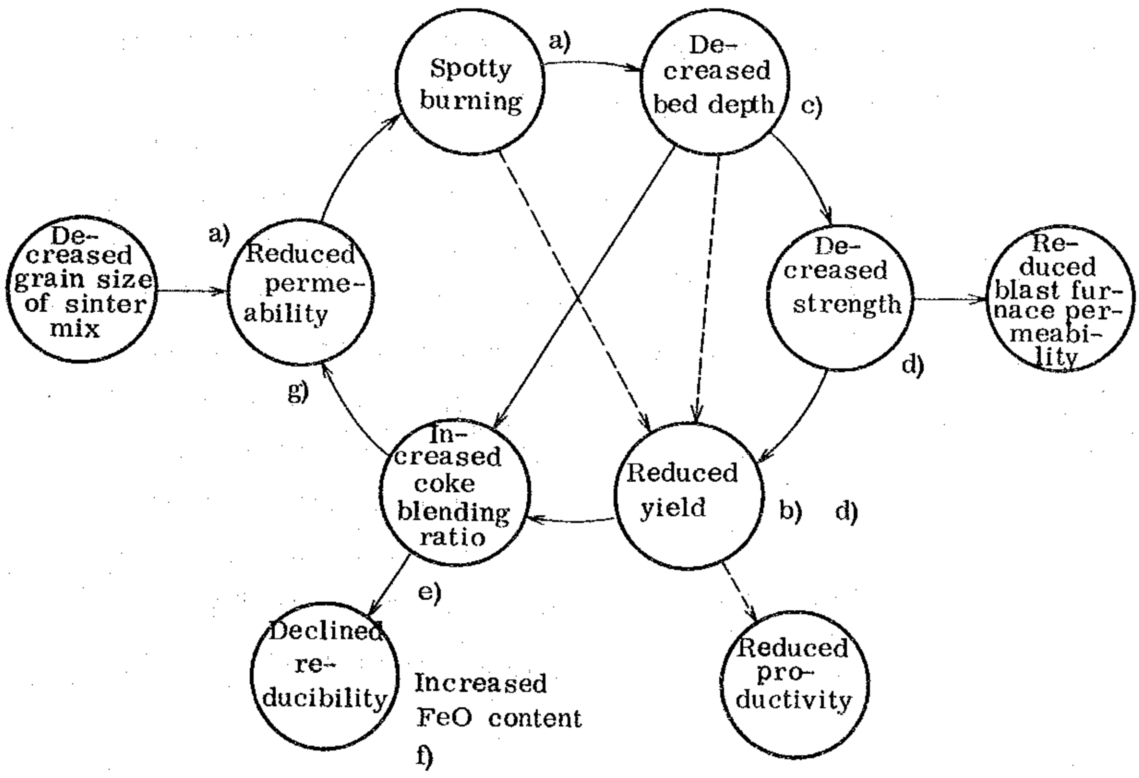


Fig. I.3 Linkage of sintering process factors

2) Fine ores

Since the fine ores contain approximately 12% of 10-mm or more coarse particles, it seems necessary to select an appropriate size of screen mesh and carry out preparation in a closed circuit.

Though the precise ratio of fine particles is not sure quantitatively because no detailed data are available on the screen analysis of the fine ores available at Helwan Works, the observation of the ores at mining site indicates a considerably high ratio of fines. It seems therefore necessary to improve the quasi-grain size distribution through intensified balling.

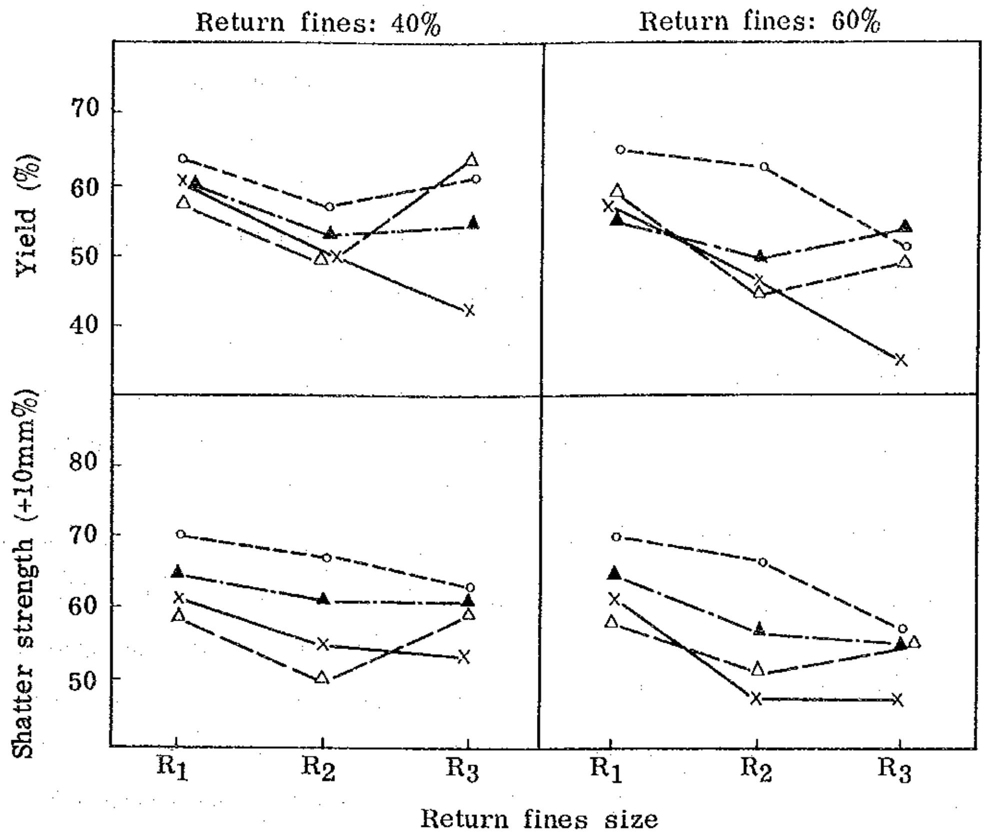
3) Return fines

The meshes of hot and cold screens currently in use at Helwan Works are 6 mm and 8 mm wide (slit), respectively. This comparatively large mesh size has made it inevitable that not only return fines generation at a high rate but also as high as about 55% of the return fines are coarse particles measuring 5 mm or more in size.

The mesh size is determined by the grain size of sinter requested by blast furnaces. It can be said that use of extremely coarse mesh size makes it inevitable to use coarse return fines as sinter feed, thereby deteriorating the quality of sinter produced.

Return fines usually contain 5 to 15% of plus 5-mm size particles. The plus 5-mm particles should be recovered by the use of screens with an appropriate mesh size, and simultaneously measures should be taken to improve the screening efficiency so that fines cannot mingle into the product sinter. It is sure that this measure, if taken properly, will lead to improved yield, increased productivity and reduced fuel consumption.

Fig. I.4 shows the result of experiment, using a pot grate for tests, of the influence of return fines size under a constant return fines blending ratio.



Return fines size	R_1	R_2	R_3
(mm)	-5	5/7.5	7.5/10

× Coke 2.5%
△ 〃 3.0%
▲ 〃 3.5%
○ 〃 4.0%

Fig. I.4 Effects of return fines size on the yield and the shatter strength

4) Limestone

It is generally said that the most suitable average size of limestone is 1.4 to 1.6 mm.

Limestone available at Helwan Works contains approximately 10% of plus 5-mm size particle. The proportion of the plus 5-mm size particles should be minimized. However, the limestone seems to be best sized of the raw materials and coke for sinter at Helwan Works.

(2) Grain size of coke

The size of coke has a vital effect on the sintering operation.

Finer coke has better igniting property compared with coarser coke. Especially, coke larger than 5 mm is not desirable in this respect.

However, when coke size is too fine, faster combustion speed shortens the high-termperature period, though the temperature attained is higher. On the contrary, when coke size is too coarse the temperature attanined is lower, the combustion time is longer and the coke distribution in the sinter bed is worse. As the result, the lower portion of the bed is sometimes fused on the grate.

Considering the above-described conditions, coke size is generally determined as minus 3 mm and average size is aimed at 1.1 to 1.4 mm. Of course, any suitable size of coke should be determined in consideration of various properties of ores used, particularly grain size, and the capacity of the exhauster employed.

The fine coke at Helwan Works is said to contain about 15% of plus 3 mm coke and even 25 to 30 % in some cases where the coke has an extra-ordinarily high moisture content.

Viewing from the fact that no hearth layer is used at Helwan sintering plant and the bottom portion of the sinter bed sticks heavily to the grate, it seems necessary to intensify crushing of coke for easier sintering operation.

The most realistic approach would be to size the coke to about 1.1 mm on an average for the time being and set later the optimum size through tests with cokes of various average sizes ranging from 1.2 mm to 1.4 mm or more. If coke crushing is done using a rod mill, it is important to select properly the unit weight and overall weight and hardness of the rod, rpm of the mill and linings in the mill, to control properly the coke feed rate into the mill and to avoid unloaded operation of the mill in order to prevent extraordinary wear of linings, since the crushing efficiency depends largely on those factors. Along with this, intensified daily operation control will essentially be required.
Table I.1 shows relation between coke size and various sintering factors.

Table I. 1 Relation between coke size and various sintering factors

	Permeability	Bulk density	Distribution	Ignition	Necessary air	Combustion speed
Coarse	Good	Good	Not good	Not good	Great	Low
Fine	Not good	Not good	Good	Good	Little	High

1.1.2 Sintering operation

(1) Proportioning control

The grain size distribution, properties and the blending ratio of return fines have various effects on the sintering process. What Helwan Works should pay particular attention to is control of the proportion of return fines. At Helwan Works, the proportion of return fines varies to a very large extent. This means wide amplitude of variation in sintering conditions. It is considered very important for Helwan Works, therefore, to take suitable actions by clarifying the cause of the wide variation in the generation of return fines and intensifying control of the stock level in the return fines hopper to maintain the proportion as constant as possible.

(2) Moisture control

At present, no moisture measurement of sinter mix is performed at Helwan Works, and moisture control is done only by operator's discretion. Therefore, consistent control cannot be achieved.

Moisture in sinter mix greatly affects permeability at the sinter bed. Both excessive and deficient moisture contents result in low productivity and poor quality.

It is needless to say that fine adjustment be made according to the sintering conditions prevailing, though it is generally believed that the optimum level of moisture content of the sinter mix is somewhere 0.3 to 0.5% lower than the moisture content which will provide the highest permeability. At Helwan Works, the moisture content is controlled by a primary mixer to 5% and by a secondary mixer to 8 to 12%. It is necessary to check again whether these represent optimum levels. Of course, an automatic moisture control by means of a neutron moisture gauge is most desired. But, for simplification, it is advisable to measure moisture content at a rate of once every two hours using the infrared moisture gauge.

The measuring instrument by infra-red ray is composed of drying furnace and measuring apparatus, and its cost is approximately US$3,000 (on Japanese basis).

(3) Hearth layer

No hearth layer is used at Helwan Works. But it is better to employ the hearth layer over the grate.

The purposes of hearth layer on the grate bars are as follows:

a) To prevent fine sinter mix dropping through the slits of grate bars.

b) To prevent sticking of sinter on the grate bars and to alleviate the thermal load on grate bars.

c) To prevent clogging of grate and to ensure uniform distribution of suction air.

Accordingly, when the hearth layer is made thin, the above described effects decrease and trouble may result. On the contrary, if the hearth layer is made too thick, the productivity decreases. Optimum thickness of hearth layer is to be determined on the basis of size distribution of materials for the layer while observing the above-described conditions. Desirably, however, it will be preferable to adopt a 20 mm thick layer of 10 to 20 mm sinter as the hearth layer materials.

(4) Charging control

Charging should be done gently. It is desirable to make the inclination angle of the tilt board as small as possible if the board is of an inclination adjustable construction.

Charging in the width direction of the sintering machine should be done uniformly and the charging surface should be kept flat in order to ensure good ignition, uniform sintering and high quality of product sinter. Furthermore, care should be taken to keep clean the drum feeder and tilt board, on which ore fines tend to build up, to assure uniform charging in the width direction.

Also of great importance is to maintain the grate bars at the best condition at all times so that no hole can develop in the sinter bed due to the drop of ores through the grate gaps. Much air tends to pass near the side wall of the pallet, therefore material feeding near the side walls should be done carefully so as the lack of feeding to this portion does not occure.

To sum up, the consideration of Helwan Works should be given to intensification of the control of charging practice.

(5) Thermal input for ignition

The purpose of the ignition furnace is not only ignition but also sintering the surface of the sinter bed. Generally speaking, the upper part of the sinter bed is poor both thermally and in strength, compared with the middle and the lower parts of the bed, and is held to contain the most of what becomes return fines. For this reason, the ignition strength and calorific value of fuel should be made as high as possible so that the temperature at the upper part of the bed is made higher. Needless to say, there is an appropriate range of ignition temperatures, as excessively high ignition temperature melts the surface of the bed and causes poor permeability. Generally, the required calorific value for ignition is 40,000 - 50,000 Kcal/t-sinter. It is desirable to control the ignition temperature at 1,200 - 1,250°C at about 1,000 mm above the surface. The igniting conditions at Helwan Works appear not so bad, but the ignition furnace is operated on a more or less rule-of thumb basis. Temperature control should be done more accurately using well-maintained pyrometers.

(6) Sintering

According to the observation of your sintering operation, the sinter bed thickness is kept constant and also the strand speed is not varied.
But the properties of materials constantly vary and some action is needed to cope with this situation. Judging from the daily report, appropriate action seems not to be being taken.

However, appropriate controls such as strand speed, moisture and fuel blending ratio, etc. should be carried out by judging the sintering conditions on the basis of information such as observation at the discharging end, wind box temperature and pressure, exhaust gas temperature and so on.
In addition, it seems that coke is added in excess at Helwan Works.
Sinter mix containing coke in excess reaches 1,400°C at relatively upper part and begins to be slagged. The result is reduced air supply or quenched bed in some extreme cases with coke at the lower part left

unburnt. (Fig. I.5)

Radical actions should not of course be taken, but the percentage of coke addition should be reduced step by step.

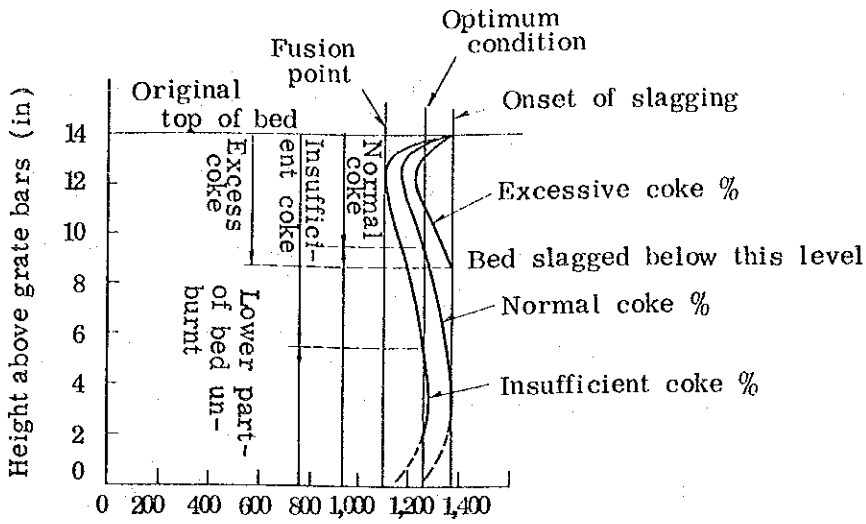


Fig. I.5 Yield of acceptable sinter related to coke control

The sintering machine at Helwan Works produces air leak to a considerable degree apparently due to improper maintenance. The maximum temperature of the wind box won't be below 300°C if the air leak is kept at a normal level. Ideally, the max. temperature of the wind box should be 350°C or so, and the burn-through point be at the location of No.12 wind box.

(7) Quality control

The fluctuation in the quality of sinter which is about 100% of the blast furnace burden, directly connects with the fluctuation of blast furnace conditions. To ensure stabilized blast furnace conditions, it is most important to detect fluctuations in composition and physical properties quickly and take necessary action. If such information as production of irregular quality sinter is given quickly, the blast furnace operation side can take necessary action most appropriately. It is pointed out that the amount of information is very little at Helwan Works, so it is very

difficult to take action needed. It is suggested that a testing system to provide appropriate information should be established very shortly.

To this end, measurement of the grain size and shatter strength of sinter should be done at least twice per shift. It is desired that the sinter have the shatter index around 82%.

Also, the grain size measurement of coke, limestone, ores, sinter mix and return fines should be carried out using increased number of screens with mesh sizes 10, 5, 3, 2, 1, 0.5, 0.25 and 0.125 mm. It is also to be taken care of that the FeO content of sinter be within ±1% of the aimed value. The aimed value of the FeO content should be 10% for the time being, and it is desirable for higher reducibility to lower the level of the aimed value gradually while observing the quality of sinter.

(8) Slag constituents

1) Effects of SiO_2

At a given basicity, any excess or deficiency in the SiO_2 content of the sinter mix affects adversely the yield and productivity, as indicated in Fig. I.6.

In case of low-SiO_2 sinter mix at a given basicity, limestone is added in smaller amounts. The result is production in smaller amounts of FeO-SiO_2-base melt and calcium-ferrite-base melt which are produced with a relatively small amount of thermal input; metallurgical bonding depends largely on the diffusion bonding of FeO which requires a comparatively large amount of calorie. This, as a logical consequence, requires an increased amount of coke to be added to the mixture, thus causing a reduced productivity.

High-SiO_2 sinter mix, on the other hand, contains larger proportions of SiO_2 and CaO at a given basicity. The metallurgical bond in this case comes mainly from the FeO-SiO_2-base slag and calcium-ferrite-base melt. Any excess in the production of these melts will hamper the permeability of the sinter bed and uniform sintering, with the result of a lowered yield and reduced strength of the product sinter. Further, glass produced from overcooled melts acts to weaken sinter. Higher SiO_2 content will result in increased production of such glass.

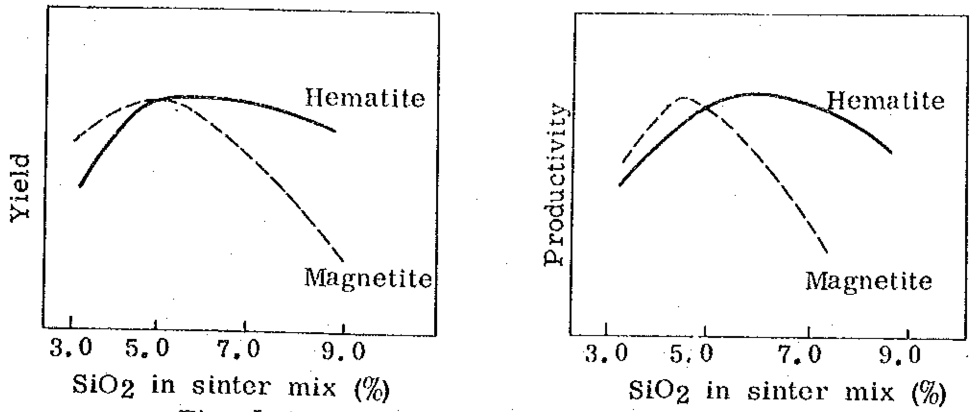


Fig. I.6 Effects of SiO_2 in sinter mix on yield and productivity

At varied basicities, on the other hand, the relation between SiO_2 and CaO to obtain the best sinterability (yield and productivity) can be expressed as shown in Fig. I.7. So far as the sinter yield is concerned, lower basicity is desired at higher SiO_2 contents while higher basicity at lower SiO_2. This means that the production of slag must be maintained at an appropriate level. With regard to productivity, however, a certain level of CaO content is required over a substantial portion of the SiO_2 content range.

The above considerations indicate that the increased basicity, if attempted at Helwan Works, will make it rather difficult to produce high-quality sinter.. Raising the basicity of sinter will require prior tests on quality in a test pot.

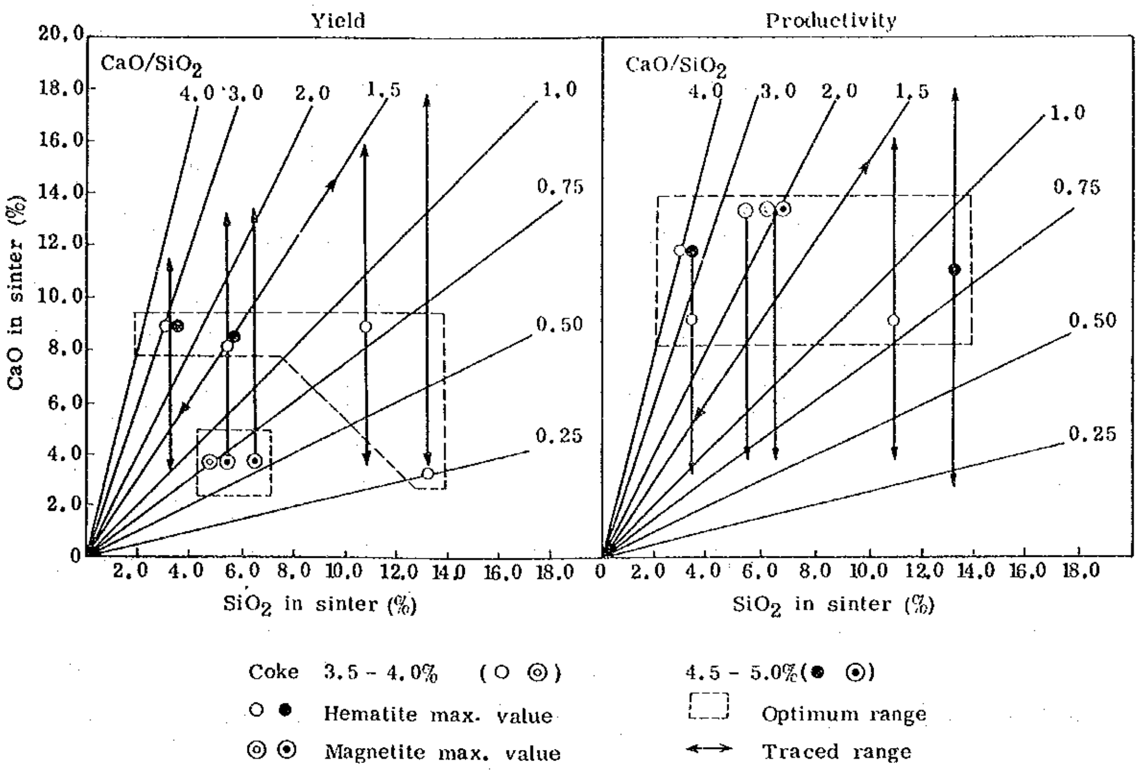


Fig. I.7 Effects of SiO_2 and CaO on sintering operation (basicity: 0.2 - 4.0)

2) Effects of MgO

Addition of MgO tends to decrease the yield and strength. The mechanism of this is assumed to be as follows:

In the ordinary sintering process which depends largely on the reaction of CaO, MgO cannot react adequately because of insufficiency in calorie available and, as a result, is left unreacted in the system. This causes weak points in the sinter structure to the detriment of the yield and strength.

To recover the loss in the yield and strength, increased addition of coke becomes necessary to increase the heat for sintering.

If heat is given in sufficient amounts to expedite MgO to react, however, the CaO slag system has heat in excess so that non-crystalline slag is produced in increased amounts also to the detriment of the yield and strength.

If situation requires addition of MgO, therefore, it is essentially desired that some relatively coarse additives which contain a high percentage of MgO and are hard to react with such sinter constituents as SiO_2, FeO and Fe_2O_3 be used.

Dolomite is not desirable as a source of MgO since it, if added to the sinter mix, will substantially decrease the yield and productivity.

1.1.3 Equipment control

At Helwan Works, the availability* of sinter plant was only 56.2% on an average over a year from November, 1975 to October, 1976. During the period there were months in which the plant shut-downs were induced by the blast furnace bankings. Even the normal months, however, it was only two months that the plant was operated at the availability of 70% or more in that period.

These figures are too low compared to the average availability of sinter plants in Japan, 93 to 98%.

The breakdown of the down-time at Helwan Works between August and October, 1976 is shown in Table I.2.

$$* \text{ Availability} = \frac{\text{Operating hour}}{\text{Calender hour}} \times 100 \ \%$$

Table I.2 Causes of shut-down and down time

	Aug.	Sept.	Oct.	Total	%
Scheduled shut down time	80-00	64-00	128-00	272-00	15.0
Extension of scheduled shut down time	104-30	29-30	35-20	169-10	9.3
Mechanical	140-00	473-15	56-10	669-25	36.8
Electrical	42-10	9-20	13-50	65-20	3.6
Instrument	0-40	0-30	-	1-10	0.0
Refractories	-	-	28-30	28-30	1.6
Preceding production line	124-25	53-15	66-20	244-00	13.4
Lack of water	9-25	4-25	22-35	36-25	2.0
High tension	9-10	-	1-15	10-25	0.6
Civil work	-	2-35	-	2-35	0.1
Sinter transportation car	79-00	34-45	51-25	165-10	9.1
Shut down due to surplus sinter	-	21-55	-	21-55	1.2
Others	-	-	132-25	132-25	7.3
Total	589-20	693-20	535-50	1,818-30	100.0

As seen in the table, the scheduled shut-down time and its extension account for as large as almost a quarter of the total down time. Despite this large proportion assigned to scheduled maintenance, the total down time due to mechanical troubles represents as high as 37% of the aggregate down time. This might assumably be attributable to troubles due to attack by chlorine and alkali, but more essentially to the quality of maintenance itself.

Hence, it is necessary to carry out scheduled maintenance work at a higher efficiency by securing adequate number of maintenance personnel, making access to spare parts always ready and improving the maintenance tech-

niques so that scheduled maintenance may be accomplished in reduced time and any accidents can effectively be prevented.

Also noteworthy in that table is the high percentage, more than 10%, of the down time due to failures of sinter transportation cars and due to necessity for production adjustment.

If Helwan Works is to avoid such down time and continue operation of blast furnaces with burden of a constant sinter ratio even in the event of the sinter plant shut-down, it is essentially required to maintain a sinter stock yard as a buffer storage. It is already accepted as a commonplace practice for a steelworks to have such a sinter stock yard.

Along with these, efforts should also be directed to reduction or elimination of plant troubles due to failures of auxiliary facilities in order to attain at least 90% of the availability of the plant.

1.1.4 Measures for increased sinter production

(1) Sinter requirement

Blast furnace operation rate	90% (Refer to 2.1.3)
Pig iron production	Daily 600 t/d x 2 BFs = 1,200 t/d
	Average 1,200 x 0.9 = 1,080 t/d
Fe requirement	970 kg/t-pig
Fe content of sinter	49%
Sinter requirement	$1,080 \times \frac{970}{1,000} \times \frac{1}{0.49} = 2,138$ t/d (average)
	$2,138 \times \frac{1}{0.90} = 2,376$ t/d (daily)
	Availability of sintering plant = 90%

(2) Improvement of permeability

1) Intensified balling

Fig. I.8 indicates the dependence of balling on the sinterability.

The quasi-particle forming is determined by the inherent properties and moisture content of feed particles, the rerolling in the mixer and type of binders used.

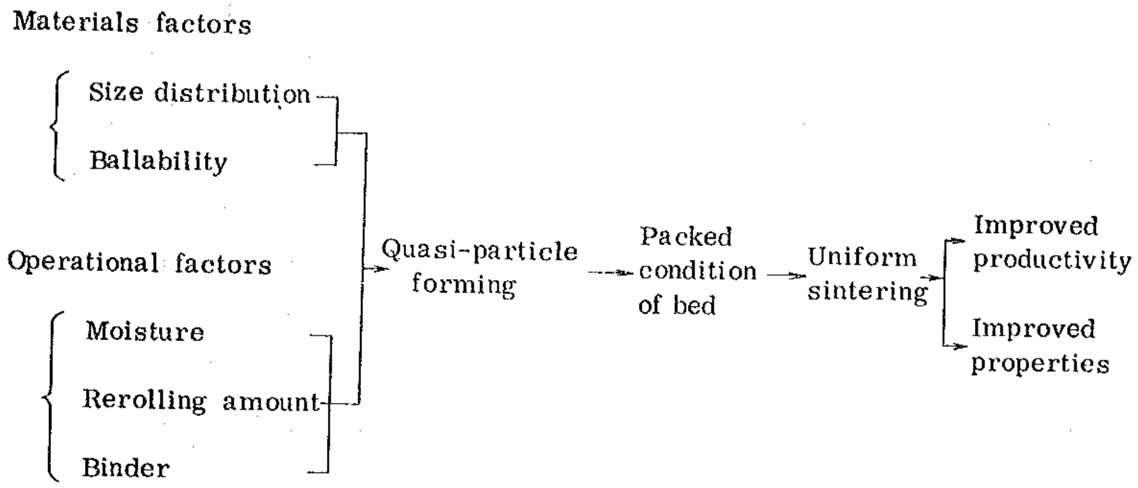


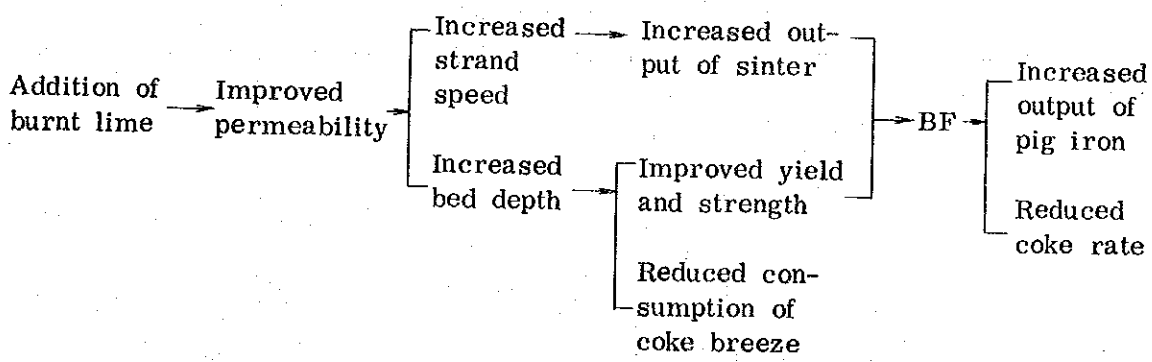
Fig. I.8 Relation between balling and sinterability

Besides appropriate control of moisture content and operation of balling drum mixers, it is recommendable to use binding additives.

Addition of binders is aimed at improving the shape-retaining strength of quasi-particles so as to prevent them from being broken during filling or drying and simultaneously promoting the quasi-particle forming process.

Burnt lime is best suited for use as a binder, and higher affinity for water favors better quasi-particle forming, a factor contributing to the improved productivity.

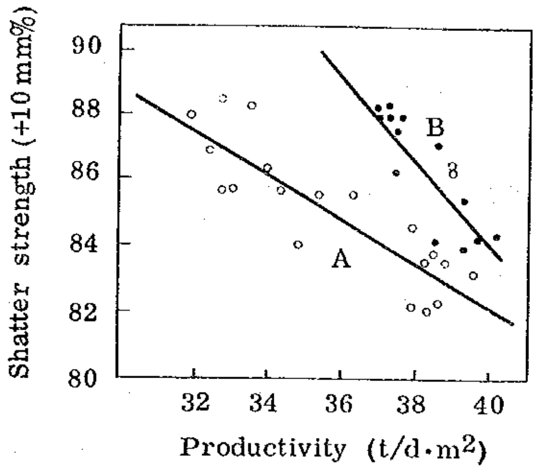
This relation can be expressed as follows:



A typical relation between addition of burnt lime and sinter productivity and strength is indicated in Fig. I.9.

At a 1% of mixing rate, the burnt lime requirement is about 25 t/d per sintering machine. This requirement should be secured for the sintering operation after due consideration of the limestone balance at the steel-making plant.

It can generally be expected that addition of burnt lime in amounts up to 1% of the sinter mix will result in a 5% or so increase in the productivity.



A: Without burnt lime addition
$y = -0.66x + 108.5$

B: Burnt lime addition 1.3 - 1.8%
$y = -1.25x + 134.0$

Fig. I.9 Effects of burnt lime addition on productivity and shatter strength

2) Slit bars

Though not an essential means of improving air permeability of the sinter bed, use of slit bars provides an easy but effective means.

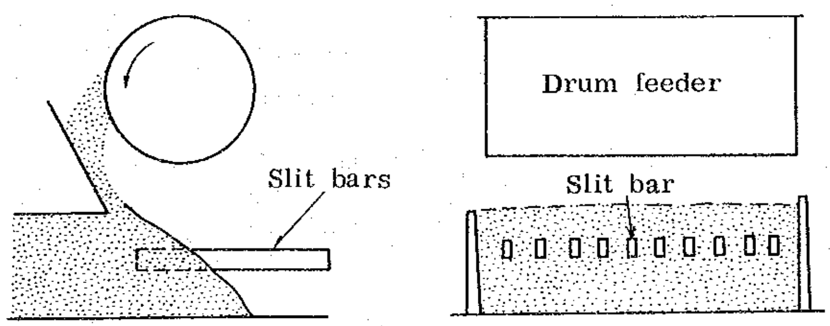


Fig. I.10-a Slit bars

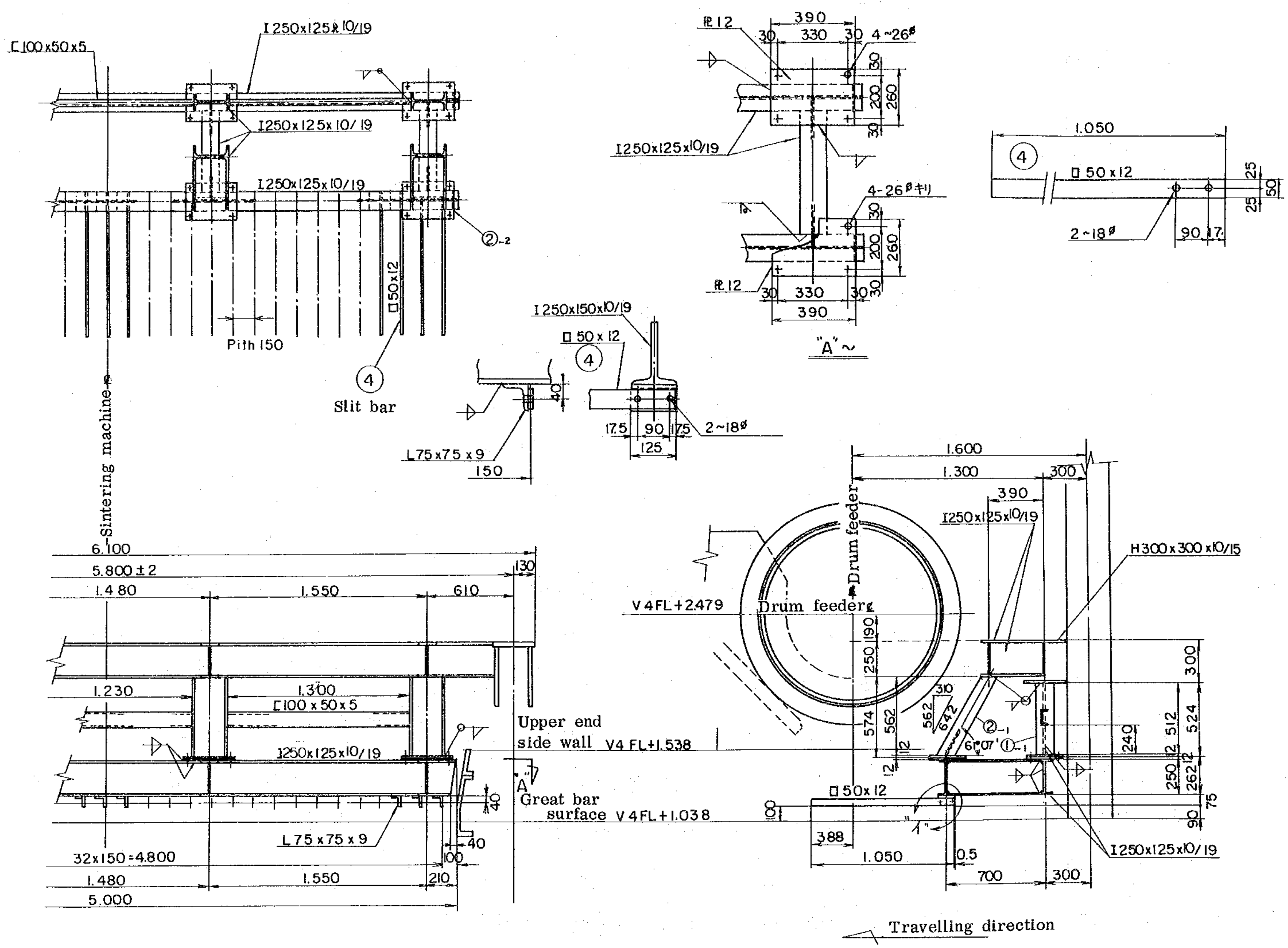


Fig. I-10-b) Example of slit bar construction

This device consists of bars inserted in the raw materials charging portion in a comblike arrangement at an interval of about 15 cm.
The bars should be so constructed that they can be adjusted freely both horizontally and vertically.
These bars should be cleaned periodically since the fine ores tend to stick to the bars.
The use of the slit bars can result in a 5% increase in the productivity. One of the examples of application is given in Fig. I.10-b.

(3) Rise in suction pressure

Increasing suction pressure raises sintering speed, thus increasing productivity. This benefit from increased suction pressure is smaller, however, with finer particles.
Fig. I.11 presents the result of a test on the effect of the suction pressure on productivity which was conducted in a test pot.

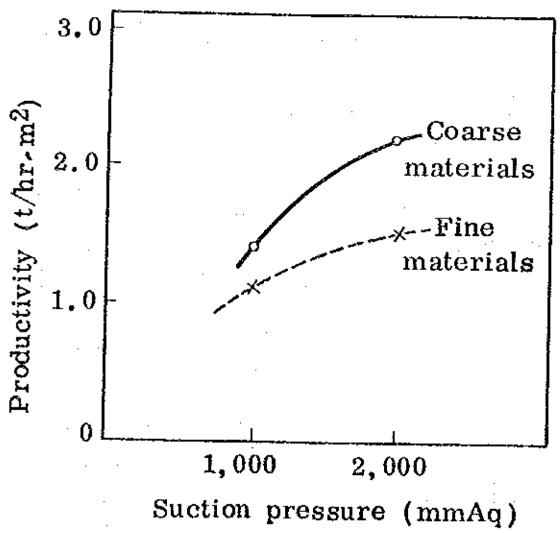


Fig. I.11 Effect of suction pressure on productivity

The designed suction pressure of the exhauster used at Helwan Works is -760 mmAq (actually as low as -600 mmAq because of heavy air leakage). It should be replaced with an exhauster with a suction pressure of minus 1,200 mmAq. By interpolating a curve for the fine materials (the benefit is estimated conservatively compared with coase materials) in Fig. I.11, the net effect of increasing the suction pressure by about 400 mmAq can be estimated to be a 14% increase in productivity. What is particularly required here is further efforts for better maintenance of equipment since increased suction pressure will produce increased air leak.

(4) Improvement of screening operation

Helwan Works' return fines contain about 55% of plus 5-mm particles. More screens should be added to recover coarse particles and reduce fines in the product sinter and, simultaneously, to permit the use of hearth layer. To sum up:

a) Coarse particles should be recovered from return fines and the plus 5-mm fraction of the return fines should be reduced down to 15%.

b) The minus 5-mm fraction of sinter should be reduced down to 2%.

c) A total of 130 kg/t-sinter of 10 to 20 mm sinter should be used as hearth layer materials.

In the following, a potential improvement in productivity is estimated from the average achievements in the period from August to October, 1976.

	Average for Aug. - Oct. period			Corrected	(Oct.)
New feed	1,285.8 kg/t			1,285.8 kg/t	(1,284.5)
Coke	111.7			86.3	(93.0)
Return fines	973.6	490.4 20.0	510.4	394.2	(330.3)
Hearth layer materials	0	168.3		130.0	(130.0)
Product sinter	1,000.0	483.2 811.7	1,294.9	1,000.0	(1,000.0)
η_1	83.2%			80.4	(79.5)
η_2	50.7%			65.6	(68.5)
$\eta_1 \cdot \eta_2$	42.2%			52.7	(54.5)