No. 6

THE FEASIBILITY STUDY REPORT ON THE MODERNIZATION OF BURNPUR WORKS OF INDIAN IRON AND STEEL CO., LTD. IN INDIA

(SUMMARY)

June 1987

Japan International Cooperation Agency

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Contents

1. Introduction

1-1. The objective and course of the study

This study was made, in compliance with the request of the Government of India, for the purpose of modernization of BURNPUR Works of Indian Iron and Steel Co., Ltd. (IISCO), a subsidiary of Steel Authority of India Ltd. (SAIL). Accordingly it aimed at drawing up a modernization plan for IISCO's BURNPUR Works by studying the present condition of the Works and examining technological, financial and economic facts.

The study did not aim at giving advice on their renovation and operation, but it was to plan modernization of BURNPUR Works of IISCO by introduction of new facilities in an adjacent site while utilizing effectively existing facilities.

When India's Prime Minister Rajiv Gandhi visited Japan in November 1985, he made a request to the Japanese government for cooperation in modernization of the steel industry in India.

Having received the request, the Japan International Cooperation Agency (JICA) dispatched a preparatory survey team to India in February 1986 and signed a scope of work (hereinafter referred to as S/W) for carrying out a feasility study on the modernization of BURNPUR Works of IISCO (hereinafter referred to as F/S) between the Government of India.

JICA entrusted the Japan Iron and Steel Federation (JISF) to carry out the F/S and JISF organized a survey team consiting of 15 experts and executed the F/S.

The survey team visited India for about one month from June to July 1986 and conducted field survey of plants and

sites centering on BURNPUR Works and discussion with those concerned of Indian side, and after return to Japan, the team engaged in the study in Japan for about three months based on data and information obtained during the field survey. The period spent for the field survey and the study in Japan was extremely short as compared with that usually spent for a feasibility study of this kind.

For six days in November 1986 when the Indian counterpart visited Japan, the study team had intermediary discussions with them on the contents of F/S.

By strong request of the Indian side in the course of the discussions, the study team was obliged to repeat the work for review of capital investment and others from the standpoint of obtaining the maximum effect with investment of limited funds.

This F/S report is the final report that covers all the results of reviewing work in the period from November 1986 to February 1987.

For giving explanation on the draft final report, JICA dispatched a mission to India from March 18 to 25, 1987. The mission explained the details of the report to Department of Economic Affairs, Ministry of Finance, Department of Steel, Ministry of Steel, Mines & Coal and SAIL of India, and signed minutes between SAIL and Ministry of Steel, Mines & Coal on March 24, in which it was agreed between JICA and India that the final report will be submitted by the end of June, 1987.

JICA hopes that this report can contribute toward the modernization of IISCO's BURNPUR Works.

1-2. Scope of the study

The scope of work of this F/S is specified in S/W signed between the Government of India and JICA's preparatory survey team dispatched to India for 13 days starting from February 25, 1986.

In IISCO's BURNPUR Works, all processes of raw materials, iron making, steelmaking and rolling were made the object of the study, and the study was made for drawing up a modernization of the Works.

At IISCO's GUA mine, the study was confined to treatment of fine ore which is required in connection with the modernization of BURNPUR Works.

1-2-1. Field survey

As regards IISCO's BURNPUR Works, the study was made and necessary data obtained concerning the present condition of facilities, operation, organization and personnel of each production process of raw materials and fuel, iron making, steelmaking and rolling, and also each field of maintenance and utilities as well as the present financial condition of the Works.

The present F/S is for BURNPUR Works alone and the infrastructure such as railway, roads and township around the Works was put outside of this study.

To obtain reference data for the modernization plan, the study team visited SAIL's steel plants at Bhilai, Bokaro and Durgapur, IISCO's KULTI foundry and Tata Iron and Steel Co.'s Tata Works and others.

The team also collected data and information related to the present condition and forecast of steel demand and supply in India.

At IISCO's GUA mine, field survey was made concerning fine ore treatment.

The officials and others of the Indian side with whom the team had a pleasure to meet and discuss during the stay in India totalled more than 180 including the counterparts of SAIL and IISCO.

JICA takes this opportunity to express sincere gratitude to those who cooperated with the team in its field survey.

1-2-2. Study work in Japan

Based on the data and information obtained by the field survey, technical experts in respective fields made study of production technology, facilities, plant layout, personnel and others, and drew up modernization plans, in their respective fields.

On such plan, overall adjustment was made on works layout, material balance, energy balance, capital investment and others to make an overall modernization plan.

In addition, on this modernization plan, financial analysis and economic analysis were made.

The study at home was made on the following premises.

(1) Based on the discussion between JICA preparatory study team and the Indian counterpart, production capacity of 2 to 2.5 million T/Y in terms of crude steel was made the target for the Works. And it was also decided that blast furnace - basic oxygen furnace process was to be adopted as production method to achieve the target.

(2) A tract of land owned by IISCO and adjacent to existing facilities of the Works was considered as the site for modernization of the Works.

(3) As a result of discussions with the Indian counterpart based on the steel demand and supply forecast provided by SAIL, it was decided that the study be made with the Works' product mix being centered on non-flat, or long, products.

In view of the limited space of the Works and also for effective utilization of existing facilities, the team considered it more advantageous that the Works produces mainly non-flats as at present.

(4) The target in productivity and level of production technology was that it be not inferior to that of other steel plants in India and as close as possible to international standards.

(5) Prices of imported equipment were estimated on the basis of domestic purchasing prices in Japan. Prices of those to be purchased in India were estimated based on Indian prices where unit price was provided by the Indian side and on Japanese domestic prices where Indian unit price was not available.

(6) As data and information necessary for the F/S could not be obtained adequately because of the limitation of time for field survey and others, the F/S had to be made by setting some preconditions or assumptions at stages of the study work in Japan.

(7) Financial analysis was made on the assumption that the accumulated deficit of IISCO at present has no effect on the financial accounting under consideration.

1-3. Study schedule

June 23 - July 25, 1986:

Field survey conducted. The team consisted of 15 members and Mr. K. Takeda, Head, Industrial Survey Div., JICA. During the period the team gave explanation on Inception Report and submitted Progress Report to the Indian counterpart. (See Study schedule given later.)

August - November 1986: Study work in Japan

November 1986:

Discussions with the Indian counterpart on Interim report.

The Indian counterpart consisted of 5 members as follows:

SAIL : Mr. H. Bandyopadhyay, Additional Director

IISCO: Mr. M.F. Mehta, Managing Director

Mr. J. Ganguli, General Manager (Projects), BURNPUR Works

Mr. M.S. Chawla, Deputy General Manager (Iron and Steel), BURNPUR Works

MECON: Mr. S.L. Narasimhan, Chief Engineer

November 1986 - February 1987:

Restudy based on discussions with the Indian counterpart on the Interim report

February - March 1987:

Preparation of Draft Final Report

March 18 - 25, 1987:

Explanation on the Report to the Indian counterpart

2. Present condition and problems of BURNPUR Works

2-1. Outline

BURNPUW Works has a long history, which dates back 1922 when No.1 blast furnace was commissioned. It became an integrated steel plant with startup of open hearth furnace and rolling mills in 1939. However, in the age of rapid progress in iron and steel technology since 1950s, BURNPUR Works did not carry out major replacement or remodelling of its facilities for many years to date nor introduce new technologies (software). As a result, the Works is now an old and deteriorated steel plant.

Though the Works has nominal capacity of one million T/Y in terms of crude steel at present, the actual production is forced to be as low as about 500,000 T/Y due to low yield and productivity. As of March 1985, IISCO's financial condition shows a huge accumulated deficit of Rs.3,958.3 million (¥52.4 billion at ¥13,25=Rs.1).

BURNPUR Works still operates such processes as duplex steelmaking process using bessemer conveter and open hearth furnace and pull-over mill which are no more used in any industrialized steelmaking countries and are very inefficient. In addition, old production facilities started up in 1930s and 1940s are still in operation without any improvement.

In addition to such old facilities, it does not have raw materials pretreatment facilities such as sintering plant which modern steel plants should have for improvement of productivity and this is also a problem for the Works. Also it should be pointed out common to all production processes that instrumentation to grasp operation condition is very inadequate and that even where installed, some are out of order. Inevitably size control and moisture control of raw materials, temperature control at steelmaking, etc. are poor. In rolling dept. electric equipment are old and their control functions are also poor.

The above mentioned condition resulted in poor operation in BURNPUR Works and poor maintenance work is also one of cause of low operating rate.

2-2. Problems in respective processes

Coal and coke:

Coke oven body is severely deteriorated, which is giving adverse effect on coke production, COG generation and consumption.

Accessory equipment of coke ovens are all old and not properly repaired.

Iron ore:

As crushing and screening facilities are not installed, size control is not well done. In addition, bedding facilities are not used, making it difficult to obtain uniform composition of charges.

With no sintering plant, productivity of blast furnaces is low and coke ratio is high.

Iron making:

Of all existing four blast furnaces, productivity (tonne per unit of inner volume), coke ratio and slag ratio are very bad.

Causes of low productivity are: (1) Charged ore is not beneficiated, (2) Coke ash is high, (3) Size control and moisture control are poor and (4) High temperature, high top pressure operation is impossible.

In order to ensure stable BF operation for long time and high productivity, it is essential to replace old facilities and strengthen instrumentation and centralized control system.

Steelmaking:

The duplex process being used at present is too old in every aspect including productivity. Instrumentation to grasp actual operation condition is inadequate and even

temperature control is not performed.
Facilities are left unmaintained for a long period.
In ingot casting, poor quality of materials resulted in frequent operation troubles and low ingot quality.

Rolling:

Facilities, especially electric equipment, are not only old but not improved for a long time.
The mills that need to be shut down during the period of modernization under study are light structural mill and sheet mill.

Utilities:

One of the causes by which BURNPUR Works is compelled to operate at low operating rate is unstable power supply (17 MW) from power companies and another is shortage in COG balance in the Works.
On the other hand, own power generating facilities are old themselves and besides, inadquate capacity of coal crusher, low quality of coal and deterioration of control are noted.

Maintenance:

It can be seen that under the present maintenance condition of the Works, there is a kind of vicious circle of poor maintenance---short lives of facilities---increase of repairs---insufficent maintenance.
With too big a organization and personnel (about 8,500 persons), proper supervision and command may not be conveyed to the bottom-line organization and personnel.

3. Modernization of BURNPUR Works

3-1. Selection of product mix

In planning modernization of BURNPUR Works, product mix was determined on the basis of the forecast of steel demand and supply balance by product in India up to 2000 which was made after discussion with SAIL. On the precondition that the Indian side wants the modernization of the Works to be carried out as early as possible, selection of bar mill products as products for capacity expansion is considered most appropriate in view of the demand and supply balance forecasted at the time when the modernization is completed. For reference, supply deficit of bars in India is forecasted to increase year after year from 620,000 T in 1986/87 to 870,000 T in 1989/90, 1.6 million T in 1995/96 to 3.63 million T in 2000.

On the other hand, supply deficit of hot coils appears in 1995, but the tonnage is only 450,000 T, which is too small to be selected as product for the modernization. The deficit is forecasted to increase to 2.6 million T in 2000, but if the modernization is planned with schedule to complete a hot strip mill by the year, BURNPUR Works cannot be modernized by that time, and besides, compared to the bar mill, the modernization based on hot strip mill involves a huge capital investment because subsequent processes such as cold strip mill and others have to be installed. This makes it extremely difficult to improve the financial condition of BURNPUR Works.

3-2. Outline of modernization plan

3-2-1. Image of BURNPUR Works after modernization

The Works after modernization will look as follows:

On the conditions that its product mix is non-flats and that the site available for construction of new facilities is limited to 1.5 million square metres (a tract owned by IISCO and adjacent to existing facilities) and further that maximum economy of scale is aimed at, the present capacity of the Works of one million T/Y in terms of crude steel (actual production is 0.5 million T) is expanded to 2.15 million T/Y.

Such existing facilities as coal yard, coal transport facilities, coke ovens and part of rolling mills, etc. which can be used are to be utilized as much as possible to reduce investment. However, the introduction of sintering plant, overall replacement of blast furnaces, shift from the duplex steelmaking process to BOFs, introduction of continuous casting machines, and addition or new construction of rolling facilities which are prerequisite for the capacity expansion are carried out. To cope with unstable power supply in the country, self power generating facilities are replaced with modern ones.

Those new facilities and technologies to be adopted are to be considered compatible with the level of operation technology in India and the ones established and proved in the world. The construction of new facilities will be carried out without stopping production with existing facilities.

In the meantime, it was decided to install necessary facilities for pollution control measures with a view of protecting inhabitants as well as employees in the region from environmental pollution.

Material balance of the Works is as shown in attached sheet.

3-2-2. Construction schedule

What should be kept in mind when planning construction schedule is that if BURNPUR Works continues to be operated under the present condition, its accumulated deficit will increase year after year and that therefore it is essential to modernize the Works at an earliest date to improve it as a profitable steel plant. The construction schedule that is planned to enable commencement of the work soonest possible is described below.

First of all, it should be decided soon if the project is implemented and the owner consultant is selected. Selection of equipment suppliers is to be completed by the end of March 1989. It is necessary to commence land reclamation by 1988 and complete it by the end of September 1989.

The 1 million T/Y production scale occurs as a point of transition (1st step) before arriving at the 2.15 million T/Y scale (2nd step) and the period of this 1st step was made one year by the request of the Indian side. This 1st step period also serves as a period for training for startup of new facilities, but this involves many a difficult problems in that the new facilities have to be put into operation and started up while keeping close relation with existing facilities which are kept in operation, and perfect preparation work is indispensable.

3-2-3. Outline of the modernization plan by process

Coal and coke:

Remodelling of coal washing plant at CHASNALLA is to be completed before the modernization of BURNPUR Works is implemented so that 1.2 million T/Y of washed coal with ash content of 17% may be used.

In line with increase in coal consumption, new coal yard is constructed.

As to coke ovens, it is necessary that IISCO rebuild

No.9 battery following No.8 battery, which is an important factor in the modernization plan.

With the above, existing Nos.8, 9 & 10 batteries and their by-product chemicals facilities are to serve the one million T/Y production scale, and a conveyor system is installed for transport of lump coke to No.5 BF.

In the 2.15 million T/Y scale, new large No.11 battery and rebuilt Nos.8 & 9 batteries are operated at two separate areas. With respect to No.11 battery, chemical plant, coke sizing facilities, coal yard and blending facilities are installed. In addition, conveyors are to be installed to transport coking coal from receiving yard to the new coal yard.

Iron & sinter:

As regards iron ore, sizing facilities are installed to ensure proper size (10-30 mm) as BF charges. Lump ore of high grade (purchased) and general ore (GUA & CHIRIA) are used in the rates of 70% and 30%, respectively. Fines are blended mainly of GUA ore.

Crushing facilities are installed for limestone and dolomite which are received in lump, and they are sized to 3 mm or under for use in sintering plant.

To stabilize quality of raw materials, ore bedding system is employed.

Sintering machine is installed to produce self-fluxing sinter and assist stable operation of blast furnaces. (Startup: No.1 sinter plant in 1992 and No.2 in 1993)

Iron making:

Several plans are conceivable for modernization of BFs, but from long-range viewpoint, most desirable modernization plan is as follows:

Considering that existing four BFs come to be relined in around 1993 to 1996, firstly new No.5 BF (2250 m^3) is blown-in in 1993 to meet the one million T/Y production

and in 1994 new No.6 BF (2250 m^3) is blown-in. With the two BFs, the 2.15 million T/Y system is established. The total inner volume of BFs is 4500 m^3, and with productivity of 1.41, annual iron production will be 2.2 million tonnes. The existing four BFs are planned to be closed at the end of 1992 or early 1993.

Steelmaking:

As new facilities for modernization, basic facilities of BOF plant and facilities such as OG facilities, sublance facilities and automatic relining tower, etc. that are required for modern BOF plant are installed. BOF plant will have two 130T units with one in constant operation in the 1st step (1 million T/Y) and three units with two in operation in the 2nd step (2.15 million T/Y). As for burnt lime, major flux used in BOFs, existing shaft kilns are closed and new large shaft kilns are to be installed for direct feeding in view of consumption and quality.

Continuous casting (CC):

At the 1st step, one unit each of bloom CC (BL-1)(of 3-strand type with mold size 300x400 mm) and billet CC (BT-1)(of 8-strand type with mold size 100 mm sq.) is installed, making CC rate 48.5%.

At the 2nd step, two more billet CCs (BT-2 & BT-3)(of 6-strand type with mold size 150 & 180 mm sq.) are installed and sequence casting method is employed and CC rate is increased to 86.2%

All CCs are of curved mold type which is most popular.

Rolling:

The basic policy is to utilize existing rolling facilities by improvement wherever possible, and for meeting the increased steel production, No.1 bar & section mill (capacity 600,000 T/Y) and No.2 bar & section mill (capacity 700,000 T/Y) will be installed.

Of the existing facilities, blooming mill, billet mill, heavy structural mill and merchant bar mill are to be remodelled to meet the condition under the 1st step and 2nd step, but light structural mill and sheet mill which are very old and cannot be remodelled are closed in the 1st step and 2nd step, respectively, and are not included in production plan.

Product mix of the new bar mills was determined based on production of plain and deformed bars in India as well as of BURNPUR Works as follows:

Product Mix of New No.1 and No.2 Bar & Section Mills

(Unit: 1,000 T & %)

Mill	Size (mm)	Production 10-12	14-22	25-38	40-80	Total
No.1 Bar and section mill	10-32	180 (30%)	300 (50%)	120 (20%)	-	600 (100%)
No.2 Bar and section mill	20-80	-	210 (30%)	370 (53%)	120 (17%)	700 (100%)
Total	10-80	180 (14%)	510 (39%)	490 (38%)	120 (9%)	1,300 (100%)

Maintenance:

New investment for facilities for maintenance is not planned for the 1st step (1 million T/Y), but for the 2nd step (2.15 million T/Y) not only maintenance shops are centralized but also finishing shops, forging shop and electric repair shops are replaced or newly constructed and new investment is made.

Scope of maintenance work in the Works after modernization is as follows:

1) Repair of equipment is to be carried out in the Works in principle.
2) Repair of reheating furnaces, except overall repair, is performed by personnel of the Works.
3) Maintenance of railway tracks within the Works or under the control of the Works is performed by Works' personnel.

4) Repair of structures and buildings, except partial repair, is ordered to outside contractors.

Utilities:

Because power supply for maintaining operation is not stable at present, BURNPUR Works expressed a strong wish to JICA team that in planning its modernization plan, self power generating facilities are to be constructed by all means.

In compliance with such request, it was decided to construct captive power plant in the Works. Its scale is to be 120,000 kW in view of gas balance in the 2nd step with two units of 60 MW plants, one unit being built in the 1st step and the other in the 2nd step.

In addition to the above power facilities, as energy supply facilities, oxygen plant as well as gas and steam supply facilities are constructed or expanded.

Civil and building work:

The site required for construction of new facilities for modernization is limited to areas filled with wastes of the Works and green site in the compound of the Works. Their total area is about 2.2 million sq. m, but because of limitation from complicated boundary lines and underground coal deposits, the available area is about 1.5 to 1.8 million sq. m. at most.

Positions of main new facilities are:

1) Ore yard: Southwest part of the Works which is closer to DAMODAR station
2) Coke related facilities: Main facilities are to be constructed at the area newly prepared.
3) Rolling mills: The area close to the existing rolling mills
4) Steelmaking & CC: Southwest of the new rolling mills in consideration of position of the new rolling mills and topographical condition of the prepared land

5) Blast furnace: Positioned considering transport of hot metal, receiving of raw materials from sinter and coke plants, positions of existing slag crushing facilities and slag pit.

6) Power receiving and distributing: Placed between existing plant and the new plant area in view of power from DVC being supplied through existing plant area and power distribution to new facilities

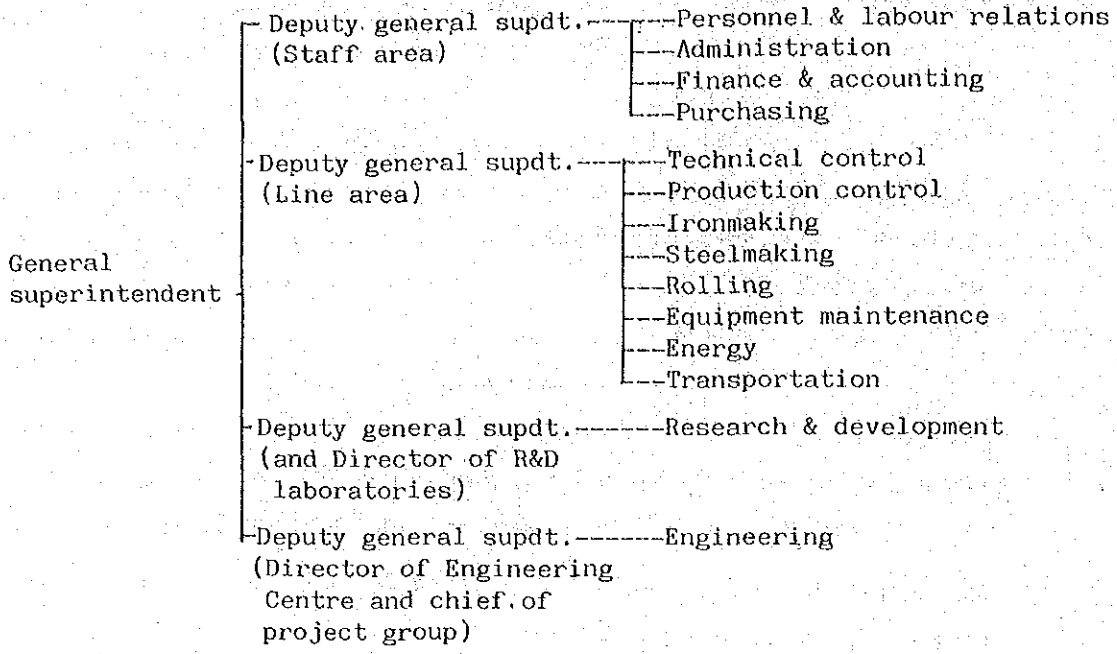
Ground level of the land prepared is so planned that the area required for building new facilities can be obtained with minimum earthwork based on the above layout plan.

As regards civil and building work, direct foundation system is employed for foundations of facilities and structures, and specifications usually applied in India are adopted to buildings in the Works. For important foundations or foundations bearing heavy load are to be direct foundation type but only after improvement of soil is made.

Organization:

Organization of BURNPUR Works was reviewed from three aspects, namely (1) Simplification of organization, (2) Conformity with technological progress and (3) Management.

Firstly, the present complex organization is thoroughly simplified. Secondly, to satisfy the need for technological progress, engineering centre is installed to establish R&D organization and system with a view of improving software technology and promoting introduction of better facilities. Lastly the following organization is recommended for facilitating management.



Personnel (No. of employees):

Determination of the personnel in planning the modernization was based on the system in Japan. As a result, the present working condition of 7-group 3-shift system in BURNPUR Works is changed to 4-group 3-shift system, and the personnel of the Works was set as follows. With this change, labour productivity per person is improved from 20-30 T/Man·Y to 152 T/Man·Y in the 2nd step.

General superintendent (Works)	(1)	Deputy general supdt. (1) - Staff area			(570)
		Deputy general supdt. (1) - Line area			(13,254)
		Deputy general supdt. (1) - R&D area			(189)
		Deputy general supdt. (1) - Eng. area			(121)
Total	(1)	+	(4)	+	(14,134)

4. Financial analysis

4-1. Total investment (Total of the 1st and 2nd step)

The total investment is Rs.129,153 Lakhs in the 1st step and Rs.115,713 Lakhs in the 2nd step, totalling Rs.244,866 Lakhs, of which domestic purchases is Rs.156,052 Lakhs (64%) and imported purchases is Rs.88,814 Lakhs (36%).

The breakdown of the total investment by item is shown below.

Breakdown of Total Investment

(Unit: Rs. in Lakhs)

Item	Amount	%
Direct construction cost	167,485	68.4
Customs duties & taxes	45,872	18.7
Engineering fees	7,396	3.0
Training	771	0.3
Pre-operating expenses	370	0.2
Spares	3,425	1.4
Contingencies	8,373	3.4
Interest during construction	11,174	4.6
Total	244,866	100.0

(Bases of estimation)

1) Time of estimation and currency used:
   Domestic purchases: July 1986 --- Rupees (India)
   Imported purchases: December 1986--- Yen (converted Rs.)
2) Exchange rate: 1 Rupee = ¥13.25 (July 1986)
3) Price fluctuation: Not considered
4) Duties on imported articles: 55%

4-2. Production cost

For both the 1st step (Crude steel, 1 million T/Y base) & the 2nd step (Crude steel, 2.15 million T/Y base), production cost was estimated by variable cost and full cost under normal operation condition.

Construction of production cost was analysed and sensitivity analysis was made.

Production Cost (2nd Step under Normal Operation Condition)

(Unit: Rs./T)

Product	Variable Cost	Full Cost	Product	Variable Cost	Full Cost
Sinter	201	324	Billet(BT-2&3 CC)	1,401	2,522
Coke	981	1,416	Bloom(Existing)	1,522	2,916
Hot metal	773	1,593	Billet(Existing)	1,615	3,257
Cold pig iron	775	1,650	Merchant mill products	1,555	3,061
Molten steel	1,327	2,345	No.1Bar -"-	1,488	3,057
Ingot casting	1,521	2,645	No.2Bar -"-	1,494	3,093
Bloom (BL-1 CC)	1,402	2,598	H.S.M. -"-	1,587	3,399
Billet(BT-1 CC)	1,429	2,663	Saleable products	1,516	3,117

Construction of Production Cost (2nd Step Normal Operation)

Item	Rs./T
Iron ore (incl. fines)	204
Coking coal	778
Scrap (purchased)	168
Reused by-products	623
By-products	(-) 814
Depreciation	841
Fixed material cost	304
Others	1,013
Saleable product cost	3,117

Sensitivity Analysis

Factor	% change	Effect Rs./T
(Base)	-	(3,117)
1) Investment	±10%	± 105
2) Unit price coking coal	+10%	± 78
3) Scrap(purchased)	+10%	± 17
4) Iron ore (")	±10%	± 20
5) Operating rate	-10%	+ 178

4-3. Result of financial analysis

(1) Result of analysis of Base case

Profit & Loss and Cash Flow Balance

(Unit: Lakhs of Rs.)

Year	P & L	C.F.Balance	Year	P & L	C.F.Balance
1st	1	(-) 22	11th	84	186
2nd	47	86	12th	91	221
3rd	50	124	13th	92	217
4th	53	111	14th	132	219
5th	57	116	15th	167	181
6th	61	120	16th	134	113
7th	65	123	17th	134	142
8th	34	79	18th	168	190
9th	37	95	19th	168	177
10th	75	147	20th	168	177

Investment Efficiency (Internal Rate of Return)

ROI (after tax) : 7.112%/Y
ROI (before tax) : 9.845 "
ROE (Cf.) : 7.253 "

Premises for Financial Analysis

1) Forecast period: 1987-2012
   Of which operating period: 20 years
2) Source of fund from capital: 50% of total investment (excl. IDC)
3) Borrowing conditions of long-term loans:
   a. SDF loan:
      Interest rate: 8.0% p.a.
      Term: Net 13 years
   b. EXIM loan:
      Interest rate: 5.6% p.a.
      Term: Net 10 years
4) Interest rate of short-term loans: 14% p.a.
5) Corporate income tax: 50%

Sensitivity Analysis

Case	Description	ROI after tax	ROI before tax
1	Low operating rate at start-up	6.57%	8.90%
2	No duties	8.30	11.78
3	Equipment life 10 years	7.34	9.85
4-1	Variable cost: 10% up	6.37	8.72
4-2	10% down	7.83	10.92
5-1	Operating fixed cost: 10% up	6.84	9.44
5-2	10% down	7.38	10.25
6-1	Total investment: 10% up	6.44	8.81
6-2	10% down	7.89	11.04

5. Economic analysis

The Economic Analysis of which methodology is the same with that of The World Bank has been conducted to evaluate the economic viability of the modernization project for Burnpur Works from India's national economic point of view in order to realize the optimum allocation of resources in Indian economy.

The economic cost-benefit analysis, which is based on the import substitution model of "UNIDO Method", has been applied to this project as an evaluation method.

"Economic Internal Rate of Return" has been employed as a relative yardstick with which past and existing Indian projects will be compared one another* and by which industrial projects of India will be ranked in terms of priority for starting-up.

The following are the results of calculation in comparison with Financial Analysis:

* See reference table

(Case Base)

a) Capital Cost	Financial lacs	Economic lacs
Investment	233,692	207,524
Old plant	8,588	4,596
	242,280	212,120
b) Operating Cost (Step 2)		
Variable	49,370	30,555
Fixed	* 10,877	10,337
	60,247	40,892
c) Sales (Step 2)	95,061	86,825
(Net Cash Flow	34,814	45,933)
d) Internal Rate of Return	9.845% (before tax)	15.397%

* excluding depreciation and interest on loan

What the result indicates is a moderate economic viability. Considering the opportunity cost of capital in India, which is said around 12%, this project satisfies the minimum requirement for optimum allocation of resources. However, thorough consideration on resource allocation to the Burnpur expansion project shall be made from India's standpoint if the project will be implemented.

Several tests are performed to evaluate the sensitivity of the project according to the same scenarios assumed in Financial Analysis. The following are the results of calculations:

Sensitivity Cases	Prerequisites to Tests	Economic I.R.R. (%)	Financial I.R.R. (before tax) (%)
a) Case 1	Slowdown of production level during the starting period (1993-1995)	14.036%	8.895%
b) Case 2	No tariffs	-	11.781%
c) Case 3	Shortening depreciation term for machinery & equipment from 13 years to 10 years	-	9.845%
d) Case 4	Variable cost changes		
4-1	10% up	14.372%	8.723%
4-2	10% down	16.390%	10.920%
e) Case 5	Fixed cost changes (excl. BF relining)		
5-1	10% up	15.036%	9.439%
5-2	10% down	15.755%	10.245%
f) Case 6	Investment cost changes		
6-1	10% up	14.134%	8.806%
6-2	10% down	16.843%	11.037%

(Reference table)

Internal Rate of Return

	Financial	Economic
Tata (Phase I)	17.5 %	26.5 %
Nagarjuna Steel	16.7 %	21.4 %
Bharat Forge	?	33 %
Bokaro (Expansion)	6.98%	?
Bhilai (Expansion)	negative I.R.R.	7.85%
Bihar (Sponge Iron)	?	16.1 %
Tata (Phase II)	14.9 %	17.3 %

6. Conclusion and recommendations

6-1. As reported in the above, the JICA F/S team made detailed studies from various aspects on the modernization project of BURNPUR Works. In making those studies, many data and informations gathered by field survey and others were fully used, but some premises and assumptions had to be made in the study work.

The result of the study by JICA team is as follows:

(1) It is possible technically to modernize BURNPUR Works as a modern steel plant having production capacity of 2.15 million T/Y in terms of crude steel.

(2) The results of financial and economic analyses are as given in Chapters 8 and 9, and the conclusion of the team is like this: This project can not necessarily be said to have adequate economic viability and profitability, but if IISCO themselves make maximum efforts and the Indian Government provides a strong support for the project, it cannot be said that the project is not feasible.

(3) Therefore, the team considers that whether this project is implemented or not should be determined after judgement from policy measure of the Indian Government is made.

6-2. In the following are enumerated the matters that are prerequisite for implementing this project and the main matters that are considered to have a significant effect on the economic feasibility of the project.

(1) In order to operate the steel plant modernized with new facilities and technology as planned, it is essential to give thorough training by various measures designed for employees (engineers and workers) in advance. This has an effect on not only its smooth start-up but the economic viability of the project. Therefore, concurrently with construbtion plan, training plan should be made and impremented as early as possible.

(2) In order to achieve high yield and efficient and stable operation by utilizing new facilities and technology, it is necessary to have a simple, integrated control organization which can ensure transmission of correct orders and instructions throughout the line of organization. It is also necessary to establish a long-range facilities maintenance plan and a system to implement such plan. Without such system, the facilities, however new and modern, will be deteriorated in a few years.

(3) The Indian Government should take necessary measures to promote supporting industries for manufacture and repair of machinery and parts used in steel plants.

(4) Considering the huge accumulated financial deficit of IISCO and continued operation of some old existing facilities during the construction period, it is highly desirable that the construction be commenced as early as possible. Therefore, a decision of the project should be made at an earliest date.

(5) As any cost overrun during the construction results in deterioration of payability of the project, care should be taken in awarding construction orders so as to prevent any delay in the construction and ensure scheduled implementation of the project.

(6) Customs duties imposed on imported machinery and equipment is a factor to increase burden of equipment cost and deteriorate profitability of the project. It is desired therefore that the Indian Government take some measures of tax incentive.

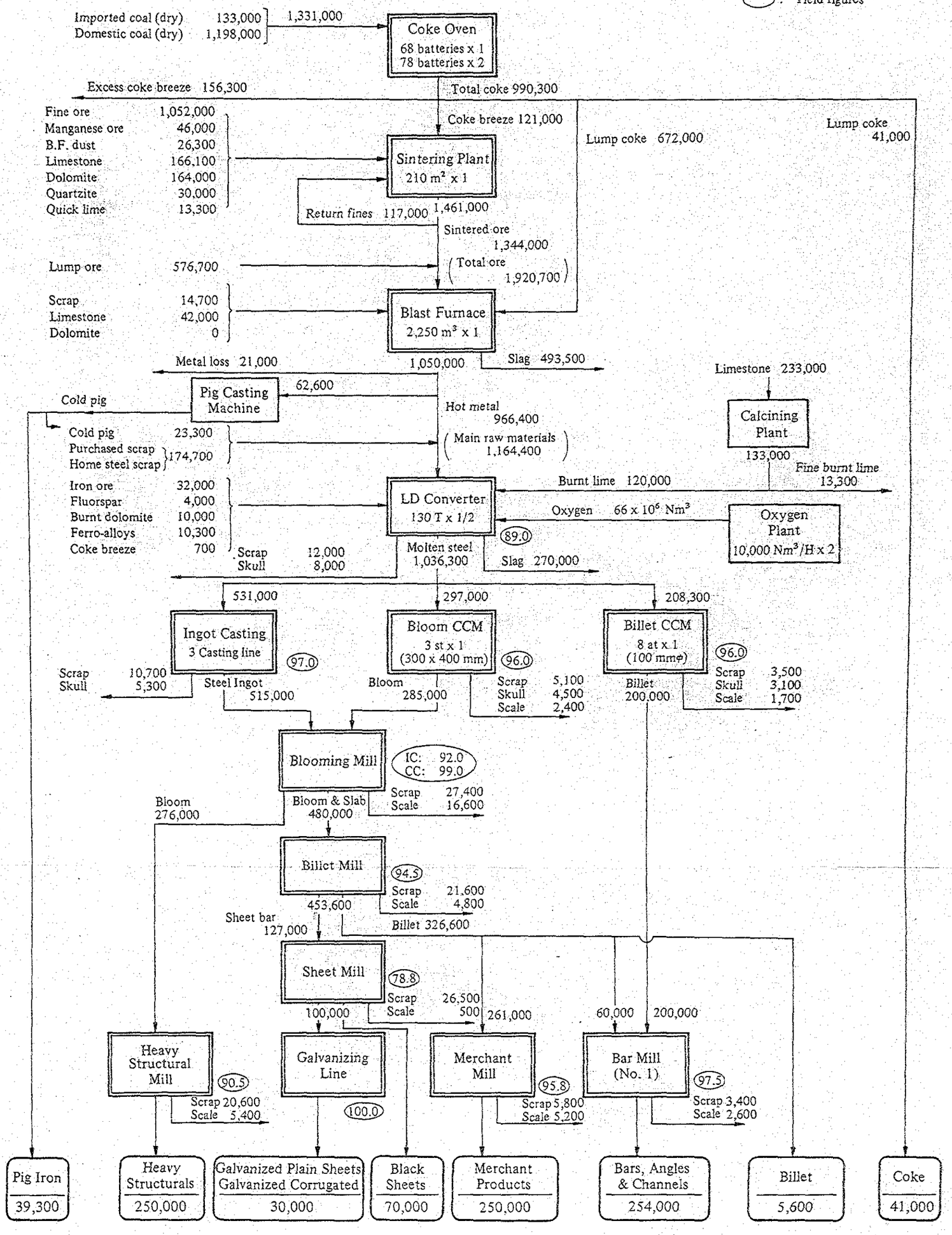
(7) Before drawing up actual implementation plan, soil exploration (by boring) and topographical survey must be made at the proposed construction site.

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Remarks
Annual production								1 MT	2.15 MT	2.15 MT	2.15 MT	
Feasibility study												—— 1st step ---- 2nd step
Basic & detailed engineering												
Basic engineering												
Technical specification												
Inquiry												
Evaluation of proposals & contracting												
Contract award												
Earth moving & improving												
Detailed engineering												
Foundation & building												
Manufacturing of equipment												
Erection												
Commissioning												
Hot run & commerical operation												

Basic construction schedule

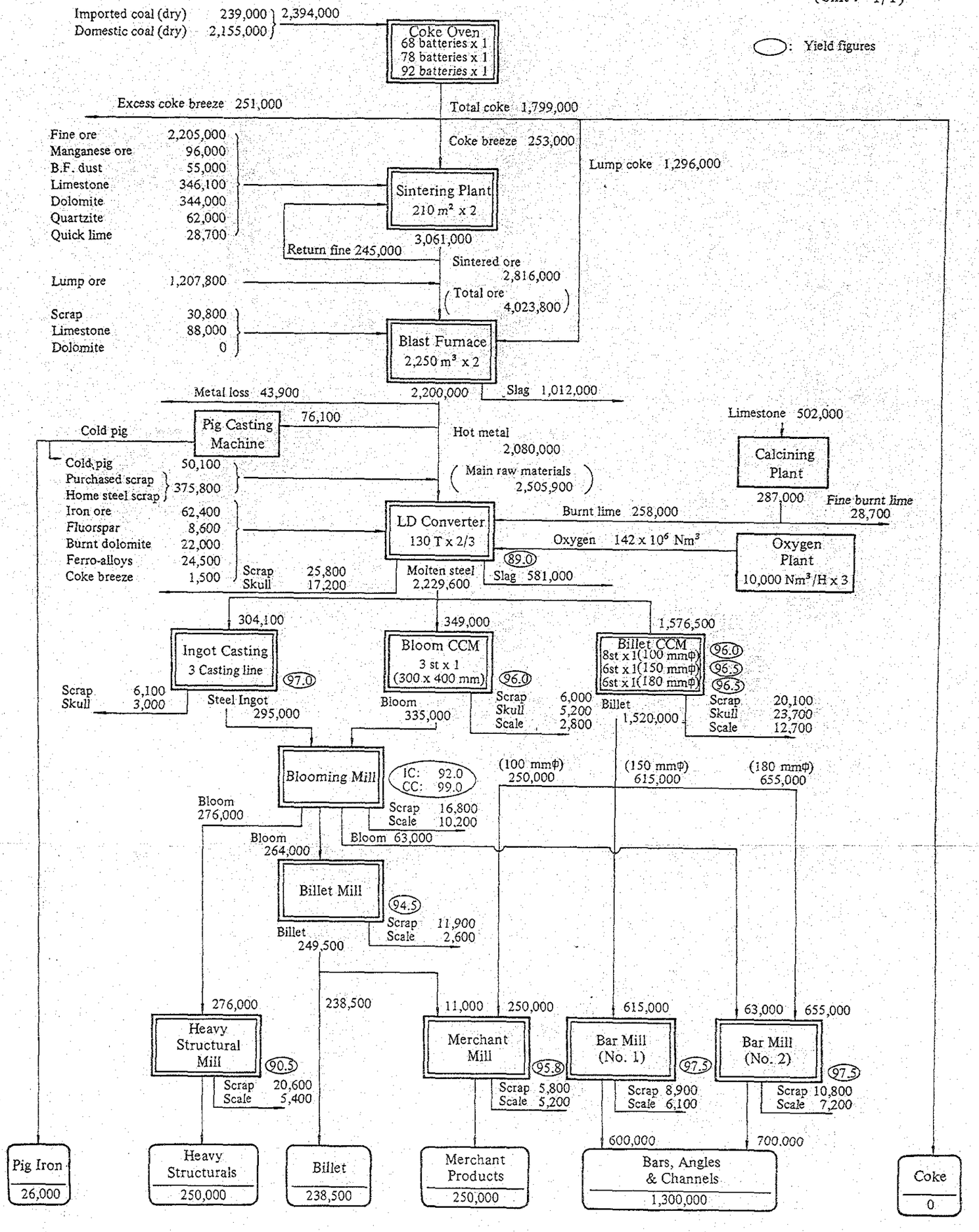
(Unit : T/Y)

⬭ : Yield figures



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

(Unit : T/Y)



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

Comparison between Present Condition and Condition after Modernization of BURNPUR Works

	Present Condition Nominal capacity: 1 million T/Y (85/86 output: 565,000T)	1st Step (Completed at the end of 1992) (1 million T/Y)	2nd Step (Completed at the end of 1993) (2.15 million T/Y)
Coke	4 coke oven batteries (Nos.7,8,9 & 10) (of 228 ovens, 127 ovens operated)	Nos.8,9 & 10 batteries	Nos.8, 9 batteries and new No.11 (92 ovens) battery installed
Sinter plant	None	No.1 sintering machine (210 m^2) installed	No.2 sintering machine (210 m^2) installed
Blast furnace plant	500 m^3 BF x 2, 1170 m^3 BF x 2	Existing 4 BFs all closed and No.5 BF (2250 m^3) installed	No.6 BF (2250 m^3) installed to make the number to two BFs
Steelmaking shop	Duplex process in use Bessemer conveters (25T x 3) Open hearth furnaces (225T x 6)	Two BOFs (130T) installed Two units fixed and one constantly in operation One lime calcining plant installed	One BOF (130T) installed Three units fixed and two constantly in operation One more lime calcining plant installed (Two-unit operation)
CC plant	None	Bloom (BL-1) CC installed (3-strand type, 300x400 mm) Billet (BT-1) CC installed (8-strand type, 100 mm sq.)	Two billet (BT-2, BT-3) CC installed (6-strand type, 150 mm sq. & 180 mm sq.)
Rolling mills	Blooming millx1, billet & sheet bar millx1, heavy structural millx1, light structural millx1, merchant & bar millx1, sheet millx1, galv. line x1	Existing light structural mill closed, but other existing mills such as blooming mill, billet mill, heavy str. mill, merchant & bar mill remodelled and used New No.1 bar & section mill installed (600,000 T/Y) Sheet mill operated in 1st step only	Sheet mill closed New No.2 bar & section mill installed (700,000 T/Y)
Self power plant	60 MW x 1 (Actual outputL 12 MW)	One 60 MW unit installed (Existing power plant left as it is)	One more 60 MW unit installed (Two-unit operation: output 120,000 kW)
Site area	2.6 million sq. m (Existing plant)	Site area available for new facilities: 1.5-1.8 million sq. m	
Personnel	24,323		14,134 (within the Works alone)
Productivity	20-30 T/Man·Y		152 T/Man·Y
Investment		Total investment: Rs.12.92 billion	Total investment: Rs.11.57 billion