4-6 Education and training

(a) Education and training dept.

IISCO's education and training department belongs to the Department of Personnel and Administration.
The organization of the dept. is as shown below.

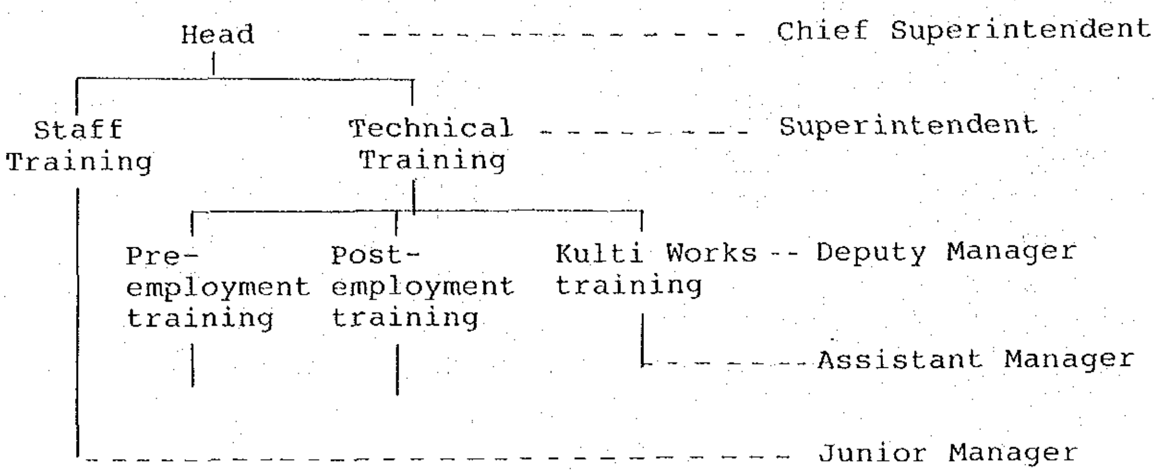


Fig. 4.6.1 Organization Chart of Training Dept. of IISCO

Personnel in the department number about 45, including both Executive and Non-executive.

(b) Education and training facilities

The facilities for education and training for staffs are located at BURNPUR and those for technical personnel at BURNPUR and KULTI.

Table 4.6.1 Facilities for Education and Training at IISCO

	BURNPUR		KULTI
	Staff Training	Technical Training	Technical Training
Class room	1	4	2
Drawing hall	-	1	1
Library	-	1	-
Office room	2	6	1
Store room	1	1	1
Model room	-	1	-
Workshop for basic trade training	-	1	1
Accommodation trainees	248 persons		24 persons

Staff Training Center, BURNPUR, has a hall capable of accommodating about 400 persons and equipped with a 16 mm sound projector, a 35 mm slide projector and an overhead projector.

(c) Education and training system

In IISCO, the training system is divided into two parts: namely, staff training and technical training.

Staff training:

Staff training programme was initiated in 1973 and its purpose is:

a. To give participants a broad understanding on modern management so that they appreciate the expertise involved and the interdependence of these functions and that they appreciate the applicability of certain techniques and skill in their day-to-day work.

b. To familiarize participants with the Company's plans so that they can adapt themselves to changing management styles.
c. To get them to see and analyse management problems from not only a specialised point of view but broad Company's point view.

The staff training is divided into that for Executives and that for Non-executive supervisors.

For the Executives there is Management Development Programme (M.D.P.) with four types of training as follows:

a. Inhouse training: This is given at IISCO's Staff Training Center by IISCO alone or in collaboration with outside education and training organizations. The participants are Junior Manager and above to Asst. Gen. Manager. This forms the base of staff training.
b. M.T.I. training programmes: The participants are sent to SAIL's Management Training Institute and include Deputy Manager and above to Asst. Gen. Manager. The training covers general and advanced management techniques, function and behaviour science.
c. External programmes: The participants are sent to outside education and training organizations as it is necessitated in their functions. They are nominated from among all categories of Executive as well as Non-executive supervisors.
d. Foreign training: Participants are nominated from among Executives according to the subject of training and dispatched overseas after appointed by SAIL's Training & Management Development Section. They are trained at programmes by UNIDO, Technical Cooperation between India and Italy, or training organizations of the U.K. government under Colombo Plan.

For the non-executive supervisors there is Supervisory Development Programme (S.D.P.) and its contents similar to that for Junior/Asst. Manager. In addition there is training under External Programme.

The table below gives the number of persons who received staff training during the past five years.

Table 4.6.2 Number of Persons Trained under Staff Training

	1981	1982	1983	1984	1985	1986 (Jun.26)
M.D.P. (Executives)						
Inhouse	230	247	170	337	289	404
M.T.I.	36	64	87	78	92	23
External	59	120	124	51	104	105
Foreign	1	4	-	1	6	-
S.D.P. (Non-executives)	164	79	125	131	169	25
Total	490	514	506	598	660	557

Note: As of June 26, 1986

Source: IISCO, Training Department

Technical training:

IISCO's technical training in the early years was given to supervisory and craftsman cadre based on On-the-Job Training with night schooling, but when the capacity of crude steel production was expanded to one million tonnes, the technical training scheme was formalized and the present Technical Training department was established.

Education and training of Officer Trainees was begun in 1958. In 1960 a training scheme for student and Trade Apprentices was introduced. Officer Trainees, student and Trade Apprentices intaked numbered 15-30 a year, but the number increased from year to year. Till March 1986 the total number of persons trained reached such extent as 739 Graduate Engineers and Management Trainees (Tech), 271 Student Apprentices and 748 Trade Apprentices. In 1983 the training was given to 20 senior operatives.

As additional training programme, there are long- and short-term training courses which are held for employees throughout the year.

(d) Education and training at Iron Ore Mines

IISCO operates the Vocational Training Center under the Vocational Training Scheme framed by the Directorate of Mines Safety, Government of India.

At the Center, employees engaged in the Mines are given training periodically on safety, including safety rules, manner of safe performance of various jobs in the Mines, and others in addition to trade training.

Information of the Center is as follows:

a. Manpower:	13 (Including four instructers)	
b. Facilities:	Class room	3
	Library	2
	Office room	4
	Store room	2
	Model room	1
	Workshop for basic trade training	1
c. Equipment:	16 mm projector	2
	Portable slide projector	1
	Portable loud speaker	1
	Epidiascope	1
d. No. of persons trained:	1984	358
	1985	319

4-7. Financial statements

Reading of the financial statement:

Table 4.7.1 Balance sheet

(Unit: Rs. in Lakhs)

Item	31st March, 1986		31st March, 1985	
Source of Funds				
Share Holder's Fund				
Share capital	9,315		9,315	
Share money pending allot.	2,710		974	
Reserve & Surplus	385	12,410	191	10,480
Loan Funds				
Bank Ovendraft (secured)	3,354		4,907	
Consortium Loan for P.R.S. (secured)	4,218		4,229	
Loan from Government (unsecured)	20,017		14,380	
Loan from SAIL (unsecured)	13,990		13,923	
Loan from SDF	4,468		4,447	
Loan from others (unsecured)	100	46,147	101	41,987
(Source Total)		(58,557)		(52,467)
Application of Funds				
Fixed Assets				
Gross Block	31,771		30,766	
Less Depreciation	(-)18,748		(-)17,441	
Less Other	(-) 25		(-) 25	
Net Block	12,998		13,300	
Capital Work in progress	5,097		2,738	
Investment	338	18,433	339	16,377
Currout Assets Loans and Advances				
Inventories	14,111		13,925	
Sundry Debtors etc.	9,651		6,861	
Cash and Bank Balances	1,153		2,688	
Others	11,313	36,228	9,030	32,504
Less: Current Liability	(-)35,687	541	(-)29,995	2,509
Profit & Loss Account	39,583		33,581	
(Application Total)		(58,557)		(52,467)

Table 4.7.2 Profit and loss statement

(Unit: Rs. in Lakhs)

Item	31st March, 1986	31st March, 1985
Income		
Sales	42,013	31,429
Other Revenues	1,421	900
Other Items	(-) 116	(-) 361
Loss for the year carried down	5,465	10,973
	48,783	42,940
Expenditure		
Raw Materials	21,495	16,469
Employees' Remuneration & Benefits	10,801	10,651
Stores & Spares	5,969	5,092
Power & Fuel	4,909	3,915
Repairs & Maintenance	3,394	2,705
Excise Duty	2,326	1,934
Contribution to SDF	0	0
Contribution to JPC & Others	494	308
Freight Outward	2,426	1,849
Interest	1,191	3,581
Depreciation	1,311	1,728
Purchase of Semi/fini. products	1,578	657
Other Expenses & provisions	3,063	2,769
Less: Transferred to Expenses on Capital Items, etc.	(-) 10,174	(-) 8,719
	48,783	48,783
Loss for the year	5,465	10,973
Less: Adjustment (previous)	537	(-) 2,813
Loss Brought Fwd. from previous	33,581	---
Less: Development Rebate Reserve	---	25,421
Balance Carried Over to B/S	39,583	33,581

Table 4.7.3 Unit-wise sales and profit/loss

(Unit: Rs. in Lakhs)

	31st March, 1986		31st March, 1985	
	Sales	Loss	Sales	Loss
1) BURNPUR works incl. ore mines and CALCUTTA office	36,918	(-) 2,856	26,275	(-) 7,656
2) KULTI works	3,964	(-) 1,366	3,655	(-) 1,494
3) Collieries	1,131	(-) 1,243	1,499	(-) 1,823
Total	42,013	(-) 5,465	31,429	(-)10,973

(1) Main indications (Unit: Rs. in Lakhs)

	1985 F.Y.	1984 F.Y.
1) Total assets in use	54,661	48,881
2) Accumulated deficit	(-)39,583	(-)33,581
3) Owned capital	12,410	10,480
4) Real owned capital	(-)27,173	(-)23,101
5) Long-term loans	46,147	41,987
6) Fixed assets	18,433	16,377
7) Current assets	36,228	32,504
8) Current liabilities	35,687	29,995
9) Loss for the year	(-) 5,465	(-)10,973
10) Labour cost/Sales	26%	34%
11) Depreciation/Sales	3%	5%
12) Interest/Sales	3%	11%

(2) Deficit

As of the end of March 1986, accumulated deficit amounts to a huge amount of about Rs.4 billion, which is about three times larger than capital (incl. pending allotment). Therefore, the real owned capital is about minus Rs.2.7 billion (so-called liabilities exceeding assets), and the company is barely alive with unsecured loans totalling about Rs.3.9 billion consisting of about Rs.2.7 billion from Government, about Rs.1.4 billion from SAIL and about Rs.0.45 billion from SDF. In the past 15 years except 1974, it reported deficit every year.

Chapter 5

Production processes and facilities (Present condition and problems)

Contents

5. Production processes and facilities
(Present condition and problems)

Pages

5. Production processes and facilities (Present condition and problems)

5-1. Coal and coke

5-1-1. Main facilities

Specifications of main facilities are shown in Table 5.1.1 and process flow and layout of coke oven batteries in Figs. 5.1.1 through 5.1.4.

Features of those facilities are as follows:

(1) Coal yards

On a site of about 25,000 m^2, about 80,000 tonnes of coal is stockpiled according to four classifications of prime, medium, blendable and import. Therefore coal control or stockpile by brand is not used and brands belonging to each classification are bed blended in one stockpile.

The coals are received by rail, ropeway or motor truck and transported to coal yards or coal handling facility by belt conveyors or stacker-cum-reclaimer.

(2) Coal handling facility

There are two facilities, one for Coke Batteries Nos. 7, 8 and 9, and the other for Coke Battery No. 10., both consisting of process flow of primary crusher (by classification) - blending bin - secondary crusher - Charging coal bin.

Belt feeder or vibrating feeder is used to discharge coal from blending bins, but no weighing machines are provided. The amount of coals from each bin necessary to determine blending ratio of coals is fixed by experience.

Crushers are so adjusted that coals in size of 3 mm or less account for 80% or more of charged coal, and their actual capaicty is 150T/h whereas their designed capacity is 200T/h.

(3) Coke oven battery

There are four Otto type coke oven batteries. However No. 8 battery is being reconstructed, and the number of ovens installed totals 228. But in actual operation are 127 ovens, about 56% of the total.

Specifications of oven components of No. 9 battery which was started up in 1958 and those of No. 10 battery that began operation in 1982 are almost same, both being out-of-date. In particular, there is much room for improvement of oven door, oven machine, environmental facility and instruments. There are spares of oven machines for each battery, but repair is not adequate.

(4) Coke handling equipment

There is one coke wharf for each battery, and coke from Nos. 7 and 8 batteries and that from Nos. 9 and 10 batteries are separately treated at screen facilities.

Coke is screened to three kinds of "Nut", "Pearl" and "Fine" after screened to coke for blast furnace charge in size of 25 - 75 mm and that in size less than 25 mm.

(5) By-product plant

There are facilities with necessary capacity to exhaust and refine coke oven gas which is generated from each battery. Crude benzol recovery and distillation equipment is installed to No.10 battery only.

Facilities to produce sulphuric acid are installed, and the acid is used as auxiliary raw material to react with ammonia in coke oven gas to form ammonium sulphate. But operation of the both facilities tends to be suspended for a considerable time by reason of repair and during the time coke oven gas bypasses the ammonium sulfate facilities.

Ammonia in ammonia liquor is stripped in the ammonia still and fed to the ammonia saturater. Waste liquor from the still is treated by bacteriological oxidation facilities to remove phenol.

There are batch-type crude benzol rectification facilities and tar dehydration facilities to produce benzol products and dehydrated tar.

Measuring instruments of the above facilities are mainly of field indication type and manual control is used in most cases.

5-1-2. Operation performance

(1) Production

Details of production condition and production in 1985/86 are shown in Table 5.1.2 and production performance in June 1986 when the field survey was made and in the preceding month of May is shown in Table 5.1.3.

Those figures are based on Operational Statistics 1985/86 issued by IISCO and data obtained on the site.

(2) Operation condition

a. Coking coal blending

Because of limited yard space and ability to handle coal received, coking coal is divided into four classifications of Prime, Medium and Blendable (domestic coal) and Import (imported coal) for use. Use of imported coal began experimentally in June 1986.

According to the answer to Inception report which the mission received after it returned home, coal blend in 1985/86 is

Prime : Medium : Blendable = 56 : 35 : 9,

but the blend ratio as calculated from Operational Statistics is as shown in Table 5.1.2.

According to the said answer, the blending ratio on July 1, 1986, was

Prime:Medium:Blendable:Import = 35:35:10:20.

As Indian coal contains high ash and is poor in washability, washed coal contains high ash. In addition, as unwashed raw coal is used in part, charged coal is high in ash content.
(Ash in charged coal: 22%, ash in coke: 28.5%)

b. Coke ovens

The condition of coke ovens available is shown in Table 5.1.4.

In Nos. 7, 8 and 9 batteries, the number of ovens available decreased rapidly from around 1980, and the condition is such that routine work of hot repair can not increase the oven availability.

Damage of ovens occurs in No. 10 battery which was put into operation in 1982, and of 78 ovens installed, only 49 are in operation. The oven availability for Nos. 7, 9 and 10 batteries in the aggregate is 126, which means 102 ovens, or 44% of 228 ovens installed, are not in operation.

As a result of such decrease of oven availability, self-support of blast furnace coke in 1985/86 was 71.9%.

In order to produce required amount of coke, coal is charged into ovens to an abnormally high level to increase the charged amount. This resulted in extreme shortage of gas space over the charge in the chambers. Because of this as well as poor gas seal of doors, gas leakage from the ovens is very high.

Gas leakage promotes deformation of metalwork of ovens by ignition or even damage to ovens and is one of major causes of increased stoppage of ovens.

The cause of gas leakage includes improper control of level of charged coal, and poor improvement, guidance and implementation for prevention of gas leakage from doors. Not only facilities but also human factors have considerable effects. As regards the latter, it may safely be said that poor housekeeping and cleaning around the ovens and incomplete observance by workers of safety clothes and working methods show the true nature of this problem.

Because there are a number of ovens not operated and also because temperature inclination in the length of ovens is not fully adjusted, energy used for carbonization is very high.
A little less than 80% of coke oven gas generated is self-consumed as energy source for carbonization, and this disturbs gas balance in the Works and brings about shortage of coke oven gas.

No environmental facilities such as smokeless charging equipment, dust collector, various types of cleaner are installed, and besides, facilities such as resting room are inadequate despite the working place is very hot, dusty and needs heavy labour.

c. By-product plant

The facilities are generally old and out-of-date, and instrumentation for their operation and monitoring is inadequate, but the facilities for exhaustion and clarification of the gas perform their functions one way or another.

Separation of ammonia liquor, tar and tar sludge is poor, causing sludge trouble at coke ovens.

Recovery of crude benzol from coke oven gas is done at No. 10 battery and yield is 5 lit/T due to high gas temperature (because temperature of industrial water is high). Crude benzol recovered is pretreated by sulfuric acid washing and then processed by batch type rectification distillation to produce benzene and toluene and others at the yield of 81%. Any trouble or repair of sulphuric acid production facilities is directly linked with stoppage of ammonia sulfate facilities.

Heaters, pumps and compressors which use steam as energy source are used, and steam consumption is as high as 70T/h. In the meantime, leakage of steam is very large in the plant.

d. Testing facilities

Testing and analysis rooms related to coal and coke are located in three places; namely, sample preparation room including sampling of coal is located in coal yard, and laboratory to measure strength and others of coal and analysis room for coal, coke and by-product chemicals are located in coke oven area.

Analysis of coking coal is mainly size distribution and industrial analysis, and microscopic analysis and fluidity measurement necessary for deciding blending ratio of coking coal are not performed.

For coke, size distribution and Micum strength test and others are performed.

For by-product chemicals, analysis directly related to the operation is performed, and for ammonium sulphate, chemical measurement is partly performed on the site.

Environmental facilities at the places where those tests and analyses are performed are also inadequate.

Table 5.1.1 Equipment specification

Equipment	Specifications			
	Battery - 7	Battery - 8	Battery - 9	Battery - 10
1. Coke ovens				
(1) No. of ovens	72	78	78	78
(2) Type of Battery (maker)	SIMON-CARVES	OTTO	SIMON-CARVES	OTTO
(3) Commissioning	1950 ~ 1975 1976 ~	1957 ~ 1983 under rebuilding	1958 ~	1982 ~
(4) Oven dimension				
1) Height	4,450 mm			
2) Length	12,750 mm			
3) Width	420 ~ 480 mm			
(5) Effective volume	23.8 m^3			
(6) Bulk density	0.78 T/m^3			
(7) Oven charging	18.56 T/oven			
2. By-product plant				
(1) Primary cooler	26,400 (Nm^3/h) x 3/4	New equipment	26,400 (Nm^3/h) x 3/4	26,400 (Nm^3/h) x 2/3
(2) Detarrer	13,200 (Nm^3/h) x 2/3	New equipment	13,200 (Nm^3/h) x 2/3	13,200 (Nm^3/h) x 2/3
(3) Ammonium sulfate equipment	26,400 (Nm^3/h) x 1/2	New equipment	26,400 (Nm^3/h) x 1/2	26,400 (Nm^3/h) x 1/2
(4) Naphthalen equipment	26,400 (Nm^3/h) x 1	New equipment	26,400 (Nm^3/h) x 1	26,400 (Nm^3/h) x 1
(5) Benzol scrubber rectification equipment	—	—	—	26,400 (Nm^3/h) x 1 9.5 m^3/D
(6) Bacterio-logical oxidation facility	Improvement			9.9 m^3/D
(7) Sulphuric acid equipment	60 T/D x 2 NOs. (at 77 % H_2SO_4)			
(8) Tar dehydration equipment	10 T/charge			

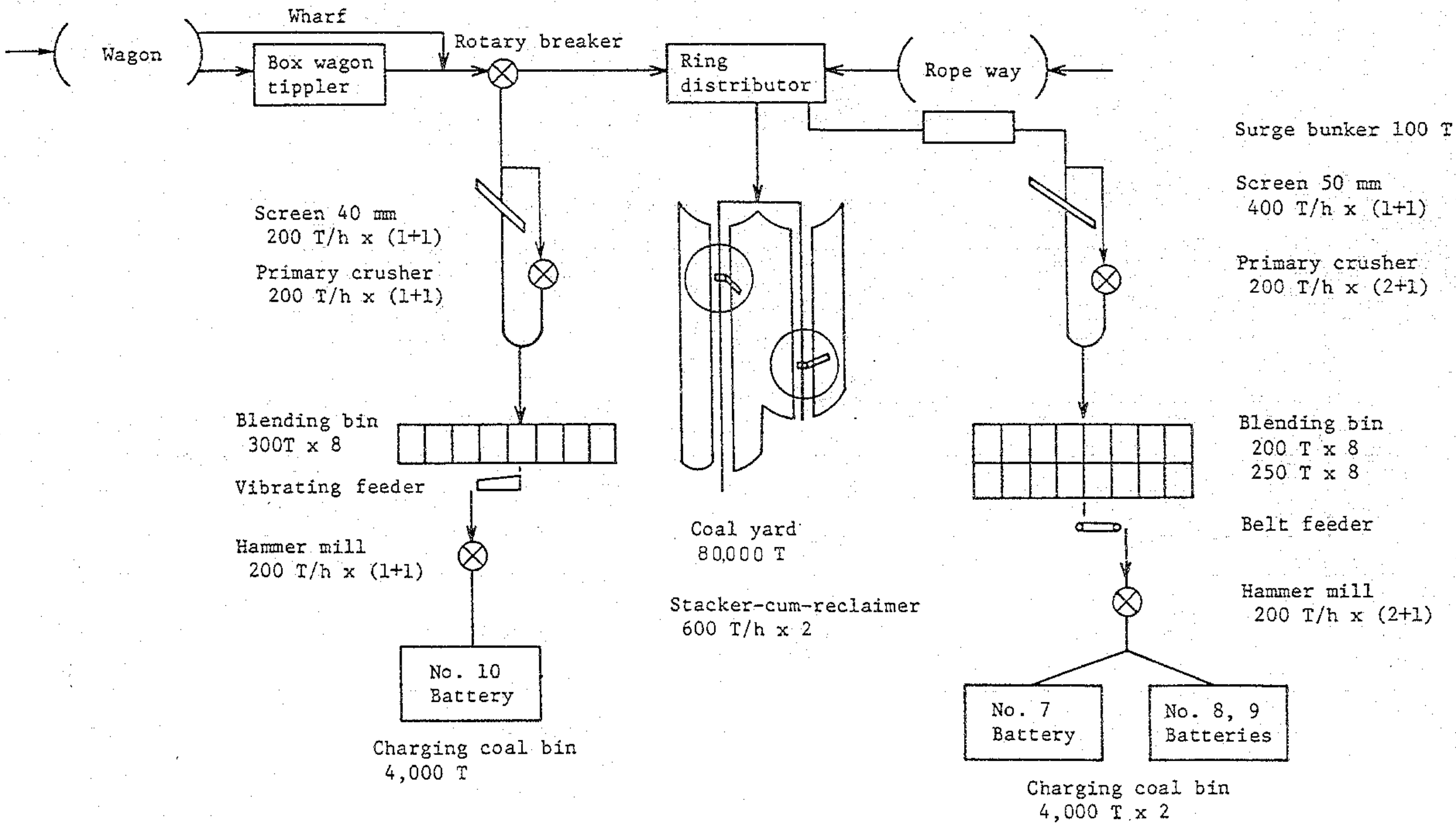


Fig. 5.1.1 Coal handling flow

Pusher machine	2	2	2
Charging car	2	2	2
Coke guide car	2	2	2
Quenching car	2	1	2
Q/C locomotive	2	1	2

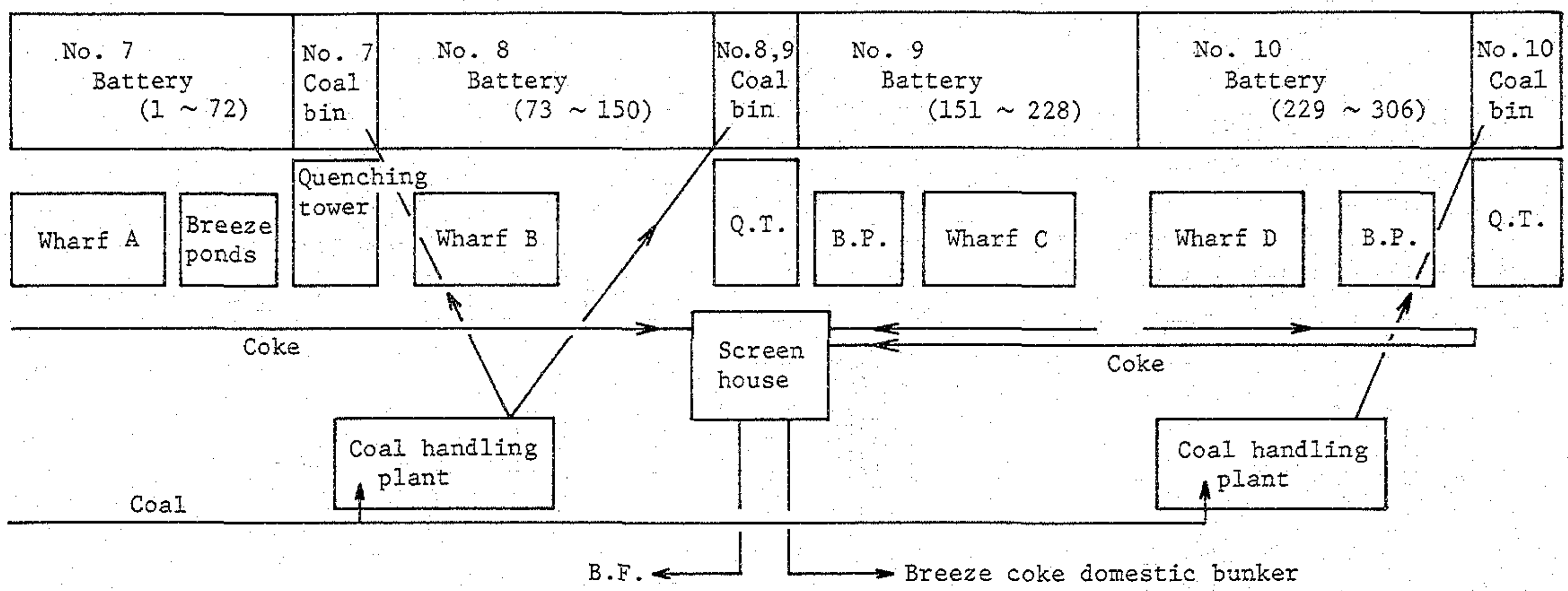


Fig. 5.1.2 Coke oven batteries layout

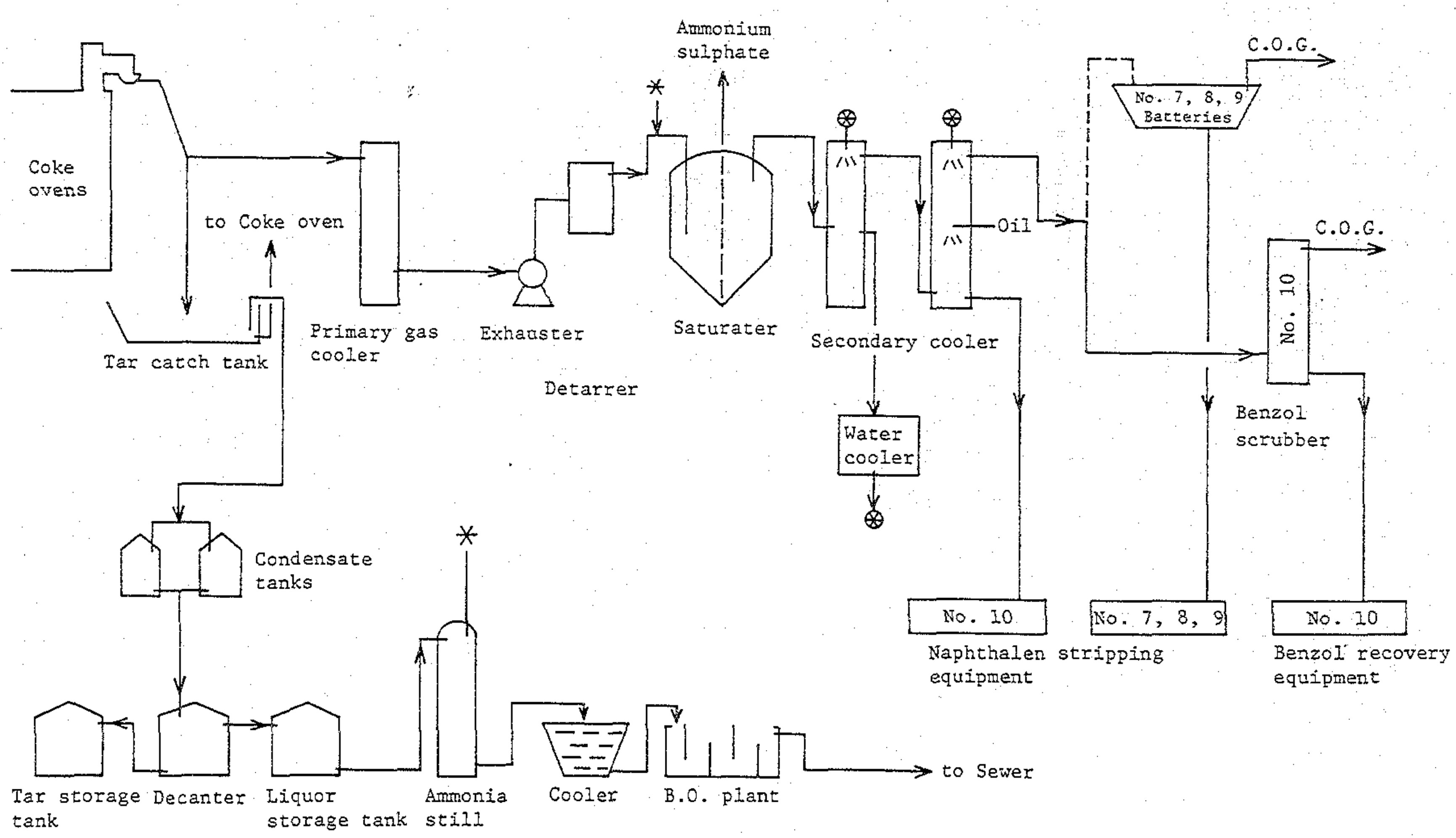


Fig. 5.1.3 By-product plant

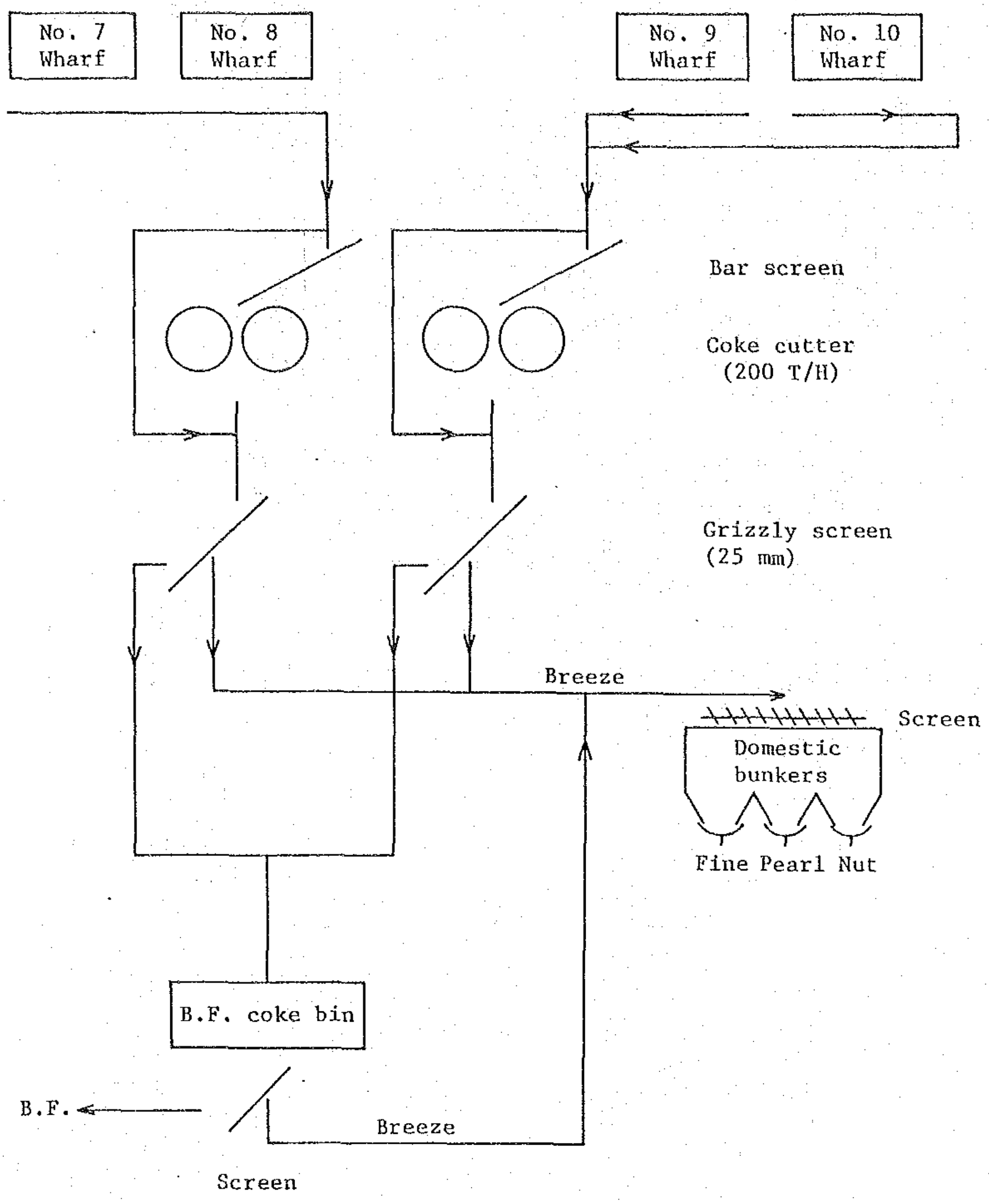


Fig. 5.1.4 Coke handling flow

Table 5.1.2 Production performance: 1985/86

Item		1985/86
Coking coal blending ratio and quality		Prime 65.9% Medium 26.0% Blendable 8.1% V.M. 25.1% Ash 22.0% Moisture 5.1%
Coal throughput		1,209,420 T/Y
Utility	Heat Consumption	783 Kcal/kg.coal
	Electricity	19,165,889 kwH/Y
	Steam	614,110 T/Y
Man-power	Executive	55
	Non-Executive	1,760
Production	Gross coke	912,672 T/Y
	B.F. coke	748,666 T/Y
	Pearl coke	59,402 T/Y
	Fines Breeze	104,604 T/Y
	Coke oven gas	316,851 x $10^3 Nm^3/Y$
	Coal tar	24,911 T/Y
	Crude benzol	3,218 kℓ/Y
Quality of coke		V.M. 1.2% Ash 28.5% Moisture 8.3% M_{10} 16.7% M_{40} 74.1%

Table 5.1.3 Production performance: May and June, 1986

Item	June. 1986	May. 1986
Coal throughput (T/D)	2,787	2,888
Quality of coal charged V.M./Ash (%)	25.2/20.4	25.4/22.0
Oven availability		
Batt. - 7	51.2	50.0
9	25.3	26.2
10	52.8	56.8
Total	129.3	133.0
Pushed (Nos./D)		
Batt. - 7	55.1	55.0
9	20.1	20.5
10	67.0	71.8
Total	142.2	147.3
Coking time (h)		
Batt. - 7	20.44	20.30
9	29.55	29.55
10	18.20	18.17
Batt. temperature (°C)		
Batt. - 7	1,147	1,145
9	1,043	1,043
10	1,202	1,203
Heat consumption		
Batt. - 7	697	743
(kcal/kg.coal) 9	1,743	1,823
10	702	646
Average	847	846
Gross coke (T/D)	2,112	2,175
B.F. coke	1,756	1,805
Pearl coke	114	101
Fines, Breeze	242	269
C.O.G. (Nm^3/coal T)	261	257
Coal tar (kg/coal T)	21.5	21.5
Crude benzol (kℓ/coal T)	4.5	4.83
Quality of coke		
Ash (%)	27.0	28.6
M_{10}/M_{40}(%)	15.2/75.3	16.1/74.7

Table 5.1.4 Condition of coke oven batteries

Description		Battery-7	Battery-8	Battery-9	Battery-10
Year of Commisioning		1950	1957	1958	1982
Date of previous rebuilding		Aug. 17, 1976	Under rebuilding		
Nos. of ovens		72	78	78	78
Nos. of ovens available	1971			78	
	72			58	
	73			71	
	74			73	
	75			73	
	76	72		73	
	77	72		73	
	78	72		73	
	79	65		73	
	80	60	72	71	
	81	59	68	70	
	82	72	46	54	65
	83	71	33	56	71
	84	59		34	74
	85	50		34	69
	May, 1986	50		26.2	56.8
	June, 1986	51.2		25.3	52.8
	July 1, 1986	52		26	49
Year of hot repair done		1981 ~ 82 1985 ~		1972 ~ 74 1982 ~ 84 1984 ~ 85	1983 ~ 84 1986 ~

5-2. Iron ore

5-2-1. Ore mines

IISCO mines iron ore at its captive mines and purchases some from others. Its main mines, GUA mines, is located 267 km southwest of BURNPUR Works, and the other mines, CHIRIA mines, is located nearby.

Ore reserves is said 233 million tonnes at GUA and 2 billion tonnes at CHIRIA, the latter's reserves being the largest in Asia.

At the both mines, open air mining is used and ores are mainly hematite. Ore deposit contains blue dust with iron content of 67% (high quality hematite in fines in natural condition).

At GUA mines, undersize fines produced from primary screening accumulated to 30 million tonnes. It is necessary to wash and screen these dumped fines ore and utilize them effectively as material for sinter.

550,000 tonnes of lump ore from GUA mines is shipped to BURNPUR Works and 550,000 tonnes of its fine ore is sold. From CHIRIA mines 250,000 tonnes of lump ore only is shipped to BURNPUR Works.

Figs. 5.2.1 and 5.2.2 show material flow at the two mines, respectively.

5-2-2. BURNPUR Works

Present material handling flow is shown in Fig. 5.2.3. Iron ore is unloaded from bottom opening type wagon to receiving hopper and then transported to ore storage yard by belt conveyer.

Feeding of iron ore into ore bin at blast furnaces is mostly done by belt conveyer.

However, flux materials such as limestone and part of iron ore are unloaded manually to storage along railway, and when required for charging them into blast furnaces, they are loaded manually again onto wagons, which carry them to ore bins at blast furnaces, and unloaded there. Therefore, quality control of raw materials cannot be said adequate. For example, though the optimum size of materials charged into blast furnaces is 10 - 30 mm, inclusion of large lumps as big as 100 mm occurs. And in some cases, inclusion of fine ore reaches as high as 10%.

As regards composition control of raw materials, since there are not adequate yard or bed and the Works does not have crushing and screening facilities, fluctuation in the composition is great, making operation of blast furnaces difficult. Also as there is no sintering plant, heat loss at blast furnaces is big, making blast furnace operation unstable.

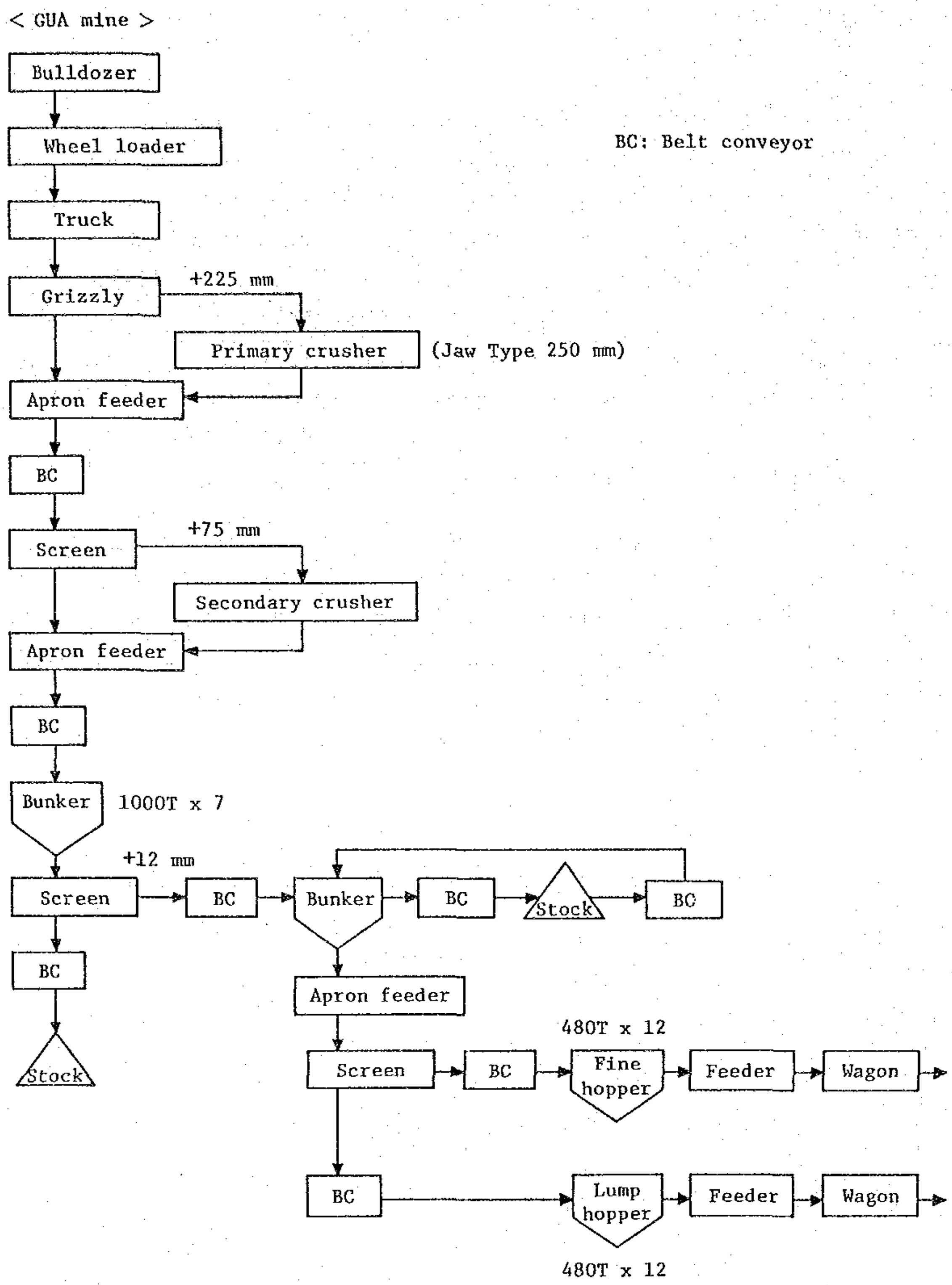


Fig. 5.2.1 Material flow at GUA mine

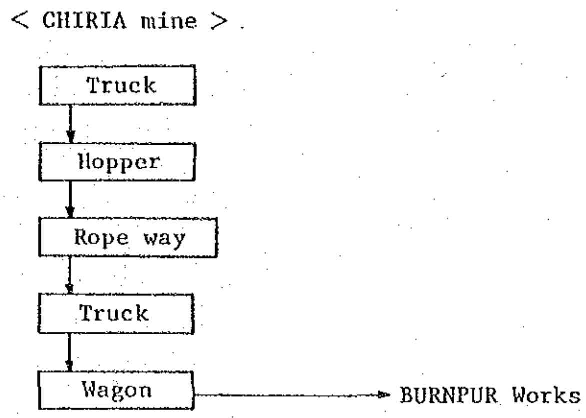


Fig. 5.2.2 Material flow at CHIRIA mine

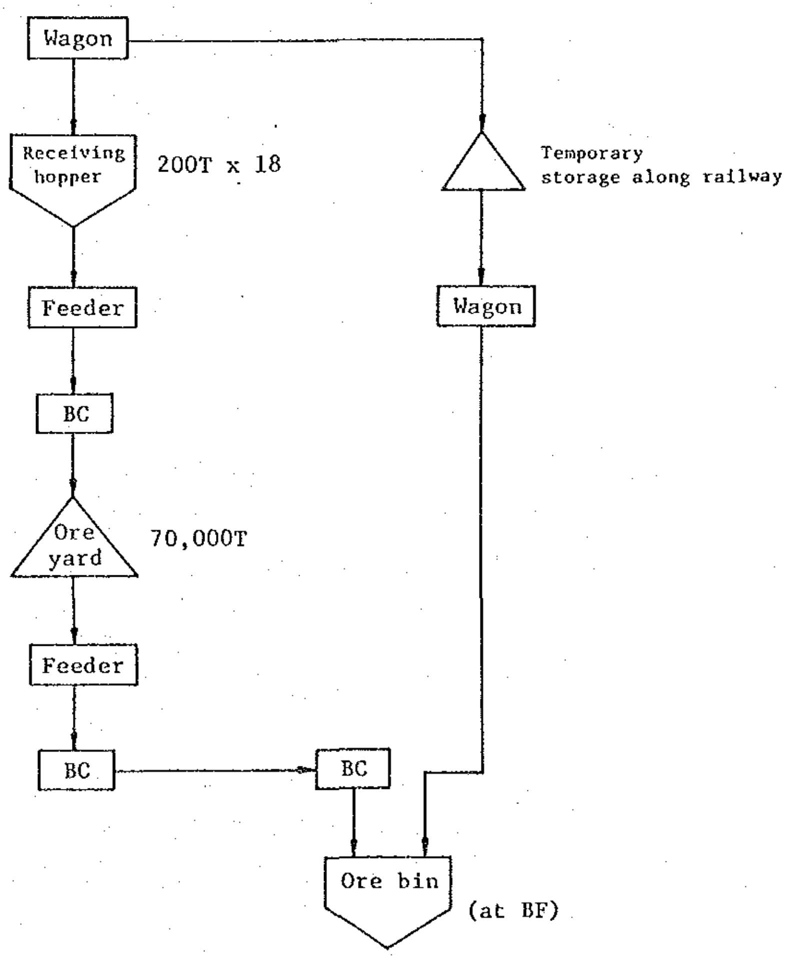


Fig. 5.2.3 Material flow at BURNPUR Works

5-3. Ironmaking

5-3-1. Present layout and flow

There are four blast furnaces, located at the east area of the Works. They receive coke by conveyer from coke ovens also located at the east side of blast furnaces. Iron ore is received in ore bins by conveyer from underground raw material bins (which receive ore direct from wagons) at the south side of blast furnaces.

Flux materials and part of iron ore are loaded on wagon on high line which runs parallel with conveyer and dumped directly into ore bins at blast furnaces.

There is a small ore storage yard which is fed by by-pass line of the above conveyer for raw materials.

There are no ore sizing plant and sinters and pellets are not used as blast furnace charge.

Steelmaking plant is located northwest of the blast furnaces and consists of bessemer converters, open hearth furnaces and teeming yards lined up in this order.

Hot metal from blast furnaces is transported by 75T hot metal ladle car to bessemer converter and open hearth furnace. Truck scale type weigher is located at the north side of blast furnace area. Part of hot metal is sent to a pig machine to produce cold pig. Major part of cold pig is for sale to foundries at KULTI, UJTAIN and others.

Blast furnace slag is transported by 20T slag pan to extensive slag dump yard at the west area of the Works (about 1~2 km distance from blast furnaces). There are slag pits and slag granulators, which are used for all blast furnaces in common.

Blower room and pump room for blast furnaces are installed close to the west side of blast furnaces.

5-3-2. Production by blast furnaces (See Table 5.3.1.)

(1) The total annual hot metal production by the four blast furnaces is about 1,300,000 tonnes/year (Rated capacity). However the production in the period from April 1985 to March 1986 was only 861,556 tonnes as shown below.

Operating rate of the furnaces is fair, however, slag rate and coke rate are very high and resultant productivity (T/m^3-day) is very low.

1985/86	Volume (m^3)	Production (T/Y)	Productivity (T/m^3·D)	Availability (%)	Coke Rate (kg/THM)	Slag Rate (kg/THM)
No.1 BF	500	138,724	0.76	94.9	1334	736
No.2 BF	500	139,549	0.76	93.2	1313	796
No.3 BF	1170	310,758	0.74	94.1	909	718
No.4 BF	1170	272,525	0.64	94.9	950	768
Total	3340	861,556	0.71 (0.75 daily)	94.4	1056	749

Incidentally, No.4 BF shows lower productivity than the other furnaces and it was caused partly by the furnace condition being chilled during power failure in the previous year and shortage of coke and partly by the furnace situation being at the end of campaign. At present (July 1986), No.4 BF is being relined.

(2) As seen from Table 5.3.1 which gives main indicators of operation performance of the blast furnaces during the period from 1962/63 to 1985/86, hot metal production has been deteriorating since 1962/63 and shows no sign of improvement. It is clear that there is correlation with increase of ash content of coke.

The increase of coke ash resulted from inundation at the CHASNALLA colliery which made it impossible to obtain high quality coal mined from the deep mine. The rapid decrease in production in 1984/85 was caused by chilled furnace condition due to power failure as mentioned above. The recovery in 1985/86 resulted mainly from solution of coke shortage, favourable weather condition and fairly satisfactory operation of bessemer converter and open hearth furnace.

(3) This Table also shows that productivity of bigger No.3 BF is generally poor as compared with smaller No.2 BF.

(4) Besides the above, major reasons why production cannot be increased include:

a. Untreated ore: As there are no beneficiation plants (sizing plant, sintering plant, pellet plant), lump ore, as it is, are charged direct from mine to furnace.

b. Quality: In addition to high ash content of coke, all brands of ore are domestic (ore from its captive mines, GUA and CHIRIA, and purchased domestic ore accounting for 30%), and there is limit in selection of ore as well as in ore blend adjustment. Ore contains about 61% Fe, but is high in Al_2O_3 content, which makes it necessary to use a large amount of dolomite lump as source of SiO_2 and MgO. This increases slag rate and coke rate.

c. Size control of ore and coke:

Coke: Size is about 25~100 mm. Coke is screened by Grizzly screen (round 25 mm dia. hole) below coke bin at blast furnace.

Iron ore: Size is mainly 25~100 mm. As there is no sizing facility for ore unloaded at the Works, lumps about 100 mm size and fines less than 6 mm are mixed in blast furnace charge as it is.

d. Moisture control: Water is sprinkled over ore for dust control, but there is no moisture meter under ore bin and moisture control is not done for ore and coke. This increases thermal fluctuation in furnaces.

5-3-3. Problems

(1) To recover original rated capacity of the blast furnaces, it is basically necessary to solve the following matters and implement modernization.

a. Coke: Resumption of deep mining at CHASNALLA and use of imported coal to reduce coke ash and improve coke strength (M10),

b. Size control of raw materials: Installation of crusher and screening facilities for complete removal of fines,

c. Installation of sintering machine: This is to improve reduction performance by decreasing charge of flux materials and using self-flux sinter, and lower coke rate and improve productivity of blast furnaces, and

d. Stable availability of power: Expansion of own power station --- Renewal of worn-out facilities and installation of efficient ones.

More specifically, as matters at blast furnaces,

e. Size control at blast furnaces:
Installation of sinter screen and improvement of coke Grizzly,

f. Weighing and moisture control of raw materials:
Installation of auto weigh calibrater and of coke moisture meter.
Correct weigh control of raw material blend, and if possible, conveyor and weighing hopper system instead of scale car weighing system,

g. Increase of temperature of hot blast from stoves:

To reduce coke rate, efforts are to be made to increase hot blast temperature, and

To maintain high level operation, refractories are to be improved and automatic stove-changing system is to be introduced.

h. Control of blast moisture:

Blast moisture is controlled by adding steam.

High level operation: In order to ensure stable operation and achieve high level, economic operation on the conditions of the above a. through h.,

i. It is necessary to strengthen instrumentation and centralized control system.

At present, instrumentation and centralized control system are poor, which makes operation control of blast furnaces inadequate. Besides, some instruments are damaged and left as it is. Except No.4 BF as relined in 1986, points of measurement, points of record and automatic control are insufficient. Also no central control room exists for each blast furnace and control organization is scattered. These should be improved immediately.

j. It is necessary to improve durability of facilities (renew worn-out facilities).

Blast furnaces, hot stoves, primary gas cleaning equipment and other facilities are of riveted construction, and the bosh is the steel band construction. With such construction, blast furnaces cannot be operated under high top pressure. Blast furnace blowers also cannot stand high pressure, and boilers too are out-of-date and inefficient.

Facilities are generally old and worn-out and it is time to renew them.

No.3 & No.4 BF will be 35 years old in 1993 and 42 years old in 2000.

No.1 BF will be 71 years old in 1993 (16 years old since rebuilding).

No.2 BF will be 69 years old in 1993 (27 years old since rebuilding).

k. Burden distribution device should be installed to the bigger furnaces to obtain better control of burden distribution in the blast furnace stack and thereby improving the gas flow and the fuel efficiency. Also it is necessary to install monitoring system.

l. It is necessary to send to Steelmaking plant low silicon hot metal and high temperature hot metal through high level and stable operation of blast furnaces.

m. Higher pressure of blast furnace cooling water:

Use of high cooling efficiency tuyere and coolers

n. Mechanization of hot metal tapping and slag removal facilities:

Adoption of remote control taphole drill, cinder notch stopper, splash cover crane and tilting runner and others.

o. Facilities of granulated slag:

Slag from blast furnaces is directly processed into granulated slag, thereby preventing delay of slag ladle from deterring hot metal tapping.

p. Expansion of environmental facilities:

Installation of deduster and waste water recirculation system

q. Installation of energy saving facilities:

They should be installed if economic viability is confirmed.

(2) Problems related to layout (See Fig. 5.3.1)

When the above improvement is to be done, the present facilities have the following problems.

a. The four blast furnaces are lined up in a row close each other and surrounded by raw materials bins and power facilities such as blowers and pumps, leaving very limited space.

   Therefore it is difficult to build granulated slag facility, environmental facility and future energy saving facility at a close distance from the blast furnaces. In addition, tracks for hot metal and slag ladle cars are in common for the four furnaces, and this makes it difficult to manage ladle cars when hot metal production increases.

   Considerable device and remodelling is necessary for installation of sinter screens, conveyor system and control rooms.

   Enough space is not available for use of the tilting runner in cast house, and there is no proper space to install control room.

   Much less it is difficult to increase the capacity of existing furnace without large scale of modification.

b. Slag dump is far from the blast furnaces (the distance is increasing) and disposing capacity is insufficient, hindering smooth operation of blast furnaces. When slag increases more than one million tonnes a year, the space will be more inadequate and the slag has to be processed to granulated slag for outside sale.

c. As ore bed yard for ore beneficiation and site for sintering plant are not available adjacent to blast furnaces, slag yard at the west side of the Works has to be used. In such case, sinter and ore will have to be transported from the western end of the Works to the blast furnaces at the eastern end.

(3) Rough specifications of existing blast furnaces

Table 5.3.2 shows rough specifications of the existing four blast furnaces.

Layout of each furnace is as shown Fig. 5.3.1.

The facilities are very old and generally out-of-date though some partial improvement is being made.

If the Works wants to compete with blast furnaces in the world as well as with other blast furnaces in India, it is necessary to carry out extensive modernization of its blast furnaces.

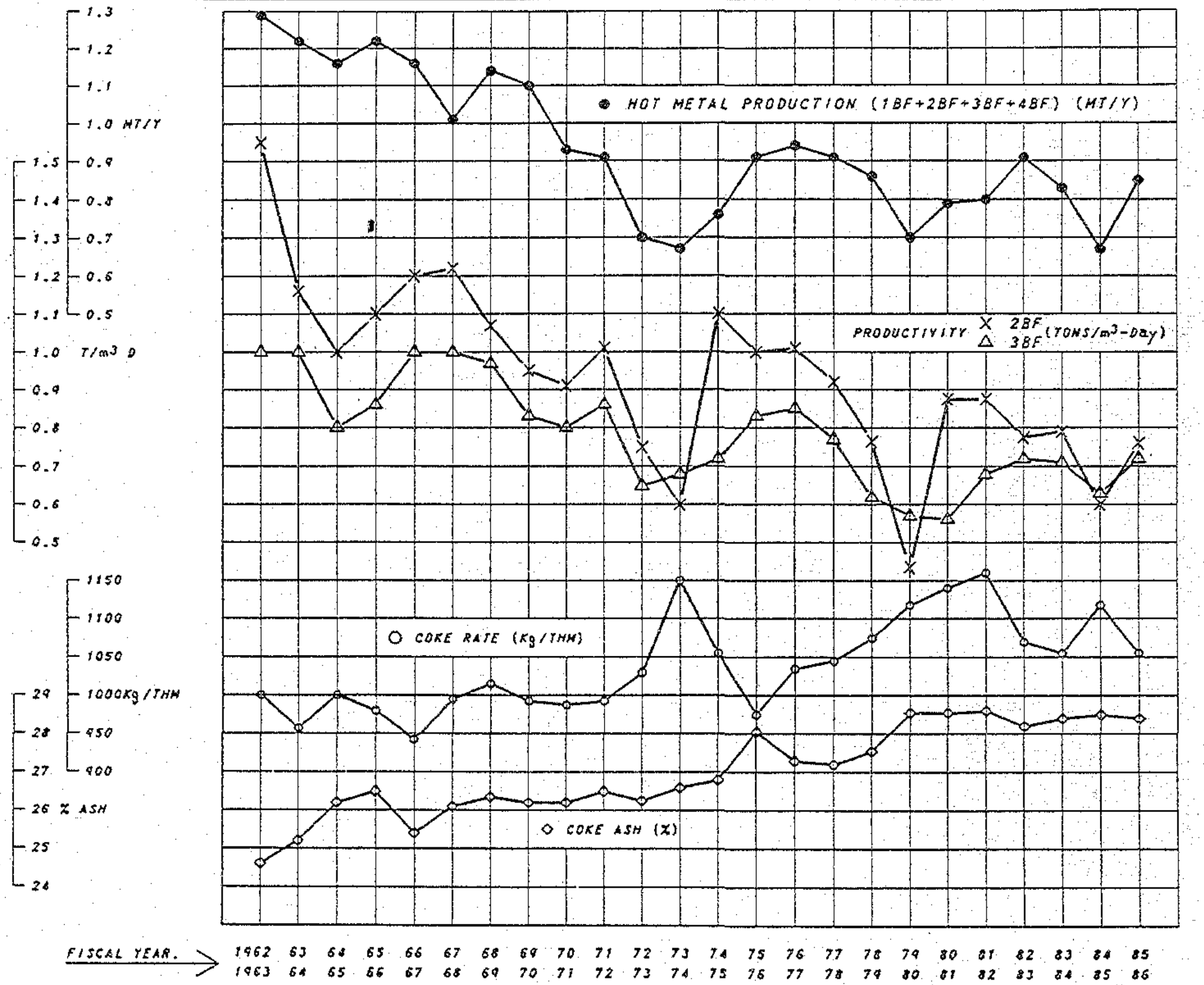


Table 5.3.1 Blast furnace performance (1962/63 - 1985/86)

Table 5.3.2 Equipment list of existing blast furnaces

	Small furnaces	Big furnaces
1. Name of B.F	NO.1 & NO.2 BFs	NO.3 & NO.4 BFs
2. Rated capacity (T/D)	600	1200
3. Date of commissioning	NO.1 : 1922-11-10 NO.2 : 1924-01-07	NO.3 : 1958-10-11 NO.4 : 1958-01-30
4. Rebuilding	NO.1 : 1977-05 NO.2 : 1966-09	------ ------
5. Blowing date of this campaign	NO.1 : 1983-12-31 NO.2 : 1981-01-18	NO.3 : 1981-09-14 NO.4 : 1979-10-08
6. Blast furnace proper		
Type	Ashmore Benson & Pease UK (Old type)	
Inner volume (Useful vol. m^3)	500	1170
Working volume (m^3)	434	1040
Hearth diameter (m)	5.23	7.70
Throat diameter (m)	4.86	6.16
Number of tuyeres	12	18
Number of tap holes	1	1
Number of cinder notches	1	2
7. Furnace refractory		
Hearth-bosh	42% Alumina fire bricks	
Belly & upper shaft	37% Alumina fire bricks	
Throat	32% Alumina fire bricks	
8. Stock house	Charged by conveyor and high line	
Scale cars	3	3
Coke screen	25mm	200T/h (25mm)
Moisture Measuring/Auto-weigh calibration	Non	Non

(... Continued)

		Small furnaces	Big furnaces
9. Charging equipment			
Skip volume	(m^3)	2.83	6.23
Type of top		2 Bell	2 Bell
Top pressure	(mm WG)	700 ~ 800	700 ~ 800
Movable armour		----	NO.4 BF only (after revamping of 1986)
10. Cast house		Common	One each
Tap hole drill		No mechanized	No mechanized
Crane capacity	(T x No.)	15/3.2 x one for both	15/3.2 x one each
Ladles	(T x No.)	Iron ladle 75T x 18 total fleet Slag ladle 20T x 29 total fleet	
Pig casting machine		Max 600T/D x 2 (Nor. 400T/D x 2)	
11. Hot stove			
Type / Number		Cowper/ 3 + 4	Cowper/ 3 + 3
Type of checker		Freyn	Freyn
Hot blast temperature	(°C)	700	800
Gas calorie	(kcal/Nm^3)	900	900
Blast volume	(Max/Nor Nm3/min)	1000/1050	2200
Coke oven gas		Non	Non
12. Gas cleaning		1st DC + 2nd DC + Theisen washer	1st DC + 2nd DC + Scrubber + EP + (EP)
Clean gas pressure	(mmWG)	400 ~ 450	400 ~ 450
Thickeners		3 for old &	3 for new
13. Blowers			
Number of blower	(Nos)	2	3
Blast volume Max.	(Nm^3/min)	1696	2985
Blast pressure Max.	(kg/cm^2)	1.27	1.55

(... Continued)

		Small furnaces	Big furnaces
14.	Cooling water	River water in reservoir / Closed circuit	
	BF colling devices	Copper plates & Hearth staves	
	Temperature x pressure	32°C x 2 kg/cm²	32°C x 2 kg/cm²
	Water balance	4000gpm for both Fce	4000gpm for each Fce
15.	Instrumentation	Insufficient number of measuring points, recorders and data loggers. No-centralized control and less-automatic control. No.4 BF is more or less modernized in the relining of 1986. (See table 5.3.3 and 5.3.4)	
16.	Automation of machines	Less- automation	
17.	Slag pit (Westward yard)	Slag pit and Slag granulator	

Table 5.3.3 List of field instruments at blast furnaces

Sl. No.	Instruments	Furnace Nos.
1.	Stove dome temp. recorder.	1, 2, 3, 4.
2.	Stove back heat temp. recorder.	1, 2, 3, 4.
3.	Hot blast temperature recorder & controller.	1, 2, 3, 4.
4.	Top gas temp. recorder.	1, 2, 3, 4.
5.	Peripherial temp. recorder.	3, 4.
6.	Top gas pressure recorder.	1, 2, 3, 4.
7.	Hot blast pressure recorder.	1, 2, 3, 4.
8.	Gas (for stoves) pressure recorder.	1, 2, 3, 4.
9.	Gas (for stoves) flow recorder.	1, 2, 3, 4.
10.	Air flow (blast volume) recorder.	1, 2.
11.	Air flow (blast volume) indicator.	3, 4.
12.	Steam flow recorder (for blast humidity).	1, 2, 3, 4.
13.	Colling water pressure recorder.	1, 3.
14.	Stock level recorder.	1, 2, 3, 4.

Note : No.4 blast furnace is underlining new. This furnace is being provided with thorough instrumentation.

Table 5.3.4 Instrument List of BF No.4 (Plan for 1986 relining)

1. Air volume recorder.

2. Cold blast pressure recorder.

3. Hot blast temperature recorder.

4. Hot blast temperature controller.

5. Stove dome & back heat : stove No.1 recorder.

6. Stove dome & back heat : stove No.2 recorder.

7. Stove dome & back heat : stove No.3 recorder.

8. Stove gas flow recorder.

9. Mid zone pressure recorder.

10. Peripheral temperature recorder.

11. Uptake temperature recorder.

12. Uptake pressure recorder.

13. Pressure after dust catcher recorder.

14. Hot blast pressure recorder.

15. Differential press. between U/T & M/Z, M/Z & H/B

16. Cooling water flow recorder.

17. Cooling water pressure recorder.

(... Continued)

18. Stove gas pressure recorder.

19. Fixed probe temp. recorder - short probe.

20. Fixed probe temp. recorder - long probe.

21. Humidity & steam flow recorder.

22. Stove combustion & heating control system.

23. Electronic coke weighing system.

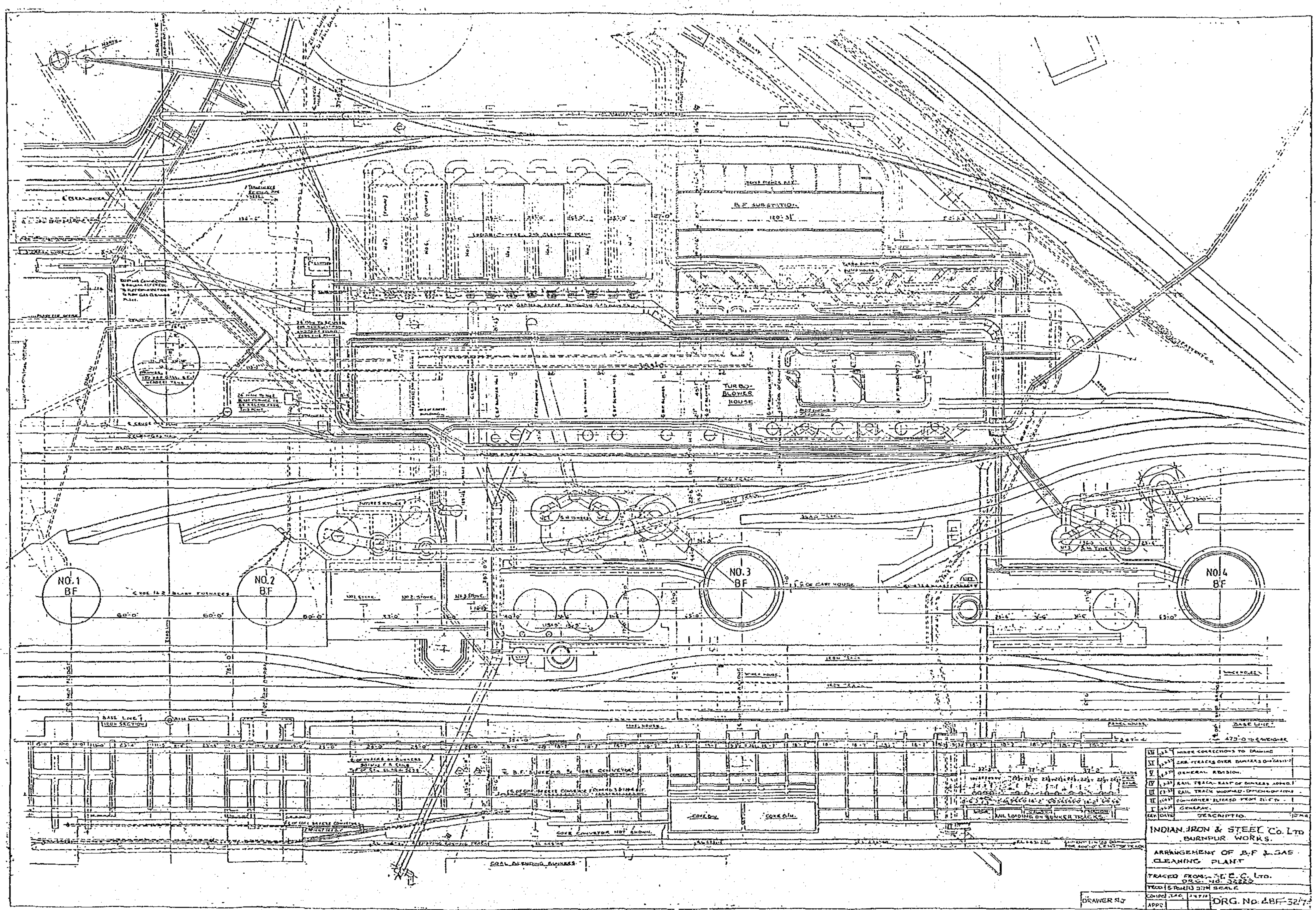


Fig. 5.3.1 Layout of blast furnaces

5-4. Steelmaking

5-4-1. Production process

Steelmaking process employed at BURNPUR Works is duplex process combining bessemer converters and open hearth furnaces, the process now considered a completely out-of-date steelmaking process. In 1939 when the first 4 open hearth furnaces of the existing 6 furnaces were constructed and in 1945 when the bessemer converters were constructed, the process was an efficient steelmaking process under the condition of given hot metal and before appearance of basic oxygen steelmaking process. At present, however, it is no match for new steelmaking process of basic oxygen process in productivity and every other respect. Besides, because of inadequate improvement and maintenance of facilities since their construction, the facilities cannot produce even at originally designed capacity, and with other adverse factors, annual steel production of the Works has been hovering at a 500,000-tonne level as against the rated capacity of a little more than one million tonnes.

Fig. 5.4.1 shows the process flow and metal balance. The process where small ladles are used and molten metal has to be transported in numbers of time, brings about loss of sensible heat and accumulated metal loss between unit processes. Disadvantage in the process impairs operation result of energy consumption and yield which have large effects on production cost.

If BURNPUR Works is to survive as a steel plant that can have competitiveness, the subject of the first priority of implementation should be modernization of steelmaking process which now depends on out-of-date duplex process.

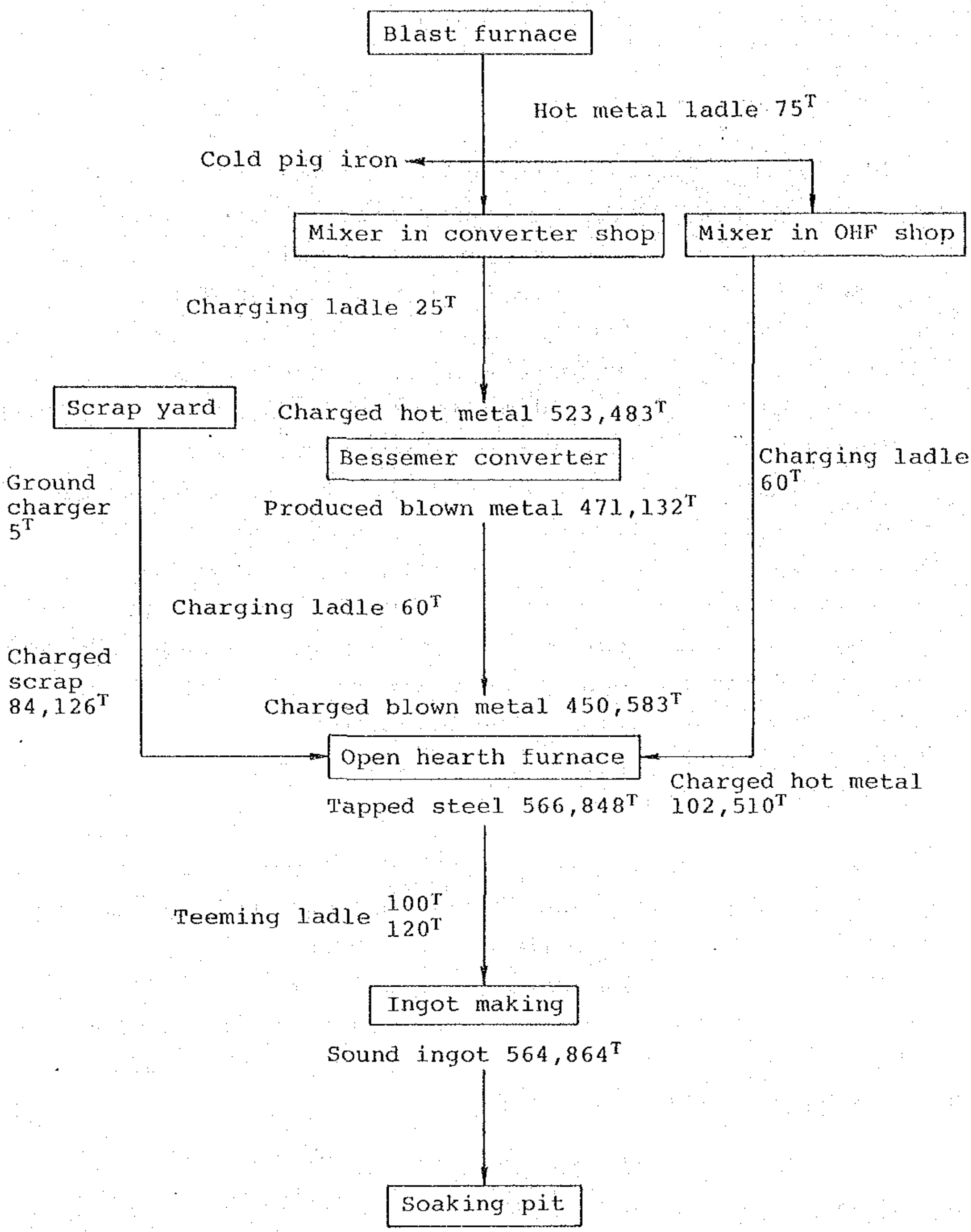


Fig. 5.4.1 Process flow and metal balance
(Based on the production statistics of Apr. 1985 to Mar. 1986)

5-4-2. Facilities

Facilities of Steelmaking Plant consists of main facilities for refining through ingot making including receiving hot metal to teeming and auxiliary facilities such as lime calcining plant and burnt dolomite plant which produce main auxiliary raw materials for open hearth furnace. Outline of main steelmaking facilities is given in Table 5.4.1.

Hot metal from blast furnaces is transported by 75T open ladles to two 900T dead mixers which hold hot metal charged into bessemer converters and one 900T dead mixer which holds hot metal directly charged into open hearth furnaces.

There are 3 bessemer converters of rated capacity of 25T, with two blowers installed. Scrap is carried in 0.75m^3 open hearth furnace charging boxes on buggies to the position in front of the furnaces and charged into the furnaces by four units of rotating ground chargers. Hot metal charged into open hearth furnaces consists mainly of blown metal which is hot metal blown in bessemer converters, and hot metal taken out of the mixer at open hearth bay and carried by 60T ladles and charged into the furnaces.

There are six 225T tilting open hearth furnaces in the open hearth furnace plant, of which four units, A, B, C, and E, were built in 1939 and two units, F and G, in 1958 for expansion. Refractories adopted in the open hearth furnaces are basic chrome-magnesia for furnace body and silica-chrome-magnesia for zebra roof. For burners both gaseous and liquid fuels are used and natural draught is utilitzed. As there is no oxygen plant, oxygen is not used. Instrumentation is inadequate, and combustion control by roof temperature, pressure control, burner switching and others are not automated.

Table 5.4.1 Main equipment of steelmaking plant

Equipment	Specification
1. Hot metal handling equipment	
1) Hot metal ladle	75^T x 30
2) Mixer	Inactive mixer
	900^T x 2 at Bessemer shop
	900^T x 1 at O.H.F. shop
3) Mixer ladle	25^T x 4 for converter charging
	25^T x 4 transfer car ladle
	1 transfer car ladle
4) O.H.F. charging ladle	60^T x 14 for blown metal and hot metal
2. Scrap handling equipment	
1) Scrap charging box	0.75 m^3 x 90
2) Scrap weighing machine	Weigh-bridge : 1
3) Scrap charging car	18
4) Scrap charging machine	5^T x 4
	Ground charger
3. Bessemer converter	
1) Converter proper	25^T x 3
	Tuyere : 18 mm x 7 fire brick
	Inner volume : 144 m^3
	Tilting device : Electro-mechanical
4. Open hearth furnace	
1) Type and capacity	225^T x 6 tilting
Hearth area	63.0 m^2
Roof height	2.66 m for furnaces A,B,C & E
	2.71 m for furnaces F & G
Inner volume of regenerator-chamber	193.0 m^3 for furnaces A,B,C & E
	213.5 m^3 for furnaces F & G
2) Draughting equipment	Natural draught
Type of charging valve	Gas : Saunder pneumatic valve
	Liquid fuel : Manual lever

(continued)

Equipment	Specification
	Air : Balanced, electrically operated reversing plate valves
3) Blower	Capacity : 45,000 m^3/h 75 HP for furnaces F & G 30 HP for furnaces A,B,C & E
4) Chimney	76.3 m
5) Steel ladle	Two ladle for one heat Oval ladle : 100^T x 20 Round ladle : 120^T x 13 Double stopper
5. Crane equipment	
1) Bessemer converter plant	$110^T/30^T$ x 2 $130^T/30^T$ x 1
2) Bessemer plant ladle house	$110^T/30^T$ x 1 $75^T/30^T$ x 1
3) Scrap yard	15^T x 2 magnet crane
4) Open hearth shop	$110^T/30^T$ x 4
6. Lime calcining plant	
1) Shaft kiln	$30^T/D$ x 4 Gas fired
7. Burnt dolomite plant	
1) Rotary kiln	$100^T/D$ x 1 2.55 m dia x 84 m length
2) Cooler	1.9 m dia x 19.4 m length Drum-type

Burnt lime and burnt dolomite, open hearth furnace flux materials, are produced and supplied by captive plants. There are 4 home-built shaft kilns to produce burnt lime and they use coke oven gas as fuel. Handling of limestone and burnt lime is manual and no mechanical facilities and instrumentation are installed.

Dolomite is calcined by a rotary kiln of 100T/D rated capacity built in 1959. Fuel is burnt by common burners with mixed combustion of heavy oil and coke oven gas at the ratio of 50:50, and the burner heads are imported.

It can be said about the facilities in general that they are very old and besides left neglectfully without proper reconditioning and maintenance necessary to perform their functions and ensure their stable operation. Both bessemer converters and open hearth furnaces, main steelmaking facilities, are in so bad condition that they cannot perform the capacity at the time of construction. As regards bessemer converters, blowing capacity of blowers has become short and the two blowers are used concurrently as one unit, but even with such measure, heat size of the bessemer converter decreases considerably. As for the open hearth furnaces also, fuel system has worsened in capacity, and even if other factors that hinder production increase were removed, it is questionable that production can be increased to the rated capacity.

5-4-3. Operation

Because of raw materials condition, hot metal produced at BURNPUR Works is high in Si, P and S, and due to present condition of blast furnace facilities and operation, hot metal temperature is low as given below.

	Ave.	Max.	Min.
%C	3.6	3.8	3.4
%Si	1.9	2.9	0.9
%Mn	0.84	1.00	0.45
%P	0.28	0.30	0.25
%S	0.050	0.110	0.030
Temp.	1280 - 1330 ^{o}C (measured by an optical pyrometer)		

Product mix includes mainly non-flat, long products, but it includes also sheet for galvanized sheet. They are shape, rail, round section, square section, bar, deformed bar and galvanized sheet. Specifications for P and S are not severe and products with P and S being below 0.050% are acceptable.

Table 5.4.2 shows main operational indices of steel-making plant.

The bessemer converters process about 1200 ^{o}C hot metal to about 1400 ^{o}C blown metal containing 0.08-0.40% carbon by blowing for 13 minutes, and several heats of blown metal are put together and charged into the open hearth furnaces. The rated capaicty of a converter is 25T, but the capacity of blowers is insufficient and average heat size is 15 to 16T. Though three converters are in use, they are operated one at a time and unlappedly. It takes much time to fill 60T open hearth furnace charging ladle with blown metal, which causes much ladle skull.

Open hearth furnace charge consists of blown metal from the converters (70%), hot metal (17%) and scrap (the rest).

Average steelmaking time of open hearth furnaces is 11 hours, of which 8 hours is spent for charging and melting. This results from the fact that scrap charging box is too small for 225T O.H. furnace, but main reason is that much time is spent for receiving enough blown metal from the conveters. Another reason may be that oxygen is not used.

Though there are six open hearth furnaces, three units are the maximum number which can be operated concurrently by reason of limitation of fuel. As coke oven gas is in short supply for the Works as a whole, liquid fuel of coal tar or heavy oil is being used to the maximum of 45-55%.

Types of steel produced are mostly low carbon semi-killed steel, but in part rimmed steel is made for billets for outside sale. One heat of molten steel tapped from the furnace is received by two double-stopper steel ladles.

Total number of workers are about 1,300 in whole steelmaking plant including ingot making and sub-material production.

Same as other working places of three-shift working, the working condition of the steelmaking plant is 3-shift with two groups per shift in 7-group 7-week cycle and the rate of standby shift is 1/7. The number of personnel is big for a steelmaking plant with annual capacity of one million tonnes and the reason is that there is delay in mechanization and automation, the duplex process is employed and a great number of persons are employed in auxiliary and sundry works.

The present crude steel production is only a little more than a half of annual rated capacity and there are many factors hindering production. Even if factors outside the steelmaking plant are removed, it is considered difficult to achieve annual production of one million tonnes using the present facilities.

Table 5.4.2 Main operational indices of steelmaking plant

Process	Item	Index
Mixer	Fuel COG	430 m^3/h
	Refractory	0.47 kg/T
Bessemer converter	Blow time	13 min/ch
	Non blow time	5 min/ch
	Repair of refractory	3.30 h/D / fce
	Average heat size	15.2 T/ch
	Life of furnace	350~400 blows
	Life of furnace bottom	28~ 30 blows
	Unit consumption of converter refractory	22.8 kg/T
Open hearth furnace	Steelmaking time	11 h
	1) Charging time	3 h
	2) Melting and filling time	5 h
	3) Refining time	2.5 h
	4) Fettling time	0.5 h
	Periodical repair time	8~9 D/fce
	Heating up time	3 D/fce
	Good ingot production	16.4 T/h
	Average heat size	205 T
	Hot metal ratio	15~17 %
	Blown metal ratio	68~72 %
	Scrap ratio	12~14 %
	Unit consumption	
	1) Fuel	1.3 Mkcal/T
	2) Iron ore	40.4 kg/T
	3) Burnt lime	59.4 kg/T
	4) Ferro manganese	11.6 kg/T
	5) Burnt dolomite	20.6 kg/T
	6) Total refractory	17.2 kg/T
	Utility	
	1) Electricity	1,025 MWH/M
	2) COG	165 m^3/T
	3) Oil	15 kg/T
	4) Tar	45 kg/T
	5) Industrial water	2,647 Mℓ/M

5-4-4. Control

Control items at Steelmaking Plant are wide and varied including production control, quality control, cost control, maintenance and others. To implement those controls, most important factors are control system, control equipment and education of personnel. From the viewpoint of control, the present condition of Steelmaking Plant contains many points to be improved. First of all, instruments to grasp actual operation condition correctly are short. Measurement which is indispensable for control of materials, the basis of production, is hardly performed, and any measurement between processes is done by rule of thumb. In respect to control of temperature which is important for steelmaking process, even open hearth furnace tapping temperature is not fully controlled. This is also an organizational problem, and the fact that temperature control is not the responsibility of steelmaking operators but is made a control item of other people leads to low consciousness of steelmaking operators.

Instrumentation for monitoring operation is also short. There is only pressure gages for blown air for bessemer converters and combustion control of open hearth furnaces is done manually. In addition, installed facilities are not effectively used in some cases; for example, adjustment of unit ingot weight by actual weight is rarely done though weighing machine is available.

As regards product quality, the idea of quality control is not yet fully developed partly because quality standard for types of steels produced is not so severe.

For cost control, the first thing to be done is to know the present condition correctly, and to do so, it is necessary to take preliminary steps, by which cost control items are determined and an organization is arranged.

The condition that maintenance of facilities is entirely responsibility of maintenance department with operation side being not involved in the maintenance scheme must be improved. Close contact and cooperation between operators who can sense condition of facilities directly and maintenance people is essential for repairing trouble before it becomes serious and also for establishing preventive maintenance. As expenditures for facilities have an effect on production cost, such cooperation is very important also in cost control.

From metal balance shown in Fig. 5.4.1, yield of sound ingot from hot metal delivered from dead mixer and processed by besemer converter and open hearth furnace is calculated to be 76%, and this is extraordinarily low. This integrated yield can be improved only by investment in steelmaking process and facilities and improvement of the entire control system.

5-5. Ingot casting

5-5-1. Outline of process

Liquid steel refined in open hearth furnaces is tapped into two ladles concurrently. One ladle has capacity of 110 tonnes and the other 120 tonnes. Liquid steel in a ladle is top poured into 24 5T big-end-down molds by using double stoppers. Steel grade produced is mostly semi-killed steel and rimmed steel accounts for less than 1%. After a lapse of a certain holding time from pouring, teeming wagons on which molds stand are led to stripping yard, where overhead stripper crane removes molds from wagons. After stripping, ingots still on the wagons are transported to soaking pits.

5-5-2. Problems

A number of operational and quality problems are noticed while field survey was made, and some of major ones are given below.

(1) Measurement of tap temperature and teeming temperature is seldom performed; in other words, it can be said that those temperatures are not controlled. This is caused by low reliability of thermometers and inadequate maintenance.

(2) Quality of refractories for stopper is poor and running stoppers occur frequently.

(3) As the control of deoxidation of molten steel is poor, ingots with sound skin are not obtained.

(4) Height of molds is not uniform, and as a result, weight of ingots varies considerably, which brings about a big error in calculation of teemed steel weight.

As a result of the above, teeming yield (sound ingot weight/tapped steel weight) is as low as 95.5%. To improve this, it is necessary to take respective measures to solve the above problems, but measurement and thoroughgoing control of tap temperature and change of stoppers to sliding gate nozzle are considered very urgent.

5-5-3. Operation condition and performance

Table 5.5.1 shows main operational conditions and performance of ingot casting.

Table 5.5.1 Main operational conditions and performance

Item	Description	Remarks
Steel grade	Semi-killed steel ≒ 100% Rimmed steel < 1%	
Chemical composition (%)	Grade / C / Si / Mn / P / S IS226 / .17/.23 / .03/.06 / .75/.90 / <.055 / <.055 IS1977Gr.0 / .08/.12 / <.05 / .30/.50 / <.050 / <.050	 Structual steel Sheet
Ladle	Capacity Elliptical (double stoppers) : 110 Ton Invular (double stoppers) : 120 Ton Lining permanent : MG Fire brick IS-1525 Gr.1 Wear : MG Fire brick IS-1525 Gr.1	
Teeming	Number of mold per ladle : 24 Ingot weight : 5.1 T (Ave.) Mold weight : 4.35 T Teeming time : 20 min.	
Others	Holding time : 5~10 min. for S. Killed Steel 2 H for Rimmed Steel 2H for Killed Steel Stripping time : 30 min.	
Production tonnage	564,866 T / '85 - '86	
Teeming yield (good ingots / tapped steel)	95.5% (Loss Butt 1.5% Spoilt steel 1.0% Skull in ladle 1.5% Others 0.5%)	
Unit consumption (kg/T)	Mold : 22.3 Steel : 3.8	

5-6. Rolling

In the Rolling Department, there are six mills in operation, including a 1,000-mm bloom mill, a 850-mm heavy structural mill, a 450-mm light structural mill, all completed in 1939, a sheet mill completed in 1941, a sheet bar & billet mill completed in 1953 and a merchant & rod mill completed in 1960.

Not only were those mills constructed many years ago but also any improvement or replacement of facilities, even in in part, has not been made for these many years. On top of the short supply of steel materials and the inconsistent supply of the fuels and the power, the deteriorated command of technological skill, the defective facilities and the degradation of the entire system owing to rude manner of operation are all to be blamed for the productivity, the material consumption and the availability of the current facilities, all of which are now in the level far below where they originally were at the start-up period, let alone where the modern facilities recently built generally are.

The number of operation personnel of the mills reach 3,970 (sheet mill including 534 maintenance personnel), and production per worker of sold rolled product is only 126T a year.

Among the rolling mills presently in operation, those which will have to be stopped during the period of the modernization plan under the present study are the light structural mill and the sheet mill. The both mills are so fatally deteriorated in both machinery and electric parts that the remodelling investment outweighs the return in the form of improvement in production efficiency. Much expectation may not be placed on effect of any modernization investment.

The product quality, poor because of lack of communication with the preceding steelmaking area and of inadequate performance in the intermediate quality control, needs much improvement.

The production condition of the rolling mills is shown by the material flow chart in Fig. 5.6.1.

5-6-1. Bloom mill

The facilities in the blooming mill is given in Table 5.6.1 "Equipment List of Rolling Department, Item 1", and its operational performance in Table 5.6.2 "Operational Statistics of Rolling Department, Item (1)".

The ingots weighing about 5 tonnes each are transported by wagons from the stripper yard to the soaking pit yard in the blooming mill and charged into the soaking pit by the soaking pit crane. The ingots heated in the soaking pit are discharged by the pit crane again from the pit and transported to mill line by the ingot buggy or the pit crane. On the blooming mill, the section of ingot is reduced to specified dimensions and is sent to the next process after defective area at the top and bottom of ingot is discarded.

The ingot shows many surface defects and fins, which indicate that quality control and operation control at the steelmaking and ingot casting processes are not proper.

The ingot buggies subject to continued troubles are demanding the inappropriately high rate of use of pit crane unnecessarily. Also there is much leakage of heat around the soaking pit covers, and occurrence of scale is as high as 4 percent. Conbustion facilities of the soaking pit are obsolete and controlled entirely manually without instrumentation, making any degree of controlled operation impossible. Therefore, the fuel consumption is as extraordinally high as 897×10^3 kcal/T.

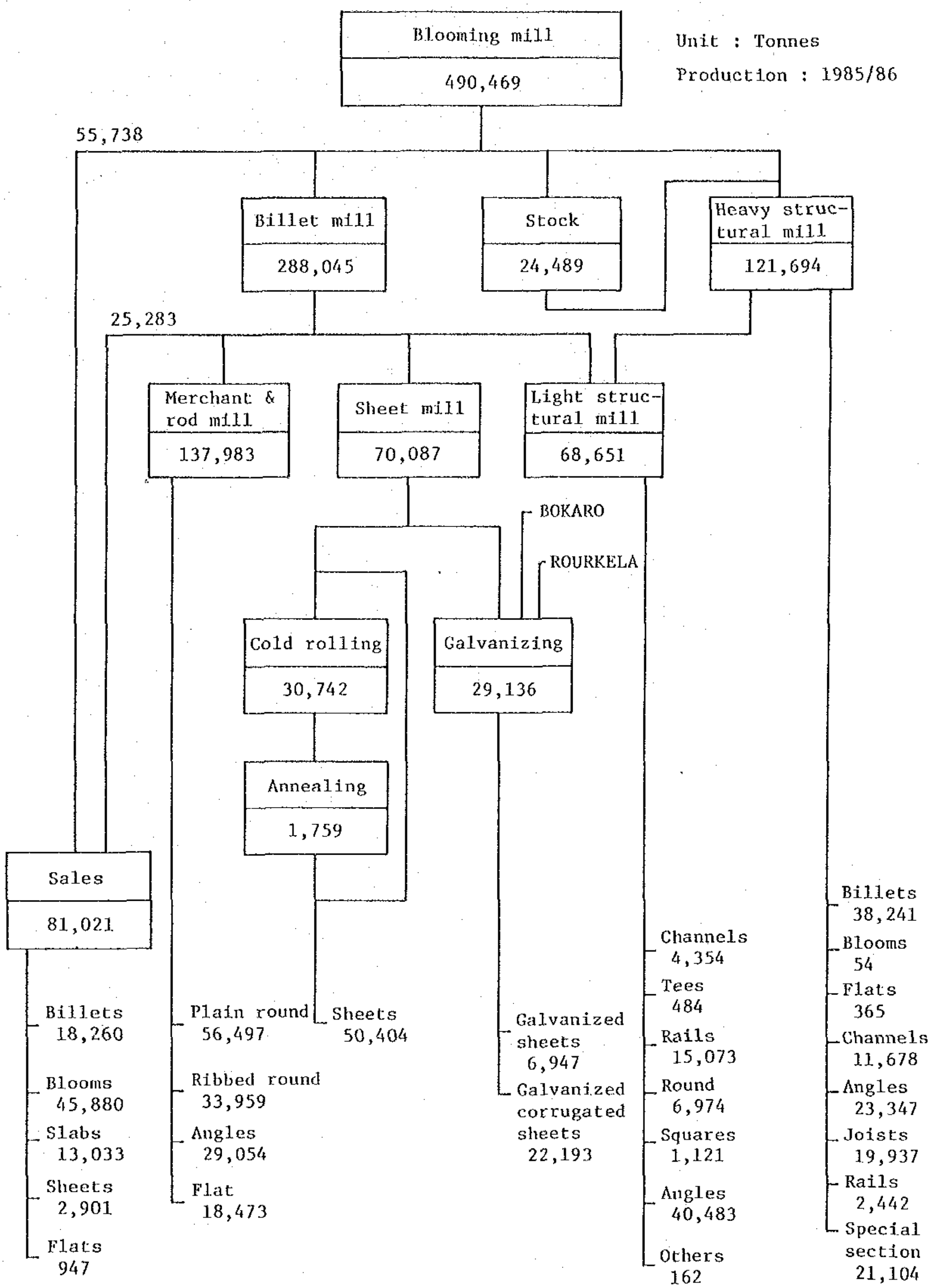


Fig. 5.6.1 Material flow chart

Electric equipment of the blooming mill are also obsolete. In addition, breast roll of the mill is left dismounted and failure of rolls to grip the steel occurs. The roller table between the 500T shear and the billet mill also is very old, and so smooth transfer of the material is hindered.

5-6-2. Billet & sheet bar mill

The facilities of the billet and sheet bar mill are outlined in Table 5.6.1 and the mill's operational statistics are given in Item (2) of Table 5.6.2.

The blooms rolled on the blooming mill are further rolled on a billet & sheet bar mill comprising as main facilities 2-stand roughing train, 4-stand intermediate train and 4-stand finishing train into billets for the non-flat rolling mills and sheet bars for the sheet mill, and after cooling, sent to the rolling mill of each product.

The total production output in 1985/86 was about 288,000T. The problems in this mill, among others, are:

(1) The bloom transfer roller table between 500T shear and this mill does not work well for smooth transfer of blooms.

(2) The material delivered from No.5 stand (5H) and No.7 stand (7H) is not fed in proper shape into the following stand.

(3) Electric equipment is obsolete and the control of roll stands and shear is not proper.

Because of those major problems, the yield is low and 94.5%.

5-6-3. Heavy structural mill

The facilities of the heavy structural mill are given in Table 5.6.1 and its operational statistics in Item (3) of Table 5.6.2.

The hot blooms rolled on the blooming mill are transferred by roller table directly to the heavy structural mill, and the cold blooms are heated in the reheating furnaces. Those blooms are rolled on the mill consisting of one roughing, one intermediate and one finishing stand into products of specified dimensions and shapes, and then sheared to final lengths.

The production in 1985/86 is about 121,000 tonnes in billets, flats, channel, angles, joist, rail and special sections.

There are three reheating furnaces, but the newest one is out of use because its location too far to permit an access of blooms. The other two furnaces in use are obsolete, not equipped with any measuring instruments, and are operated manually. Though a majority of blooms are sent from the blooming mill by the roller table directly to this mill for rolling, the fuel consumption is very high, 616×10^3 kcal/T, and the material is not heated uniformly and occurrence of scale is overmuch. The furnaces are really out-of-date.

The roll bearings of each stand are seriouslly worn out and proper rolling cannot be obtained. Spindles and their hydraulic balancing system are old and not stable. Besides, much of rolling operation depends on manual skill and even a tilter is not installed at each stand.

Electric equipment are completely obsolete and inferior in control function.

As to finishing facilities, the straightening equipment are low in efficiency and much manpower is required.

5-6-4. Light structural mill

The facilities of the light structural mill is given in Table 5.6.1 and its operational statistics in Item (4) of Table 5.6.2.

Billets rolled in the billet mill are transported to the light structural mill, where they are heated in reheating furnaces and rolled by 2 roughing stands, 1 intermediate stand and 1 finishing stand into products of specified sizes and cooled on the cooling bed and shipped.

The rolling mill was built in 1939 and the efficiency of the reheating furnaces is very low.

Roll bearings and inner housing of each stand are in damage, making the rolling operation laborious and inefficient.

In addition, the electric equipment are obsolete and unlikely to bear a long use to come.

In the finishing line, the cutting facilities for products are not adequate and not working effectively.

The production in 1985/86 is 68,700 tonnes, and the capacity of the mill is decreasing year after year.

5-6-5. Merchant and bar mill

The facilities of the merchant and bar mill is given in Table 5.6.1 and the mill's operational statistics in Item (5) of Table 5.6.2.

Billets heated in the reheating furnace is rolled on the mill consisting of 9-stand roughing train, 6-stand intermediate train and (2+6)-stand finishing train into products and cut to lengths or coiled.

The reheating furnace is not equipped with fuel control equipment and the recuperator of the furnace is not efficient, with the unit fuel consumption being as high as $560x10^3$ kcal/T.

Roll stands of finishing train for produce of coil are seldom used.

The production in 1985/86 is 137,983 tonnes. This resulted from shut-down by no shift, shortage of billets as well as the shortage of power and fuel.

5-6-6. Sheet mill

The facilities of the sheet mill are outlined in Table 5.6.1 and its operational statistics in Item (6) of Table 5.6.2.

The sheet bars rolled on the billet mill are cut to the size of 9.4/25.4(mm)x680/1240(mm)x304.8/406.4(mm) and, after heated in reheating furnaces, rolled on roughing stands and then heated again and rolled on finishing stands into sheets with specified thicknesses.

The sheets are rolled in a pile packs of two or more wheets and, after rolling, they are separated manually.

A part of sheets are hot dip galvanized.

Both the heating and rolling facilities are very old and their operation depends heavily on manpower.

The mill is very low in efficiency and unproductive and requires heavy labour as seen from the operation statistics in 1985/86 such as yield of 78.8%, unit fuel consumption of $1,572x10^3$ kcal/T and production of 70,087 tonnes by 1,635 workers.

Table 5.6.1 Equipment list of rolling department

Equipment and facility	Quantity	Specification	
1. Blooming mill			
Soaking pit	32 Holes	Type	; Regenerative type hard bottom end fired.
		Dimension	; 3962 mm x 1981 mm x 2667 mm x 16 Holes (in 1939)
			3962 mm x 2134 mm x 2743 mm x 16 Holes (in 1959)
		Fuel	; BFG 890 kcal/m^3
		Control method	; Manual
		Buggy	; Two unit (both not available)
Blooming mill	1 stand	Type	; Two high reversing mill
		Roll dimension	; 1066/941 mm x 2438 mm
		Main motor	; D.C. 6650HP x 1
		R.P.M.	; 0/60/100
		Bearing	; Phospher-bronze
Shear	2 units	Type & capacity	; 1 no 1000 t Sack shear
			1 no 500 t Sack shear
		Stroke	; 505 mm and 335 mm
Crane	7 units	Soaking pit crane	; 4 nos x 5 T
		Mill crane	; 1 no x 90 T/30 T
		Bloom stock yard crane	; 2 nos x 15 T

(continued)

Equipment and facility	Quantity	Specification	
2. Billet mill			
Roughing train	2 stands	Type	; 1 no two-high horizontal mill
			1 no vertical mill
		Roll dimension	; 806 mm x 457/1220 mm
		Main motor	; 2 nos D.C. 800HP
Intermediate train	4 stands	Type	; 2 nos two-high horizontal mill
			2 nos vertical mill
		Roll dimension	; 648/706 mm x 381/1220 mm
		Main motor	; 4 mos D.C. 600HP
Finishing train	4 stands	Type	; 4 nos two-high horizontal mill
		Roll dimension	; 518/566 mm x 558/813 mm
		Main motor	; 1 no A.C. 7000HP
Shear	3 units	Type	; 2 nos up and down cut shear
			1 no flying shear
Cooling bed	3 units	Type	; 9.1 m x 25.9 m each
Crane	6 units	Mill crane	; 1 no x 30 T/10 T
		Billet yard crane	; 5 nos x 16 T

(continued)

Equipment and facility	Quantity	Specification	
3. Heavy structural mill			
Reheating furnace	2 nos 1 no in 1939 1 no in 1959	Type	; Regenerative batch type
		Fuel	; Mixed gas (3100 kcal/ m^3) or furnace oil' (10000 kcal/kg)
		Combustion control	; Manual
Roughing	1 stand	Type	; Two-high reversing
		Roll dimension	; 965/1220 mm x 2286 mm
		Main motor	; 1 no D.C. 6700HP common for roughing and intermediate
Intermediate	1 stand	Type	; Two-high reversing
		Roll dimension	; 965/1220 mm x 2286 mm
Finishing	1 stand	Type	; Two-high reversing
		Roll dimension	; 965/1220 mm x 2286 mm
		Main motor	; 1 no D.C. 6650HP
		Bearing	; White metal
Shear	4 units	Type	; 2 nos 650 psi pendulum type 2 nos 50 psi longitudinal traverse up and down type shear
Cooling bed	6 nos		

(continued)

Equipment and facility	Quantity		Specification
Crane	12 units	Mill crane	; 1 no 130 T/30 T
		Bloom transfer	; 2 nos 5 T
		Yard crane	; 7 nos 16 T 1 no 20 T 1 no 10 T
New reheating furnace	1		Out of use.
4. Light structural mill			
Reheating furnace	2 nos 1 no in 1939	Type	; Recuperative continuous pusher type (2 zone)
		Fuel	; Mixed gas (3100 kcal /m^3) or furnace oil (10000 kcal/kg)
		Combustion control	; Manual
		Materials	; 100 - 125 mmSQ x 3.25 - 3.75 m billets
Roughing	2 stands	Type	; Three-high
		Roll dimension	; 482/584 mm x 1524/1372 mm
		Main motor	; 1 no A.C. 1710HP 2nd roughing stand and Intermediate stand are driven by the same D.C. 1920HP motor
Intermediate	1 stand	Type	; Three-high
		Roll dimension	; 482/584 mm x 1372 mm

(continued)

Equipment and facility	Quantity	Specification	
Finishing	1 stand	Type	; Three-high
		Roll dimension	; 482/584 mm x 762 mm
		Main motor	; 1 no D.C. 1920HP
Shear	2 units	Type	; Pendulum-saw hydraulic traverse type
Cooling bed	3 nos		12.8 m x 19.2 m each
Crane	4 units	Mill crane	; 1 no 35 T/10 T
		Yard crane	; 3 nos 10 T
5. Merchant and rod mill			
Reheating furnace	1 no	Type	; Recuperative continuous pusher type (1 zone)
		Dimension	; Furnace floor 9.85 m x 16.3 m
		Fuel	; Mixed gas (3100 kcal /m^3) or furnace oil (10000 kcal/kg)
		Combustion control	; Manual
		Material	; Billet 57 SQ - 91 SQ x 9 m
Roughing	9 stands	Type	; 7 nos two-high horizontal stand 2 nos vertical stand
		Roll dimension	; 343/421 mm x 152/800 m

(continued)

Equipment and facility	Quantity	Specification	
		Main motor	; Horizontal stand D.C. 250/500/500HP each Vertical stand D.C. 75/150/150HP each
Intermediate	6 stands	Type	; 4 nos two-high horizontal stand 2 nos vertical stand
		Roll dimension	; 330/413 mm x 152/610 mm
		Main motor	; 2 horizontal stand D.C. 250/500/500HP each 2 horizontal stand D.C. 300/600/600HP each Vertical stand D.C. 75/150/150HP each
Finishing	(2+6) stands	Type	; 2 nos two-high horizontal for straight rolling to cooling bed 6 nos two-high horizontal for wire rod rolling
		Roll dimension	; 330/(257 - 278) mm x 610/520 mm
		Main motor	; 2 horizontal stand for straight rolling D.C. 300/600/600HP each 6 horizontal stand for wire rod rolling 1 no D.C. 750/1500/1500HP

(continued)

Equipment and facility	Quantity	Specification	
Shear	5 units	Type	; 2 nos rotary dividing shear 2 nos Q-bar shear 1 no up and down cut shear
Cooling bed	2 nos		82.3 m x 2.5 m each
Crane	9 units	Mill crane	; 1 no 35 T
		Yard crane	; 8 nos 15 T
6. Sheet mill			
Reheating furnace for roughing	2 units	Type	; Single chamber angle type continuous chain drive furnace
		Fuel	; Mixed gas (3100 kcal /m^3) or oil (10000 kcal/kg)
		Combustion control	; Manual
		Materials	; 9.4/25.4 mm x 680/1240 mm x 304.8/406.4 mm
Reheating furnace for finishing	4 units	Type	; Dual chamber angle type continuous chain drive furnace
		Fuel	; Mixed gas (3100 kcal /m^3) or furnace oil (10000 kcal/kg)
		Combustion control	; Manual
Roughing	2 stands	Type	; Three-high

(continued)

Equipment and facility	Quantity	Specification	
		Roll dimension;	813/521 mm x 1575/1372 mm
		Main motor ;	1500 kW
Finishing	4 stands	Type ;	Two-high non-reversing
		Roll dimension;	813 mm x 1113/1168/1270/1420 mm
Shear	5 units	Type ;	Guillotine shear
Finishing facility			Cold rolling mill, Annealing furnace Acid pickling bath
			Hot dip galvanizing line (4 lines) (acid bath-flux roll - bottom roll - exit roll - spangle conveyor - washer tank - dryer - leveller - inspection table)
			Corrugating machine
Crane	10 units		Material handling 10 nos

Table 5.6.2 Operational statistics of rolling department

(1) Blooming mill

Blooming mill production

Unit: tonnes

Break-up of production		Period				
		1985/86	1984/85	1983/84	1982/83	1981/82
Saleable	Blooms	43,679	20.743	44,284	50,725	16,010
	Slabs	12,059	7,432	7,767	9,615	7,740
Semis	H.S.M.	103,379	78,024	101,744	93,554	97,389
	L.S.M.	-	-	-	34	285
	Billet mill	304,863	275,195	307,708	358,392	384,163
	Stock	24,489	33,912	25,243	33,017	38,875
Total yield weight		490,469	415,305	486,746	545,337	544,462
Yield (%)		90.97	90.59	90.59	89.85	90.42
Performance	Net utilization (%)	49.84	41.97	49.99	57.35	55.89
	Rolling rate (T/h)	116.37	116.65	115.44	115.41	115.59
Consumption	Electricity (kWh/T)	25.74	34.54	31.68	29.16	28.78

Fuel consumption ; 897,000 kcal/T

Roll consumption ; 0.07 kg/T

Maintenance cost ; 58.73 R/T

Manpower organization ; 11.91 R/T
work shift/turn

Yield scrap ; 5.03%
scale ; 4.00%

Number of manpower ; 192 persons

(continued)

(2) Billet mill

Billet mill production

Unit: tonnes

Break-up of production		Period 1985/86	1984/85	1983/84	1982/83	1981/82
Saleable	Billets	18,260	19,825	37,918	35,319	30,532
	Blooms	2,201	1,118	1,757	1,473	1,345
	Slabs	974	586	920	1,050	890
	Sheet bars	2,901	1,180	700	5,492	3,222
	Flats	947	668	243	557	152
Semis	Billet for L.S. mill	31,767	60,272	63,767	76,508	79,643
	Billet for M & R mill	144,156	119,105	122,187	139,491	157,813
	Sheet bar for sheet mill	86,839	60,435	67,015	83,977	92,936
Total yield weight		288,045	263,189	294,507	343,867	366,533
Yield (%)		94.51	95.13	95.61	95.95	95.41
Performance	Net utilization (%)	32.21	29.60	33.75	38.65	40.17
	Rolling rate (T/h)	105.53	102.39	103.28	108.80	108.57
Consumption	Electricity (kWh/T)	27.45	27.60	27.54	25.25	25.44

Roll consumption ; 0.15 kg/T

Maintenance cost ; 52.29 R/T

Manpower organization ; 20.72 R/T
work shift/turn

Yield scrap ; 3.99%
scale ; 1.50%

Number of manpower ; 270 persons

L.S. mill ; Light Structural Mill

M & R mill ; Merchant & Rod Mill

(continued)

(3) Heavy structural mill

H.S. mill production

Unit: tonnes

Break-up of production		Period 1985/86	1984/85	1983/84	1982/83	1981/82
Saleable	Billets	38.241	42,217	59,147	60,851	84,460
	Blooms & slabs	54	36	26	-	18
	Flats	365	-	116	-	-
	Channel	11,678	3,143	8,879	7,102	968
	Angles	23,347	16,925	20,640	19,580	17,210
	Joist	19,937	13,725	10,991	16,698	8,467
	Rail	2,442	2,591	1,713	-	-
	Special section	21,104	14,425	12,473	10,521	10,376
Semis	For L.S. mill	4,526	7,261	237	569	-
	For sheet mill	-	200	383	-	-
Total yield weight		121,694	100,523	114,605	115,321	121,499
Yield (%)		88.52	89.21	90.67	91.41	90.81
Performance	Net utilization (%)	36.65	29.69	33.46	34.74	34.72
	Rolling rate (T/h)	44.87	44.30	45.30	45.33	47.03
Consumption	Electricity (kWh/T)	124.63	129.04	113.82	146.63	201.01

Fuel consumption ; 616,000 kcal/T

Roll consumption ; 1.5 kg/T

Maintenance cost ; 199 R/T

Manpower organization ; 121.34 R/T
work shift/turn

Yield scrap ; 6.98%
scale ; 4.50%

Number of manpower ; 796 persons

(continued)

(4) Light structural mill

L.S. mill production

Unit: tonnes

Break-up of production		Period				
		1985/86	1984/85	1983/84	1982/83	1981/82
Saleable	Channels	4,354	2,959	875	3,835	379
	Tees	484	1,068	1,114	926	2,509
	Rails 30 Lbs.	15,073	16,744	15,309	14,845	16,200
	Rounds	6,974	15,103	22,423	17,161	34,120
	Squares	1,121	-	-	1,547	4,207
	Angles	40,483	30,112	17,807	33,170	14,721
	Others	162	651	1,356	1,424	5,927
Total yield weight		68,651	60,637	58,884	72,908	78,063
Yield (%)		91.37	91.28	91.49	91.65	91.88
Performance	Net utilization (%)	54.76	50.49	49.54	57.36	64.28
	Rolling rate (T/h)	17.20	17.60	16.52	17.00	17.08
Consumption	Electricity (kWh/T)	51.54	58.02	79.81	57.65	57.85

Fuel consumption ; 885,000 kcal/T

Roll consumption ; 0.8 kg/T

Maintenance cost ; 246.68 R/T

Manpower organization ; 140.63 R/T
work shift/turn

Yield scrap ; 4.63%
scale ; 4.00%

Number of manpower ; 605 persons

(continued)

(5) Merchant & rod mill

Merchant & rod mill production

Unit: tonnes

Break-up of production		Period				
		1985/86	1984/85	1983/84	1982/83	1981/82
Saleable	Plain round	56,497	49,205	48,043	47,233	77,982
	Ribbed round	33,959	32,917	41,118	56,288	52,046
	Angles	29,054	24,639	20,681	20,409	7,617
	Flats	18,473	5,199	9,642	12,517	14,531
Total yield weight		137,983	111,960	119,484	136,447	152,176
Yield (%)		95.81	95.39	95.30	95.62	95.51
Performance	Net utilization (%)	60.99	48.14	57.52	61.52	72.34
	Rolling rate (T/h)	46.3	46.4	43.9	45.0	44.5
Consumption	Electricity (kWh/T)	63.52	67.96	68.74	67.88	64.54

Fuel consumption ; 566,000 kcal/T

Roll consumption ; 0.22 kg/T

Maintenance cost ; 109.73 R/T

Manpower organization ; 53.25 R/T
work shift/turn

Yield scrap ; 1.69%
scale ; 2.50%

Number of manpower ; 438 persons

(continued)

(6) Sheet mill

Sheet mill production

Unit: tonnes

Break-up of production		1985/86	1984/85	1983/84	1982/83	1981/82
	Black sheet	70,087	49,080	54,849	69,637	74,168
	Yield (%)	78.76	78.49	76.88	75.97	75.39
Annealing		1,759	857	1,445	5,319	7,035
Cold Rolling		30,742	19,964	21,672	32,053	33,423
Galvanized	IISCO	20,249	11,362	17,614	33,009	30,366
	IISCO black to galvd. yield (%)	102.87	102.99	103.50	102.10	102.75
	BOKARO	2,889	4,145	963	-	-
	BOKARO cold rolled to galvd. yield (%)	102.92	103.91	106.06	-	-
	ROURKELA	5,998	2,592	250	-	-
	ROURKELA cold rolled to galvd. yield (%)	103.11	103.00	107.73	-	-
	Total galvd. sheet weight	29,136	18,099	18,827	33,009	30,366
Performance	Roughing mill utilization (%)	65.94	43.66	53.38	69.50	72.39
	Roughing mill rolling rate (T/h)	7.66	8.35	7.91	8.01	8.07
	Finishing mill utilization (%)	61.24	45.07	55.59	76.39	78.39
	Finishing mill rolling rate (T/h)	3.84	3.69	3.41	3.27	3.28

(continued)

Fuel consumption	;	1,572,000 kcal/T
Zinc consumption	;	81.75 kg/T
Maintenance cost	;	241.09 R/T
Manpower organization work shift/turn	;	352.84 R/T
Number of manpower	;	1,628 persons
BOKARO	;	Cold rolled sheet from BOKARO works
ROURKELA	;	Cold rolled sheet from ROURKELA works

5-7. Utilities

5-7-1. Outline of facilities

5-7-1-1. Non-utility power generation

The power station generates the total of 60 MW with 4 turbo-generators backed by 14 boilers generating steam of 639 T/h in the aggregate and supplies power as well as steam for blast furnace blowers and steam for plants in general.

No. 1 through No. 12 boilers use coal and gaseous fuel of mainly blast furnace gas and coke oven gas, and A and B boilers use coal and heavy oil. Table 5.7.1 shows specifications of the boilers.

Table 5.7.1 Equipment specifications of boiler

Equipment	Quantity	Capacity				Remarks
		Coal+BFG +COG	Coal+ BFG	Coal	Coal or Oil	
No.1~6 Boiler & No.12 Boiler	units 7	T/h 27,223	T/h 16.0	T/h 10.0	T/h -	Lopulco water tube boiler I.C.L. single stoker fired
No.7~11 Boiler	5	54.446	46.0	30.0	-	Lopulco type I.C.L. U.K. Make Twin stoker fired
A & B Boiler	2	-	-	-	90.75	A.V.B. Make Twin stoker fired

Year of installation: No.1~No.4 - 1939, No.5 - 1947, No.6 - 1948, No.7 - 1953, No.8~No.10 - 1957, No.11, No.12 - 1959, A, B - 1980

The steam turbines are medium pressure turbines of steam pressure 22.5 kg/cm^2 and there are two 10-MW units and two 20-MW units.

Cooling water for No. 1 and No. 2 steam turbines is supplied from No. 1 reservoir pump house and returned to No. 2 reservoir. Cooling water for Nos. 3 and 4 turbines is of circulating type.

Table 5.7.2 shows specifications of steam turbine generators and Fig. 5.7.1 shows power plant system flow.

Table 5.7.2 Equipment specifications of turbo generator

Equipment	Quantity	Maker	Year of installation	Capacity	Steam consumption	Cooling system	Cooling water consumption
No.1 Turbo-Generator	unit 1	Stal-Asea	1939	MW 10	kg/kwh 5.45	Open channel cooling system	m^3/h 546
No.2 - " -	1	- " -	- " -	10	- " -	- " -	546
No.3 - " -	1	- " -	1948	20	- " -	Hyperbolic cooling system	455
No.4 - " -	1	Parsons	1959	20	- " -	- " -	455

5-7-1-2. Blower equipment

Blower equipment consists of 4 blast furnace blowers, 2 bessemer blowers and one spare blower used in common.

Blowers are all steam turbine blower type and steam is provided from the power plant under medium pressure of 22.5 kg/cm^2 at 390 ^oC.

Plant system flow is shown in Fig. 5.7.2 and equipment specifications in Table 5.7.3.

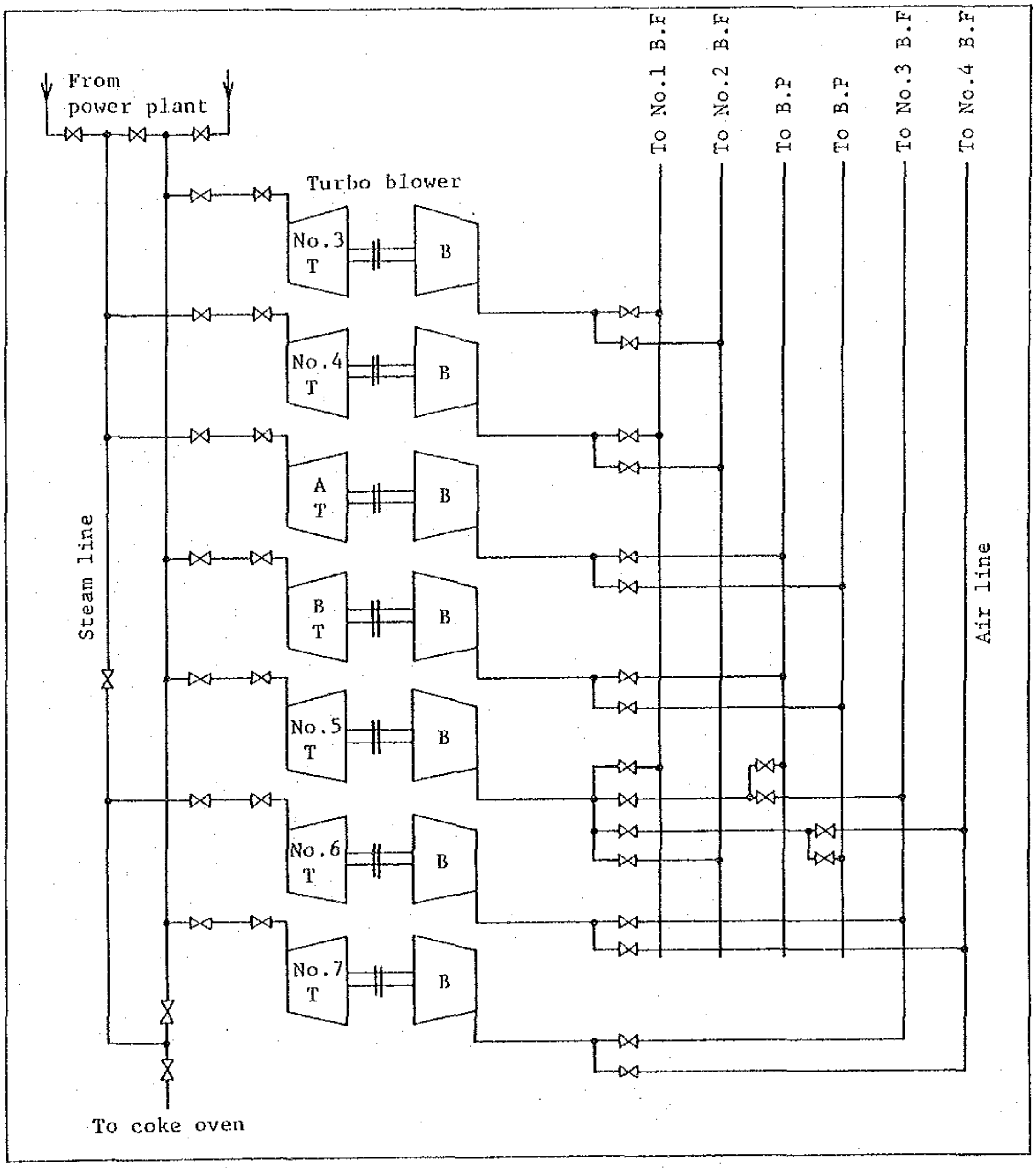


Fig. 5.7.2 Blower plant system flow

Table 5.7.3 Equipment specifications of blower plant

Equipment	Maker	Turbine					Blower		Remarks
		Year of instal-lation	Steam pressure	Steam temp.	Steam con-sumption	R.P.M.	Max.air volume	Max.air pressure	
No.3 Turbo-blower	M/S. C.A Parsons U.K.	1928	kg/cm^2 22.5	°C 387.8	T/h 20.5	3340	Nm^3/min 1,696	kg/cm^2 1.265	For No.1 B.F & No.2 B.F
No.4 – " –	– " –	1929	– " –	– " –	– " –	– " –	– " –	– " –	– " –
A – " –	– " –	1947	– " –	– " –	16.1	– " –	848	2.465	For Bessemer plant
B – " –	– " –	1958	– " –	– " –	– " –	– " –	– " –	– " –	– " –
No.5	M/S. G.H.H W. Germany	1958	– " –	– " –	34.0	– " –	2,685	1.550	For all B.F & B.P
No.6	– " –	1958	– " –	– " –	– " –	– " –	– " –	– " –	For No.3 B.F & No.4 B.F
No.7	– " –	1958	– " –	– " –	– " –	– " –	– " –	– " –	– " –

5-7-1-3. Power receiving and distributing facilities

To receive power, there are four lines; two lines from Kalipahari S/S and two lines from Kulti Works S/S. Both are 33 kV transmission lines, and generally power is supplied from Kalipahari S/S. Kulti Works S/S lines are for use in an emergency.

Power received at 33 kV is stepped down by two 12.5 MVA transformers to 11 kV and distributed to each plant at 11 kV. 11 kV distribution lines are underground lines.

Fig. 5.7.3 shows power system.

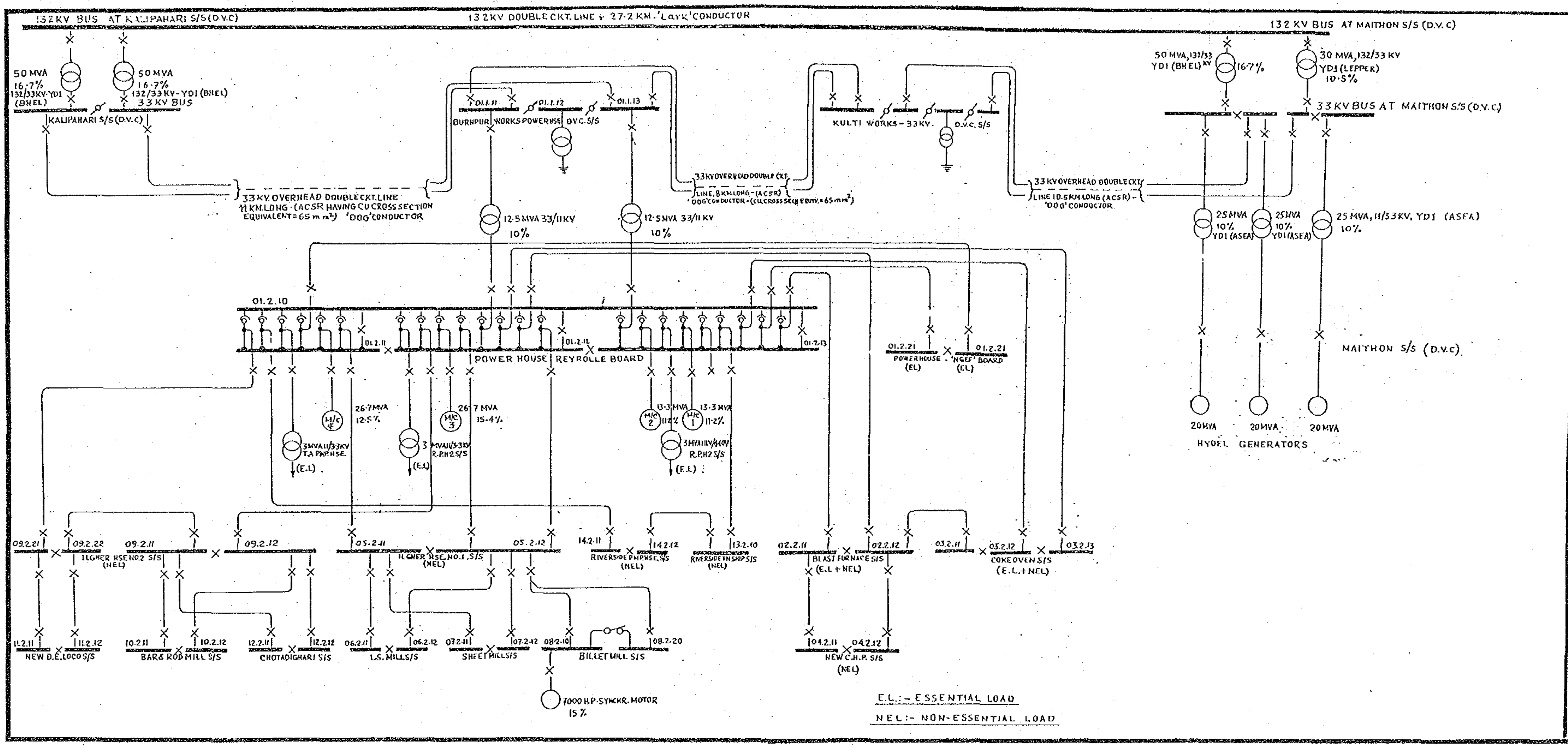


Fig. 5.7.3 Power system

5-7-1-4. Gas supply facilities

Fuel used in the Works includes by-product blast furnace gas, coke oven gas and tar. Purchased fuel includes heavy oil. Facilities to supply those fuels to each plant are gas supply facilities.

Blast furnace gas and coke oven gas are used singly in blast furnaces, coke ovens and steelmaking plant and used as mixed gas in rolling plants.

Coke oven gas is more or less in short supply and heavy oil is stocked so that it can be supplied as substitute fuel to rolling, steelmaking, dolomite plants and power plant.

Fig. 5.7.4 shows gas supply system.

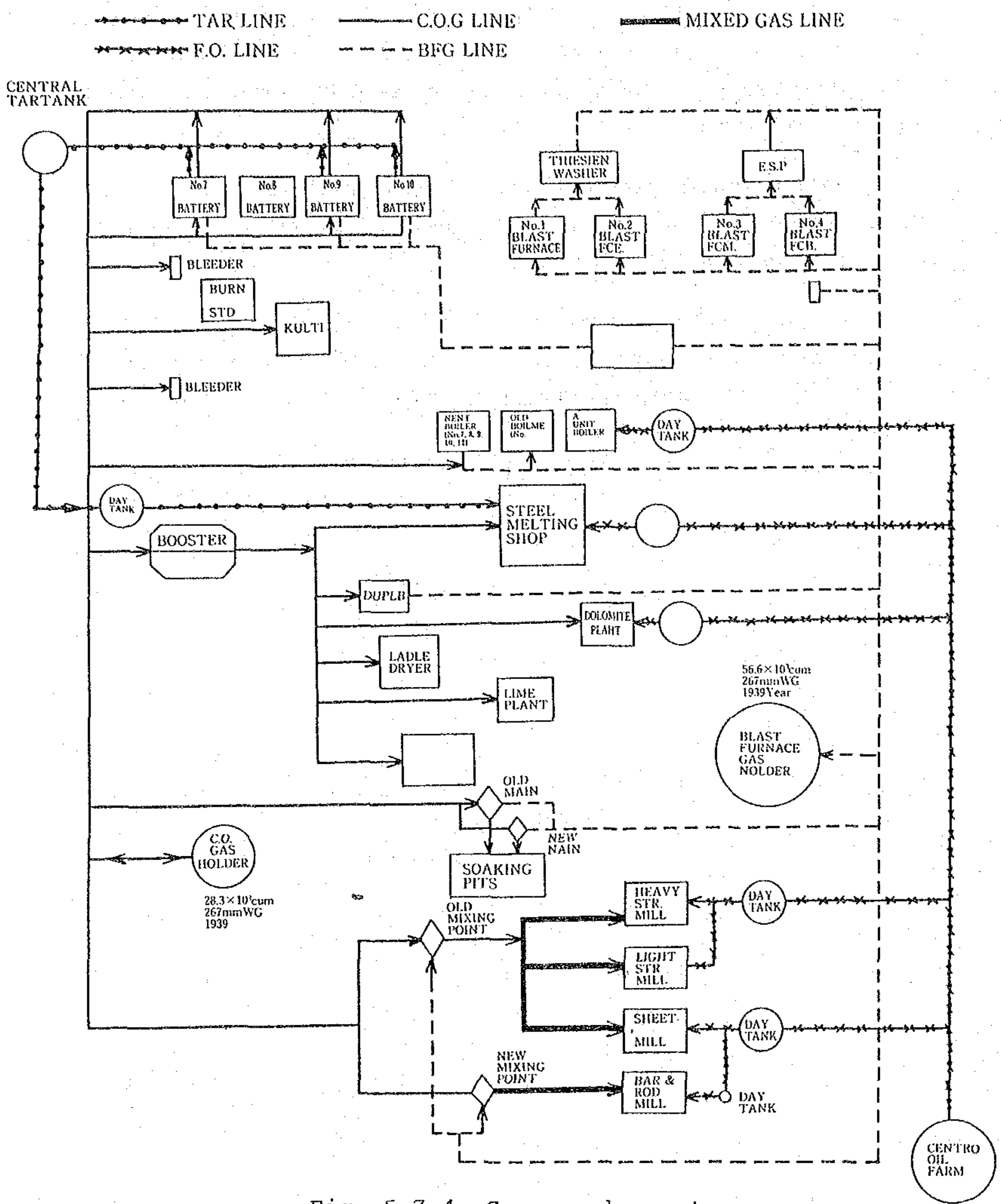


Fig. 5.7.4 Gas supply system

5-7-1-5. Water supply facilities

Cooling water supply system consists of supply from No. 1 reservoir pump house and return to No. 2 reservoir.

Cooling water supply system for power station, blowers, and part of coke plant is circulating type where water is re-circulated after treatment by the side of plants.

To replenish water of the reservoirs, water is pumped up from Damodar River and after suspended solids settled in the settling pond, sent by pumps at No. 2 Riverside pump house.

Clean water is obtained from No. 2 Riverside pump house and after cleaning at Town Water Works, supplied to Town and Works.

Fig. 5.7.5 shows water supply system.

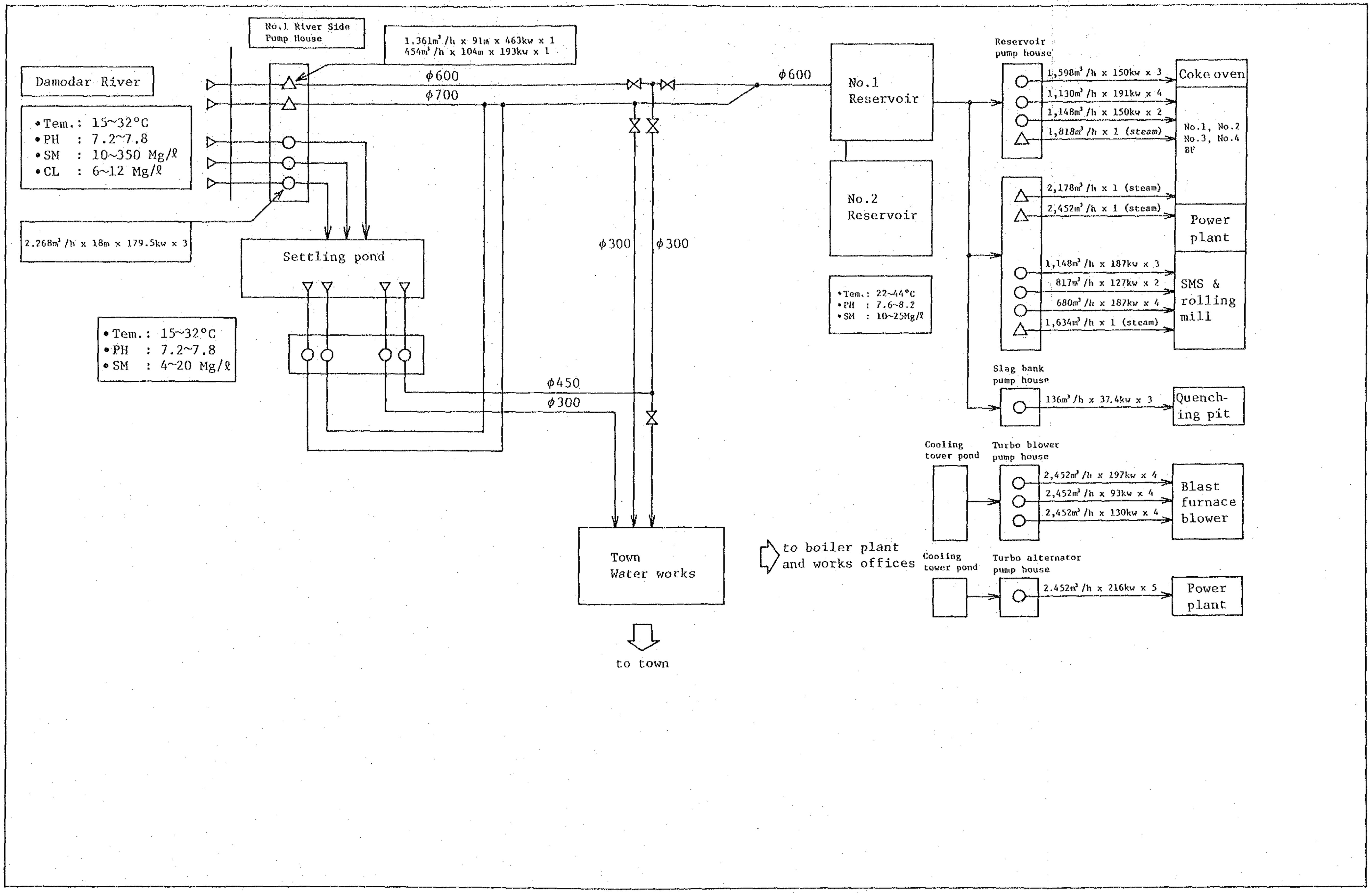


Fig. 5.7.5 Water supply system

5-7-2. Problems

5-7-2-1. Energy in general

Crude steel production of BURNPUR Works decreased year by year after hitting the peak in 1963 and at present is in the range of 500,000-600,000 tonnes/year. Many factors can be considered as the cause of such unsatisfactory production, but from the viewpoint of energy supply, the following two have a large effect.

1) Unstable power supply from power companies:
   There is frequent power restriction.
2) Gas shortage:
   Shortage of coke oven gas affects energy balance.

5-7-2-2. Present condition and outlook of power restriction

(1) Present condition of power restriction

As shown in Fig. 5.7.6, power restriction is imposed by power companies every day and amounts to 70% of working time/month. Under such condition, it is difficult to maintain normal production activity.

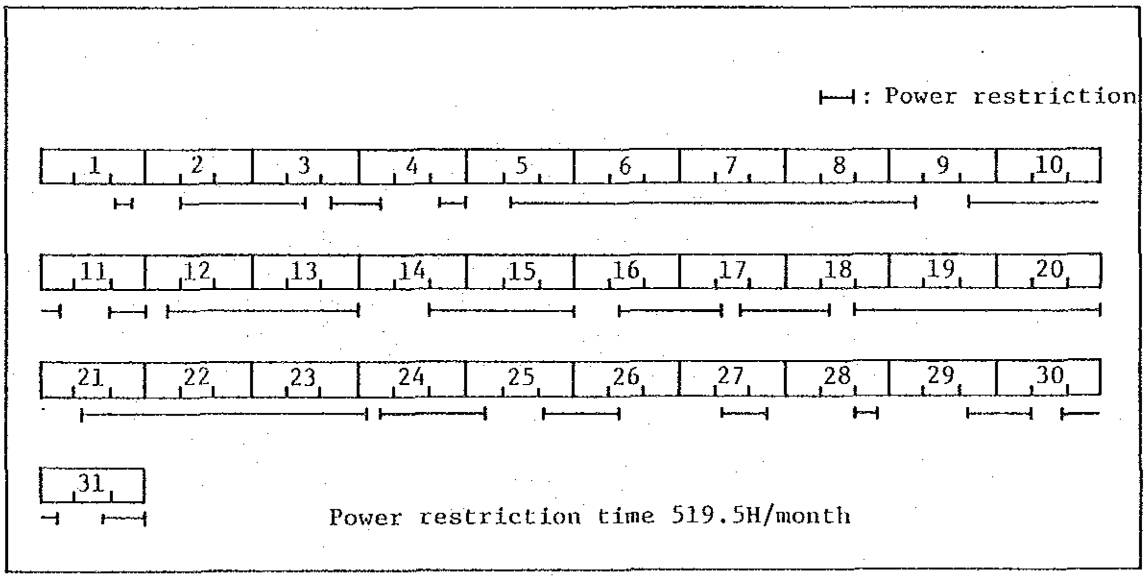


Fig. 5.7.6 Power restrictions 1985/86

(2) Power plant capacity and outlook

Power companies supplying power to BURNPUR Works have generation capacity of 1,549 MW in the aggregate and 95% is coal-based power generation.

In figures power supply and consumption is in balance, plant capacity of 1,549 MW against maximum load of 1,100 MW, but as shown in Table 5.7.4, power generation is about 700 MW.

Actual power generation capacity of the power companies is estimated from Table 5.7.4 and Fig. 5.7.7 to be about 60% in terms of maximum utilization factor.

Table 5.7.4 Power plant capacity and generation of D.V.C.

	Power plant capacity	Power plant generation	Utilization factor
1986. 6. 2	1,549 MW	700 MW	45 %
1986. 6. 5	1,549	600	39
1986. 6. 7	1,549	650	42

$$\text{Utilization facter} = \frac{\text{Generation}}{\text{Capacity}} \times 100$$

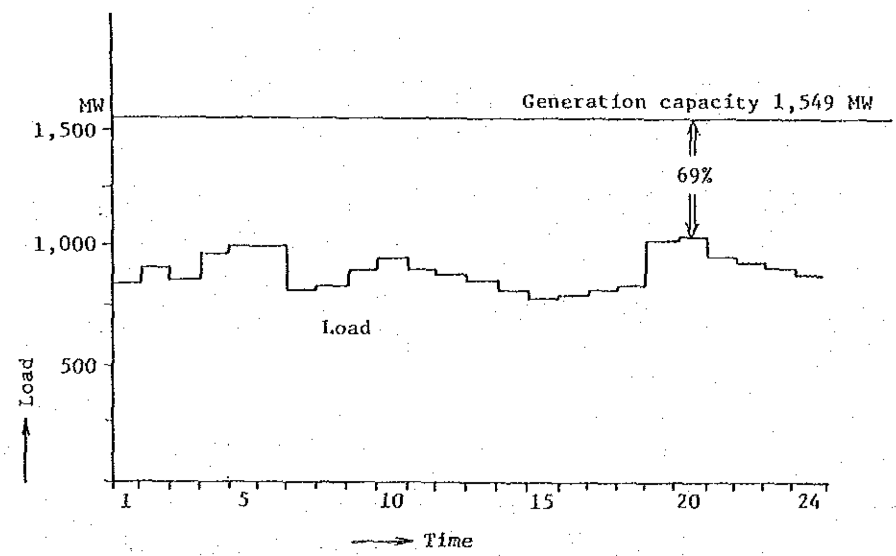


Fig. 5.7.7 Load curve (max., day) of D.V.C.

Analysis of future plan of the power companies shows as seen from Fig. 5.7.8 that utilization factor is 68% in 1993 and 70% in 1995, no difference from the condition at present.

From above it may be considered reasonable to expect the power restriction to continue unless there is technical improvement in future.

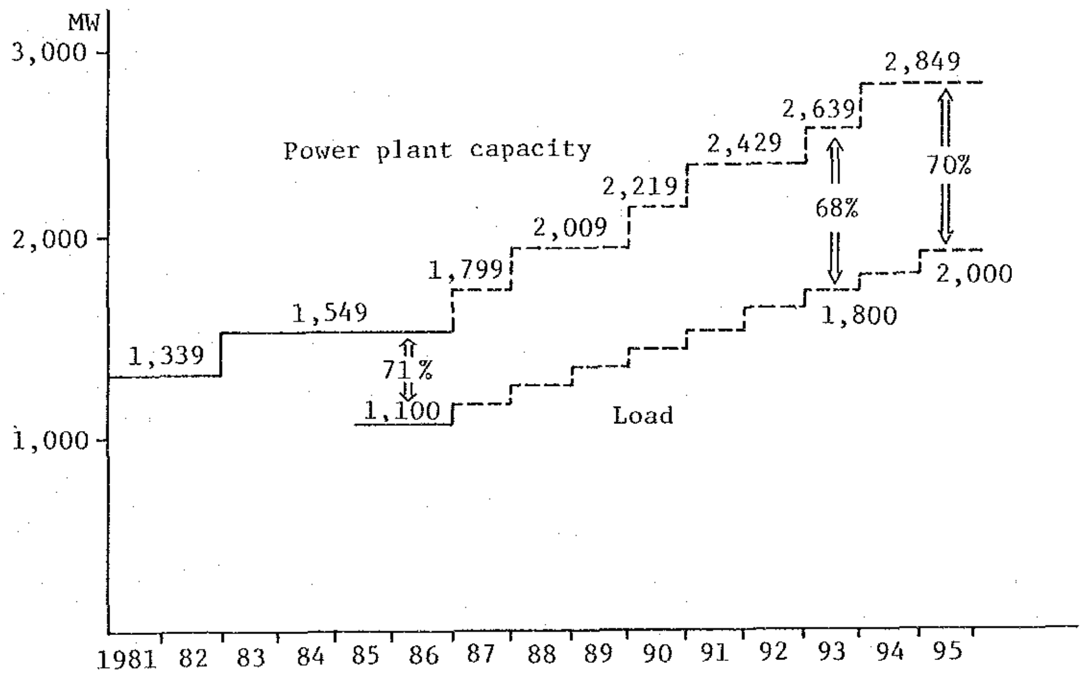


Fig. 5.7.8 Expansion plan of power plant and load forecast of D.V.C.

5-7-2-3. Gas shortage

Problem of gas shortage originates from shortage of by-product coke oven gas. As shown in Fig. 5.7.9 production of the gas decreased year by year to 300,000x10^3 m^3/y in 1985.

As a result, the supply and demand balance deteriorated and there occurred many cases where coke oven gas could not be supplied to rolling department, causing decrease in production. In the blooming mill, for instance, restriction by shortage of coke oven gas totalled 1,030 h/y in 1985.

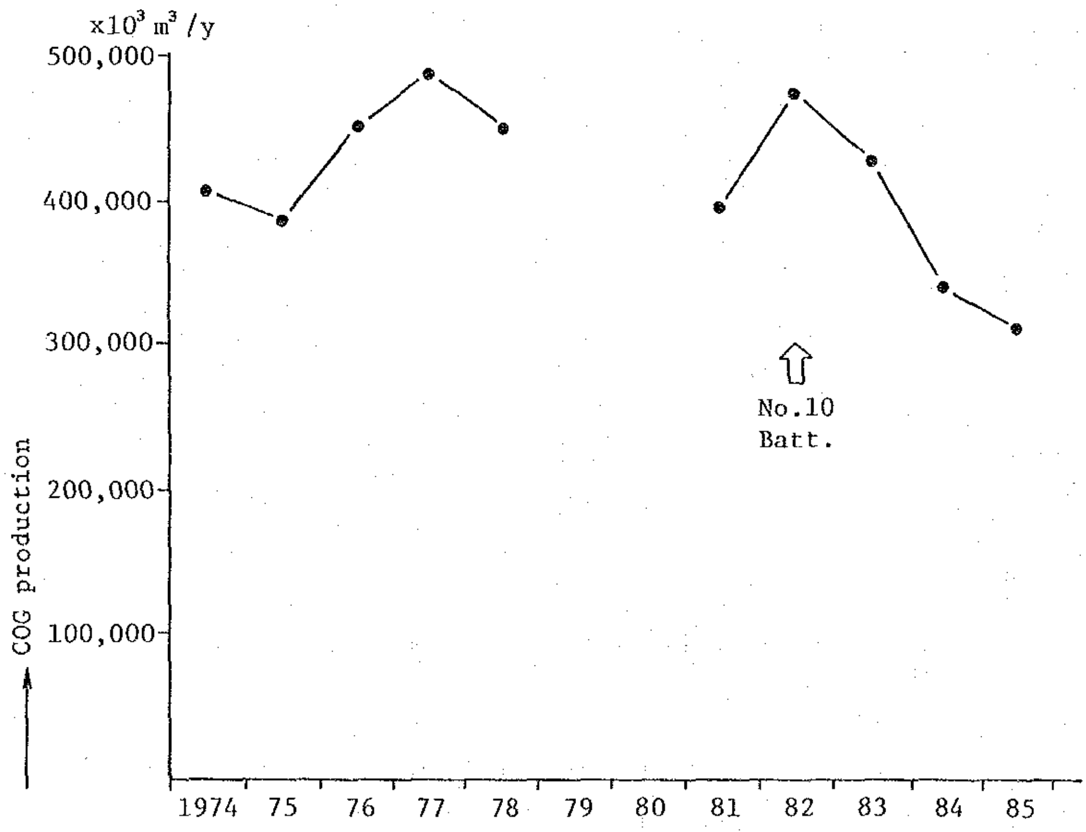


Fig. 5.7.9 COG production

Table 5.7.5 COG restriction of blooming mill

	1981-82	1982-83	1983-84	1984-85	1985-86
COG restriction time	570 h	898 h	1,116 h	1,974 h	1,029 h

The supply of coke oven gas to the Works' power station also was stopped completely from 1983 and as a result steam generation decreased.

5-7-2-4. Other problems

There are other problems such as decreased power self-supplying rate, increased steam consumption and increased power consumption.

(1) Decreased power self-supplying rate

Though there is adequate power plant capacity, the self-supplying rate of power has been decreasing as shown in Fig. 5.7.10.

The reason is considered to lie in the following.

Steam generation is small as against capacity.*1
Increased use of steam at steel mill proper prevented adequate steam supply to power generation.*1
Power consumption has increased.*2
(Notes: *1 See Item (2) *2 See Item (3))

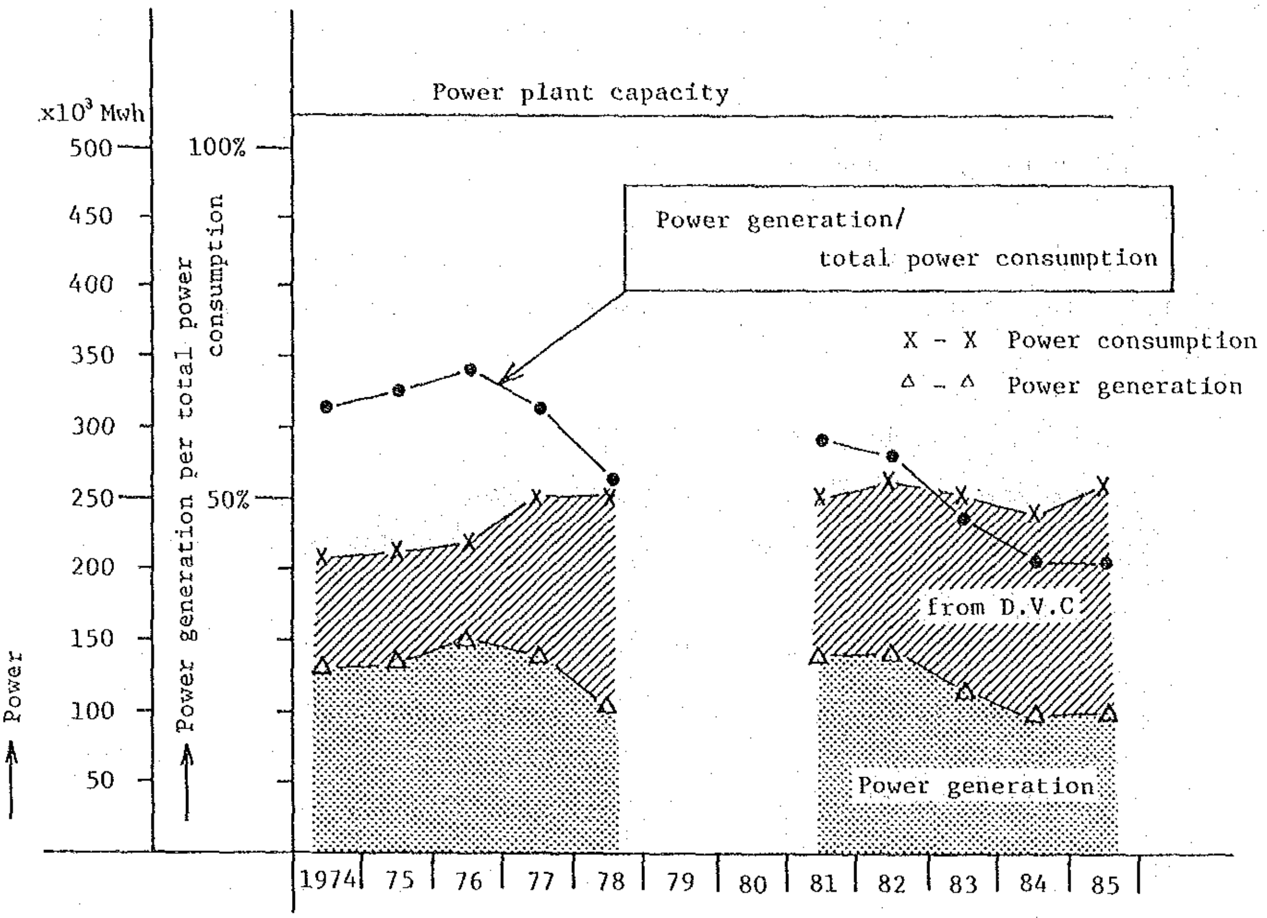


Fig. 5.7.10 Power generation per total power consumption

(2) Increased steam consumption

Steam is used for power generation, blast furnace blower and other facilities of steel plant in general.

As seen from Fig. 5.7.11, what matters with respect to steam are two, namely,

Steam used for others increased and steam supplied to power generation decreased.

Steam generation is small as against boiler capacity.

The matter of increased use of steam for others cannot be analyzed because sufficient data are not available, but leak from piping and leak in plants may be given as one of reasons. In any case it is necessary to improve control.

The decrease in steam generation may be considered to result from decrease in capacity utilization rate and efficiency due to cut of coke oven gas supply and deterioration of the facilities.

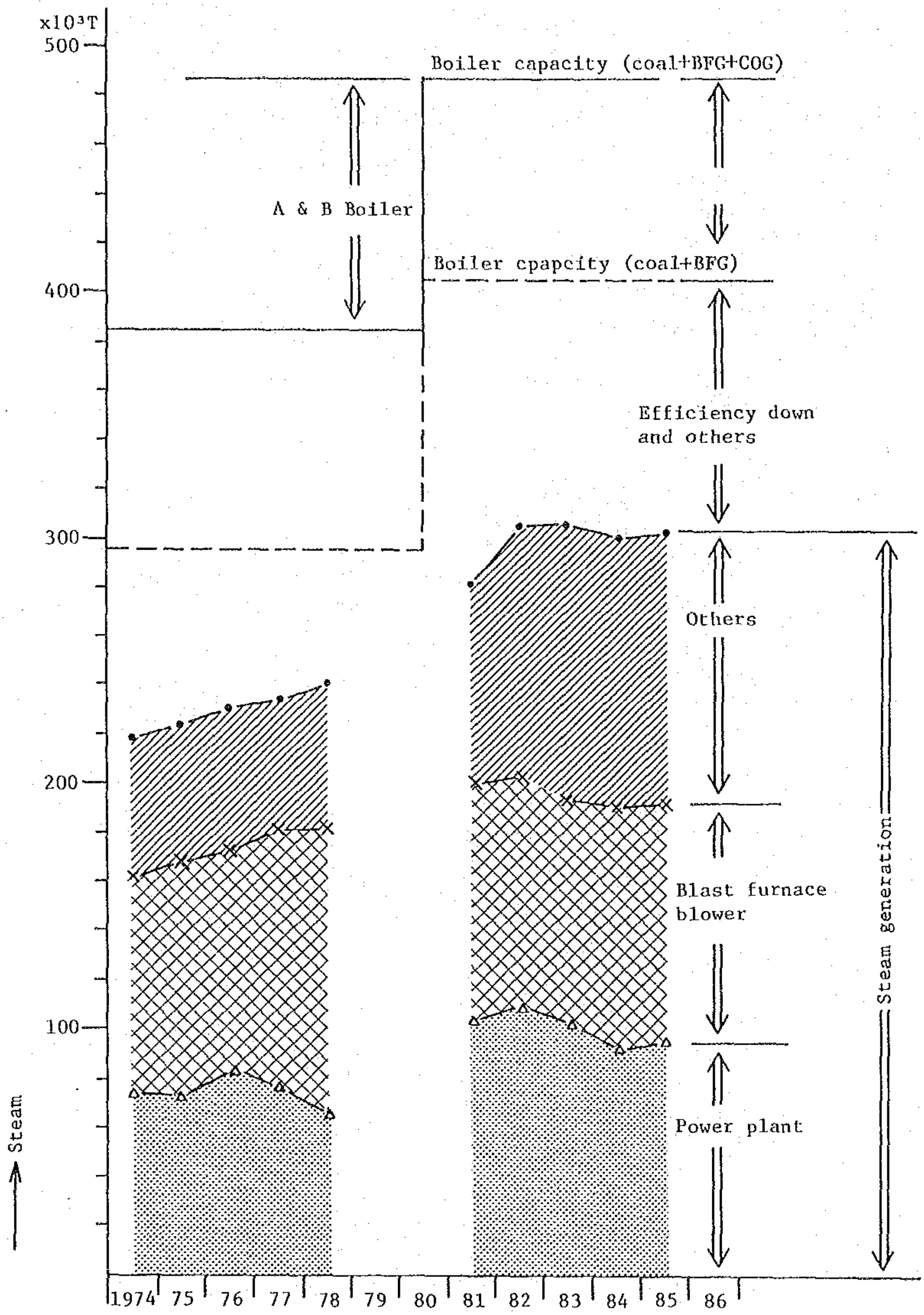


Fig. 5.7.11 Steam consumption

(3) Increased power consumption

As shown in Fig. 5.7.12, unit power consumption, kWh/Ton of ingot, increased by 50 kWh/T since 1979 though no new facilities were put into operation and shows a tendency to rise further.

Under the condition that an increase of power generation by the Works' power plant cannot be expected, increased power consumption will not only result in cost increase but also be a factor to intensify power restriction as more power has to be purchased from the outside. It is necessary to study the matter and take measures.

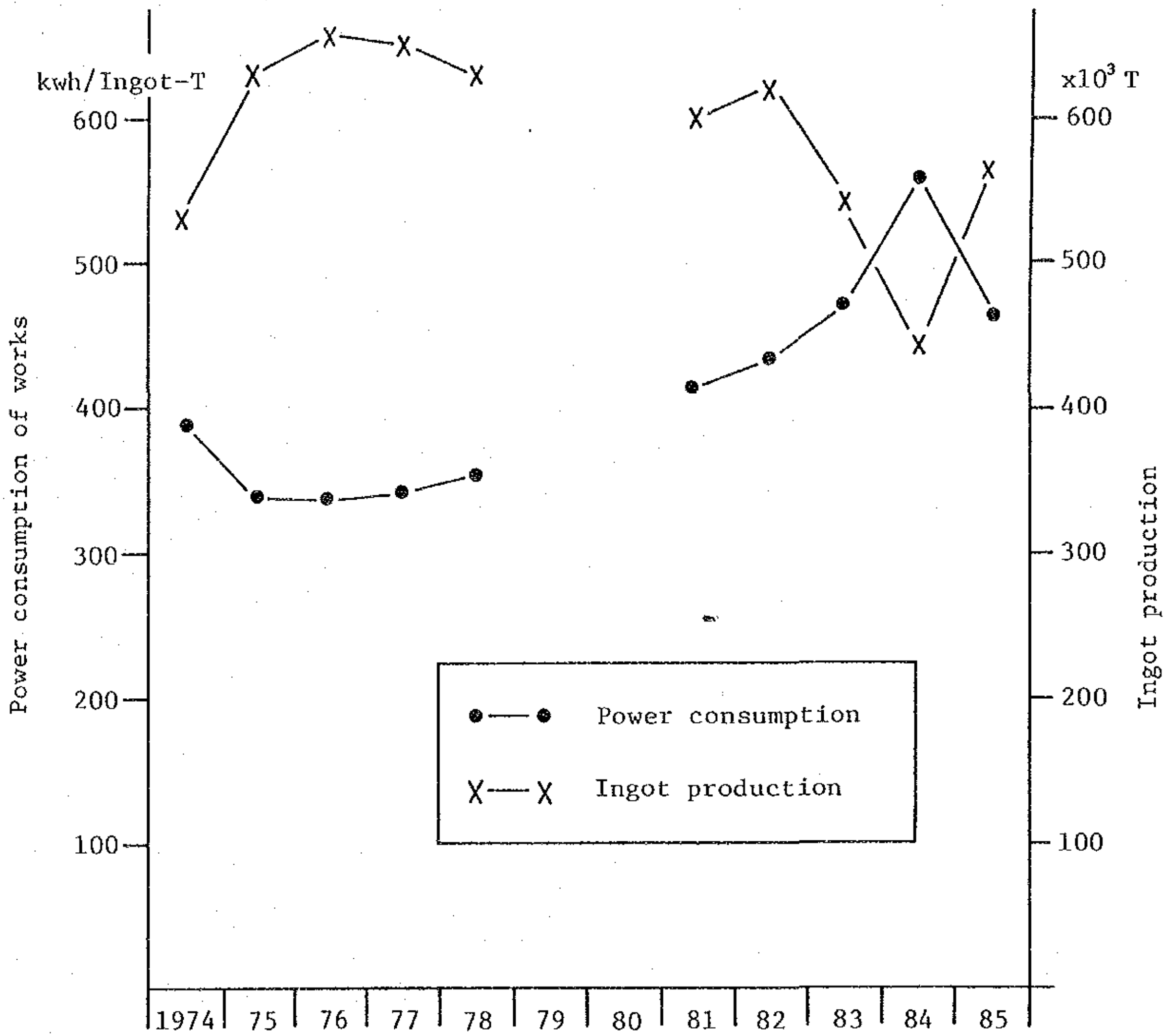


Fig. 5.7.12 Power consumption of works

5-7-3. Utility facilities

(1) Power generation facilities

With respect to the power plant facilities, there are problems such as:

The facilities are old and have an adverse effect on capacity utilization rate and operation efficiency.

Capacity of coal crushers is inadequate.

Quality of coal is low.

Control instruments are deteriorated.

These resulted in decreased steam and power generation.

As shown in Fig. 5.7.13, heat rate of boiler is 1,050 kcal/kg and steam rate of turbine generator 6.18 kg/kWh as against designed rate of 5.45 kg/kWh. Year-to-year change of steam rate of turbine generator is shown in Table 5.7.6.

Table 5.7.6 Steam rate of power plant

	1974	75	76	77	78	1981	82	83	84	85
Steam rate (kg/kwh)	5.50	5.29	5.35	5.55	5.74	5.79	6.10	6.68	7.26	6.18

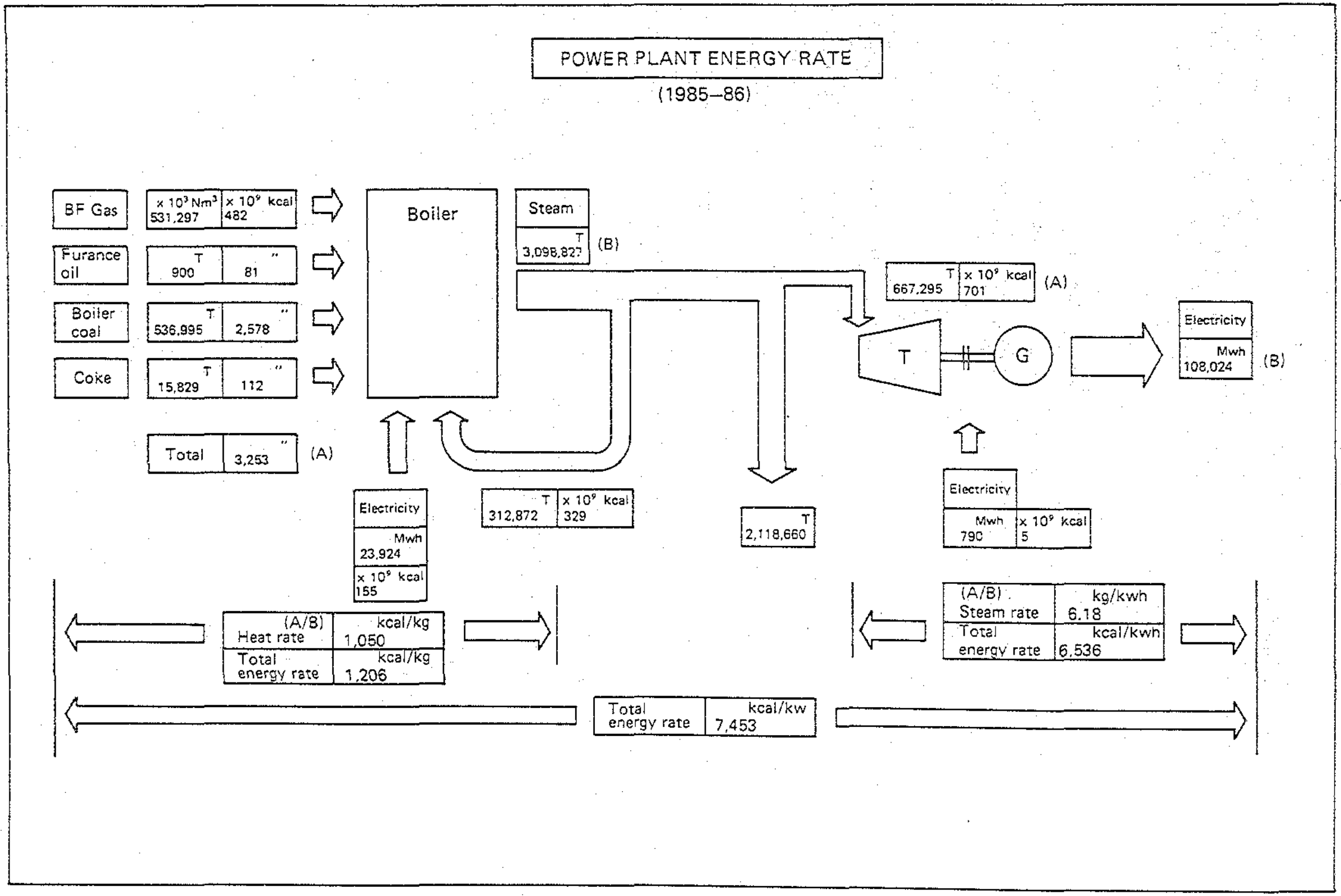


Fig. 5.7.13 Power plant heat rate

(2) Blast furnace blowers

Being old and out-dated and their control instruments being deteriorated, blast furnace blowers are very low in efficiency and their unit consumption of energy is extremely high, making them uneconomical.

(3) Gas supply facilities

Gas supply facilities are well maintained and central data control system is being established. From now on efforts should be made to improve the system so that it can be utilized effectively.

One exception is coke oven gas holder. There are cases when the holder is not used because of trouble in blower. The holder is used for ensuring good energy balance and if it is left in such condition, production activities are certainly further hampered.

(4) Power receiving and distributing facilities

The facilities in general are deteriorated and their short-circuit capacity is inadequate and improvement is necessary.

(5) Water supply facilities

The facilities are deteriorated same as other facilities.

5-8. Maintenance

5-8-1. Maintenance system

(1) Maintenance system at BURNPUR Works is of the centralised type, having the following responsibilities:

Inspection of the machinery and equipment,
Planning routine and scheduled maintenance,
Planning Major/Capital repairs,
Planning and placing order for spares to be made in related shops,
Planning and sending indent for spares to be procured indigenously as well as to be imported,
Assisting inspection dept. for checking of spares,
Take care of house keeping, safety and personnel affairs.

An exception to above is Sheet mill shop where mixed maintenance system is employed, and routine maintenance job is done by Sheet mill shop personnel.

It is difficult to say unreservedly which is better system, centralised maintenance or mixed maintenance. In general, however, many modern integrated steel plants have recently adopted mixed maintenance system.

This is because:

By performing routine inspection, simple repairs and repair of parts that are used repeatedly only in specific plants at each operation department, it becomes possible to utilize its workers more effectively. For example, this can reduce idle time of workers at the operation plants while Maintenance dept. personnel are engaged in scale removal or roll change at the time of shutdown of rolling mill shops.

In addition, the maintenance work by operation depts. induces change in worker's attitude from that operation dept. is responsible only for operation of facilities to that maintenance is very important to ensure production and quality.

(2) Problem in maintenance control activity

There are problems in control activity of maintenance. For example, it cannot be said that preparation of work standards to enable speedy restoration of troubled equipment and other activities such as measures to prevent recurrence of troubles or prolong life of parts by using data collected in routine maintenance work are done well.

5-8-2. Production facilities

Many of production facilities of the Works are very old, rather deteriorated and not competitive.

The following may be cited as main reasons:

Renewal/replacement of the facilities was neglected for many years.
Long-range maintenance plan, namely for modification/alteration/updating of technology and equipment, was not made.

In Japan also there are old facilities in use for more than 20 years, but due to programmed modification/alteration/updating of technology and equipment, they are still working excellently.

Even if a large-scale modernization was carried out, but programmed maintenance as above is not in effect, sooner or later the facilities would be deteriorated and the Works become a steel plant having no competitiveness. A number of examples can be found in the world. Preparation and implementation of maintenance plan is therefore essential and indispensable for IISCO.

5-8-3. Maintenance & repair shops

The present situation of maintenance and repair shops under Maintenance department is as follows:

Machine shops, repair & assembly shops, welding and plate/structural shops, and forging/blacksmith shops are separately located in two areas of Light maintenance area and Heavy maintenance area.

Many of the facilities are old and deteriorated.

Repair & assembly shops are small, dark and building height is low and inconvenient for handling work.

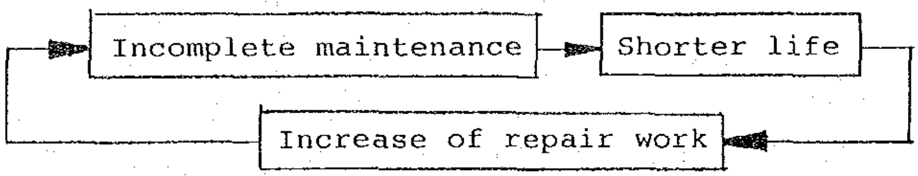
Devices to ensure correct precision seem to be lacking.

Delay of rationalization of forging facilities

There are piles of motors and other equipment waiting repair in Electric repair shop and it is doubtful whether adequate maintenance is being performed.

Shortage of facilities for improvement of durability of parts, for example, equipment and means for hard facing and heat treatment of spare parts

As a result, it seems there occurs a kind of vicious circle as below.



5-8-4. Organization and personnel

As one of characteristics of BURNPUR Works, remarkable vastness of organization and personnel may be cited. Among others, in maintenance department executive class personnel are classified to 9 grades including deputy general manager.

In an organization with such large number of grades, it may be suspected that there is shortcoming such as

Confusion in lines of direction and order,
Obscurity where the responsibility lies, and
As a result, correct instructions and orders are not delivered to lowermost organizations and workers.

5-8-5. Manufacturing and repair work for parts

Another characteristics of the Works is that there are great many work to manufacture/repair various parts within its premises.

The reason may be as follows:

(1) Around BURNPUR City there are a few sub-contractors who engage in manufacture and repair of parts.

(2) These sub-contractors are low in capacity.

(3) As many facilities are old, the number of repairs is inevitably many.

(4) There are many cases where the makers of equipment had stopped production of genuine parts of such old equipment and they have to be manufactured within the Works.

The above reasons (1) and (2) result due to poor location of BURNPUR Works. Therefore it may be said that the modernization cannot slove the problem as many parts manufacture/equipment repair have to be performed within the Works. It is necessary to draw up long-range measures to slove the matter fundamentally in West Bengal State or India as a whole.

5-9. Site location condition

5-9-1. Outline of conditions around the Works

Location condition of BURNPUR area for the modernization of the Works in West Bengal State can be said satisfactory as stated below.

(1) Raw materials and fuel

BURNPUR area is blessed with abundant raw materials and fuel as it sits on coal fields and ore mines are nearby.

(2) Industrial water

Adequate water can be obtained from Damodar River which runs at a distance of 6 km from the town.

(3) Manpower

Not only West Bengal State has a large population (about 54.60 million in 1981) but also there are a number of able workers available who are descendants of employees who worked at the time when No.1 BF was blown-in in 1922.

(4) Transportation

Adjacent to BURNPUR City is ASANSOL City, an important place of transportation in both railways and roads.

Railways: Broad gauge, two-track and electrified railway of Eastern Railway which runs between Delhi and Calcatta and the same type railway of South Eastern Railway which runs Jamshedpur and Rourkela to the south can be used.

Roads: Prime national highway, Grand Trunk Road, which connects Delhi and Calcatta passes close to the Works.

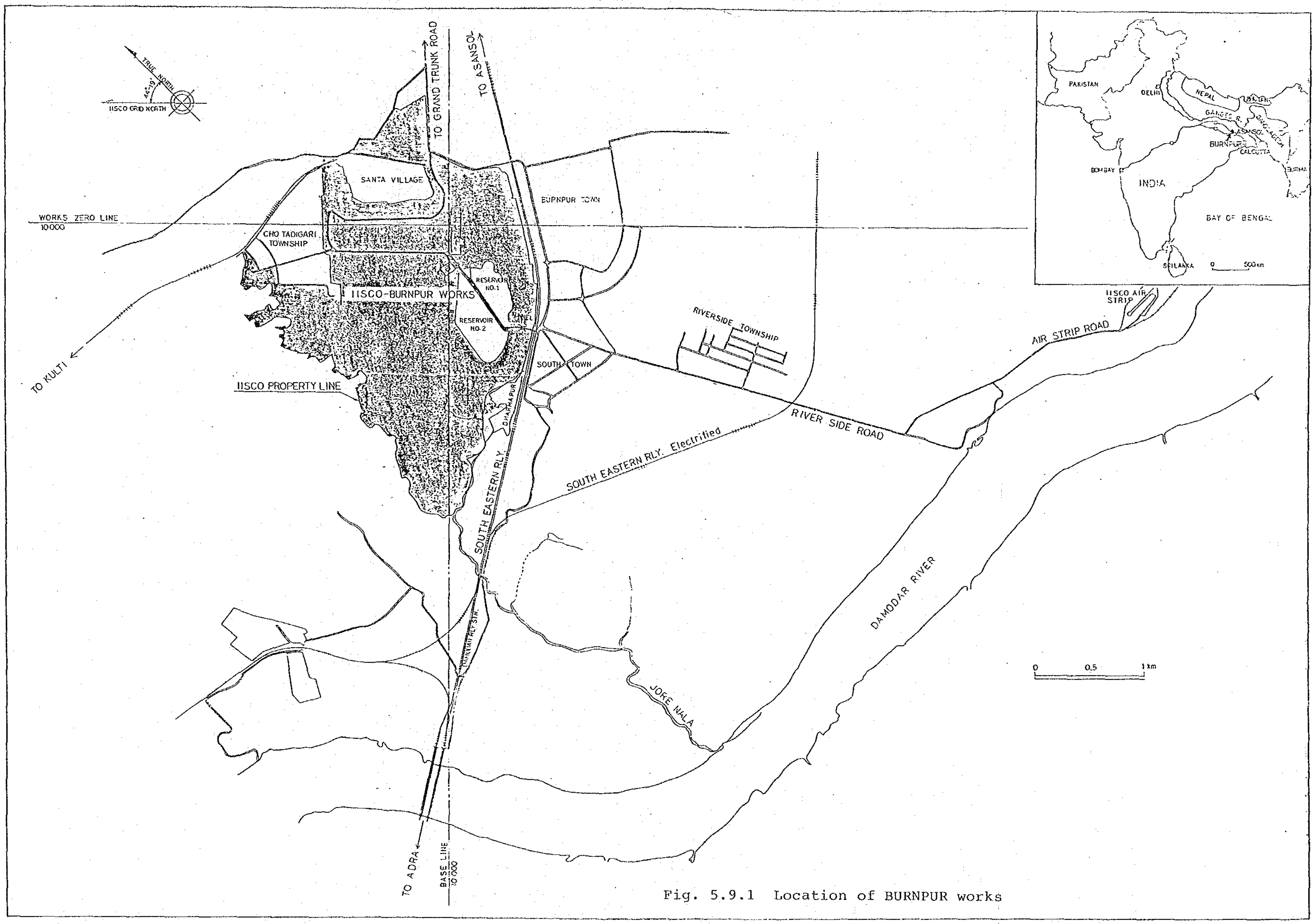


Fig. 5.9.1 Location of BURNPUR works

(5) Supporting industries

Though supporting industries for steel industry are yet a few in India and West Bengal State, KULTI foundries and refractories industries are nearby.

Also Durgapur and Bokaro steel plants, sister plants of the Works, are located in a short distance, which makes it possible to assist and cooperate mutually in technical fields and in material flow and distribution.

However, it is necessary as a matter of course to take into consideration the following as problems of India as a whole.

(1) Electric power

Power supply from D.V.C. is insufficient and unstable.

(2) Markets for rolled steels

Steel markets spread not uniformly over the big country. The existing BURNPUR Works is not located market-oriented. (This means that expectations must be placed on further progress of all industries in India in future.)

5-9-2. Natural conditions

(1) Meteorological condition

Temperature, humidity, rainfall and wind direction at BURNPUR Works in 1985 are shown in Table 5.9.1 and Fig. 5.9.1, but the following two points need attention.

a. Rainfall

The majority of rainfall occurs in the rainy season called "monsoon" from June to October.

Special care is required in reading statistics of rainfall. Namely annual or monthly rainfall figures are useless for planning drainage for instance, and it is necessary to grasp rainfall per hour.

Table 5.9.1 Weather conditions

1985/86	Temperature(°C)		Humidity (%)		Rainfall (m/m)	
	Max.	Min.	Max.	Min.	Max./day	Total/month
85 April	44.5	22	76	27	--	
May	43.5	21	77	58	23.0	53.9
June	43.0	23.5	90	51	28.0	152.8
July	36.0	24	95	72	61.6	298.2
Aug.	36.5	25	95	80	46.0	281.8
Sep.	35	25(24)	95	72	50.4	219.8
Oct.	35.5	18.5	94	69	63.5	115.2
Nov.	32.0	13.0	84	66	3.0	3.0
Dec.	31	12.0	83	59	--	--
86 Jan.	31.5	9.5	88	60	3.0	3.0
Feb.	34	14.5	79	43	--	--
(85 March)	40.5	18	80	37	5.5	5.5

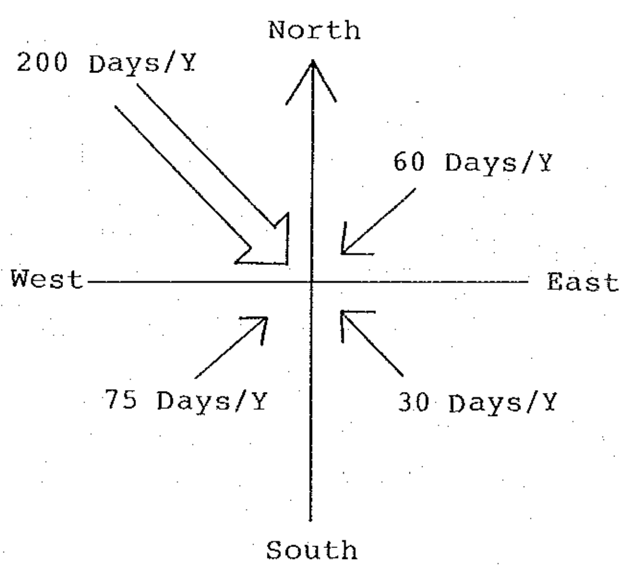


Fig. 5.9.2 Direction of the wind

On the other hand, almost no rain falls in dry season from November to May.

b. Wind velocity

In this regard it is necessary to assume windstorm with velocity of 45-50 m/sec (160-180 km/h) according to the height of structure. Normally it is about 2.5-5 m/sec at most.

(2) Topographical and geological conditions

The Works sits on a plain 110-130 m mean sea level and its site has a shape as shown in Fig. 5.9.1.

Major facilities of the Works are built in the northeast part of the site, occupying area of about 2.6 million square metres.

In the southwest of the site are dump sites for blast furnace slag, open hearth furnace slag, coal waste and ash and refractories waste, occupying area of about 2.2 million square metres. The site was in use as such for more than a half century since the start-up of blast furnaces in 1922 and of open hearth furnaces in 1937 and a geological study should be made thoroughly as well as in advance for utilization of this site.

Also important is confirmation of location and size of unusual waste disposed there and also confirmation of stratum structure and soil characteristics under dumped matters.

(3) Ground water

According to a geological study data, ground water level lies generally in the dumped layer, but its level varies according to different places studied. However, the level is more or less close to the level of the surface of the original ground.

Therefore soil investigation should be made in advance to confirm ground water level also.

Analysis of ground water reveals that it can be used in ordinary Portland cement or similar cement.

(4) Earthquake

According to IS-1893 "Criteria for Earthquake Resistant Design of Structures", the site of BURNPUR Works belongs to Seismic Zone III. "Reference data-Present Status and Modernization of BURNPUR Works" shows the basic horizontal seismic intensity to be 0.06, and it is necessary to consider earthquake load corresponding to this basic seismic intensity in planning facilities.

5-9-3. Existing structures on the site of the Works

On the southwest site of the Works where new facilities are to be constructed, there exist now such facilities as slag granulation plant, slag pit, blast furnace flue dust disposal area, scrap yard, sewage treatment station, railway tracks and others. In order not to impede operation of the existing facilities, measures should be taken to move or remove them prior to land reclamation and construction of the new facilities.

There are also underground structures for plant effluent and rain drainage running between existing plant facilities in the northeast part and JORE NALA River, and special care should be taken in planning land reclamation and facilities construction.

In addition, confirmation of locations where cables for power and instrumentation and piping works are buried may be necessary in some cases.

Chapter 6

Management

Contents

6. Management

As discussed in Chapter 4, the survey team could visit for firsthand study not only BURNPUR Works but also KULTI foundry and both GUA and CHIRIA ore mines, and so it is believed the image of entire IISCO could be grasped fairly correctly.

Based on such overall image of IISCO, the present status of management of BURNPUR Works and related problems will be discussed in this Chapter.

It should be noted here that the definition and actual condition of the term "Control", the basic concept in management, differ among countries and companies. Therefore it is considered desirable to explain the definition of the term "Control" as used by the team in this report first so that common understanding about "control" may be established.

It is widely known among steel men the world over that the Japanese steel industry has been registering an exceptionally steady growth ever since its miraculous revival from the postwar annihilation.

Growth in Japan's crude steel production
(in millions of metric tons)

1950	5.3
1960	23.2
1970	92.4
1980	107.4

Numerous factors lie behind the rapid growth. One of the most important contributing factors is, in our view, the concept of quality control which was introduced from the United States soon after World War II having been infiltrated deep into the business concerns from the management to the rank and file.

To help you grasp a clearer image of the organization and personnel stated in Table 7.1.3 (Chapter 7-1) the general profile of the "Japanized" philosophy of management is briefed below.

It should be noted here that this is just the Japanized management philosophy "tailored to the disposition of Japanese people". In India, SAIL, IISCO and Burnpur Works, therefore, it must be modified to the one that fits the disposition of indian people, SAIL's people, IISCO's people and Burnpur's people.

For this modification, exhaustive effort must be continued on a try-and-error basis.

(1) Basic attitude toward "Control"

Prior to entering the specific consideration, we would like to stress three points concerning our basic attitude towards "control". The last two relate to a problem that can be discussed as the differences in the social climate and national character but involve our basic stance on the problem of control.

1) No royal road to control

Strenuous effort has been directed in Japan in pursuit of new control techniques. "TQC" developed by "Japan Science and Technology Federation" is one of the most famous control techniques. What is herein termed "control" is "to do common things in a common but scrupulous way" and accumulating everyday efforts is the sole shortcut to sucessful contol.

Even in Japan, however, many people still pin their hope to "control techniques" and "TQC" for 'miracle' or 'magic'.

Here, please look at Fig. 6.0.1. Making efficiently products of quality tailored to users' specification by raising the control level reduces the direct manufacturing cost but increases the control cost and does not always cut back the overall cost. The best way of control varies with different countries, companies, works and offices and the direct importation of control techniques from overseas bears less fruit unless they are modified and adapted to the recipient's own disposition. Further, even though the recipient successfully establishes a good way of control, it often goes off an optimum level too soon unless it is adjusted to the changing situation.

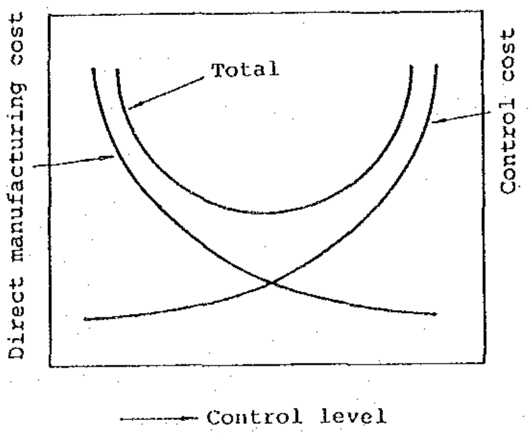


Fig. 6.0.1 Control level vs. cost

To improve control practices, what is needed most is to accumulate everyday efforts since there is no royal road to control.

2) Greater stress on "bottom up" flow

Information and instructions flow in two directions: the one from top to bottom ("top down" flow) and the other from bottom to top ("bottom up" flow). Generally speaking, the "bottom up" flow receives greater weight in Japan in controlling variables compared with the United States and European countries. This is because (1) operators and young engineers in Japan was very positive for the improvement of operational practices and (2) the rank and file on the front have the deepest knowledge of what is going on shop work or desk work.

In Japan, the management staff tries to make decisions in conformity with the actual conditions by hearing their subordinates attentively, a practive that has borne fruit under various situations.

3) Emphasis on training

Industrial training consists of on-the-job training and off-the-job training, each being promoted vigorously in Japan. The reason for this is explained in various ways but one thing certain is that it is economically beneficial. Without industrial training, it would be impossible to attain a high level of operational achievements.

Such an industrial training must be a real one wherein the expertise, experience and know-how of superiors are unreservedly transferred to their subordinates.

(2) Control Categories and Steps

1) Classification by control range

For an integrated steelworks where manufacturing processes are complicated and involve many people, it is a very difficult problem what steps are to be taken to raise the control level. A close observation of Fig. 6.0.2 will reseal that control practices can be classified into four categories.

a) Control of individual units of equipment
This is to control individual equipments that comprise each process, e.g. reheating furnace.

b) Control of individual processes
This is to control individual processes, such as ironmaking, steelmaking and hot rolling, that comprise the integrated iron- and steelmaking process.

c) Integrated control over individual functions
This is to control in an integrated manner individual functions such as production control and quality control.

d) Integrated technical control
This involves a works-wide integrated control of variables such as overall production costs. The scope of control spreads out and the nature of control becomes sophisticated in the descending order from a) to d).

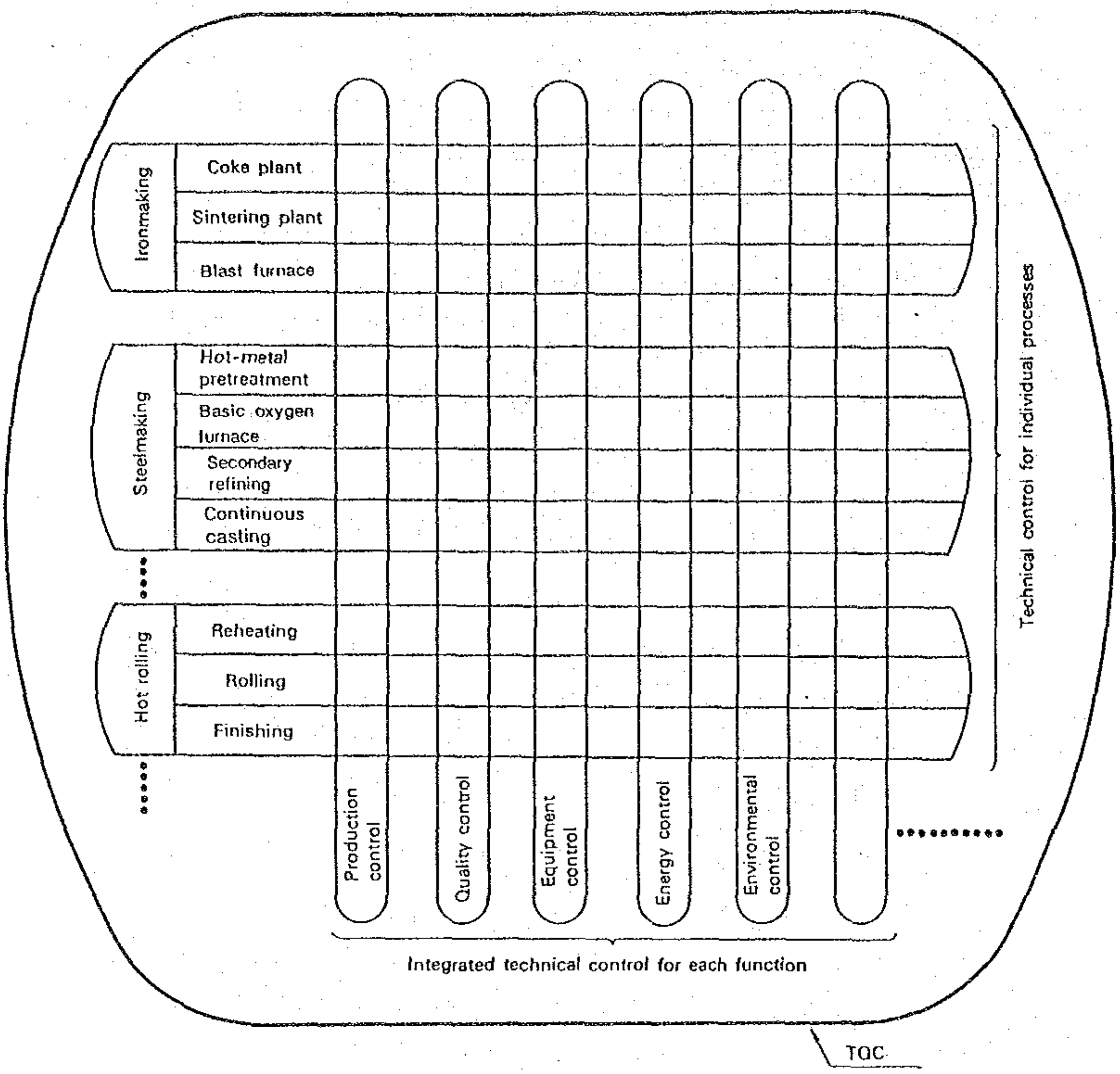


Fig. 6.0.2 Classification of technical control elements

2) Responsibilities and results

The ultimate purpose of "control" is to improve operating efficiency. Though qualitative, the relationship between responsibilities and results is illustrated in Fig. 6.0.3 for each control category. The relative importance of the duty and responsibility of each control level is indicated by area in this figure. As the sophisticatedness of control increases, upper-level managers assume greater responsibilities.

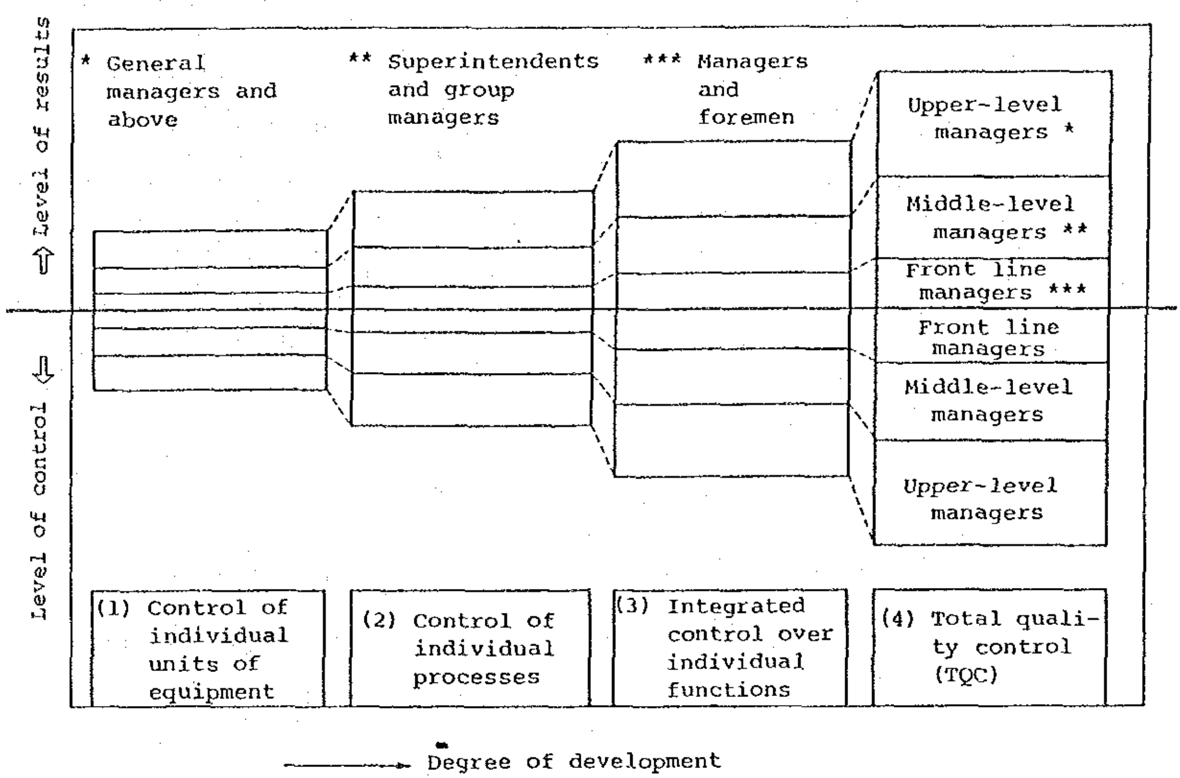


Fig. 6.0.3 Responsibilities for control and results

(3) Fundamentals of Control

1) "P-D-C-A Circle" as a basic philosophy

The most important basic philosophy of control is to rotate the "Circle of Control" shown in Fig. 6.0.4.

By securely rotating the circle for all variables that need to be controlled, it is possible to control them with imporved accuracies and thereby improve the disposition of a steelworks as a whole as shown below.

Event-based disposition	→	Plan-based disposition
Only after a problem arises, both management and employees hasten to patch things up for the moment.		By attaching great importance to planning, it is possible to forestall the occurrence of problems.

If a steelworks is reoriented to a plan based one, the operating policy of the top management can be infiltrated into employees working in the forefront, thereby making it possible for all people in the steelworks to reach a consensus about the problem they face.

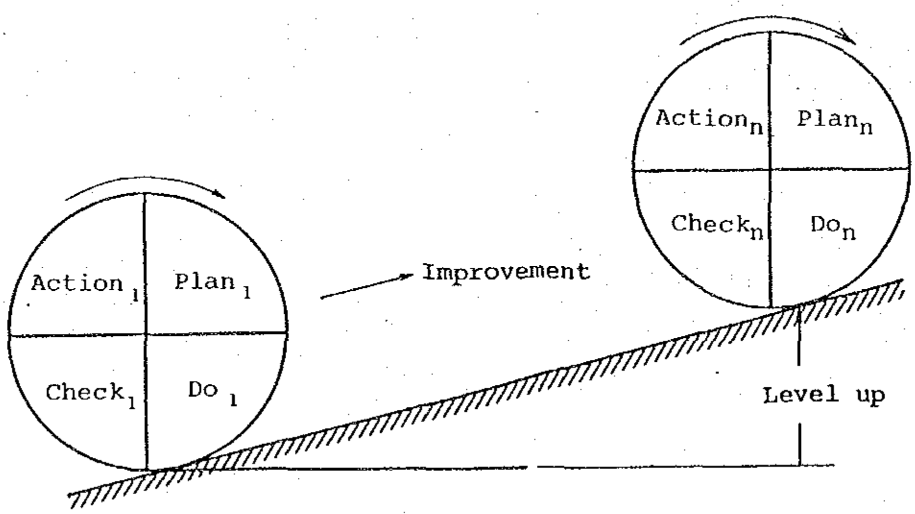


Fig. 6.0.4 Circle of control

Scrupulously rotating the P-D-C-A circle, though seemingly an easy task, is very difficult and requires exhaustive efforts especially for a steelworks where many people and processes are involved. Senior managers, in particular, need to recognize and come to grips with this in a tenacious manner.

2) Key points

The key points needed in rotating the P-D-C-a circle are discussed hereunder.

a) Spiral-up

A slow but steady pace must be sought until the custom of securely rotating the P-D-C-A circle is firmly established in the workshop. Seeking perfection from the outset may cause a pause halfway. We recommend what we call "Spiral Up" wherein the first cycle is rotated while neglecting imperfections to some degree, and faults, if any, are corrected from the second cycle onwards.

b) 5Ws and 1H

A number of people of various job classes are usually involved in a task, To fulfill the task without any fault, it is important to pre-arrange "5Ws and 1H" - What, Why, When, Who, Where and How. Especially "who", that is, the person responsible, must be clarified in advance.

c) Check & action

It is to be especially noted here that the P-d-C-A circle often gets into malfunction because of only an instruction being given without subsequent checkup and action steps. The blame rests with senior managers.

It is also to be noted that when checking the result of a thing done, the way or manner in which the thing has been done should also be checked and the way or manner must be corrected if necessary based on the result checked, rather than checking the result alone. Another consideration of similar importance is to pre-schedule the frequency of checkup, reckless checkup of numerous items is only timeconsuming. A priority-based check-up frequency must be worked out.

d) Data-based study and discussion - "Fact Control"

A qualitative discussion without quantitative data or with raw data yet to be analyzed must be avoided. Data acquisition and processing may sometimes require a large sum of expenditure but if the data is of crucial importance such an expenditure must not be saved.

e) Large P-D-C-A and small P-D-C-A

If a problem to be solved is of major importance, it is divided into small elements. A long period of time is often taken to solve problems in some cases because of sticking to the small circle alone without giving due attention to the major problem and in other because of problem-solving activities being not well timed among individual participants involved.

As the scope of control and the sophisticatedness of problem increase, greater attention must be given to this point.

3) Approach to total participation

A thorough control requires concerted cooperation of all parties concerned. To meet this requirement, use must be made of various approaches. A few approaches most commonly used in Japan are shown below. These may not be new, but implementing them efficiently and periodically over a long period of time requires considerable effort.

a) Meeting

Meetings are indispensable to rotate the P-D-C-A circle. Daily, weekly and monthly meetings are to be held and steered efficiently with membership and frequency adjusted to the control item involved. Such meetings sometimes offer a forum of OJT (on-the-job training) but separately providing a training course may be workwhile if situation requires to do so.

b) Notice

For important control items, a control chart (this is a very important information to give employees a clearcut image of the change with time in each control item) is displayed in each workshop and meeting room to inform all persons involved of the results thus far achieved and thereby arouse their interest. The way of such notification is improved from time to time as necessary.

c) "Campaign"

If it becomes necessary to rotate the P-D-C-A circle for a limited period to solve an improtant problem, all-out effort must be concentrated recongnizing the problem as the one relevant to all workshops concerned. In such instances, a leader is selected to take initiative of the group activities and other special approaches are tried, including giving the group activities a nickname "MEHTA-PROJECT", for example, drafting and displaying slogans together with control charts and holding a special meeting the top management attends.

d) Incentive

It is also important to grant some incentive in the form of commendation or others to those groups and individuals who have produced excellent results.