6-1. Actual condition of management at BURNPUR Works

The memorandum which follows was to present a comment on some real condition of management at BURNPUR Works to some key personnel of IISCO (on July 18,1986, at BURNPUR) and the key officers of SAIL (on July 23, 1986, at NEW DELHI) when the JICA team finished the field survey.

As discussed in Chapter 5, all of technical members of the team expressed same opinion unanimously. A half year passed since that time, but even at the present the understanding expressed therein is believed correct though it is hoped that much improvement has been made since by efforts of those concerned of SAIL and IISCO. In any event there will be days when the memorandum must be rewritten.

Items discussed in the memorandum will be discussed in more details in Chapters 6-2, 6-3 and 6-4, below.

Memorandum "For IISCO Burnpur Works"

Thank you very much for your kind courtesy extended to us during our stay in Burnpur. Before going back to Japan, we ourself with to comment our very frank views of IISCO Burnpur Works for its future, which, please allow us if we misunderstand and or haven't understood the real situation of IISCO in our such limited short study of our limited stay in IISCO.

1. Summary

In short, there has been "Lack of Management on long term basis" in IISCO Burnpur Works.
Namely, although it is the fact that even very old equipments could have been operated because of which, consideration how to prevent relative inferiority of product quality and relative increase of production cost has been neglected in the long term management strategy up till now. In other words, the fundamental improvement, the revamping and the replacement of production equipments haven't been done. If you look at the actual situation of steel industry of Pittsburgh (which was Mecca of steel industry of U.S.A.), you can easily understand that "Lack of Management on long term strategy basis" has caused drop down of international competitiveness.

2. To implement Modernization

Top management people of steel industry are vulnerable to think following in case of installing brand-new equipment, that is:

"If only new equipments are installed, expected quality and production could be achieved and accordingly productivity would be increased and high competitiveness could be secured." However, to pay attention only to equipment (hard) by neglecting the following production technology (soft) which we will mention here, hasn't been achieved high productivity in the expected learning curve, which example of steel industry are too many to be counted in the world. Unless special and urgent attention should be paid to improvement of "soft", the future of IISCO Burnpur Works would be very dark only in the replacement of "hard" of modernization.

2.1 Frankly speaking, in IISCO, "Arrangement, putting in order and Cleaning" hasn't been well done at all which we cannot compare with around 30 steel works which we have ever seen all over the world.
In IISCO, we think that we cannot say that this is only due to old facility.
For example, above "Arrangement, Putting in order and Cleaning" are nothing in IISCO, except some area in front of the major road. As there is no open space in works, workers cannot work safely which couldn't achieve high productivity. Also, control of spare-parts are not well done, therefore, workers have to find-out the same whenever necessary by paying much money and time.

2.2 Instrumentation System

One of the most important items not only for steel works but also for company management is to improve the instrumentation system. However, in IISCO, weighing machine hasn't been arranged to achieve the strict yield control. For example, weighing machine for ingot of bloom mill hasn't been used for a long time. Also, important instruments such as thermometer/flow meter haven't been utilized (or not existence) for a long time.

It seems to us that energy problem hasn't been considered seriously even while that actually such lack of energy causing stop of production line and decrease of yield. It is this steel works that really is in need of campaign of saving energy. It might be the most important and the biggest item for IISCO to introduce the concept of instrumentation.

2.3 The mechanization and automation of the operation

The change from the manual operation into the machanized and automatic operations would be badly needed for IISCO, from the view points of not only the decrease of the number of persons, but also the improvement of operational circumstances, improvement of productivity, and improvement of operational accuracy and currectness. It is one example that there are still remaining in IISCO Burnpur Works so many operations by heavy manual labours under very high temperature conditions which have caused much obstructions for the safety and the productivity, and have brought the deterioration of the quality in a narrow sense.

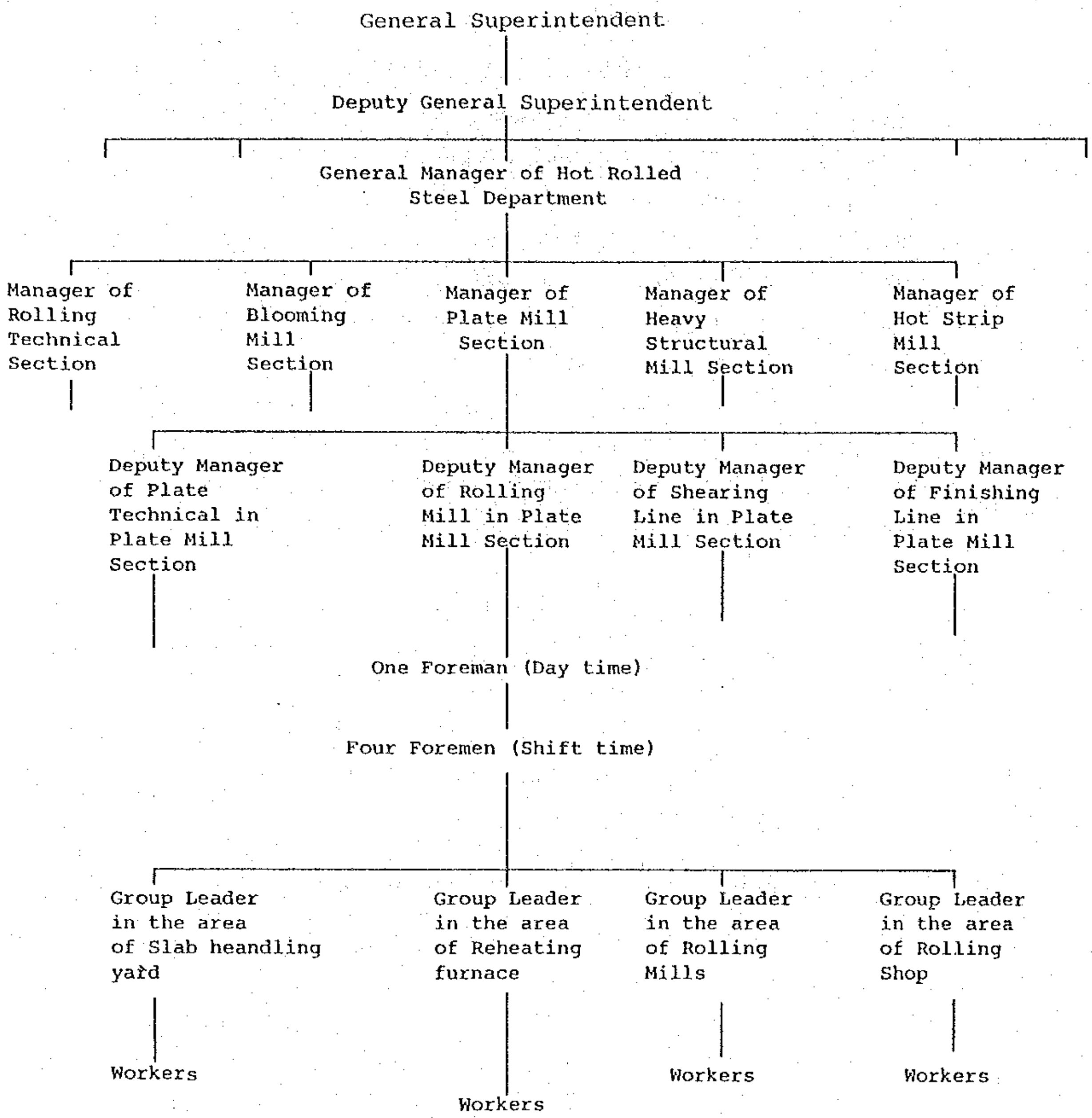
It is highly appreciated for you not to misunderstand the meaning of the object of mechanization and automation of the operation. The final target of this object should be the improvement of the operational circumstances which would be directly connected with the improvement of the productivity.

2.4 The multiplicity in an organization

The multiplicity in an organization is the real situations, not only at IISCO, but also at the other works and plants of iron and steel industries in India including SAIL's other plants. It might be the problem of the whole India or an unique problem in India.

The more multiplex in an organization from the top management to the labourer causes the more obstruction of the improvement of productivity induced by the increase of the number of persons in an organization, and furthermore generates the further delay in operation and the worse inconsistent and insufficient instruction and order.

In case of the iron and steel industries in Japan, the following chart has been applied.


General Superintendent
Deputy General Superintendent
General Manager of Hot Rolled Steel Department
Manager of Rolling Technical Section
Manager of Blooming Mill Section
Manager of Plate Mill Section
Manager of Heavy Structural Mill Section
Manager of Hot Strip Mill Section
Deputy Manager of Plate Technical in Plate Mill Section
Deputy Manager of Rolling Mill in Plate Mill Section
Deputy Manager of Shearing Line in Plate Mill Section
Deputy Manager of Finishing Line in Plate Mill Section
One Foreman (Day time)
Four Foremen (Shift time)
Group Leader in the area of Slab heandling yard
Group Leader in the area of Reheating furnace
Group Leader in the area of Rolling Mills
Group Leader in the area of Rolling Shop
Workers
Workers
Workers
Workers

2.5 The idea of the controlling:

(such as Production control, Quality control and Cost control, etc.)

The idea of the controlling came into existence in U.S.A. After introduction of this idea from U.S.A. and its improvement at Japan, Japan has established Japanese own idea of the controlling.

The followings are a part of introduction of the idea of the controlling in Japan:

On Controlling in Japan

On Controlling not only on cost, but also on quality, production, maintenance and so on, we have the following common idea in Japan, that is, Controlling consists of four factors, Plan (P), Do (D), Check (C) and Act (A).

P means concrete planning or concrete target making and furthermore P is discussed studied and decided by the responsibility of, for instance, Plant Manager, and authorized by, for instance, Plant General Manager. That also means Plant Manager is to have contract with his General Manager to do.

D means carrying out according to the Plan, for this, for instance, Plant Manager orders concretely to his men to keep the plan, under limited conditions, As a matter of course, when the Plant Manager establishes the plan, he always discusses, studies and concludes with his men. His men mean his staff (engineers, officers and so on) and his workers (including assistant managers, foremen, group-leaders -if any-, and workers).

C means checking the results of D if they followed P concretely or not. And, this is very important for the Controlling, C is done sometimes by themselves who did - we call it voluntary Control Activities, in Japanese Jishu-Kanri, JK activities. As a matter

of course, sometimes done by the third party people, what is called, the staff people.
The difference of the results of C are analysed thoroughly whether the results of C are correct or not. If the results of C are correct, the higher target is surely established at the establishment of the next target. If the results of C are incorrect, the cause of incorrectness could be eliminated, and then incorrectness would not be happened repeatedly.

A means action, using the results of C, they must remake the plan which they established before, concretely. This also means, the any kinds of standards which are "one-of-P" must be corrected everytime they need.

Due to this process, they can establish better P for the next stage.

This controlling method is called, in Japan, P-D-C-A Circle Control System, namely the endless activity such as P_1-D_1-C_1-A_1-P_2-D_2-C_2-A_2 .... is continueing and connected with the drive of the improvement of Productivity.

In the system, however, we must pay more attention when we decide P, that is, as human being, sometimes or always we hesitate to establish the higher target, for instance, to do higher rolling yield, to do better fuel consumption and etc.

Therefore, the plant manager, must have "challenge spirit" to establish higher target, and at the same time, the general manager must forgive the plant manager who could not achieve the target, even if he did his best.

Example of C and A to improve the rolling yield:

1. We check the past twelve months rolling yield.
2. We eliminate worst three automatically and the best one when it is too good.

3. We calculate the average value of the rest (average of eight months).

4. We adopt, as the new rolling yield, one of two, that is, one is the average value, another is the second best one.

5. For adopting the second best, we need the strong challenging spirit, and at the same time, the boss must understand the spirit and the possibility of the new target.

6. After all, the target curve can approach to the theoretical value as possible.

6-2. Production control

(See Items 2.1 through 2.5 in the memorandum in Ch. 6-1)

In a narrow sense, to control production means
to deliver to a customer
within the limit of reasonable production cost
by the time desired by the customer
a rolled steel desired by the customer (conditioned in quality, quantity and price).

Quality may have priority over others, but a steel mill must not neglect production cost nor delay delivery by lowering yield in ensuring quality. Likewise, it must not make a product in disregard of production cost nor ship inferior product regardless of quality only for keeping delivery.

For this reason, it is essential for managers of steel plants to

Firstly, keep working environment in order for workers (Items 2.1 & 2.3 in the memorandum)

Secondly have workers perform operation correctly (Items 2.2 & 2.4 in the memorandum)

Thirdly have workers familiarize with and implement the idea of "Controlling" on their jobs. (Item 2.5 in the memorandum)

Needless to say, all personnel of BURNPUR Works from top officials, managers and superintendents down to the rank and file are working strenuously from early morning to late night. "I want work and work and work ---- I want you to build up India." So saying with high spirit and enthusiasm, they are making good efforts to solve problems.

But it should be said there are a lot of problems which they must solve. It is necessary for them to think afresh about what management and control means.

6-3. Facilities control

(See Items 2.2, 2.3 & 2.5 in the memorandum in Ch. 6-1)

It is often said that production facilities once introduced, constructed and put into opertion have perpetual life and can be used for decades until they become scrap.

However it must be said such thought is wrong from the viewpoint as given below.

(1) The facilities get old same as or faster than man.

This fact is well known because their life is generally fixed and because their deteriortion progresses and repair cost increases as they are used longer. Steel mill machinery in particular get deteriorated very fast as they are used under very hard condition.

(2) As a matter of fact, various facilities are designed and manufactured to produce products of specific quality and characteristics.

However, quality of products in demand generally tends to change often to meet changing demand of the market, and consequently the facilities sooner or later come to have relative (or, for some, absolute) difficulty in the manufacture and production of products which fit exactly the need of the martket.

For this reason, maintenance to prevent deterioration of those facilities or enable them to satisfy the need of the market is important. This is facilities control.

In some cases it means overall replacement of facilities and equipment and in other cases it is extensive improvement and remodelling or daily repair and renewal.

In fact, however, there were observed many instances at BURNPUR Works that as mentioned in Item 2.2 in the memorandum facilities which became unable to properly function were left as it is. Under such condition, it is very difficult to perform adequate production control as discussed in Ch. 6-2, which results in losing competitiveness day by day.

In executing and implementing the modernization in future, the following two suggestions may be given.

(1) When facilities (hardware) are to be introduced, their function and application (software) must be fully known and in no case the following idea should be bad.

"Only if new facilities are constructed, the modernization will be complete. Only with it BURNPUR Works will be reborn."

However good facilities (hardware) you have, forgetting their maintenance to ensure good function only results in the modernization with utter loss of capital investment.

(2) For prevention of deterioration of facilities, repair cost of 3% is included in the investment in this F/S. This is included not only as repair cost but in view of necessity of facilities control as discussed above. In usual case, it is generally accepted idea that repair cost of about 3-5% is required to operate steel plants efficiently. But it must be always kept in mind how the repair cost can be used most effectively.

6-4. Personnel control

(See Item 2.4 in the memorandum in Ch. 6-1)

The organization of BURNPUR Works is big and has many layers in class and grade, and the number of employees is far greater than that of other steel plants of similar scale.

It is well known fact that such condition is reflected in extremely low productivity, crude steel production 22 T/Man-Y (1984/85). As discussed in Item 2.4 in the memorandum, an organization with so many layers of class and grade and so many employees, if in steel industry, tends to have difficulties as described below.

(1) Personnel cost has high percentage in production cost. (In India at present unit labour cost is very low, and so this does not cause decrease in competitiveness for some years to come.)

And more important points are

(2) Direction and order line system becomes complicated and conveyance of orders and various informations and communication to the workers at the bottom is slower and less accurate.

(3) Employees (including not only those at the bottom but some others in upper ladders) lose morale backed by their sense of participation and responsibility.

From the above viewpoint it is suggested that organization and personnel control be actively executed.

Chapter 7

Modernization Plan

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7. Modernization plan

7-1. Outline of the modernization plan

Having understood the actual condition of IISCO (including not only BURNPUR Works but both GUA and CHIRIA ore mines and KULTI foundry) as discussed in Chapters 4, 5 and 6, and knowing the condition of circumstances surrounding IISCO as mentioned in Chapters 2 and 3, and on various premises for implementing the F/S for this project as described in detail in Chapater 1, the survey team drew up modernization plan (draft) as given below.

The team is well aware that there should be several proposals from some different viewpoints for this modernization plan, but the JICA survey team drew up the draft plan on the basis of the following conditions and premises and considers it the best plan.

(1) Conditions given in Chapter 1 --- Major premises in implementing the F/S

(2) Conditions given below --- Medium premises (at the level of Works, as discussed in detail in Ch. 7-1) and minor premises (at the level of plants, as described in detail in Ch. 7-2 through 7-10) confirmed through discussions with those concerned of SAIL/IISCO.

The idea and procedure of preparation of the draft plan is shown in Fig. 7.1.1. The draft plan includes the plan that was explained when the team visited India in July 1986 and some additions as a result of later studies.

The summary of this Chapter and compilation of the draft plan are given in Ch. 7-11, which forms technological premises for financial analysis in Chapter 8.

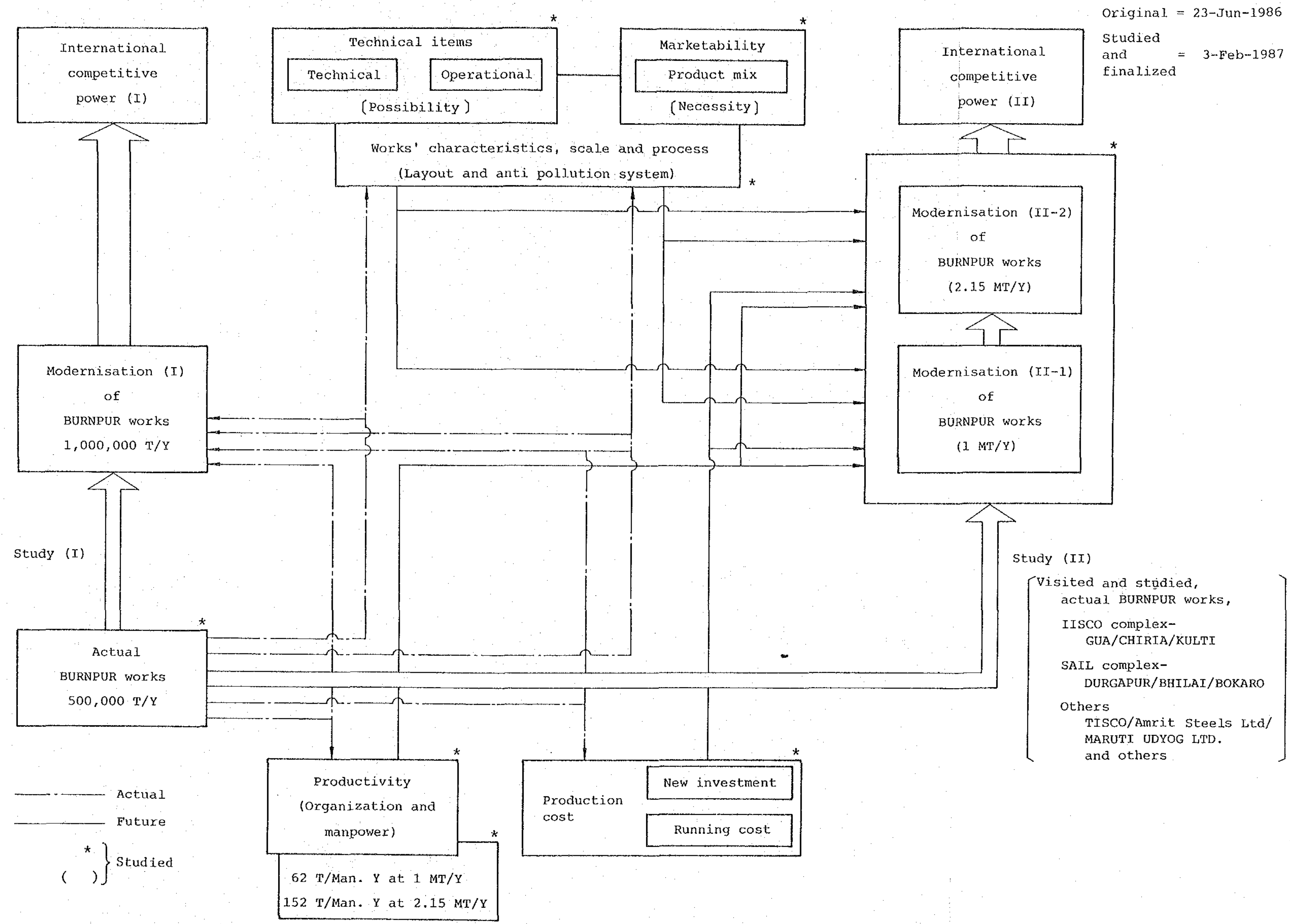


Fig. 7.1.1 The philosophy of modermization of BURNPUR works

7-1-1. Premises for the modernization plan

In this section premises at the Works level were firstly considered. On the basis of the premises, studies discussed in Ch. 7-2 through 7-10 were made.

Premises at Works level:

(1) The modernization plan is to be implemented in the compound of existing BURNPUR Works.
(The maximum capacity of the Works---7-1-2 & 7-10)

(2) CHASNALLA coal is to be transported by ropeway to BURNPUR Works.
(Overall layout of the Works & coal yard plan--7-1-3 & 7-2)

(3) Surplus coke produced is to be all sold outside.
(New coke ovens plan & blast furnace operation plan ---7-2 & 7-4)

(4) Blast furnace slag is to be all sold outside.
(Granulated slag plan---7-4.)

(5) Measures for thorough energy saving are to be made.
(Direct link of CC and rolling---7-6 & 7-7)
(Fuel plan for power plant---7-2, 7-4, 7-5 & 7-9)

(6) Product mix is basically to be non-flats (long products) based on demand/supply balance (SAIL). This forms major premise but is also medium premise.
(Overall layout of the Works---7-1-3 & 7-7)
(Construction plan for new rolling mills---7-7)

(7) Power plants are to be built in the Works to provide power as power supply from outside is unstable.
(Power plant construction plan---7-9)

(8) Environmental and pollution control measures are to be implemented. This is of course major premise,but is considered as medium premise also.
(Air and water pollution control---7-1-4, 7-2, 7-3, 7-4 & 7-5)

(9) Rationalization of railway networks
(Overall layout of the Works---7-1-3, 7-2 thru 7-10)

(10) Introduction of computer
Study is to be made with a view of introducing computer for single facility and equipment. For example, computer to control sublance of BOFs is installed,but computer for production control at the entire Works level is not to be introduced.

7-1-2. Image of the Works after modernization

(1) Character = Non-flats (long products)

As discussed in Chapters 1 and 3, the Works' product mix is macroscopically non-flats, provided, however, that

Small products such as wire rod are excluded as they can easily be produced by mini-mills, and

Large ones such as large-sized sections are excluded also in view of the total demand, capacity of BHILAI steel plant and possibility of substitution by welded sections.

In addition to the above condition, technological reason which excluded flats (plate and sheet) from viewpoint of various conditions of the Works, especially location condition, is as follows:

1) The maximum crude steel capacity is 2.15 million T/Y which is only 1.15 million T/Y incease from existing nominal capacity of one million T/Y. Production of flats corresponding to such increased steel production is generally disadvantageous in terms of scale of economy. (Flats here means sheets produced on hot strip mill.)

2) On the other hand, in point of added value, so-called hot final cannot be conceived, and so a series of large rolling facilities including hot strip mill and cold strip mill becomes necessary. This requires a considerable number of facilities such as reheating furnace, hot strip mill, coiling equipment, pickling line, cold strip mill, annealing furnace and skin pass mill, but there cannot be found a site for those facilities in the compound of BURNPUR Works.

3) In addition, as upstream facilities, not only slab caster but also corresponding BOF, quality improving treatment facilities (degassing, secondary refining facilities, etc.) are required. The total investment required is considerable.

4) There may be thought the other way that to retain the existing 30,000 T/Y galvanizing line, its upstream is to be studied. But in conclusion it can be said that if simple facilities such as Steckel mill is used in view of the present flat rolling technology, it gives rise qualitative problem, and basically irrespective of scale, the above facilities mentioned in 2) and 3) would be required.

(2) Scale = 2.15 million T/Y

As long as BF-BOF process is adopted in accordance with the major premise discussed in Chapter [illegible], the larger the scale of the Works, the better the improvement of profitability, so it is generally believed. Therefore the maximum scale permissible in the site was studied. The reason for such judgement is given below. One conclusion arrived at indicated the scale to be 2 million T/Y, but as a result of subsequent study, it was judged it could be raised to 2.15 million T/Y, and the production scale of 2.15 million T/Y was used as premises for studies in 7-2 through 7-10.

(3) Production process = BF - BOF (LD) - CC

As discussed in Chapter 1, general BF-BOF-CC process is to be adopted. However, it can generally be said that payability of a medium/small integrated steel plant based on BF-BOF-CC process is not always "very good" though it will be discussed in Chapters 8 and 9.

Production Scale

The production size of a steelworks is determined by various factors. In the case of BURNPUR the annual production size of max. 2.0 million tons is recommended for two reasons. The one, the main reason, is the limited space available for use as the construction site and the other the production projected being recommendably confined to non-flat products.

According to the BURNPUR's prerequisites, the area available for use as the construction site is approximately 1,500,000 m^2 (Ref. 7-10) of the total area shown in the map. Most commonly, an average integrated steelworks requires about 1.5 m^2 of land area to produce every ton of crude steel. Hence, the capacity that can be newly added is 1,500,000 m^2/1.5 m^2/T=1,000,000 tons a year. Adding the existing installed capacity (1,000,000 tons per year) to this, the final production scale is 2,000,000 tons a year.

As can be well understood from the general layout described in Fig. 7.1.2 the figure is the very limit.

Furthermore, production of non-flat items alone entails a lower productivity and greater difficulties in controlling many variables compared with production of flat items alone, a factor that impedes large-scale production. If the world's past experience is any guide, the production scale of such a non-flat-concentrated steelworks would be no more than 2,000,000 tons a year.

The non-flat-concentrated steelworks is characterized by a less unit weight of products, a smaller size of order lot, hence production lot, and greater versatility in product-mix and size-mix. The smaller size of rolling lot, lower rolling T/H and higher frequency of roll changes will add up to a lower operating rate of rolling mills, which in turn will restrict the steelmaking lot size as well as production effeciency.

Moreover, low volume runs of numerous items will restrict the capacity utilization rate of the product warehouse and the efficiency of transportation. Obviously, more labor, time and costs will be required in quality control.

7-1-3. Layout of the Works

(1) Facilities

Detailed explanation of facilities and equipment in each process for the modernization of the Works is given in 7-2 through 7-9, but main facilities are shown in Table 7.1.1, but efforts are made to reduce the total investment as much as possible by utilizing existing facilities, equipment and installations wherever practicable. They include the following in addition to coke ovens and rolling mills as shown in Table 7.1.1.

1) Coal yard & coal transfer facilities
2) Maintenance & repair shops
3) Analysis and test equipment
4) General Manager office & other offices

Table 7.1.1 Main Facilities of BURNPUR Works after Modernization

1. Coke ovens

No.8 coke oven battery	68 ovens
No.9 -"-	78 "
No.11 -"-	92 "

Note: Dimensions of No.11 battery:
7200 mm H x 16500 mm L x 450 mm W

2. Sintering machine

No.1 sintering machine	210 m^2
No.2 -"-	210 "

Note: Width of sintering machine is 3500 mm W.

3. Blast furnace

No.5 blast furnace	2250 m^3
No.6 -"-	2250 "

Note: 1) Working volume 1932 m^3
2) Twin cast-house with bell-less top
3) High top pressure: Normal 1.3 & Max 1.5 (kg/cm^2)

4. Steelmaking shop

4-1. Lime calcining kiln

No.1 kiln	400 T/D	Becken Bach type
No.2 "		-"-

4-2. Basic oxygen furnace (BOF)

No.1 BOF	130 T/heat	Inner volume 123 m^3 after lining
No.2 "	-"-	-"-
No.3 "	-"-	-"-

Notes: 1) Sub-lance equipment
2) Waste gas treating equipment:
LDG recovery rate 70-100 Nm^3/T

5. Continuous casting machine

Bloom caster	BL size: 300 mm x 400 mm x 5000 mmL Max. BL weight: 4.68T
No.1 Billet caster	BT size: 100 mm sq. x 4000 mmL Max. BT weight: 0.312T
No.2 -"-	-"- : 150 mm sq. x 12000 mmL Max. BT weight: 2.112T
No.3 -"-	-"- : 180 mm sq. x 12000 mmL Max. BT weight: 3.036T

Table 7.1.1 (Cont'd)

Notes: 1) BL CC & No.1 BT CC is ladle stand type.
No.2 & No.3 BT CC is ladle turret type.
2) Machine radius is 8 m, except BL CC which is two-point bending type and its machine radius is 8 m and 16 m.

6. Rolling mill

6-1. Blooming mill (Improvement of existing facilities)

1) Soaking pit: Combustion control system

2) BL reheating furnace: 100 T/h 4 zone walking beam type furnace, 6800 mm W x 20000 mm L

3) Main drive motor: Thyrister converter for main motor 6600 Hp x 1

6-2. Billet mill (Improvement of existing facilities)

1) Main drive motor: Thyrister converter for
roughing mill 800 Hp x 2
intermediate mill 600 Hp x 4

6-3. Heavy structural mill (Improvement of existing facilities)

1) Replacement of two reheating furnaces:
1 zone pusher type furnace
6700 mm W x 7500 mm L

2) Main drive motor: Thyrister converter for main motors
6700 Hp x 1
6600 Hp x 1

6-4. Merchant and bar mill (Improvement of existing facilities)

1) Reheating furnace: Combustion control system

2) Main drive motor: Thyrister converters for

250/500/500 Hp	x 1	#1 & #2	stands
-"-	x 7	#3 - #9	stands
300/600/600 Hp	x 2	#10 & #12	stands
-"-	x 2	#11 & #13	stands
75/150/150 Hp	x 4	E1 - E4	stands

6-5. No.1 Bar and section mill

1) Reheating furnace: 120 T/h walking hearth type

2) Roughing mill: Horizontal stands x 5
Vertical stands x 4

3) Intermediate mill: Horizontal stands x 6

4) Finishing mill: Horizontal stands x 2
Vertical stands x 2
Splitting unit (for split rolling) x 1

Table 7.1.1 (Cont'd)

6-6. No.2 Bar and section mill

1) Reheating furnace: 150 T/h walking beam type

2) Roughing mill: Horizontal stands x 6
   Vertical stands x 4

3) Intermediate mill: Horizontal stands x 4

4) Finishing mill: Horizontal stands x 2
   Vertical stands x 2

7. Generator

No.1	60 MW	Gas turbine
No.2	-"-	-"-

Notes: 1) Fuel for gas turbine is BFG, COG & LDG.

2) Existing Nos. 1 thru 4 steam turbines (total output of 60 MW) are old (startup in 1939) and are to be kept as spares for emergency.

8. Blower

No.1	Motor driven blower	3900 Nm^3/min,	19500 kW
No.2	-"-	-"-	"
No.3	-"-	-"-	"

Note: Existing steam turbine blowers are old as steam turbines, but are kept as spares while existing blast furnaces have opportunity of operation.

(2) Layout of the Works

Even if various facilities, equipment and installations from raw materials through product shipment are the same, how they are laid out or how they affect materials flow has a decisive effect on later performance of the Works. Namely, the layout, if poorly designed, will lead to a number of problems such as designed production cannot be attained or production cost is not improved.

In the following the idea how the layout was planned will be explained, but the first consideration was that many flows of materials from raw materials through products would not obstruct each other and would make their ways in one direction and in shortest distance. The layout is believed to be an ideal one, providing an ideal material flow.

One big problem in planning the layout was, as discussed in detail in 7-10, that as soil condition was not fully known and also as the time for field survey to study the matter was not available, the site was considered acceptable on the contingent judgement that it would be OK as there occurred no problems with regard to the existing facilities in operation in this respect.

Therefore it is imperative to make soil investigation with sufficient boring and aim at perfection in implementing the project.

General works layout

As can be understood from the general saying "Steel industry is transportation industry.", what is the most important in planning a general layout of a steelworks is to insure an efficient material flow. In addition to this, the requirements that the capacity expansion be accomplished as far as possible without accompanying production decrease and that existing equipment be utilized as much as possible must also be met.

Our view as to the material flow is as follows.

Most of main and auxiliary materials such as iron ore shall be transported by railway, i.e. SOUTH EASTERN RAILWAY (broad gauge, electrified double lines).

Therefore, the railway shall be branched near DAMODAR station to the railroad track in the steelworks. More specifically, main and auxiliary materials shall be conveyed into the works from its southwest end.

On the other hand, finished and semi-finished products for sale shall be transported by making use of the marshalling yard named HIRAPUR exchange yard situated at the northeast end of the existing steelworks.

Another consideration of importance second to the efficient distribution of main materials, auxiliary materials and finished and semi-finished products is to bring adjacent processes as close as possible to each other or directly link them together and thereby reduce as much as possible the process cycle time, the stock and work-in-process, and the energy consumption.

These considerations offer virtually no alternative to the following layout for IISCO.

Main and auxiliary materials shall be carried into the steelworks from its southwest end (this requirement automatically determines the locations of sintering plant, coke plant and blast-furnace plant)

Finished products and semi-finished products for sale shall be moved out of the steelworks from its northewest end (this requirement automatically determines the location of rolling mill)

The steelmaking-CC plant shall be located as close as possible to the blast-furnace plant and directly linked with the rolling mill. As for the rolling mill, the bar mills which are scheduled to be newly constructed shall be so laid out that direct rolling may be practiced.

The general layout we have planned is shown in Fig. 7.1.2.

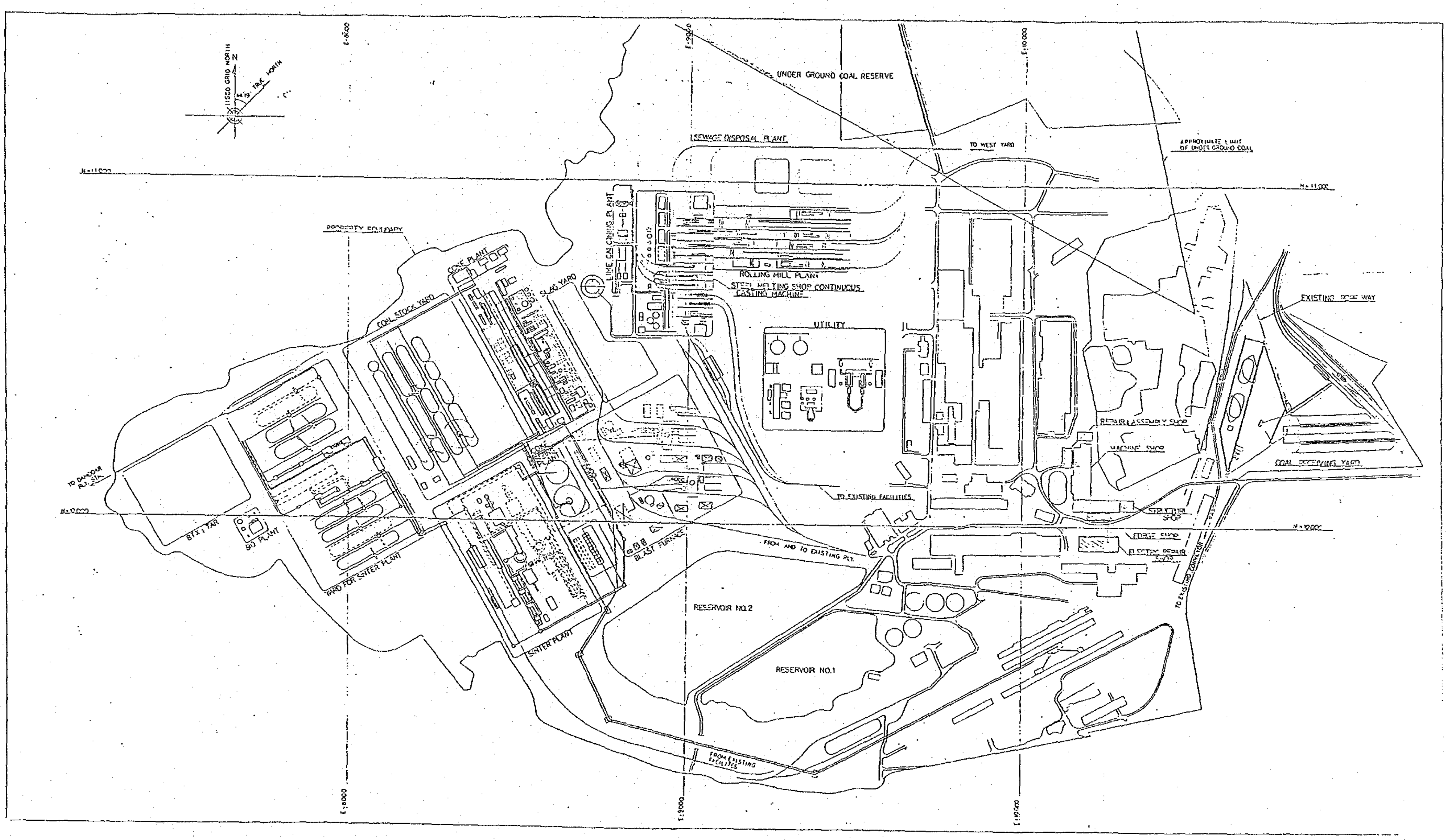


Fig. 7.1.2 General works layout

7-1-4. Environment and pollution control measures

Processes employed by steel plants in making iron, steel and rolled steels are inevitably accompanied with some kinds of emissions and pollution. Unless some measures to protect environment and prevent pollution are taken, the steel plants and communities will have to endure polluted air and water.

In considering production facilities for modernization and planning the overall layout, one of the things that came across the team's mind was to protect the inhabitants in the community as well as the employees of the Works from environmental pollution.

Numerous beehive ovens scattered from KULTI to DHANBAD reminded the team of necessity of those environmental protection measures.

However as the time of field survey was too short to see the quantitative environmental regulations in India, general environmental measures as given below were planned in regard to related plants and facilities.

(1) Atmospheric pollution control measures

Main plants and facilities considered are coke ovens (7-2), sinter plant (7-3), blast furnace (7-4) and basic oxygen furnace (7-5). The measures taken for respective plants and facilities are given below.

1) Coke ovens

a. Yard area
Dust collectors are to be installed at coke cutter and coke screen, and at coke conveyor junctions.

b. Coal handling
Dust collectors are to be installed.

c. Coke oven battery
Dust collectors are to be installed for charging cars and coke guide cars.

Dust control equipment are to be installed at the quenching tower and shower.

d. By-product chemicals

Desulphurization and de-ammonia equipment are to be installed.

2) Sintering machine

a. Yard area

Dust collectors are to be installed at tippler and sizing plants.

b. Sintering machine

Dust collectors are to be installed at main gas exhaust part and equipment.

3) Blast furnace

a. Stock house, furnace top, cast house & clay preparation house

Dust collectors are to be installed.

4) Basic oxygen furnace

a. Lime calcining kiln

Dust collectors are to be installed at main gas exhause part.

b. BOF

Waste gas treating system (See 7-5-3-(4)) and secondary ventilation system are to be installed.

(2) Water pollution control measures

Plants and facilities considered include all plants and facilities of the Works in the modernization plan. That is, water used for those facilities and their products and cooling water and polluted water related to atmospheric pollution control facilities given in (1) above have to be treated. The basic measures are to adopt independent water recirculation system in each of the plants and facilities.

7-1-5. Construction schedule

Details of overall construction schedule of the Works are given in this Chapter, and for making this construction schedule some conditions were set.

(1) Major premises---"Practicability of this schedule"

1) Conclusion

If the construction schedule is not observed and the commencement of the project delayed (naturally the completion will be delayed), and if the completion is delayed---for 3-5 years for example---though there was no delay in starting the project, then it is required to make fundamental review of this report.

2) Reason

Major premise of this project is to utilize existing facilities as much as practically possible. With the condition in mind, efforts were made to limit introduction of new facilities and the total investment to the minimum by utilizing various existing facilities and equipment such as coke ovens, rolling mills, maintenance facilities and utilities facilities.

Those existing facilities are already very old ones and in the state, "They are too old, but still alive" as explained in Chapters 4-1, 5-1 through 5-9, 6-3 and others. There is doubt whether some facilities can really survive until 1993 when the 1 million T/Y production system is completed.

Should there occur death of any one of the facilities before the time, not only such facilities have to be reviewed again but it has a considerable effect on its preceding and subsequent processes.

In particular, if such thing occurs in rolling mills, it inevitably affects facilities plan for its preceding process of CC and BOF or further upstream processes of BF, sinter and coke plants, and eventualy overall review of the entire project would be necessary and this report may have to be rewritten in some cases.

(2) Medium premise---Conditions for planning this schedule

This construction schedule was made by considering all of the construction of individual plants and facilities as discussed below (7-2 through 7-10).

Examples of construction schedule of some plants and facilities are illustrated in 7-2, 7-3, 7-4 and 7-5, and they show the schedules by which those facilities are built independently.

For the entire Works, various restrictive factors such as experience and ability of promotors, interrelation between each plant and quipment and ability of fabricaters and constructers will have a considerable effect on the construction schedule.

The construction schedule shown in Fig. 7.1.3 was made based on numerous experiences in Japan.

(3) 1st step period

The 1st step period of one million T/Y production system which is one year of 1993 corresponds to a training period before attaining the goal of this project, that is, 2.15 million T/Y production system. The survey team, in the beginning, considered three years of training period, but made it one year by strong request of the Indian side.

Some people may have thought that since the production capacity of existing facilities is 1 million T/Y nominal, the production scale of 1 million T/Y in the 1st step is

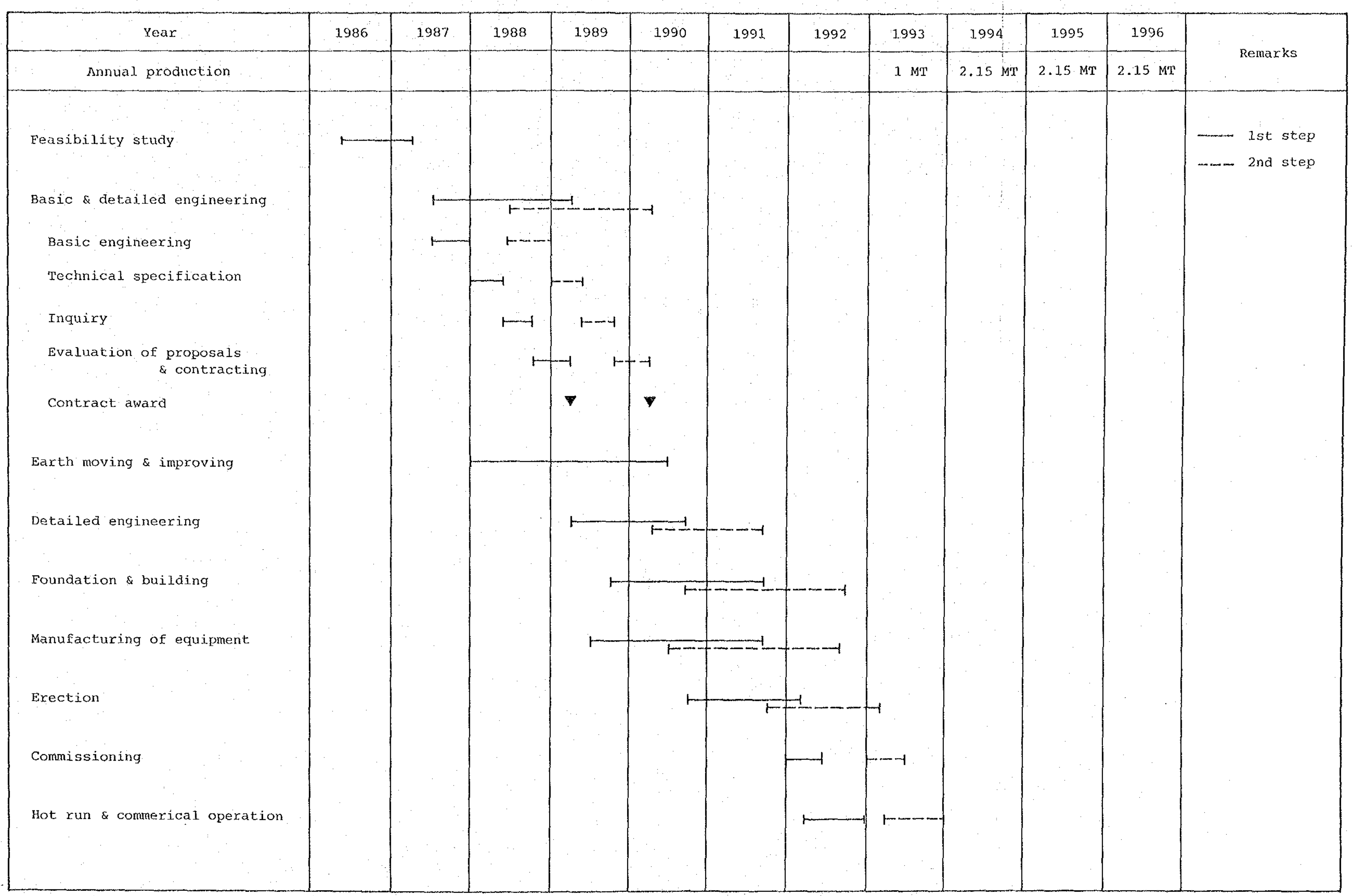


Fig. 7.1.3 Basic construction schedule

not much increase, and therefore with one year experience in operation at 1 million T/Y, it is easy to proceed to the 2nd step of 2.15 million T/Y scale.

However, it must be understood that the expression of one million T/Y is same but the content differs utterly between that at present and in the 1st step. Namely, the 1 million T/Y in the 1st step is that as a step to the final 2.15 million T/Y and accordingly produced by new facilities and it involves many problems of commencement of production and startup of new facilities while keeping close relation with existing facilities kept in operation. On the other hand, the 1 million T/Y under the present setup is nominal and the actual capacity is only about 0.5-0.6 million T/Y. The Learning curve will be as shown in Fig. 7.1.4.

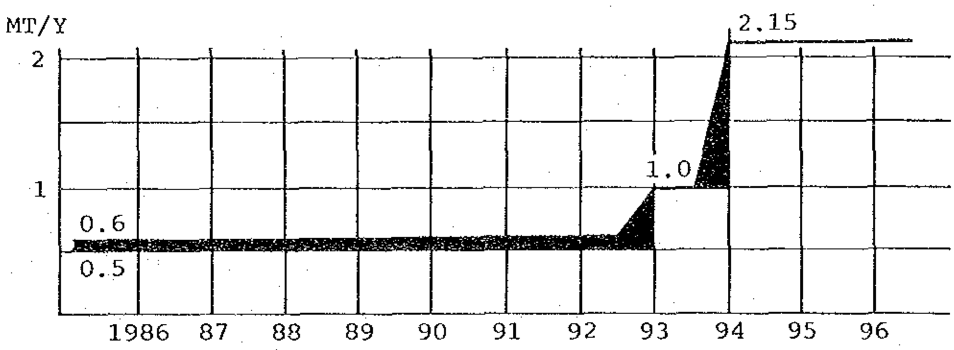


Fig. 7.1.4 Learning curve

It is not impossible to raise the capacity as much as 1.55-1.65 million tonnes in one year period, but it must be recognized that it will be accompanied with much difficulties as mentioned below and it is prerequisite that preparation is made perfectly as discussed in 7-1-9.

Some comments may be justified on the difficulties of successful startup in a short period.

For one thing, often troubles tend to occur in early days of operation of facilities and equipment (hardware) and it takes usually about one year to set up measures to solve the troubles and make improvement (software) and attain full performance of the facilities and equipment.

For another thing, it takes time to have employees get skill in operation of the topmost hardware, that is, new and modern facilities and equipment which are mechanized and automated.

Lastly, the most important thing in a steel plant with such production scale is to know that it takes lots of time to establish a system really capable of performing the topmost software, that is, integrated control for the entire steel plant.

Basic construction schedule

Without early implementation of the modernization project, BURNPUR works might lose completely its competitiveness as a whole. To avoid such a situation, it is by all means necessary to start up the new installation by the second half of 1992 at the latest. Noting this requirement and based on our own experience in the construction and operation of integrated steelworks, we have worked out a construction schedule attached hereto.

The construction schedule assumes that the following requirements, each being of crucial importance, will be met.

1) A "go-ahead" signal to start the project shall be given by the end of June, 1987.

2) An owner consultant shall be selected so that the project may be started upon signalling "go-ahead".

3) The selection of equipment suppliers shall be finalized by the end of March, 1989.

4) The land preparation work shall be started by 1988 and completed largely by the end of September, 1989, becuase of the necessity to start the foundation work as early as possible.

5) The manufacture of necessary equipment shall be completed in about two years. The scheduled period for the foreign-supply portion is based on the manufacturing period needed in Japan. The Indian portion must be completed within this time schedule. Overall, therefore, the schedule will have to be rather severe.

6) A special management system must be set up that will permit quick, smooth unloading, customs clearance, transportation and erection.

7) Only a limited period is available for commissioning and all equipments are scheduled to be started up within nine months after the hot run. This will require pre-startup training of key engineers, foremen and workers

at some similar integrated steelworks including those under the control of SAIL, TISCO, and others.

All these requirements, though very severe, must be met if BURNPUR works is to survive long through the future.

"Rome was not built in a day" but "Time is not everything". Really needed is men's concerted, exhaustive effort.

7-1-6. Production plan (Macro)

On the basis of the construction schedule discussed in the preceding 7-1-5, the following production plan (draft) was made. The basic idea is to put production facilities into full operation as soon as possible to realize increased production and profit and improve the Works' competitiveness.

(1) 1993 One million T/Y (Good steel)
Details are explained in the following 7-1-7.

(2) 1994 - 2.15 million T/Y (Good steel)
Details are explained in the following 7-1-7.

(3) Years when blast furnaces are relined 1.8 million T/Y
No.5 and No.6 BF are shut down for 140 days for relining every 7-8 years. Of course this results in a decrease in production. In the following, explanation will be given as to production plan (draft) in the years when BFs are repaired.

1 BF operated for 140 days	475,000 T	(Good steel)
2 BFs operated for 225 days	1,325,000 T	-"-
Total	1,800,000 T	-"-

As the plants in the downstream of BOF plant have capacity corresponding to 2.15 million T/Y, they can fully meet the condition of 1.8 million T/Y. But the policy in meeting the condition was decided as follows:

1) Plants (products) are to be operated in the following order to roll and produce products with priority on those of higher unit sales prices and most profitable.
Namely, 1. Heavy structural mill
2. No.2 Bar and section mill
3. No.1 Bar and section mill
4. Merchant and bar mill
5. BT CC and billet mill

2) However, due consideration is made to marketability of merchant and bar products cultivated for many years.

By taking into consideration the above two conditions, production plan for the years when BFs are relined was made as shown in Table 7.1.2 below.

Table 7.1.2 Production Plan for the Relining Period of BFs

	Normal year	BF Relining Year		
		140 days	225 days	365 days
H.S.M.	250,000 T	95,000 T	155,000 T	250,000 T
No.2 B.S.M.	700,000	266,000	434,000	700,000
M.B.M.	250,000	93,000	155,000	248,000
No.1 B.S.M.	600,000	-	372,000	372,000
BT	238,500	-	148,000	148,000
Total	2,038,500			1,718,000

Notes: 1. 2,038,500 - 1,718,000 = 320,500 T (Curtailed)

2. 2,038,500/2,150,000 = 94.8%
1,718,000/1,800,000 = 95.4% } 0.6% increase of yield

The above production plan envisages naturally shutdown of No.1 Bar and section mill, BT mill and ingot casting for a period as long as 140 days.

(4) The above is the production plan based on the construction schedule in 7-1-5, but as far as the startup curve is concerned, it seems extremely severe and difficult to follow the schedule as discussed in 7-1-5 (3). It may safely be said that it is a very fast learning curve. A more realistic startup curve is considered as shown in Fig. 7.1.5.

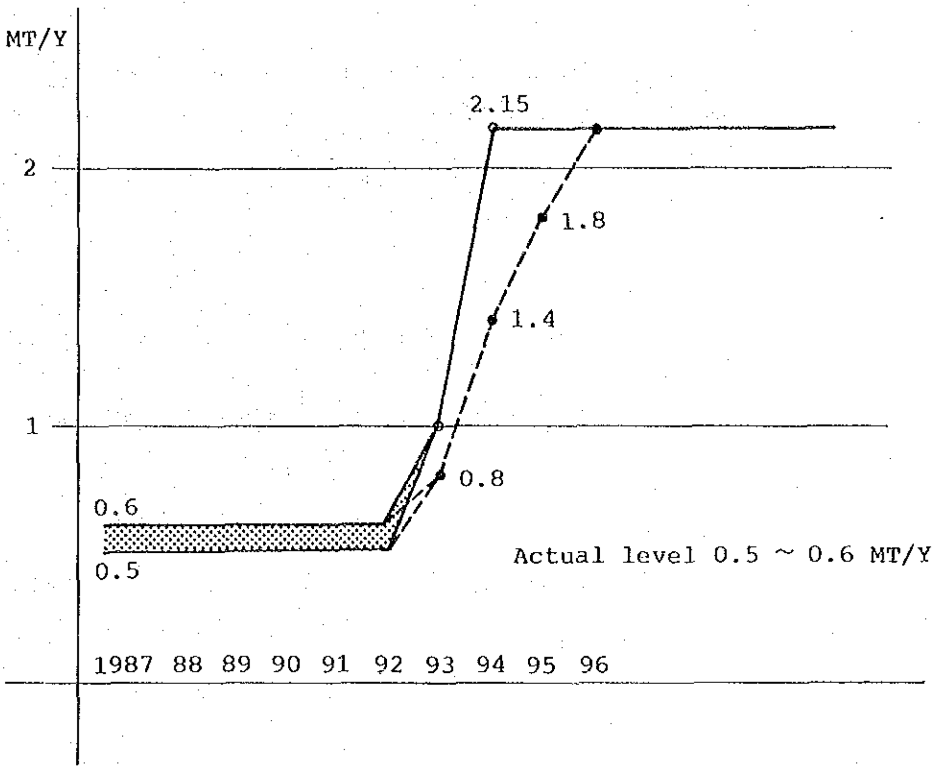


Fig. 7.1.5 Learning curve (more realistic)

Ref. Chapter 8 Financial analysis, Senditivity-case 1

7-1-7. Material flow and material balance

Material flow and material balance in the Works both in the 1st step of one million T/Y and 2nd step of 2.15 million T/Y is shown in Fi.g 7.1.6 and Fig. 7.1.7, respectively.

And material flow and material balance in each process will be discussed in 7-2, 7-3, 7-4, 7-5, 7-6 and 7-7, and energy flow and energy balance is explained in detail in 7-9.

Among the above items, those which need special attention are balances of slag, coke, scrap and cold pig.

(1) Slag
Slag is produced in BFs and BOFs, and in the past large part of slag was dumped at BF slag bank and steel slag bank. But under the plan, BF slag is planned to be utilized as much as possible.

(2) Coke
Since coke quality has a big effect on the BF operation, lump coke for BFs is 100% home produced under thorough and strict control.

(3) Scrap
Because of introduction of CC and improvement of rolling performance, generation of return scrap decreases inevitably and it alone cannot cover the scrap requirement of BOFs. It was assumed that all of scrap generated at each process and skull can be used as return scrap, but scale is planned to be used as material for sinter in future.

(4) Cold pig iron
It is not always assured that all the requirement of pig iron desired by KULTI foundry can be supplied.

As the 1st step is a transition period to the 2nd step and a short period of one year, there are not many problems expected in the flow and balance. However, in the 2nd step, production more than doubles and big problems as pointed out

(Unit : T/Y)

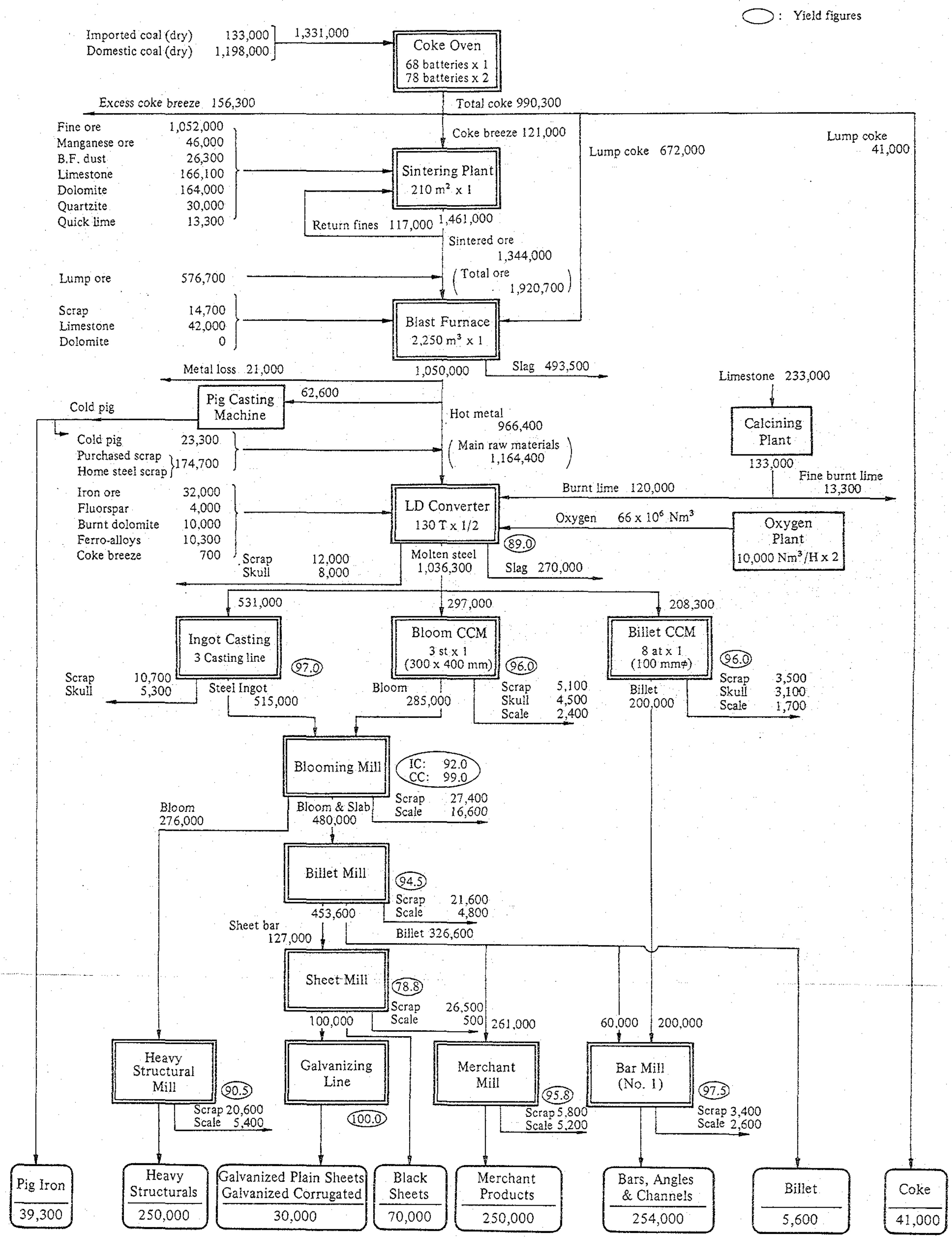


Fig. 7.1.6 Material flow and material balance
(Step-1: steel 1.0 MT/Y)

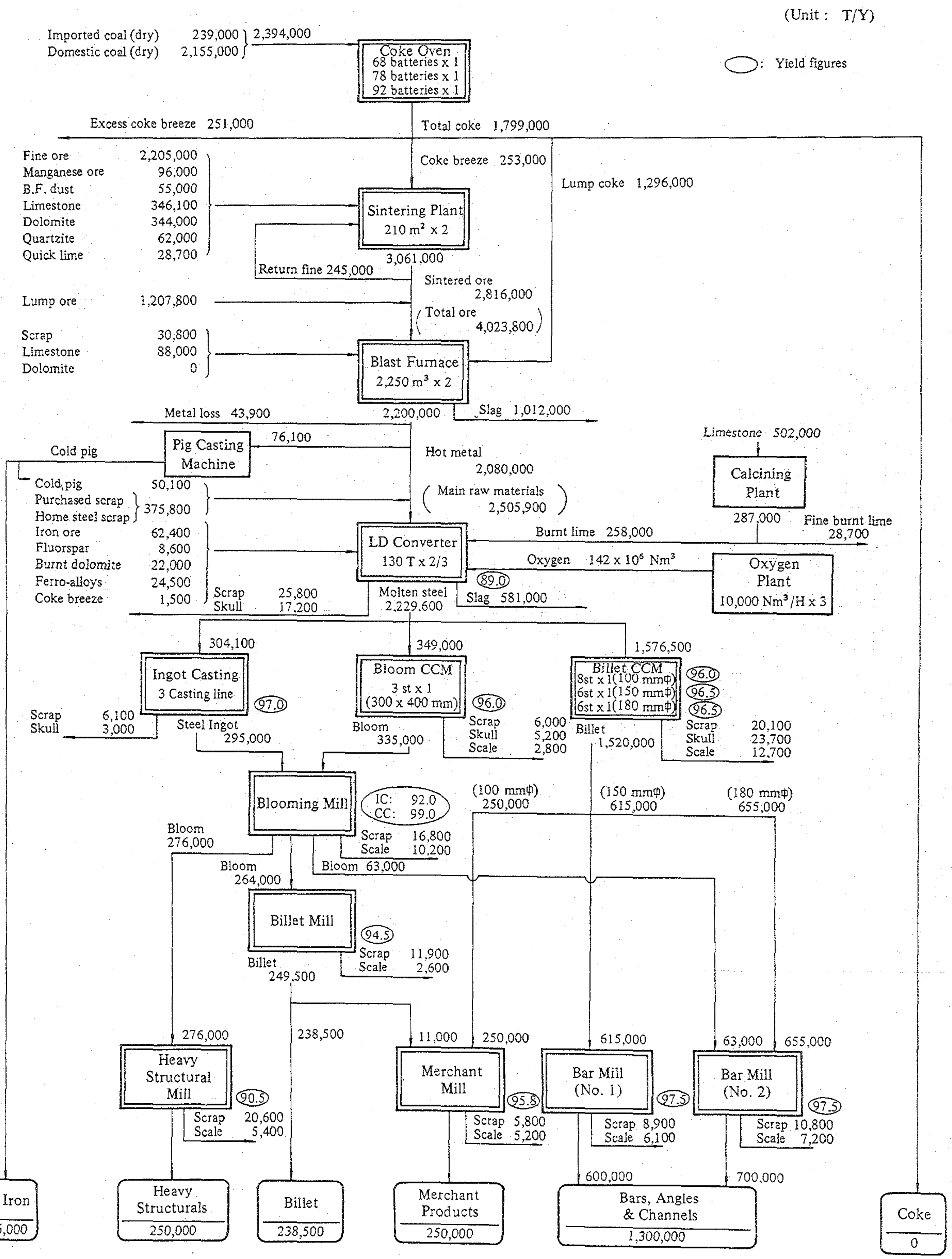


Fig. 7.1.7 Material flow and material balance
(Step-2: steel 2.15 MT/Y)

below are anticipated. The time that the team could spend for field survey on the matter was too short to investigate and solve all the problems.

(1) Slag

1) BF slag

It was assumed that the vast amount of BF slag generated, 1,012,000 T/Y, can all be made to granulated slag and sold.

2) BOF Slag

Different from the above BF slag, all BOF slag in the amount of 538,000 T/Y has to be dumped at a suitable place in the Works, for example, a vacant lot northwest of BOF plant, one of proposed sites. But the space in the Works will sooner or later be filled, which makes it necessary to look for new sites elsewhere.

(2) Coke balance

The idea about coke production is as follows:
Lump coke required for BFs is all to be produced by the coke plant in the Works. As a result, coke breeze which accounts for about 28% of the total coke production will show considerable surplus over the requirement for sinter production. For example, the surplus of coke breeze in the 2nd step of 2.15 million T/Y reaches 251,000 T/Y.

The matter may be considered the other way, namely coke production is aligned to the required amount of coke breeze. But this of course assumed purchasing of lump coke from outside. As quality of coke which can be purchased, if any, from outside could not be confirmed, the idea was not taken in the F/S. In fact, however, quality of coke has a significant effect on productivity of BFs, and purchasing coke from outside is considered impracticable.

The surplus of 251,000 T/Y of coke breeze in normal operation year is big, but it increases more in the year of relining of BFs. In the following is given explanation on the surplus coke (lump and breeze) in the year of blast furnace relining.

Coke production:

Due to characteristics of refractories used in the coke ovens, marked curtailment of production, much less decreased or increased production in a short period, is impossible. Here the lowest limit of production rate is assumed to be 90%.

Capacity of Nos. 8 & 9 coke oven batteries:
645,400 T/Y (of which, lump coke 464,700 T/Y)
Capacity of No. 11 coke oven battery:
973,100 T/Y (of which, lump coke 700,700 T/Y)
Total 1,618,500 T/Y (of which, lump coke 1,165,400 T/Y)

Coke consumption (corresponding to 1,800,000 T/Y of hot metal):

BFs (lump coke)	1,048,000 T/Y
Sinter (breeze)	207,000 T/Y

Surplus coke:

Lump coke	117,400 T/Y
Breeze	246,100 T/Y
Total	363,500 T/Y

Measures:

1) 90% operation is continued to absorb surplus lump coke---Coke quality deteriorates. In particular, the surplus occurring in rainy season may most probably become unusable unless some special measures are taken.
2) Coke balance in SAIL as a whole is to be studied.
3) All the surplus is sold outside.
In the financial analysis, all the surplus is assumed sold outside. (See Chapter 8.)

(3) Scrap balance

Crude steel production plan of 1 million T/Y in the 1st step and 2.15 million T/Y in the 2nd step was made based on using scrap in 15% of charged materials in BOFs.

BOF operation:	Hot metal	83%
	Cold pig	2%
	Scrap	15%

In the meantime, as seen from the explanations in 7-5, 7-6 and 7-7, yield at each process improves and naturally generation of scrap and skull decrease markedly. Thus it becomes impossible to operate BOFs with scrap coming from return scrap alone. The shortage of scrap in the 2nd step (2.15 million T/Y) is shown below.

Scrap and skull generated:	
Rolling	74,800 T/Y
CC	55,000
Ingot casting	9,100
BOF	65,900
Total	204,800 T/Y
Scrap consumption:	
BOF	375,800 T/Y
Scrap shortage:	171,000 T/Y

Naturally all the shortage is to be covered by purchased scrap.

Reference:

$$\frac{\text{Total of products \& semis}}{\text{Molten steel}} \quad \frac{2,038,500}{2,229,600} = 91.4\%$$

7-1-8. Organization and personnel (No. of employees)

In this Chapter explanation of organization and personnel will be given. Even if new facilities and new technologies are introduced under the modernization plan, its effect can not be expected if persons qualified to operate them are not available or if organization is such that does not encourage those persons to work well.

Namely, one of the subjects for the success of this project is to establish an organization which improves working efficiency and productivity of the Works and increases its competitiveness, or in other words, gives vitality to the Works.

(1) Organization

The matter of organization of integrated steel plants is discussed in this Chapter, but the basic idea or thought is universal and general one adopted in the steel industry throughout the world and not based on the actual condition in Japan. Therefore the organization given below is probably almost same as that adopted not only in SAIL but in private sector of the industry such as TISCO in India. It should be stressed, however, that efforts were made to make the presently multi-layered organization as simple as possible. It was judged from observing an example of mini-mills (though it was only one example) that such simplification was possible.

1) When planning a suitable organization of a steelworks, various factors need to be taken into consideration. In the case of BURNPUR works, we have planned the recommendable organization mainly from three aspects: simplification of organization; technical advances expected in the future; and management system. The detailed proposals about these are shown in the list of organization and personnel attached hereto.

2) Simplification of organization

As for the personnel management system, we think there are some aspects peculiar to India. As far as the organization is concerned, however, we are of the opinion that BURNPUR works need to drastically simplify its organization for the following reasons.

a) In a complicated organization, the line of supervision and command may become ambiguous, which in turn may cause a decrease in operating efficiency.

b) A complicated organization obviously requires more manpower than otherwise would be the case and thereby reduces productivity.

3) Technical advances expected in the future

BURNPUR works need to secure capabilities not only to develop new products but also to improve product qualities and carry out fundamental and applied re-searches under close communications with production activities in the field. To achieve this end, it is essentially needed to establish an R & D organization and system which is capable of maintaining are close tie up with the Central Laboratories at RANCH.

And introduction of better productive equipment (modification and replacement of existing equipment and installation of new equipment) is also a must because obsolete, deteriorated production equipment, if left uncorrected, will result in reduced operating rate, productivity, yield, product quality and hence competi-tiveness. To facilitate this, a research system for plant engineering, that is, an organization of engineering center, must be set up.

4) Management system

The management system presently at work at BURNPUR works, for production control, quality control, cost control and others, seems to temporizing.

It appears that at BURNPUR works an intergrated control is not sufficiently practiced either in the material flow from upstream to downstream or in time series from the past, present to the future.

In order to establish an integrated management system, the following organization system is recommended.

- General superintendent
  - Deputy general superintendent (Staff area)
    - Personnel & labor relations
    - Administration
    - Finance & accounting
    - Purchasing
  - Deputy general superintendent (Line area)
    - Technical control
    - Production control
    - Ironmaking
    - Steelmaking
    - Rolling
    - Equipment maintenance
    - Energy
    - Transportation
  - Deputy general superintendent (and director of R&D laboratories)
    - Research & development
  - Deputy general superintendent (Director of Engineering Center and chief of project group)
    - Engineering

In this management organization, the main duties imposed on general manager of technical control div., general manager of production control div. and general manager of equipment maintenance div. are as follows.

The general managers in the staff must work in close cooperation with the general managers in the line.

General manager of technical control div.: Responsible for establishing a daily integrated quality control system that insures, for instance, controlled consumption of raw materials and fuel and controlled product yields, and long-range quality assurance system.

General manager of production control div.: Responsible for establishing a daily integrated production control system that insures, for instance, controlled supply and consumption of raw materials and fuel and controlled delivery of products, and formulating long-term production and marketing strategies.

General manager of equipment maintenance div.: Responsible for promoting the maintenance of equipments installed in the works. This equipment maintenance includes both the shortrange maintenance such as preventive maintenance including monthly and yearly pre-scheduled repairs and the manufacture and repairs of equipment in the central maintenance shop intended to improve the capacity utilization rate and save repair costs and the long-perspective planning of positive equipment replacement and introduction project. In addition, he is also responsible for maintaining and upgrading engineering techniques and controlling "drawings and technical information".

In our recommendation, technical control div. includes shape quality control dept. and production control div. includes iron & steel control dept. and production scheduling dept. so that product quality may be controlled in an integrated manner by the former div. and production volume and delivery date by the latter div.

Meanwhile, the organization of the line production sector is planned as follows so that general manager of each line may fulfill his duties efficiently and effectively.

Line general manager	Superintendent (of BF plant, for example)	... Achievement of production goal Establishment of occupational safety and improvement of product quality and productivity
	Group manager of technical dept. (of ironmaking div., for example)	... Establishment of production technologies and introduction of new production equipment (intended for securing quality level)
	Group manager of maintenance dept. (of ironmaking div., for example)	... Inspection and minor repair of production equipment, formulation of repair schedules and equipment control Introduction of new production equipment (intended for securing operating rate)
	Coordination section	

5) Examples of line organization under this modernization plan (Draft)

a) General manager, Ironmaking dept. — Dy.G.M.

General manager, Ironmaking dept. — Dy.G.M.	Chief Supdt. (Coke plant)	Asst. managers
	Chief Supdt. (Chemicals)	Asst. managers
	Chief Supdt. (Sinter)	Asst. managers
	Chief Supdt. (BF plant)	Asst. managers
	Manager, Ironmaking technology	Asst. managers
	Manager, Ironmaking maintenance	Asst. managers
		Clerical office

With this organization and under powerful supervision and command of General manager of Ironmaking dept., it becomes possible to improve operation and maintenance technologies of the facilities related to iron making with close contact with the production field.

b) General manager, Steelmaking dept. — Dy.G.M.

General manager, Steelmaking dept. — Dy.G.M.	Chief Supdt. (BOF shop)	Asst. managers
	Chief Supdt. (CC plant)	Asst. managers
	Manager, Steelmaking technology	Asst. managers
	Manager, Steelmaking maintenance	Asst. managers
		Clerical office

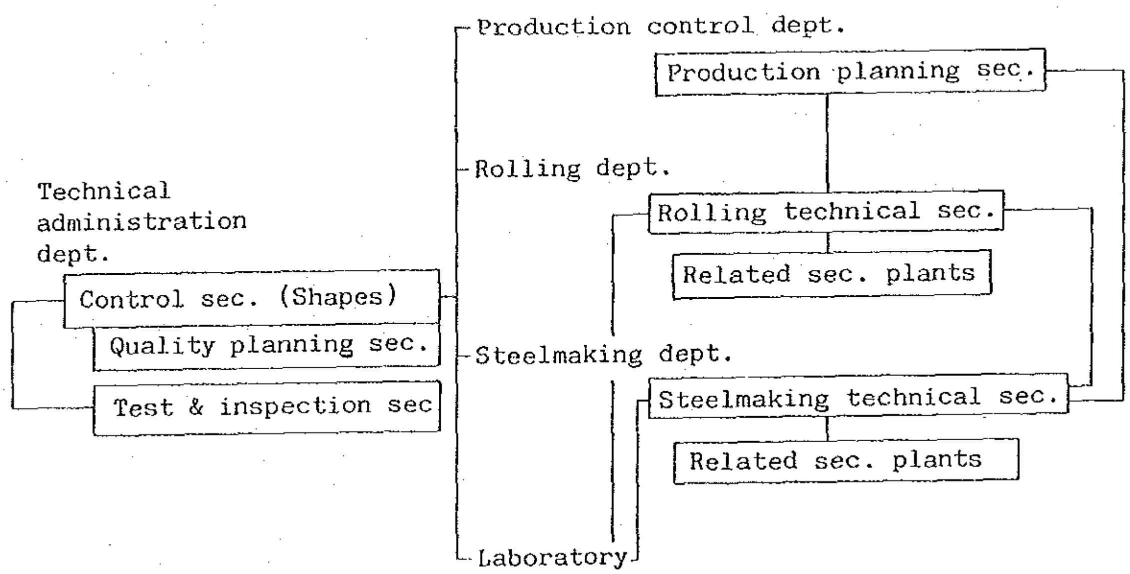
With this organization and under powerful supervision and command of General manager of Steelmaking dept., it becomes possible to improve operation and maintenance technologies of the facilities related to steelmaking with close contact with the production field.

c) General manager, Rolling dept. — Dy.G.M.

General manager, Rolling dept. — Dy.G.M.	Chief Supdt. (BL,H.S.M.)	Asst. managers
	Chief Supdt. (Bar mill)	Asst. managers
	Chief Supdt. (Galv. sheet)	Asst. managers
	Manager, Rolling technology	Asst. managers
	Manager, Rolling maintenance	Asst. managers
		Clerical office

With this organization and under powerful supervision and command of General manager of Rolling dept., it becomes possible to improve operation and maintenance technologies of the facilities related to rolling with close contact with the production field.

6) An example of staff organization under the modernization plan (Draft) (Integrated quality control)



(2) Personnel (Number of employees)

Explanation of the personnel related to integrated steel plants is given below, but its basic idea and thought is based on the system employed in Japan.

Namely, because any universal or general systems were not found in respect to acutal working conditions and also because as mentioned in Chapter 1, the time of the field survey was short and the team could not grasp fully the present system which was adopted for many years in India, SAIL and IISCO, the personnel system in this report had to be set on the basis of the Japanese system as stated below.

(Apart from superficial aspect of the system, it becomes necessary to have supplementary personnel in addition to the basic personnel for establishing the personnel since matters such as provision of annual vacation and holidays, setting up working hours, etc. have to be set up in accordance with labour laws and custom in India.)

1) Idea

a. In line departments, of those which are engaged in direct production activities (iron making, steel-making, rolling, maintenance, motive power, transport, etc.), sections and plants where continuous 24-hour operation is required will have personnel as follows:

The number of workers that is considered necessary based on the facilities and equipment plan is taken as the basic personnel. The total number of workers or the personnel of such departments is obtained by simply quadrupling the basic personnel, that is, 4-group 3-shift system is used as basis. An example of the 4-group 3-shift system is given in Fig.7.1.8. As a matter of course, the personnel is 33% larger than the 3-group 3-shift system.

Gr. \ D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
A	M	M	M	M	M	-	-	D	D	D	D	D	-	N	N	N	N	N	-	-	M	M	M
B	N	N	N	-	-	M	M	M	M	M	-	-	D	D	D	D	D	-	N	N	N	N	N
C	D	D	-	N	N	N	N	N	-	-	M	M	M	M	M	-	-	D	D	D	D	D	-
D	-	-	D	D	D	D	D	-	N	N	N	N	N	-	-	M	M	M	M	M	-	-	D

|← 1 Cycle →| (days 1–20)

Working Time:	M :	0700 - 1500
	D :	1500 - 2800
	N :	2300 - 0700

Fig. 7.1.8 3 Shifts (M.D.N.) - 4 groups (A.B.C.D.) system in Japan

For comparison, an example of the 3-group 3-shift system in operation is shown in Fig. 7.1.9.

Gr. \ D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
A	M	M	M	M	M	M	M D	D	D	D	D	D	D	N	N	N	N	N	N	N	-
B	D	D	D	D	D	D	N	N	N	N	N	N	N	-	M	M	M	M	M	M	M D
C	N	N	N	N	N	N	-	M	M	M	M	M	M	M D	D	D	D	D	D	D	N

|← 1 Cycle →| (days 1–21)

Working time:	M :	0700 - 1500
	D :	1500 - 2300
	N :	2300 - 6700

Fig. 7.1.9 Old 3 Shifts (M.D.N.) - 3 groups (A.B.C.) system in Japan

b. Concerning other departments (staff departments, line departments other than those in a. above, R&D department and engineering department), the actual condition in integrated steel mills with capacity of 2 million T/Y and experiences in Japan were used as the base to decide their personnel.

Of line departments, the jobs of transport dept. consist mainly of transport itself (locomotivemen, pointsmen, etc.) and unloading and loading (raw materials fuel, semi-finished and finished products) and the personnel should be reviewed by the Indian side when the project is studied concretely.

2) Personnel (Draft)

The personnel by department is shown in Table 7.1.3 and a summary is given below.

General manager (Works) (1)	Dy. Gen. Mgr. (1)	Staff depts.	(570)
	Dy. Gen. Mgr. (1)	Line depts.	(13,254)
	Dy. Gen. Mgr. (1)	R&D dept.	(189)
	Dy. Gen. Mgr. (1)	Eng. dept.	(121)
Total 1 +	4 +		14,134

For reference, productivity will be

2.15 million T/Y /14,139 = 152 T/man·Y

Table 7.1.3` List of divisions and departments, and No. of employees in the devision

This shows No. of 1st and 2nd step, and ( ) shows No. of 2nd step, in case of separated.

Devision	Div.	Dy. Div.	Dept.	Sect.	Others	Sub-total	Group	Sub-group	Others	Sub-total	Total	Departments in the Division
Personnel & Labour Relations	1	2	8	18	234	263	0	2	40	42	305	Secretariat, Personnel, Labour Relations, Manning, Salary, Safety, Training, Training Center.
Administration	1	1	3	6	59	70	0	3	60	63	133	Organization, Welfare, General Administration.
Finance & Accounting	1	1	4	9	67	82	0	0	0	0	82	Budget & Accounting, Settlement, Accounting (Cost Analyzing).
Purchasing	1	1	3	8	37	50	0	0	0	0	50	Raw Materials & Fuel, Machinery & Materials, Contract.
Technical Control	1	3	6	16	52	78	11	35	113	159	237	Production & Technical Control, Equipment Coordination, Industrial Engineering, Quality Planning, Shape Quality Control, Testing & Inspection
Production Control	1	2	4	12	128	147	10	24	168	202	349	Raw Materials & Fuel Control, Iron& Steel Control, Production Scheduling, Delivery Control.
Ironmaking	1	3	10	22	37 (42)	73 (78)	58 (62)	177 (202)	1,018 (1,343)	1,253 (1,607)	1,326 (1,685)	Coal, Coal-Chemicals, Coke, Sintering, Blast Furnace, Ironmaking Technical, Iron making Plant Maintenance
Steelmaking	1	1	4	13	24	43	27	84 (96)	407 (611)	518 (734)	561 (777)	BOF, CC, Steelmaking Technical, Steelmaking Plant Maintenance.
Rolling	1	2	5	14	59	81	104 (92)	240 (212)	2,528 (2,005)	2,872 (2,309)	2,953 (2,390)	Blooming & Heavy Structural, Bar, Galvanizing, Rolling Technical, Rolling Plant Maintenance.
Equipment Maintenance	1	3	6	22	135 (57)	167 (89)	462 (40)	75 (171)	4,021 (2,924)	4,558 (3,135)	4,725 (3,2240	Repair, Maintenance, Electrical & Instrumentation Maintenance, Civil Engineering, Refractory Lining, Maintenance Technical.

(continued)

Devision	Div.	Dy. Div.	Dept.	Sect.	Others	Sub-total	Group	Sub-group	Others	Sub-total	Total	Departments in the division
Energy	1	3	7	24	35	70	11	44	266	321	391	Power Plant, Oxygen Plant, Water Plant, Energy Technical, Fuel Technical, Supply/Demand Adjustment, Environmental Control, Energy Plant Maintenance..
Transportation	1	2	5	15	19	42	49	140	4,338 (3,970)	4,527 (4,159)	4,569 (4,201)	Transport Planning, Raw Materials & Fuel Transport, Product Transport, Raw Materials & Fuel Handling, Product Handling, Transport Technical.
Laboratories	5	1	14	20	24	64	4	4	117	125	189	Ironmaking R&D, Steelmaking R&D, Products R&D, Welding R&D, Basic R&D, Coordination, Testing.
Engineering Center	9	1	20	22	47	121	0	0	0	0	121	Ironmaking Plant Engineering, Steelmaking Plant Engineering, Rolling Plant Engineering, Energy & Transportation Engineering, Mechnical Engineering, Electrical Engineering, Instrumentation Engineering, Heat Technology & Engineering, Civil Engineering, Coordination.
Grand Total	26	26	99	221	979 (906)	1,351 (1,278)	736 (306)	828 (933)	13,076 (11,617)	14,640 (12,856)	15,991 (14,134)	Productivity at 1st Step 1 MT/Y 62 T/M-y at 2nd Step 2.15 MT/Y 152 T/M-Y

+ Gen. superintenent 1
+ Deputy gen. superintendent 4
} → 15,996 (14,139)

7-1-9. Education and training

In the steel industry as well, the hardware (facilities and equipment) can be effective only with the software (expertise and skill), and perfection of the software, namely, upgrading of expertise and skill through education and training is essential for 100% realization of function of the hardware to improve productivity and increase earning rate and competitiveness.

An example in this case is measures to meet the shift to larger blast furnaces. In BURNPUR Works there was a lapse of 36 years from 500 m^3 blast furnaces constructed in 1922 to the next level of 1170 m^3 blast furnaces.

This is also true of the condition in Japan. At a steel works, No.1 500 m^3 blast furnace was blown-in in 1901 and a 1100 m^3 blast furnace, corresponding to No.9, was blown-in in 1937. It took just the same number of years, 36 years, as in BURNPUR Works. Blown-in of a 1950 m^3 blast furnace or 2000 m^3 class furnace corresponding to its No.13 was in 1962.

Today, in fact, there are a great number of 2000 m^3 and 3000 m^3 class blast furnaces in the world, and thanks to the remarkable progress of construction and operation technology already there are about 20 furnaces of 4000 m^3 and 5000 m^3 classes in operation in various countries.

It is no exaggeration to say that the progress and development of blast furnace facilities and operation technology has been made possible only by the progress in the hardware and software through education and training in the field.

Of course, in addition to such education and training in a narrow sense, there are a number of education and training styles in a broad sense. For example, they include

Education in which company officials explain its management policy to its employees and make it known thoroughly.

Education to have ability of a person display fully and practice therefor

Training for learning control method, etc.

Such education and training in a broad sense includes from lecture style to 100% physical, OJT (on-the-job- training). For progress of an enterprise all such education and training is indispensable, and in fact BURNPUR Works has a number of programmes of education and training where active discussion can be had in daytime and at night.

During the field survey, the team could have a chance to attend a general quality control meeting, and it was to give education and training from Managing Director, General Managers and other company officials to all employees and the contents of the discussions was high and excellent.

Taken here for the project is education and training in a narrow sense, namely, that which aims at, in implementing the modernization plan, learning how fast the facilities can be put into operation and started up to realize production at their full capacity.

(1) Idea

1) Education and training is to be planned as for facilities and technologies which are considered new to BURNPUR Works, and the budget is included in the total investment of this F/S.

2) The plan is to be implemented in the way that education and training is given in a short period in the country which supplies the new facilities and technologies in principle.

3) If such new facilities and technologies or similar things are found in India, the education and training is to be given there.

4) If the education and training is given to related workers alone, it tends to be near-sighted, and similar education and training should be given to supervisors and managers as well where feasible. However this must be reviewed at the time of implementation and is not included in the education and training plan (Draft) given below.

(2) Education and training plan

Table 7.1.4 shows education and training plan (Draft) by field based on the above idea.

The education and training in coke dept. is generally possible at other steel plants under the control of SAIL and that for PHOSAM process among by-product chemicals facilities is assumed possible at VISAKHAPATNAM steel plant, completion of which is scheduled to be in 1988.

Table 7.1.4 Training plan

Unit: Man-days

Field		Training given by Indian trainers in India	Training given by trainers dispatched from equipment and technology suppliers, at BURNPUR	Training given in countries supplying equipment & technology
Sintering	Ore yard	0	1,037	122
	Sintering	0	1,403	122
Blast furnace	Blast furnace	0	1,500	1,056
Basic oxygen furnace	BOF	750	1,600	750
	Lime calcining	110	0	110
Continuous casting	Bloom-CC	378	158	189
	Billet-CC	378	158	189
Rolling	Bar	0	530	1,050
Mainte-nance	Machine assembling	0	30	0
	Forging	0	50	0
	Central maintenance	0	1,650	3,256
	Local maintenance	0	1,650	3,960
Power	Receiving & distribution	0	0	120
	Oxygen	480	120	0
	BF blast	0	120	240
	Gas	0	120	240
Total		2,096	10,126	11,404

7-2. Coal and coke

7-2-1. Premiss of the modernization plan

(1) Coking coal

Remodelling of coal washing plant at CHASNALLA is to be completed before the modernization plan is implemented so that 1.2 million tonnes/year of cleaned coal with ash content of 17% may be used at BURNPUR Works. On the other hand, for control of coke quality, coking coal can be imported from abroad.
Existing coal yard has no space for expansion and it is necessary to construct new yard.

Because of the domestic condition, Eastern Railway has to be used for rail transportation of coking coal. For this, it is necessary to remove a part of the present railway terminal and construct a new receiving yard. CHASNALLA coal will be transported by ropeway.

Coking coal should have quality as shown in Table 7.2.1.

(2) Coke ovens

Following No.8 coke oven battery, No.9 battery is to be rebuilt, and they form one of the bases to achieve the modernization plan.

Nos. 8 and 9 batteries which are rebuilt & a newly built battery should all be able to be operated stably for a long period under proper operation control.

Coke oven bricks such as domestic silica bricks can be used satisfactorily in large coke ovens and their stable supply is possible.

Coke production at the rate of 120 ovens/day is possible with one team under 4-group 3-shift system.

(3) Others

Along with rebuilding of Nos.8 and 9 batteries, all of related facilities including coal yards, blending facilities, operation equipment for coke ovens, by-product plant and coke crushing and screening facilities are to be replaced with modern ones one after another and also coke oven personnel fully educated.

Impurities in coke oven gas produced should be limited to the following concentrations:

H_2S : 6 g/Nm^3 max. HCN : 1.5 g/Nm^3 max.
NH_3 : 10 g/Nm^3 max.

Coke which becomes surplus at the time of relining of blast furnaces and others can be sold outside, and all by-product chemicals recovered are also saleable.

7-2-2. Outline of facilities

Production flow charts at production scale of 1 million tonnes/year and 2.15 million tonnes/year in terms of crude steel are shown in Fig. 7.2.1 and Fig. 7.2.2, respectively. In the figures, facilities to be constructed or remodelled are shown enclosed in thick line.

(1) One million-tonne production scale

The production scale is established with existing Nos. 8, 9 & 10 coke batteries and their by-product plant.
A new conveyor system is to be constructed to transport lump coke to No. 5 BF.

Various improvements are to be made for improving environmental and operational condition and ensuring stable operation of existing facilities.

(2) 2.15 million-tonne production scale

Coke is produced in two areas of existing Nos. 8 & 9 batteries and a newly built No. 11 battery, and by-product chemicals plant, coke crushing and screening facilities, coal yard and blending facilities corresponding to No. 11 battery are to be constructed.

Nos. 8 & 9 coke batteries and their by-product chemicals plant are operated as such under the one million-tonne scale.

A new conveyor is constructed to transport coking coal from receiving yard to new coal yard.

a. Coal yard

A new yard for open air storage of 180,000 tonnes of coking coal is constructed. Also, a receiving yard is built at existing yard area after removing a part of railway terminal.

Coke is in principle stocked in coke cutter & screening area. Stock and delivery of coke is possible at coal yard also.

b. Coal handling facilities

Facilities to handle coking coal for No. 11 battery are installed. The process includes blending and 2-step crushing, and crushers are of variable in r.p.m.

c. Coke ovens

No. 11 coke battery consists of big 92 oven chambers with oven height being 7 metres and is equipped with standard accessories.

d. Coke handling equipment

Coke handling equipment are installed to screen coke to lump which is sent to blast furnaces and breeze which is sent to sintering plant. Coke to be stocked is sent to a yard before sizing.

e. By-product chemicals plant

Facilities to exhaust and refine coke oven gas generated in No. 11 battery are to be constructed. From waste liquor resulting from desulphurization and containing sulphur is made sulphuric acid. PHOSAM process is imployed to remove ammonia and produce liquid ammonium. Facilities to distill coke oven gas liquor occurring from No. 11 battery and bacteriological oxidation facilities are installed.

Crude light oil is to be sold and a shipping tank constructed. Tar is utilized as fuel for power plant.

Testing and analysing equipment directly related to operation are increased and expanded.

Outline of major facilities of the above is given in Table 7.2.2 and their specifications in Table 7.2.5.

The contents of the above facilities may be changed according to the contents of investments for improvement or remodelling related to the rebuilding of Nos. 8 & 9 batteries as well as restriction of the site.

Also for establishing the 2.15 million-tonne scale, alteration of facilities and their specifications, and even change in implementation schedule may become necessary in view of actual condition at the site at the time of implementation.

Table 7.2.1 Coking coal blending schedule

Coal type	Blending ratio (%)	Volatile matter (%)	ASH content (%)	Annual consumption (1,000 Dry T/Y)		Coke quality expectation
				1 MT/Y	2.15 MT/Y	
Prime	50	24.3	17.0	665.5	1,197.0	Ash: 23~24%
Medium	30	28.0	19.0	399.3	718.2	(M10: 13~15%)
Blendable	10	31.0	18.5	133.1	239.4	
Import	10	24.0	9.0	133.1	239.4	
Total	100	26.1	17.0	1,331.0	2,394.0	

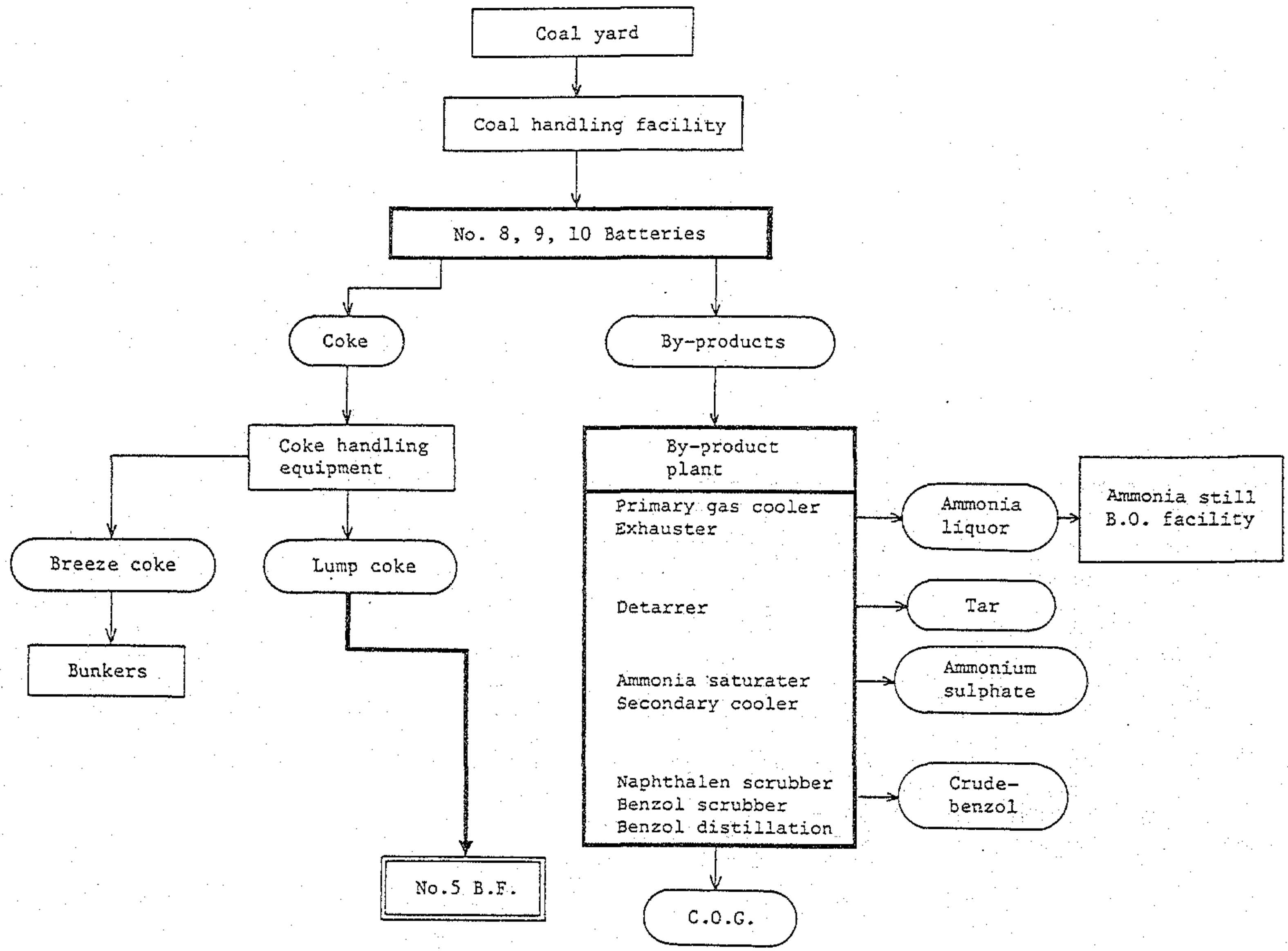


Fig. 7.2.1 Process flow (1 MT/Y)

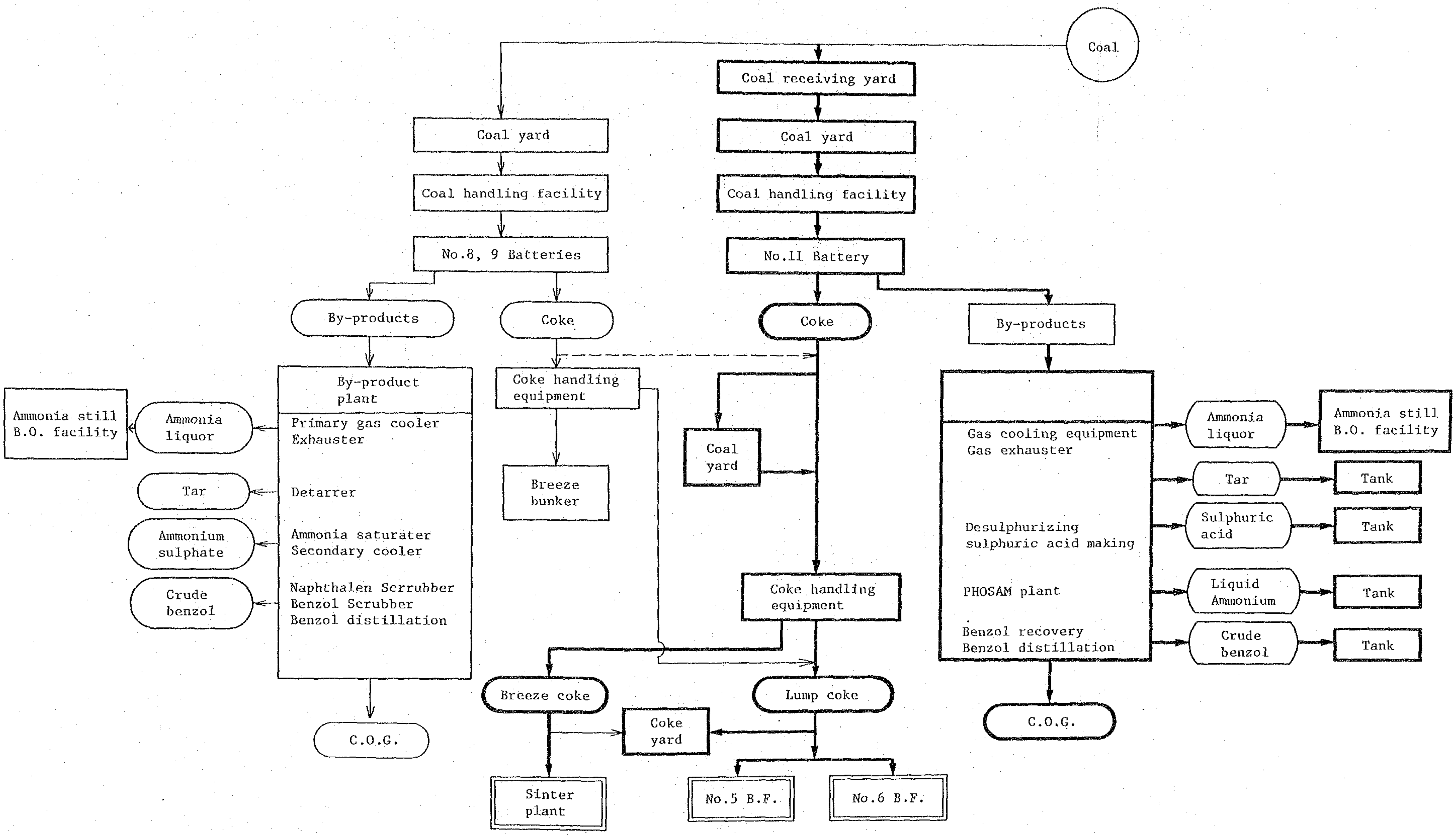


Fig. 7.2.2 Process flow (2.15 MT/Y)

Table 7.2.2 Outline of Equipments and facilities

Equipment and facility	Quantity	Outline
1. Improvement		
(1) Dust collecter	2 sets	No.8, 9 Batt.: Capacity 2,500 m^3/min
(2) Oven machine	2 sets	Coke guide car: Charging car
(3) Smokeless charge	2 sets	No.8, 9 Batt.
(4) Induction radio and V.H.F. radio	2 systems	Coal, Coke, By-product area
(5) Workers office	1 set	Coke, By-product area
2. Yard		
(1) Coal receiving yard	1 set	Yard area: 3,840 m^2 Wagon Tippler: 1 unit Stacker-cum-reclaimer: 2 units
(2) Coal yard	1 set	Yard area: 46,080 m^2 Storage capacity: 180,000 T Stacker: 1 unit Stacker-cum-reclaimer: 2 units
(3) Coke yard	1 set	Coke stacker: 1 unit Coke cutter and screen: 2 units
3. Coke/by-product plant		
(1) Coal handling facility	1 set	Coal blending bin: 350 T/bin x12bins Prime. and secondary crusher: and others
(2) Coke oven	92 chambers	Coke chamber volume: 7,200 mm(H) x 450 mm(W) x 16,500 mm(L) Effective volume: 48 m^3/oven
(3) Transportation equipment	3 systems	Coal receiving yard to coal yard: 400 T/h Coke for No.8, 9 Batt.: 220 T/h Coke for No.11 Batt.: 220 T/h
(4) Gas exhaust equipment	3 units	Gas exhaust equipment: 60,000 Nm^3/h
	6 units	Primary gas cooler: 16,000 Nm^3/h cooler
(5) Gas refining equipment	1 system	Desulphurizing equipment

(continued)

Equipment and facility	Quantity	Outline
		Final cooler Benzol recovery equipment and others Sulphuric acid equipment PHOSAM plant
(6) Bacteriological oxidation facility	1 set	Capacity: 720 m^3/D
(7) Testing and analyzing facilities	1 set	Building area: 300 m^2 x 2 floor Sample preparation device: x 1 set Testing and analyzing device: x 1 set

7-2-3. Schedule for implementation

(1) One million-tonne scale

In principle additional investments to the existing facilities should have been completed one month before the start-up of No. 5 blast furnace.

The facilities in use being the subject, it is important to schedule the project by taking into full consideration coordination among the facilities.

(2) 2.15 million-tonne scale

One month before the start-up of No. 6 blast furnace, No. 11 battery should be commissioned and started up gradually to full capacity operation in three months.

Brick drying and heating up of coke ovens is done in three months. Start-up of the coke ovens determines the time when other facilities start operation.

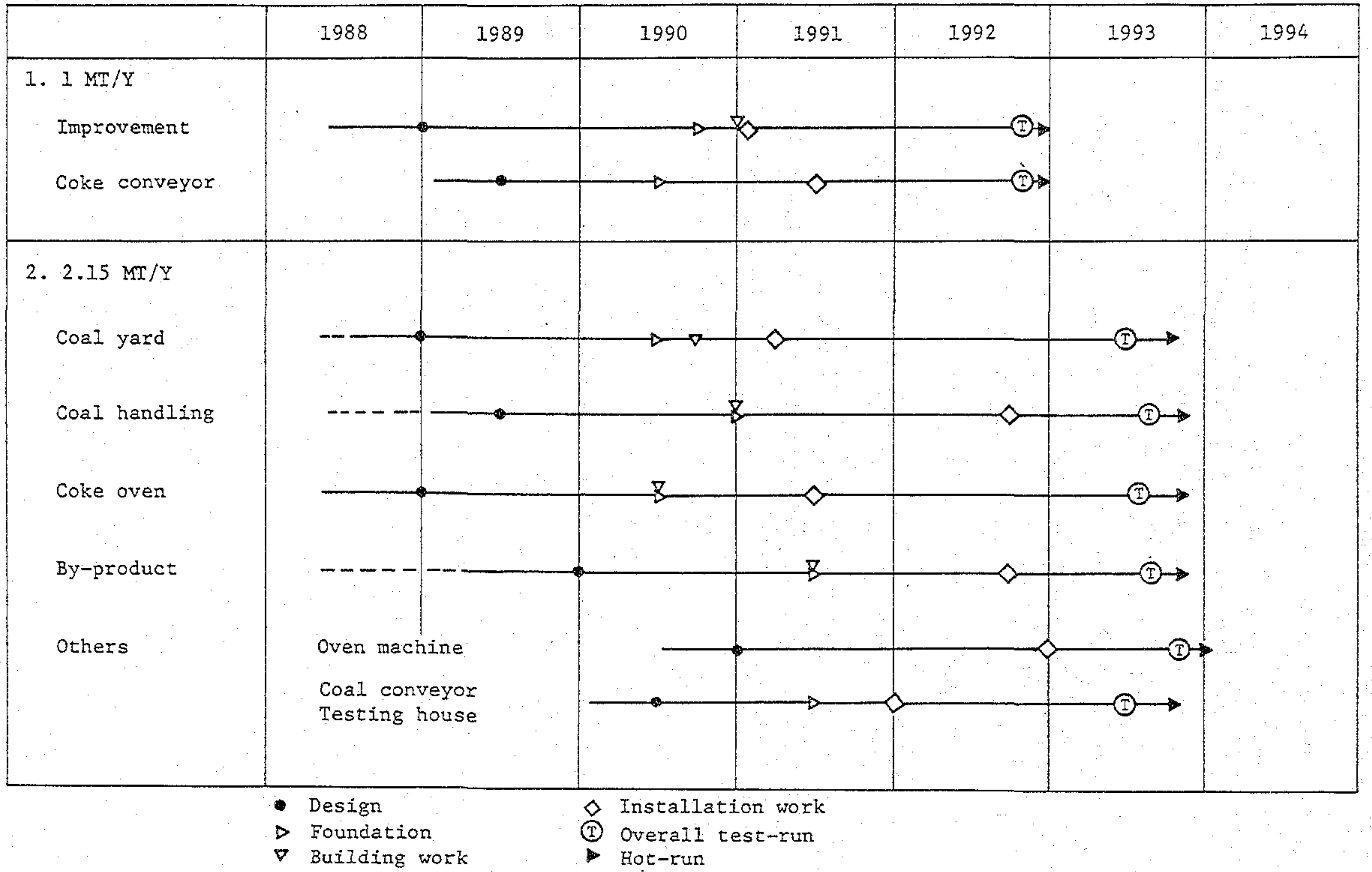
In order to ensure stable operation of Nos. 8 & 9 coke batteries, spares of oven machines should be completed by the time and kept ready for use.

Construction of the receiving yard should be performed efficiently so that coal storage may be possible two months ahead of the start-up of the coke ovens.

The above projects are to be undertaken without delay after completion of land preparation to keep work load as even as possible.

Construction schedule prepared on the above premiss is shown in Table 7.2.3.

Table 7.2.3 Construction schedule



7-2-4. Layout

Fig. 7.2.3 shows the layout of the entire plants to be newly constructed. It also shows proposed site for BTX and tar distillation which are likely to be installed in future.

The new yard is of pile arrangement considering effective coal storage area. Space resulting from arrangement of conveyors can be utilized for installation of various buildings and materials yard.

The coke battery is laid out in parallel with the yard and there is space for No. 12 battery which will replace Nos. 8 & 9 batteries.

At the coke side of No. 11B and No. 12A is reserved a space for coke dry-quenching facilities, C.D.Q., which may be installed in future.

Layout of by-product chemicals plant is prepared by also considering installation of the additional battery.

Because of available space, bacteriological plant is positioned to the east of the site for Tar and BTX.

Between the yard and the coke battery, there is a space equivalent to two yards. This space may be used for various purposes such as site for replacement of No. 11 battery, site used when the receiving yard and existing yard are integrated to improve efficiency, or site for expansion of coke breeze screening. However, the way to use this space needs be decided by overall judgement by considering lives of Nos. 8 & 9 batteries.

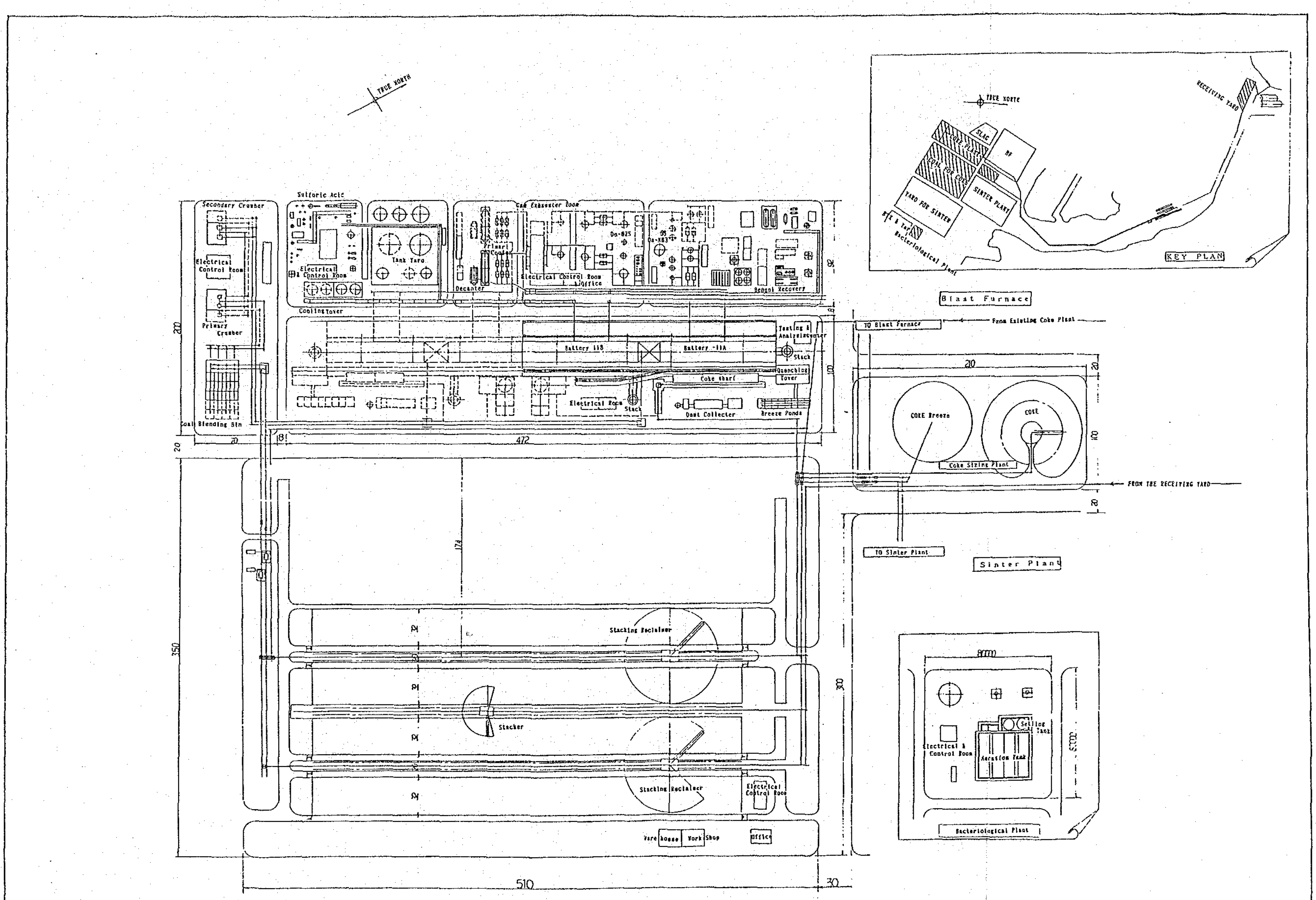


Fig. 7.2.3 Layout

7-2-5. Material flow

(1) Premiss of coking coal quality and blending schedule is shown in Table 7.2.1.

Blending ratio of coking coal is decided mainly for the purpose of lowering ash content of coke, and improvment of coke strength is considered only as a result.

For overall control of coke quality including strength, it is necessary to know accurately characteristics of each type of coking coal used and it is possible only when the 2.15 million-tonne production scale is set up.

(2) Unit consumption of raw materials, utilities and auxiliary materials for coke oven and by-product facilities and their annual consumption and production/generation are shown in Table 7.2.4.

The amount of coke to be produced is determined by the amount of lump coke used in blast furnaces and the rate of coke breeze. Under the one million-tonne/year scale, 224 ovens of Nos. 8, 9 & 10 batteries are in operation with sufficient production, but operation load factor is low, about 85%. To avoid various troubles resulting from low load operation, the factor is increased by 5% to 90% minimum and any surplus coke is to be sold outside.

Under the 2.15 million-tonne scale, considering the extension of lives of Nos. 8 & 9 batteries and location condition and efficiency of No. 11 battery, Nos. 8 & 9 batteries are to be operated at 100%.

Coke oven gas and blast furnace gas are used mainly at coke ovens. When coke oven operation is stabilized, it is necessary to employ C.P.U. for combustion control and thereby decrease gas consumption. C.D.Q. not only serves to save energy consumption but also improves coke quality and contributes to stabilize and improve blast furnace operation and its installation should be studied.

Table 7.2.4 Comsumption and generation

	Production amount 10^3 T/Y	Raw material			Utility			By-products		
		Name	Unit	Annual consumption	Name	Unit	Annual consumption	Name	Original material	Annual generation
1 MT/Y	Coke 792.2	Coal	1.68 T/T-coke	1,331 x 10^3T	C.O.G.	89.2 Nm^3/T-coal	118.8 x $10^6 Nm^3$			
					B.F.G.	360.4 Nm^3/T-coal	479.7 x $10^6 Nm^3$	Coke breeze	14.9%/T-coal	198.1 x 10^3T
					Electric power	27 kwh/T-coal	35.9 x 10^6kwh			
		(Domestic 90% Import 10%)			Steam	461 kg/T-coal	613.2 x 10^3T	C.O.G.	276 Nm^3/T-coal (4,000 kcal/Nm^3)	367.4 x $10^6 Nm^3$
					Industrial water	1 m^3/T-coal	1,331 x 10^3T			
					Nitrogen	0.25m^3/T-coal	332.8 x $10^3 Nm^3$	Tar	2.5%/T-coal	33,276 T
					Pure water	6.6 kg/T-coal	8,760 T			
					Compressed air	5 m^3/T-coal	6,655 x $10^3 Nm^3$	Crude benzol	0.5%/T-coal	6,655 m^3
					Sulphur	1.3 kg/T-coal	1,760 T	Ammonium sulphate	0.45%/T-coal	5,990 T
					Wash oil	0.3 kg/T-coal	399 T			
2.15 MT/Y	Coke 1,438.8	Coal	1.68 T/T-coke	2,394 x 10^3T	C.O.G.	50.8 Nm^3/T-coal	121.7 x $10^6 Nm^3$	Coke breeze	15.0%/T-coal	359.7 x 10^3T
					B.F.G.	533 Nm^3/T-coal	1,276.1 x $10^6 Nm^3$			
					Electric power	28.7 kwh/T-coal	68.6 x 10^6kwh	C.O.G.	275.9 Nm /T-coal (4500 kcal/Nm^3)	660.6 x $10^6 Nm^3$
		(Domestic 90% Import 10%)			Steam	218 kg/T-coal	552.1 x 10^3T			
					Industrial water	1.8 m^3/T-coal	4,233.6 x $10^3 m^3$	Tar	2.92%/T-coal	69,996 T
					Nitrogen	0.25m^3/T-coal	598.5 x $10^3 m^3$	Crude benzol	0.5%/T-coal	11,970 m^3
					Pure water	13.7 kg/T-coal	32.8 x 10^3T			
					Compressed air	5 m^3/T-coal	12.0 x $10^6 m^3$	Ammonium sulphate	0.18%/T-coal	4,251 T
					Wash oil	0.3 kg/T-coal	718 T			
					Picric acid	------	100 T	Liquid ammonium	0.13%/T-coal	3,036 T
					Steam (15kg/cm^2)	5.7 kg/T-coal	13.7 x 10^3T			
					Phosphoric acid	------	3.3 T			
					Caustic soda	------	45.5 T			

With stable power supply and adoption of coke oven gas fired reheating furnaces, steam being used in a large quantity in Nos. 8 & 9 batteries can be much decreased.

The above three items have a ripple effect on improvement of energy consumption and should be implemented as soon as possible once operation stabilizes and additional investment is possible.

Figs. 7.2.4 and 7.2.5 show material flow of coke making or production balance.

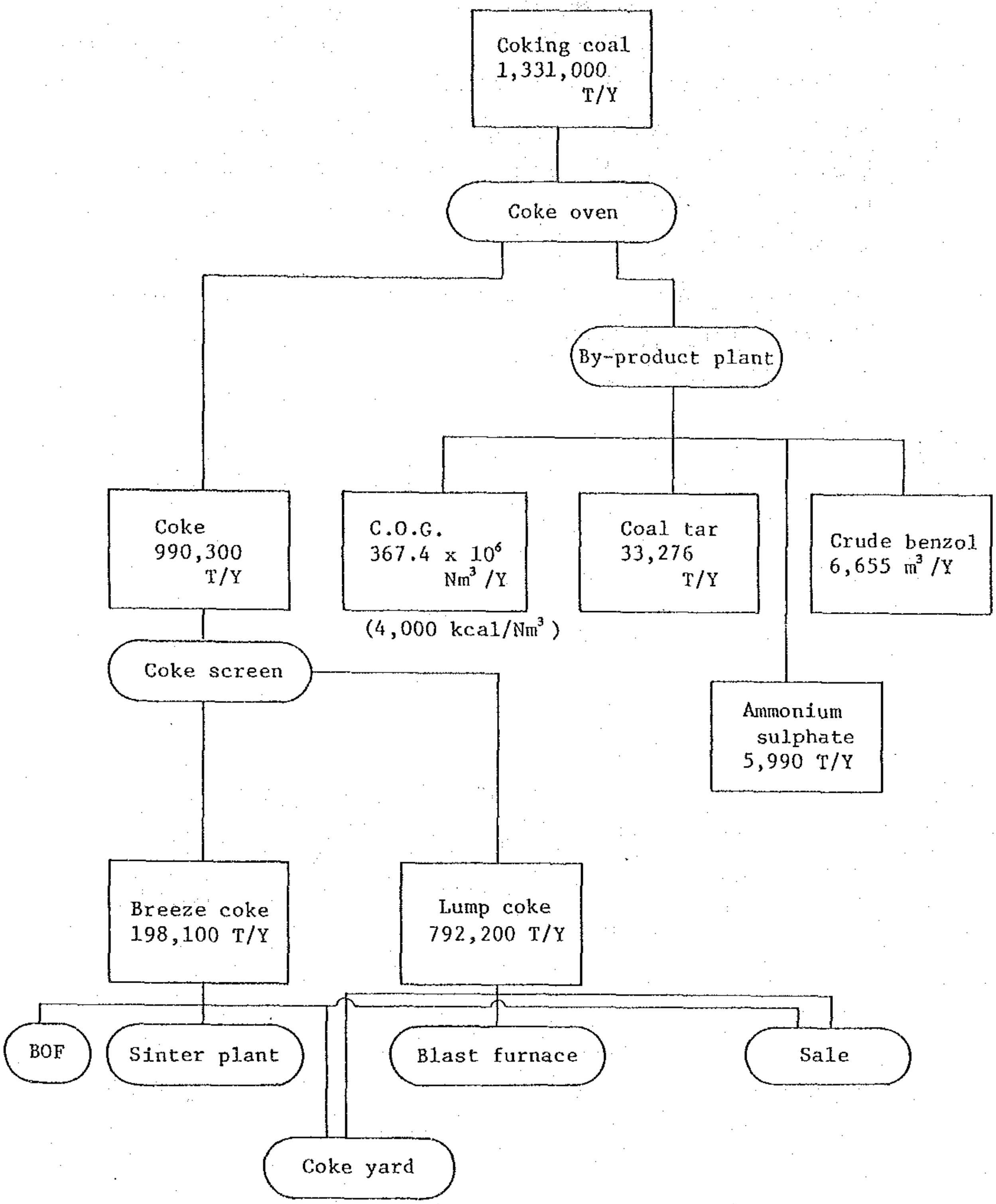


Fig. 7.2.4 Production balance (1 MT/Y)

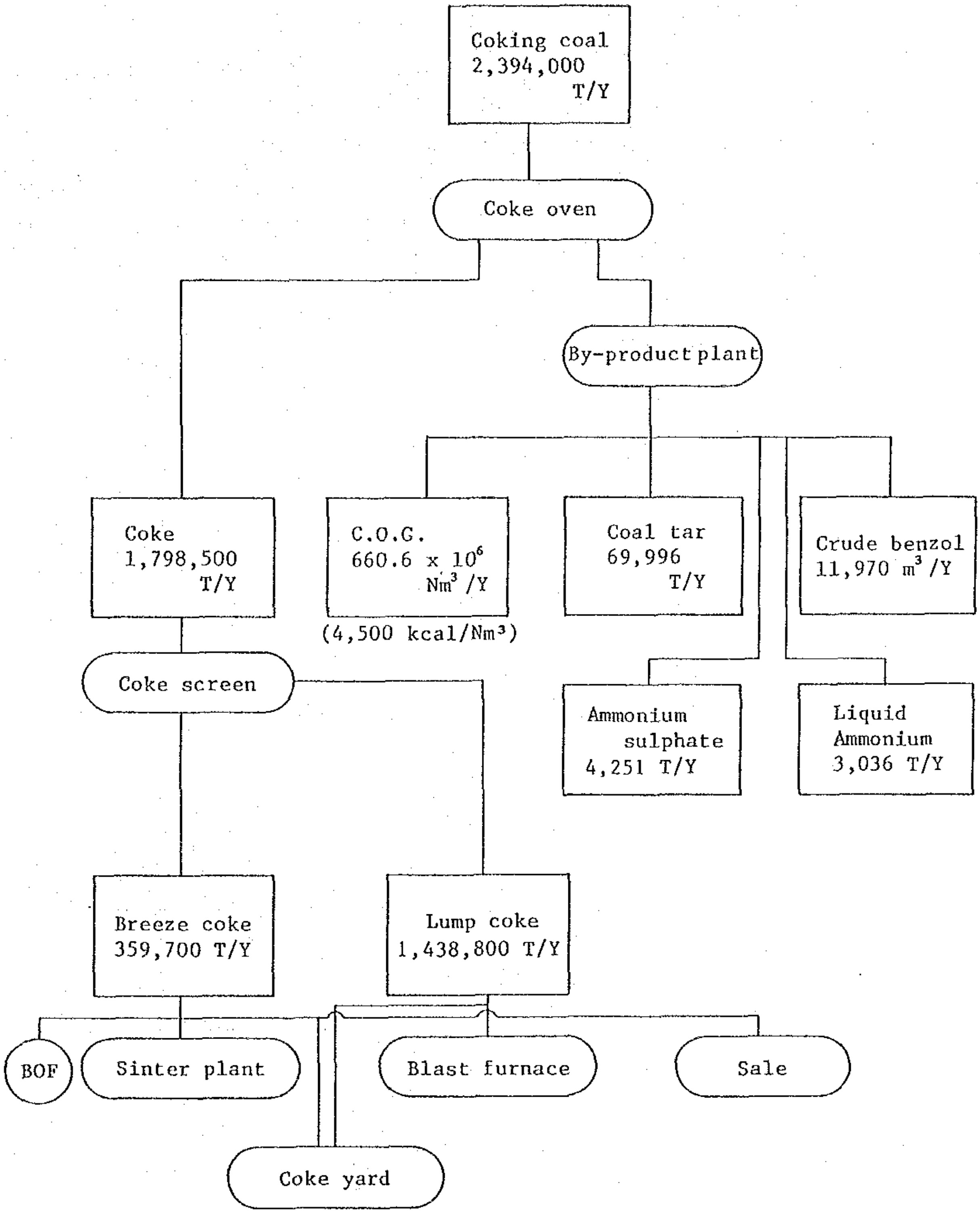


Fig. 7.2.5 Production balance (2.15 MT/Y)

7-2-6. Construction materials

In principle, domestic products are used as materials required for implementation of the modernization plan, and the materials supplied from Japan are limited to equipment such as high tension, high speed rotors, part of electric machines and high pressure equipment, guarantee of whose performance constitutes a very important factor.

Table 7.2.5 Specifications

Equipment and facility	Quantity	Specification
1. No.8, 9 Batt. and By-product		
1) Dust collecter for coke guide car and charging car	2 sets	Bag filter: 2,500 m^3/min
2) Smokeless charge	2 sets	High pressed ammonia liquor, spray
3) Oven machine	2 sets	Charging car, Coke guide car
4) Tar, Ammonia liquor, sludge, separation	1 system	Super-decanter
5) Coke transport equipment	1 system	1,050 mmw x 220 T/h x 2.4 km
6) Communication system	1 system	Induction wireless telegraph very high frequency wireless telegraph
7) Office and operators house	1 system	
2. Coal receiving yard		
1) Yard		32 m x 120 m x 1 yard
2) Wagon tippler	1 unit	600 T/h (60 T/wagon x 10 wagons/h)
3) Locomotive	2 units	80 T Diesel
4) Stacker-cum-reclaimer	2 units	400 T/h
5) Belt conveyer	1 system	1,050 mmw x 600 T/h x 7 units 1,020 mmw x 600 T/h x 1 unit 900 mmw x 400 T/h x 1 unit
6) Coal transport equipment	1 system	900 mmw x 400 T/h x 2.4 km
3. Coal yard		
1) Yard		32m x 360m x 4 yards Storage capacity: 180,000 T
2) Railless car	6 units	Shovel x 2, Dump x 4
3) Stacker	1 unit	400 T/h
4) Stacker-cum-reclaimer	2 units	400 T/h
5) Belt conveyor	1 system	1,050 mmw x 400 T/h x 2 units 900 mmw x 400 T/h x 13 units 600 mmw x 50 T/h x 2 units
6) Automatic sampler	1 unit	Width of slot: 225 mm Travelling speed: 500 mm/sec
7) Screen	2 units	Single deck ripple flow type: 400 T/h

(continued)

Equipment	Quantity	Specification
8) Electric house and control room	1 unit	300 m^2 (2F)
Office	1 unit	240 m^2
Ware house	1 unit	300 m^2
Maintenance workshop	1 unit	300 m^2
4. Coke handling equipment		
1) Coke stacker	1 unit	220 T/h
2) Coke cutter	2 units	Double roll type: 220 T/h
3) Coke screen	2 units	Single deck ripple flow type: 220 T/h
4) Dust collecter	2 units	Washer type: 500 Nm^3/min x 1 1,000 Nm^3/min x 1
5) Belt conveyer	1 system	900 mmw x 220 T/h x 8 units 1,050 mmw x 220 T/h x 6 units 600 mmw x 50 T/h x 5 units
5. Coal handling facility		
1) Coal receiving conveyer	1 system	1,020 mmw x 400 T/h x 2 units 1,400 mmw x 400 T/h x 4 units
2) Coal blending bin	12 bins	350 T/bin
3) Primary crusher	2 units	Hammer type: 250 T/h (Variable speed control)
4) Secondary crusher	2 units	Same as Primary crusher
5) Belt conveyer	1 system	1,400~900 mmw x 24 units
6) Constantfeed weigher	12 units	~50 T/h
7) Charging coal bin	1 bin	2,500 T/bin
8) Dust collecter	1 unit	Bag filter type: 2,000 m^3/min
9) Electric house and Control room	1 unit	600 m^2 (2F)
6. Coke oven Battery		
1) Coke oven	92 ovens	7,200 x 450 x 16,500 mm (Height x Width x Length) Effective volume: 48 m^3/oven
2) Stack	2 units	120 m
3) Charging car	2 units	One point table feeding type, oven-top cleaner, hopper scale, charging hole lid seal, ignition, pre-duster, dust collecter.

(continued)

Equipment	Quantity	Specification
4) Pusher machine	2 units	One point pushing and leveling, door and jamb cleaner.
5) Coke guide car	2 units	One point type, dust collecter, door and jamb cleaner.
6) Quenching car	2 cars	Dump type.
7) Q/C locomotive	2 cars	
8) Quenching equipment	1 system	Pump: 540 T/h x 2 Tower height: 25 m Dust filter, Breeze ponds
9) Coke wharf	1 system	25 m L X 10 m W x 3 Drum feeder
10) Dust collecter	1 unit	for coke guide and charging car Bag filter type: 5,000 m^3/min
11) Gas reversing equipment	1 system	Hydraulic type
12) Coke belt conveyer	1 system	No.11 Batt. to coke handling coal yard to coke handling 1,200~900 mmW x 220 T/h x 300 mL
13) Coke center	1 set	Situated under/charging-coal-bin
14) Testing and analyzing center	1 set	600 m^2 (2F) Sample preparing equipment Testing equipment Analyzing equipment
7. By-product plant		60,000 Nm^3/h
1) Gas cooling equipment	1 system	Primary cooler: 16,000 Nm^3/h cooler Decanter, Separate tank Super-decanter: x 2
2) Gas exhauster	3 units	40,000 Nm^3/h x 1,800 mmAg
3) Benzol recovery equipment	1 system	Naphthalen scrubber: Spray type x 1 Electric mist precipi precipitater: Indirect cooler: x 1 Benzole scrubber: spray type x 2
4) Benzol distillation equipment	1 system	Wash oil treating volume: 110 m^3/h Dehydration tower: x 1 Stripping still : x 1 Depitching still : x 1 Heating furnace : x 1
5) Desulphuriging equipment	1 system	Sulphur removal rate: over 90% Absorber : x 1 Regenerater: x 1
6) Sulphuric acid making equipment	1 system	KOMPACS method Sulphuric acid making plant: Max 22 T/D

(continued)

Equipment	Quantity	Specification
7) Ammonia liquor treatment equipment	1 system	Ammonia washer: x 1 Ammonia removal rate: over 90% Ammonia still: x 1
8) Liquid Ammonium making equipment	1 system	PHOSAM method Liquid Ammonia: Max 17 T/D
9) Bacteriological oxidation equipment	1 system	Ammonia liquor treating 30 m^3/h
10) Tank		Tar: 4,000 m^3, Crude benzol: 650 m^3 and others
11) Cooling tower	2 units	900 T/h x 2

7-2-7. Supplementary explanation

(1) The number of ovens of coke ovens operated

1) Nos. 8 & 9 coke oven batteries

78 ovens each of Nos. 8 & 9 coke oven batteries which would be started up in 1987 and 1991, respectively, are important facilities required to achieve the modernization plan in 1993 and after.

If the business period of this project is assumed to be 20 years, the age of Nos. 8 & 9 batteries will be 26 years and 22 years, respectively, in 2012.

It cannot absolutely be defined how many coke ovens will be in operation in 2012 as the number will vary considerably depending on operation condition, maintenance condition, operation method and others. But it is assumed in this study that of the 156 ovens of Nos. 8 & 9 batteries, 20 ovens will be idled or under repair and 136 ovens will be in operation. Regarding No. 8 battery in particular, it is expected that the ovens will be operated under high load for 4 years immediately after the start-up in 1987 and liable to early breakdown.

Therefore, average number of ovens in operation for the 20 years is assumed to be 146 (68 + 78).

2) No. 11 coke oven battery

The number of ovens required to be installed in No. 11 battery is determined by the number of ovens in operation and the operating rate of Nos. 8 & 9 coke oven batteries, assuming the effective volume of an oven of No. 11 battery to be constant at 48 m^3.

In this plan, in view of various concern expressed by the Indian mission who visited Japan in November 1986 about the age of ovens being 30 years, operating rate of No. 11 battery is assumed 100%.

Incidentally, if it is assumed that the number of ovens in operation of Nos. 8 & 9 batteries is 156 and their operating rate 120%, the required number of ovens of No. 11 battery is calculated to be 76.

The effect of such reduced number of ovens on coke oven gas balance will be gas generation 1.6% less and consumption 1.9% more than the planned figures.

(2) Coke balance

Because of decrease in ash content of coking coal, specific gravity of coke will be lower and coke yield will lower apparently. Besides, according to the difference in height of coke ovens, yields of coke, gas and others also will vary. Those changes in conditions were incorporated in this plan.

The percentage of coke breeze varies according to coke strength, occurrence of fines due to drop during transportation, and mesh size and efficiency of coke screen.

Based on the present percentage of coke breeze (18%) and considering changes in those conditions, the breeze percentage is assumed with safety allowance in this plan.

Further study on coke moisture and size distribution after the modernization of BURNPUR Works may enable attaining lower breeze percentage than that in the basic plan. And also there are methods to charge medium lump coke into blast furnaces.

(3) Estimation of gas combustion temperature when operating rate of Nos. 8 & 9 batteries is 100%

Because the present operation of Nos. 8 & 9 batteries is considerably out of standard and also because detailed design condition of the batteries after the modernization is not available, it is difficult to estimate proper gas combustion temperature. However, in view of the standard in Japan, the temperature may be estimated to be about 60 ^{o}C lower as compared to that in the case when the operating rate is 120%.

(4) It is technically possible to stop production of ammonium sulphate at Nos. 8 & 9 batteries at present and lead the gas from Nos. 8 & 9 batteries collectively to the liquid ammonium facilities of No. 11 battery. But the required cost is not included in the present F/S.