Iron and Steel Industry in India

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IN THIS short review, it is not proposed to discuss the production of iron and steel in ancient India—the subject has been well covered in many excellent papers such as by Mr. S. K. Nanavati in his Presidential address before the Annual General Meeting of the Indian Institute of Metals (1958). In different hills and jungles, the Adibasis are still extracting iron in a very crude form. However, with the establishment of iron and steel industry along modern lines, the decline of such village industry has been very rapid. The general pattern of iron and steel industry in India has undergone considerable changes under the planning and development that have taken place during the Second Five Year Plan. By the completion of the Second Five Year Plan, the ingot steel capacity is expected to increase to six million tons per annum and this is likely to be stepped up to sixteen million tons per annum by the end of the Third Five Year Plan. It is well known that India possesses immense reserves of high grade iron ores (more than twenty thousand million tons). Although India possesses huge reserves of coal estimated at about forty thousand million tons down to a depth of two thousand feet, only a small fraction of it—hardly about fifteen hundred million tons—can be classed as good metallurgical coal from which coke for blast furnace high grade can be produced. A concentrated drive for the conservation of metallurgical coal is therefore an imperious necessity. The use of good coking coals in railway locomotives, steam-raising boilers, etc., is wasteful and must be urgently checked. New locomotives are therefore being designed to operate on lower grades of coals. Electrification of the railways is being contemplated which should further reduce the demand for metallurgical coal. It is expected that as a result of changes in the design of locomotive boilers, the railways which use about 4·7 million tons of coking coal annually, will use progressively more non-coking coals releasing large tonnages of coking coal for metallurgical use. The recent policy of export of high grade metallurgical coal has also to be rationally examined.

The location of the new steel plants at Bhilai, Rourkela and Durgapur is indicated in the attached map (Fig. 1) along with locations of essential raw materials. The production during recent years of finished steel in India is given in Fig. No. 2. World's crude steel production figures are given in Table I.

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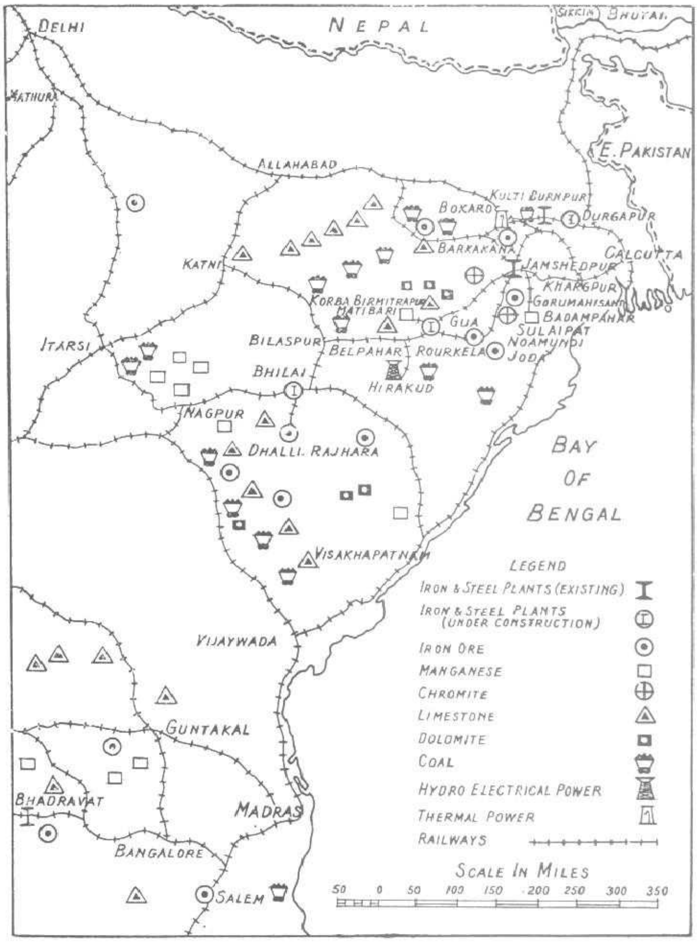


Fig. 1.

Present position in India

During the Second Five Year Plan, three new State steel plants are being set up in the public sector with a capacity of one million tons of ingots each. One is the Rourkela plant whose special features are the adoption of the L-D oxygen steel-making process and production of 720,000 tons of flat products of steel, hot and cold rolled. The second plant located at Bhilai in Madhya Pradesh provides for 770,000 tons of saleable steel, heavy and medium products, including 140,000 tons of billets for the re-rolling industries. The third plant being set up at Durgapur in West Bengal will be equipped to produce 790,000 tons of light and medium section of steel and billets. Apart from this impressive programme of expansion in the public sector, the existing public sector plant at Bhadravati will have its capacity of steel production raised to 100,000 tons by the end of the Second Plan period. In the private sector, the Tata Iron and Steel Company and the Indian Iron and Steel Company will increase their combined capacities to over double the level at the beginning of the Second Five-Year Plan. Notably, the Tata Iron and Steel Company

TABLE I

World crude-steel production in 1939 to 1955 (in thousands of tons)

Country	1939	1953	1954	1955
Africa				
Algeria	—	12*	12*	12*
S. Rhodesia	5*	25	33	40*
S. Africa	390*	1,298	1,431	1,581
Total	395*	1,335	1,476*	1,633*
Middle East				
Egypt	—	10*	10*	10*
Israel	—	—	5*	40*
Total	—	10	15*	50
Far East				
China				
Mainland (*a*)	545	1,767	2,225	2,850
Taiwan (*b*)	—	28	47	55*
India	1,067	1,531	1,712	1,731
Japan	6,696	7,662	7,750	9,408
Pakistan	—	11	10	11
Phillippines	—	—	10*	20*
Others	101 (*c*)	—	—	—
Total	8,409	10,000	11,754*	14,075*
Oceania				
Australia	1,191	2,082	2,257	2,232
Total	1,191	2,082	2,257	2,232
Latin America				
Argentina	20	100*	100*	100*
Brazil	114	1,002	1,157	1,166
Chile	—*	313	321	310
Columbia	—*	—	20*	76
Mexico	77	430	535*	575*
Peru	—*	—	—	—
Venezuela	—*	15	15*	15*
Total	211*	1,860	2,148	2,242*
North America				
United States	47,898	101,251	80,115	106,173
Canada	1,407	3,734	2,898	4,109
Total	49,305	104,985	83,013	110,282
U.S.S.R.	17,600	38,000	41,300	45,200
Europe (*Western*)				
ECSC countries	36,054*	39,633	43,838	52,578
United Kingdom	13,433	17,891	18,817	20,108
Others	2,943	5,285	6,091	6,976
Europe (*Eastern*)	6,522*	12,466	12,742	13,882
Total	58,952	75,275	81,488	93,544
World Total (*d*)	136,063	234,546	223,451	269,258

(*a*) Including Manchuria.
(*b*) Economic Survey of Asia and the Far East, ECAFE, Bangkok, 1955, page 214.
(*c*) Korea.
(*d*) Excluding North Korea in post-war years and Bulgaria which began production on a small scale in 1953.
* Estimated.

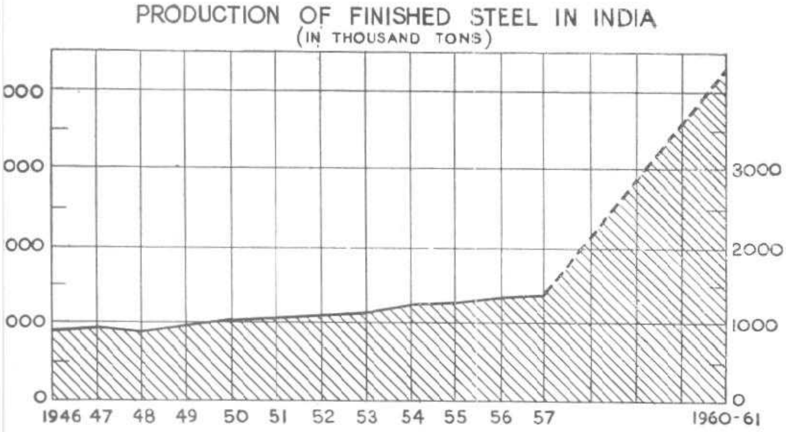


Fig. 2.

have practically completed their two million tons ingot steel expansion programme in a short period. When all the expansion programmes are completed, India's annual ingot steel production should stand at 6 million tons by the end of Second Five Year Plan.

The statement showing the proposed distribution of steel production capacity among various producers is given in Table II.

Some of the figures for Indian steel industry are summarized below along with some production figures.

Steel target

Expansion of		(Saleable Steel) Existing production (million tons)	Target 1960-61 (million tons)	
TISCO	...	0·78–0·80	1·5	
IISCO	...	0·33	0·80	
Mysore Iron and Steel Works	...	0·03	0·10	
New plants				Cost Rs.
Rourkela	...	—	0·72	170 crores
Bhilai	...	—	0·77	132 ,,
Durgapur	...	—	0·79	138 ,,
Total	...	1·14	4·68	439 ,,

Progress in public sector plants

ROURKELA

1. New mine is being developed at Barsua 45 miles from the site for supplying iron ore.
2. Coal will be drawn from Kargali-Bokaro and Jharia fields. A coal washery has already been constructed at Karagali.
3. Limestone from Birmitrapur/Hathibari area, 25 miles from the site.

BHILAI

1. First blast furnace to operate by early 1959.
2. New mine under development at Rajharapahar, 60 miles from site.
3. Coal from Kargali-Bokaro coal washery.
4. Limestone from Nandini, 12 miles away from the site.

DURGAPUR

1. Iron ore mine in Bolani in the Gua region.
2. First Blast Furnace to be commissioned by October, 1959.
3. Metallurgical coal of Jharia will be blended with high-volatile semi-coking coal of Barakar coal washery at Jharia.
4. Limestone from Birmitrapur/Hathibari area.

Items of production

NEW PLANTS

Rourkela : Flat products like plate, sheets, tin plate etc.
Bhilai : Rails and heavier range of sections.
Durgapur : Lighter sections, wheel tyre and axle.

Private Sector expansion programme

Mysore Iron and Steel Works : Spun pipe plant already under trial; sintering plant from Germany to be installed by early 1959; ferro-silicon plant from Norway to be installed.

TISCO : (Ferro-manganese plant, refractories plant, plant for recovery of scrap from slag by Heckett process). Ferrous-sulphate washing plant (Collin's plant).

Ferro-manganese production

Target of 160,000 tons per annum.
License already issued to 7 parties for 123,000 tons.
License for additional 54,000 tons per annum to 2 more parties to be issued shortly

Pig Iron and steel

Year	Saleable pig iron (m. tons)	Saleable steel (m. tons)	Available steel (m. tons)	Scrap export (m. tons)
1955	—	1·26	—	—
1956	0·352	1·337	(1·61 import) 1·33 Production	0·173 (license issued 0·098 (actual export) 0·185 (license issued)
1957	0·383	1·344	2·88	
1958	0·320	1·45	(1·344 production) (1·54 import)	—
1959	1·25	1·80	—	—

Table II

Statement showing proposed distribution of steel production capacity among various producers *('000 tons)*

Serial No.	Categories	Demand	TISCO Existing	TISCO Expansion	IISCO Existing	IISCO Expansion	Mysore	Rourkela Existing	Rourkela Expansion	Bhilai	Re-rollers Existing	Re-rollers Expansion	Total	Balance Ex. Def.	British	Balance Ex. Def.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	Heavy rails and fishplates	265 } −750	100	35	60	40	...	...	...	100	...	...	335	+70 } −85	15 (Fish plates)	+85 } +10
2.	Heavy structurals	485	80	30	90	20	10	...	...	100	...	...	330	−155	80	−75
3.	Broad and parallel flanged (beams) ...	75	...	...	...	40	...	...	...	75	...	...	115	+40	...	+40
4.	Crossing sleepers	30	3	27	...	...	...	...	...	30	...	...	60	+30	...	+30
5.	Sleeper bars	170*	30	20	...	...	...	...	...	60	...	...	110	60	60	...
6.	Medium and light structurals	510	76	221	80	40	10	...	...	...	10	...	437	−73	138	+65
7.	Deformed and pre-stressed concrete bars ...	30	...	...	...	...	10	...	...	...	...	...	10	−20	30	+10
8.	Rounds and flats ½" and above	780 }	89	55	...	160	38	...	...	245	420	...	1,007	−133	140	+7
9.	Rounds and flats ½" and below	360 }														
10.	Spring steel	30	4	...	...	...	2	...	...	...	9	3	18	−12	12	...
11.	Wheels, tyres and axles	70	25	6	...	...	...	...	...	...	...	...	30	−40	40	...
12.	Tinplates	150	...	...	...	...	...	...	...	...	80	20	100	−50	...	−50
13.	Plates 3/16" and above	300	100	...	...	...	...	100	100	...	...	...	300	...	...	...
14.	Wire and wire products	100	...	...	...	...	5	...	...	...	40	55	100	...	...	...
15.	Wire ropes	5	...	...	...	...	...	...	...	...	...	5	5	...	...	...
16.	Tool and alloy steel	10	...	...	...	...	2	...	...	...	1	1	4	−6	...	−6
17.	Stainless steel	15	...	...	...	...	15	...	...	...	...	...	15	...	...	...
18.	Hoops and box strapping	60	...	...	...	...	8	...	...	...	15	22	45	−15	...	−15
19.	Blooms and billets for forging	100	22	...	10	...	...	...	...	...	...	...	32	−68	95	+27
20.	Sheets and strips (hot rolled)	650	150	...	110	10	...	190	190	...	...	...	650	...	...	...
21.	Strips up to 12"	60	...	42	...	...	...	20	20	...	...	...	82	+22	...	+22
22.	Strips over 12"	145	...	...	...	...	...	50	50	...	...	...	100	−45	...	−45
23	Skelp (for tubes and pipes)	100	72	34	...	...	...	...	...	...	...	...	106	+6	...	+6
	Total finished steel	4,500	750	470	350	310	100	360	360	610	575	106	3,991		610	
24.	Semis for re-rollers	700	181	99		140	...	...	...	140		28†	588		140	28‡

* Since sleepers could be produced from both steel and pig iron, the demand for steel sleeper bars would increase or decrease according to the conditions of availability of pig iron and steel.

† Production from scrap.

‡ Exclusive of the ordnance factories production estimated at 50,000 tons

Coal

Year	Total raising	Total despatches	Export
1956	39·4 m tons	34·9 m tons	1·73 m tons
1957	43·5 ,,	47·7 ,,	1·75 ,,

1960-61: Demand 60 million tons. Additional 22 million tons (12 million tons public sector and 10 million tons private sector).

A Government coal washery at Kargali/Bokaro to wash 2·2 million tons of raw coal to give 1·6 million tons of clean coal (1·1 million tons to Rourkela and 0·5 million tons to Bhilai steel plants).

The basic structure of the iron and steel industry in India as it stood in the early part of Second Five Year Plan is depicted in Fig. 3.

Raw materials

DETAILED RESERVES OF INDIAN IRON ORES (in million tons)

I Hematite ores

	Proved and indicated	Possible	Fe %
Bihar and Orissa			
Singhbhum ...	1,047		62–65
Keonjhar ...	988		63–68
Bonai ...	648		63–68
Mayurbhanj ...	60		64–67
Total ...	2,743	8,000	
Central Provinces (M.P.)			
Chanda ...	22		63–68
Dhalli-Rajhara ...	114		66–69
Bailadila ...	610	3,600	68–69
Rowghat ...	740		59–66
Jubbulpore ...	100		46–61
Total ...	1,586	7,000	
Bombay			
Dharwar ...	10		45–60
Ratnagiri ...	5		
Goa ...	15		61–62
Total ...	30	300	
Hyderabad ...	37		20–60
Kashmir ...	5		
Madras			
Bellary (Sandur) ...	130	300	57–68
Kurnool ...	4		50–65
Mysore ...	764	2,000	50–65
United Provinces (U.P.)	10		40–65
Rajasthan ...	5		59–60
Patiala ...	2	30	57–58
Total Hematite ores ...	5,316	17,630	

II Magnetite ores

	Proved and indicated	Possible	Fe %
Madras			
Salem-Trichinopoly ...	305	1,000	34–44
Guntur ...	20	50	
Mysore ...	215	500	55–61
Bihar-Orissa ...	5		65–68
Himachal Pradesh ...	60	60	48–64
Total Magnetite ores ...	605	1,610	

III Limonitic and spathic ores

	Proved and indicated	Possible	Fe %
Bengal ...	500	2,000	39–47

Summary

I. Hematite Ores ...	5,316	17,630
II. Magnetite Ores ...	605	1,610
III. Limonitic Ores ...	500	2,000
Grand Total ...	6,421	21,240

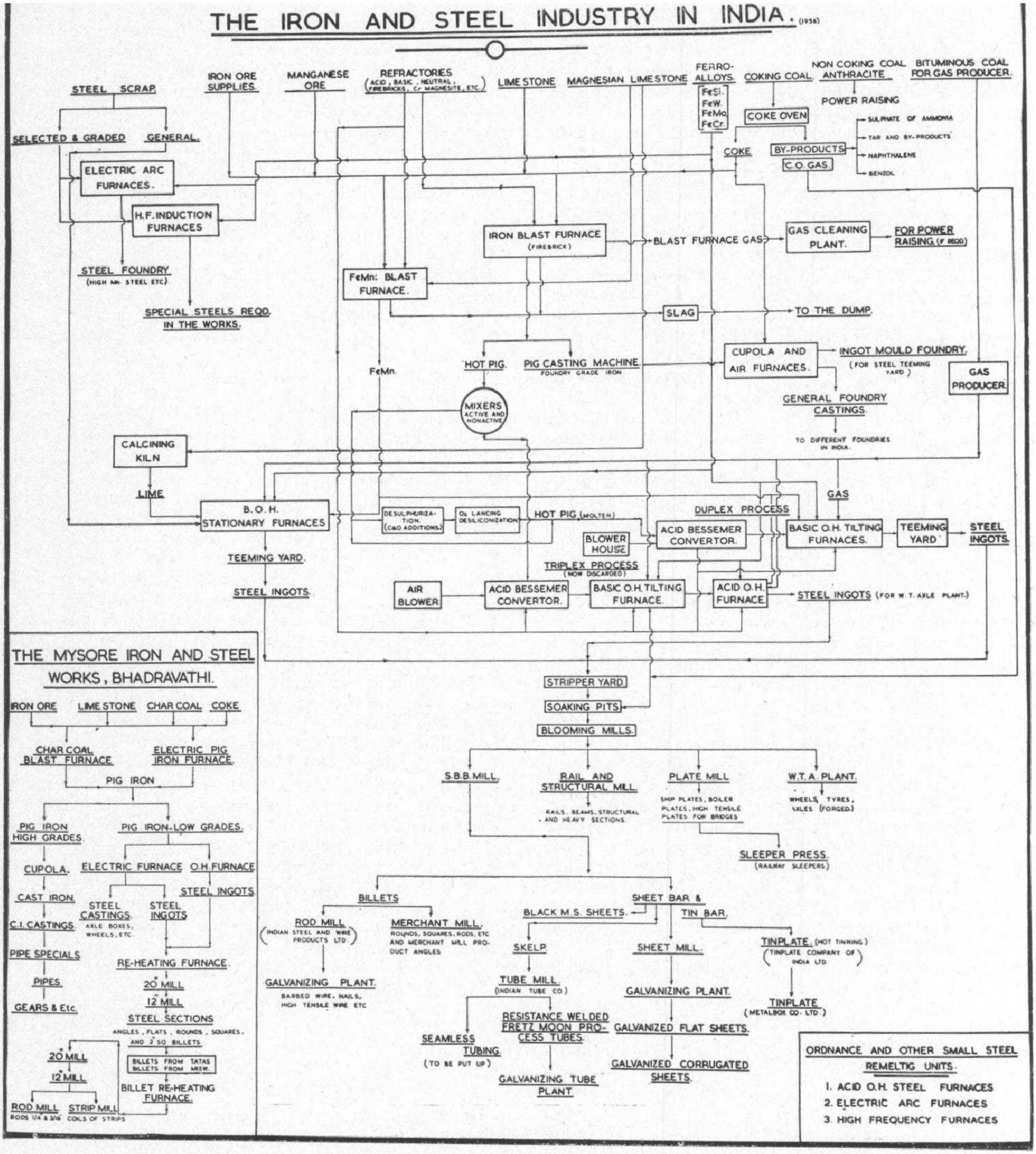
India has rich iron ore deposits in many parts of the country. The deposits containing 55% and more iron ore are concentrated in Bihar, Orissa, Andhra, Mysore, and Hyderabad. The estimated reserves of these high grade ore are estimated at about 13,000,000,000 tons. The grading of ore and the exact estimation of our deposits have not yet been fully completed. Indian iron ore apart from having 55% to 65% Fe also contains about 3 to 4% SiO_2 and 3 to 4% Al_2O_3. The high content of Al_2O_3 in the ore makes it a little difficult to have an efficient blast furnace practice because the slag becomes very viscous and this means that the furnace temperature will have to be high and there will be more Si in the pig iron due to SiO_2 being reduced by carbon to Si. To reduce this difficulty a couple of the mines have washeries installed to wash the Al_2O_3 down to 1·8 to 2%, but in so doing, the SiO_2 is also reduced to about 1·5%, which means that the ratio of Al_2O_3 to SiO_2 is unaffected.

Table III shows exact figures of Fe, Al_2O_3 and SiO_2 in the ore. The mines referred to are those situated in Bihar and belong to the Tata Iron and Steel Co., Limited.

TABLE III

	Fe P.C.	SiO_2 P.C.	Al_2O_3 P.C.
Gorumahisani	61·15	4·16	3·11
Badampahar	57·04	6·46	4·22
Noamundi I (unwashed)	59·50	3·00	6·70
Noamundi (washed) ...	62·75	1.62	5·40
Noamundi II (hard ore) and Sulaipat	66·80	1·11	1·89

Although flux is an important blast furnace raw material, the required quality is not easily available near India's steel centres. In view of high ash



THE IRON AND STEEL INDUSTRY IN INDIA. (1956)
STEEL SCRAP.
IRON ORE SUPPLIES.
MANGANESE ORE
REFRACTORIES (ACID, BASIC, NEUTRAL, FIREBRICKS, Cr. MAGNESITE, ETC.)
LIME STONE
MAGNESIAN LIMESTONE
FERRO-ALLOYS.
FeSi. FeW. FeMo. FeCr.
COKING COAL.
NON COKING COAL ANTHRACITE
BITUMINOUS COAL FOR GAS PRODUCER.
POWER RAISING
COKE OVEN
SULPHATE OF AMMONIA
TAR AND BY-PRODUCTS
NAPHTHALENE
BENZOL
COKE
BY-PRODUCTS
C.O. GAS.
SELECTED & GRADED
GENERAL.
ELECTRIC ARC FURNACES.
H.F. INDUCTION FURNACES
STEEL FOUNDRY (HIGH Mn. STEEL ETC)
SPECIAL STEELS REQD. IN THE WORKS.
IRON BLAST FURNACE (FIREBRICK)
BLAST FURNACE GAS
GAS CLEANING PLANT.
FOR POWER RAISING. (IF REQD)
FeMn: BLAST FURNACE.
SLAG
TO THE DUMP.
FeMn.
HOT PIG.
PIG CASTING MACHINE. FOUNDRY GRADE IRON
CUPOLA AND AIR FURNACES.
INGOT MOULD FOUNDRY. (FOR STEEL TEEMING YARD)
GENERAL FOUNDRY CASTINGS.
TO DIFFERENT FOUNDRIES IN INDIA.
GAS PRODUCER.
MIXERS ACTIVE AND NONACTIVE
CALCINING KILN
LIME
B.O.H. STATIONARY FURNACES
DESULPHURIZATION. (CaO ADDITIONS)
O2 LANCING DESILICONIZATION
HOT PIG (MOLTEN)
DUPLEX PROCESS
GAS
BLOWER HOUSE
ACID BESSEMER CONVERTOR.
BASIC O.H. TILTING FURNACES.
TEEMING YARD
STEEL INGOTS.
TEEMING YARD.
STEEL INGOTS.
TRIPLEX PROCESS (NOW DISCARDED)
AIR BLOWER
ACID BESSEMER CONVERTOR.
BASIC O.H. TILTING FURNACE.
ACID O.H. FURNACE.
STEEL INGOTS (FOR W.T. AXLE PLANT.)
STRIPPER YARD.
SOAKING PITS
BLOOMING MILLS.
S.B.B. MILL.
RAIL AND STRUCTURAL MILL.
RAILS, BEAMS, STRUCTURAL AND HEAVY SECTIONS
PLATE MILL
SHIP PLATES, BOILER PLATES, HIGH TENSILE PLATES FOR BRIDGES
W.T.A. PLANT.
WHEELS, TYRES, AXLES (FORGED)
SLEEPER PRESS. (RAILWAY SLEEPERS)
BILLETS
SHEET BAR & TIN BAR.
BLACK M.S. SHEETS.
ROD MILL (INDIAN STEEL AND WIRE PRODUCTS LTD.)
MERCHANT MILL. ROUNDS, SQUARES, RODS, ETC AND MERCHANT MILL PRODUCT ANGLES
SKELP
SHEET MILL.
TINPLATE. (HOT TINNING) (TINPLATE COMPANY OF INDIA LTD.)
GALVANIZING PLANT. BARBED WIRE, NAILS, HIGH TENSILE WIRE ETC
TUBE MILL. (INDIAN TUBE CO.)
GALVANIZING PLANT.
TINPLATE (METALBOX CO. LTD.)
SEAMLESS TUBING. (TO BE PUT UP)
RESISTANCE WELDED FRETZ MOON PROCESS TUBES.
GALVANIZED FLAT SHEETS.
GALVANIZED CORRUGATED SHEETS.
GALVANIZING TUBE PLANT
THE MYSORE IRON AND STEEL WORKS, BHADRAVATHI.
IRON ORE
LIME STONE
CHAR COAL
COKE
CHAR COAL BLAST FURNACE
ELECTRIC PIG IRON FURNACE.
PIG IRON
PIG IRON HIGH GRADES.
PIG IRON-LOW GRADES.
CUPOLA.
ELECTRIC FURNACE
O.H. FURNACE
CAST IRON.
STEEL INGOTS.
STEEL CASTINGS. AXLE BOXES, WHEELS, ETC.
STEEL INGOTS
C.I. CASTINGS.
PIPE SPECIALS
RE-HEATING FURNACE.
PIPES.
20" MILL
12" MILL
GEARS & Etc.
STEEL SECTIONS
ANGLES, FLATS, ROUNDS, SQUARES, AND 2" SQ BILLETS.
BILLETS FROM TATAS
BILLETS FROM MISW.
20" MILL
12" MILL
BILLET RE-HEATING FURNACE.
ROD MILL RODS 1/4 & 3/16
STRIP MILL COILS OF STRIPS
ORDNANCE AND OTHER SMALL STEEL REMELTIG UNITS.
1. ACID O.H. STEEL FURNACES
2. ELECTRIC ARC FURNACES
3. HIGH FREQUENCY FURNACES

Fig. 3.

(average 22·7%) in Indian metallurgical coke additional flux is needed to flux the ash.

For blast furnace use, maximum limit for silica and alumina in limestone is 5%. For open-hearth steel-making, it is 4%. Though there are several limestone deposits near Indian iron and coal fields, they lack the quality needed. Major producers draw their flux from Gangpur district in Orissa, located from 120 to 200 miles from the major producers.

In comparison with our reserves of iron ore, Indian metallurgical coal reserves are poor. With thickness of seam at 4′ and at a depth of 1,000 ft., reserves of all grades of coal are estimated at 20,000 million tons. Our coking coals reserves are figured at 1,500 million tons but contain high ash. These can be washed and suitably upgraded. Even after washing, the ash content may be 15%. Properties which determine the characteristics of a metallurgical coke are, ash content ash composition, reducibility and combustibility. The high ash content of Indian coals and the economic limit of 15% imposed on the ash content of washed coals, make it necessary for the Indian operator to use coke with as high an ash content as 20–23%. Analyses of coke used by Indian furnaces are shown in the following Table IV. Although the coke is low in sulphur, the advantage is more than offset by the high proportion of alumina in the blast furnace burden which leads to an aluminous viscous slag with poor desulphurizing power. The phosphorus content of the coke may be taken as an index of its ash content as the phosphorus of the coke is derived chiefly from the coke ash.

High-ash coke is detrimental to good blast furnace practice. Under Indian conditions it has been computed that each increment of 1% ash in coke would increase fuel rate by 4·5 per cent in the furnace and result in 5·6 per cent reduction in productivity. Further, a higher ash content entails a corresponding increase in the phosphorus content of the iron made with consequent repercussions on steel-making. The effect of ash content of fuel on operation is best brought out by a material balance drawn for the slag. It may be shown that nearly 60 per cent of the blast furnace slag is derived from the fuel ash and only 40 per cent originate from the gangue present in the iron ore. Any reduction in ash content of coal would lead to improved operation. However, it is doubtful whether consequent reduction in slag volume can be tolerated from the view point of the sulphur removal in the iron. A minium slag volume is necessary for maintaining the required low sulphur content of iron and reduction in coke ash content through coal washing to the level which necessitates additions of slag-forming material in the furnace defeats its very purpose. Reference has been made to the adverse alumina/silica ratio in Indian iron ore. Coke ash, however, introduces more silica than alumina and, therefore, serves to maintain the alumina content of slag within workable limits. It has been pointed out that intensive washing of coal and ore leads progressively to high-alumina contents in blast furnace slags. One should also take into account variations in moisture contents of coke charged into the furnace particularly during Monsoon weather. When charging is done by weight, variations caused by moisture content will lead to considerable furnace irregularities, as the necessary amount of carbon will not reach the tuyeres. When coke is not made on the spot, supply of wet coke would affect fuel costs very adversely.

To overcome future shortage of metallurgical coal in India which will eventually arise, the problem will have to be handled on short and long term basis. Short term will include coal washing and blending to yield suitable metallurgical coke. Long term investigations will include low shaft smelting of iron ores utilising low grade metallurgical coals, lignite coke etc., with or without oxygen injection on the air blast. Another solution would be the Electric Smelting of iron such as in Tysland Hole furnaces practised at the Works of Mysore Iron and Steel Works at Bhadravati. Possibilities will also have to be investigated of Krupp-Renn smelting of iron ore in Rotary kilns and in Stultzerberg Rotary furnaces.

The subject of refractories requirements *vis-a-vis* projected exansion of iron and steel industry during the Second Five Year Plan also requires serious consideration. The four-fold expansion of the Iron Steel Industry will involve heavy demands on refractories of different types of initial installation and subsequent recurrent demands of the steel plants. On the basis of known requirements of integrated steel plants in main steel-producing countries of the world, the initial anticipated requirements for installation of India's new steel plants have been estimated at 1,50,000 tons of refractories per million tons of ingot steel capacity installed. It is possible that these requirements may be spread over 3-4 years, at the end of which the new steel plants will be operating only on the

TABLE IV

Analyses of Indian cokes

Location	Percentage ash	Ash Analyses in per cent						
		SiO_2	Fe	Al_2O_3	CaO	MgO	P	S
TISCO Coke	20·0–21·0	10·00	1·72	6·17	0·86	0·41	0·178	0·55
IISCO Coke	21·0–22·0	11·50	1·50	6·9	1·00	0.25	0·25	0·60

basis of recurrent demands for refractories which would have to be provisioned for well in advance.

The recurrent demand of refractories has been estimated about 80,000 tons per million tons of ingot-steel. The break-down figuree into fireclay, silica and basic refractories will depend on the steel making processes employed. On the basis of consumption figures in foreign countries and the present practice in India, it is felt that requirements would be of the order of 7–075% fireclay refractories, 5–20% silica and 10–20% basic refractories of the total. These ratios approximate to the following figures in yearly requirements (Table V).

TABLE V

Annual refractories requirements

Proposed expansion	Capacity million tons	Steel melting practice open-hearth furnaces	Refractory requirements for initial and recurring consumption-unit-1,000 tons		
			Fireclay	Silica	Basic
Expansion to existing steel plants ...	1·5	All basic	126·15	12·325	31·9
		Silica roof	119·25	34·075	17·04
New steel plants ...	3	All basic	261·0	25·5	66·0
		Silica roof	266·25	40·5	55·75

To meet the requirements of the new steel plants, it is suggested that four additional firebrick plants of 70,000 tons capacity each, one silica brick plant of 40,000 tons capacity and three basic brick plants of 20,000 tons capacity each could advantageously be installed in suitable regions.

The present installed capacity in India as on 1st January, 1956 of refractories is as follows:

Type of refractory	Installed capacity per annum/tons.
Fireclay bricks and shapes	3,20,000
Silica refractories	30,000
Basic refractories	9,500
Chromite bricks	500
High alumina (H.A.) bricks ...	10,000
Insulating bricks	4,000
Refractory cement/mortar	70,000
Total ...	4,44,000

The development programme of iron and steel industry is expected to make the following demands on refractories:

Fireclay	230,000 tons
Silica	80,000 ,,
Basic refractories	25,000 ,,
High alumina	5,000 ,,
Insulating	46,000 ,,
Refractory cement mortar ...	120,000 ,,
Total ...	506,000 tons

As a background to the above figures, it is stated that by 1960 the target of 6 million tons of India's iron and steel production is fixed. The iron and steel industries consume about two thirds of the total refractories produced in the country. Refractories are required both for construction and maintenance of the steel plants. On the basis that 150,000 tons of refractories are required initially to set up 1 million tons of steel ingot plant, we shall need 450,000 tons of refractories for initial installation of Rourkela, Bhilai and Durgapur Steel Plants. Besides, the 3 existing steel plants i.e. Tata Iron and Steel Co., Limited, Indian Iron and Steel Co., and Mysore Iron and Steel Works would be requiring refractories to the extent of about 1,00,000 tons to complete their expansion programme. Currently over 130,000 tons of refractories are being consumed by the existing steel industry to produce 1,30,000 tons of steel which work out to an average of 10% of refractories per ton of steel made. In view of considerable expansion envisaged in other refactories consuming industries particularly cement, it is expected that by 1960, a total of 8 lakh tons of refactories would be required for operation purposes alone. At present there are in India 32 manufacturing units, the total rated capacity is 4,44,000 tons but with an annual production of about 2,30,000 tons. Refractories required in steel plant construction for coke-ovens and blast furnace are of special type and only 2 of the 32 units in India are reported to be in a position to manufacture them up to a limited extent. There is no dearth of suitable refractories raw materials in the country. To produce about 60,000 tons of fire-bricks, 20,000 tons of silica 10,000 tons of magnesite and 12,000 tons of chromite and magnesite bricks annually would need the following raw materials:

80,000 tons of fireclay
20,000 tons of quartzite
20,000 tons of magnesite
10,000 tons of chrome ore
10,000 tons of bauxite
65,000–75,000 tons of coal for firing purposes

Suitable raw materials exist in abundance in the country. Quality evaluation and quantitative estimation thereof should now precede well in advance so that when the new steel plants are ready, the refractories industries can shoulder the full demands thereof. This needs clear and concentrated action now.

New steel plants

The value of final products of Government of India's new steel plants is estimated to be of the order of Rs. 147·5 crores, it is learnt. The output of Rourkela 500,000 tons of pig iron and 720,000 tons of finished steel products will value Rs. 50·25 crores whereas the output of Bhilai 800,000 tons of pig iron and 770,000 tons of finished steel products is estimated to be Rs. 48·5 crores. Production at

Durgapur 360,000 tons of pig iron and 8,20,000 tons of finished steel products is likely to be the value of Rs. 48·75 crores. The three steel plants proper, are estimated to cost Rs. 439 crores. Other ancillaries are expected to cost Rs. 120 crores. The foreign exchange requirements of the steel plants proper, are estimated to be : Rourkela Rs. 120 crores Bhilai Rs. 82 crores and Durgapur Rs. 90 crores. These correspond to the estimates of total costs of Rs. 170 crores, Rs. 131 crores and Rs. 138 crores, respectively.

Rourkela steel plant

The final plant and the one that is under construction to day consists of :

Three batteries of 78 coke ovens
Three blast furnaces of about 1,000 tons size
An Austrian type tap-blown oxygen converter steel shop.
A hot strip mill
Accompanying cold mills, galvanising and tin plate equipment.

750,000 tons of ingots, would be produced by the L-D process—which has recently been developed in Austria. The balance of 250,000 tons will be produced by the conventional open hearth process. These one million tons of ingots will be rolled into :

1.	Plates 3/16″ and above	...	200,000 tons
2.	Sheets and strips (hot rolled)	...	300,000 tons
3.	Sheets and strips (cold rolled)	...	170,000 tons
4.	Tin plates ...	...	50,000 tons
	Total	...	720,000 tons

The plant will be capable of expansion to 1·25 million tons and the layout is such that ultimate capacity could be set up for 2·5 million tons of ingot capacity.

Bhilai steel project

This plant will be made up of :

Three batteries of 65 coke ovens each
Three blast furnaces of 1,135 tons per day rating
One open hearth shop
One blooming mill
Finishing mills for the rolling of heavy and medium structural shapes rails, sleepers and merchant bars.

This plant, in the initial stages, will produce one million tons of ingot. There is, however, room in the layout for ultimate expansion to 2·5 million tons. In the first phase, the production will consist of :

1.	Rails, standard gauge	...	100,000 tons
2.	Rails, narrow gauge	...	10,000 tons
3.	Railway sleeper bars	...	90,000 ,,
4.	Standard and broad-flanged beams, channels, angles and other light and heavy structural sections (beams with section height up to 24″)	...	284,000 ,,
5.	Rounds from 7/8″ to 3″ diameter and squares with sides from 7″/8″ to 3″	...	121,000 tons
6.	Flats from 2″ to 5″ wide	...	15,000 ,,
7.	Billets for re-rolling at outside rolling mills from 2″×2″ to 3″×3″ cross section	...	150,000 ,,
8.	Pig iron	...	300,000 ,,

Durgapur steel project

This plant will consist of :

Three batteries of 78 coke ovens
Three blast furnaces of 1,250 tons per day rating
Three open hearths
Mills for the rolling of medium and light sections and a wheel and tyre and axle plant.

This plant will be capable of expansion to 1·3 million tons of ingots. There is room in the layout for ultimate expansion to 2·5 million tons. Production, in the first phase, will consist of :

1.	Heavy forging blooms	...	10,000 tons
2.	Merchant sections ...	...	240,000 tons
3.	Forging billets ...	...	60,000 tons
4.	Sleeper bars ...	...	60,000 tons
5.	Light sections ...	...	200,000 tons
6.	Forging blooms ...	...	30,000 tons
7.	Wheels and tyres	...	28,000 tons
8.	Axles	...	12,000 tons
9.	Billets for sale ...	...	150,000 tons
10.	Pig iron	...	350,000 tons

For the supply of electric power to the steel works the Damodar Valley Corporation are putting up a thermal station of 150,000 kW in Durgapur. This station will use the surplus gases and middlings of coal arising from the steelworks.

The following Tables show the main features of the plants at Rourkela, Bhilai and Durgapur as also the sources of raw materials for running these three plants in the public sector : (Table VI and VII)

Indian Iron and Steel Company

When the Indian Government formulated their Second Five Year Plan which was to begin in 1956, they decided that a production of 6,000,000 long tons of ingots per year could be consumed in the country by the end of this period. It was then that they planned to build three 1,000,000 ton plants. To attain the 6,000,000-ton goal it was necessary to have the plants in the private sector increase their production to 3,000,000-tons. The Indian Iron and Steel Company was asked by the Government to plan for 1,000,000 tons. They planned to increase their iron-making capacity from 640,000 to 1,400,000 tons and their finished steel from 350,000 to 700,000 tons. This project included :

Two new batteries of 78 ovens with a corresponding increase in the by-product plant
Two new blast furnaces of 1,200 tons per day capacity

TABLE VI

Items	Main features of the plants		
	Rourkela plant	Bhilai plant	Durgapur plant
Coke ovens	3 batteries of 70 ovens each	3 batteries of 65 ovens each 3 of 1,135 tons capacity each.	3 batteries of 78 ovens each of 1,250 tons capacity each.
Blast furnaces	3 of 1,000 tons capacity each		
Steel melting	2 mixers of 1,000 tons each 3 L-D converters of 40 tons each 4 basic stationary 6 per hearth furnaces of 80 tons	6 O.H. furnaces of 250 tons each.	Seven O.H. furnaces of 200 tons each
Rolling mills	1 Blooming and Slabbing mill 1 Heavy plate mill 1 Continuous strip mill	1 Blooming mill 45·2″ 1 Rail structural mill 1 Merchant mill	1 Blooming mill 1 Intermediate mill 1 Continuous billet mill
Power plant	75,000 kW.	24,000 kW.	15,000 kW.

Note : There will be a coal washery of 360 tons per hour capacity at Durgapur to wash the coal from Jharia.

TABLE VII

Sources of raw materials

Raw materials	Rourkela		Bhilai		Durgapur	
	Source	Miles	Source	Miles	Source	Miles
Iron ore ...	Barsua (Taldih Hills)	42	Dhalli Rajhar	60	Bolari (Barajamda)	204
Coal ...	Jharia Kargali-Bokaro	190	Jharia	463	Jharia	72
Limestone ...	Hatibari	14	Deorrjhal	12	Birmitrapur Hathibari	229
Dolomite ...	Rourkela	10	Bharpuri, Bha (or vicinity)	16	Birmitrapur	229
Manganese ore ...	Barabil	136	Balaghat, Bhandra (or Ramrana)	124	Barbil (Barajamda)	198

One new 25-ton converter
Two new 240-ton tilting open hearths
Four new soaking pits
An extension to the finishing ends of the 34 in. and 18 in. mills.
Expansion of ancillary services
At their other plant located at Kulti, they have:
(*a*) Modernised the blast furnaces,
(*b*) Installed gas cleaning,
(*c*) Installed a 5,000 kW steam turbine to permit the cleaned gas to be utilised.

Before these expansions were completed, the Government requested this company to increase their finished steel output from 700,000 to 800,000 tons a year. To achieve this, the newest project entails:

The adding of two stands to their billet mill to enable them to roll 9×9 in. billets instead of 7×7 in.

To add one stand to their 34 in. structural mill in order to increase their rail and section tonnage and allow them to roll wide flange beams up to 10×10 in. and standard beams up to 20×7 in.

A new bar mill with an annual capacity of 180,000 tons
A new 20,000 kW steam turbine generator
Necessary auxiliary equipment

The Tata Iron and Steel Company Limited

The Tata Iron and Steel Company, who had already embarked on a scheme to bring their finished steel tonnage up to 931,000 tons a year, was requested by the Government to increase to 1,500,000 which called for an annual ingot tonnage of about 2,000,000 long tons.

In view of the fact that Government had decided to put the strip mill in the Rourkela Steel Plant, Tata's originial plans for a strip mill were abandoned and Tata's were asked to increase their structural, rail, billet and bar output. The main items to be included in the steel plant are as follows:

Two new batteries of 26 coke ovens each
The rebuilding of three old batteries
Ore preparation and sintering plant
One new 28′–0″ blast furnace
Seven new 200-ton open hearth furnaces
Two new rotary kilns in the dolomite plant
One 46-in 2-high blooming mill with soaking pits
One continuous sheet bar and billet mill
One medium and light structural mill
One Skelp mill
One Fretz-Moon tube mill (partially owned by Stewarts and Lloyds)
One electric ferromanganese plant located at manganese ore mines
Revamping of the present plate mill
Revamping of the present merchant mill
Revamping of the present structural rail mill
One new refractory plant of 60,000 tons per year capacity
One ferrosulphate washing plant for treatment of waste pickle liquor
One slag/scrap recovery plant
Ancillary equipment necessary for the above.

This expansion programme of the Tata Iron and Steel Company has now been virtually completed.

Ferro-alloys

Licenses have so far been granted to the firms detailed in Table VIII for setting up ferro-manganese smelting plants in India during the Second Five Year Plan.

TABLE VIII

Name of the party	Capacity sanction per annum (tons)	Location
Messrs Jeypore Mining Syndicate Ltd., Madras ...	12,000	Rayagada (Orissa)
Messrs Mysore Iron and Steel Works, Bhadravati	1,800	Bhadravati (Mysore)
Messrs Electro Metallurgical Works Ltd., Bombay	12,000	Dandeli, North Canara, Bombay
Messrs India Ferro Alloys, Samastipur ...	20,000	Comburria, Dist. Singbhum
Messrs Tata Iron and Steel Co., Ltd, Bombay ...	30,000	Joda (Orissa)
Messrs Combta Industries Ltd., Bombay ...	30,000	Tumsar (M. P.)
Messrs R. B. Seth Shree Ram Durga Prasad (Ferro-Alloy Corpn), Tumsar ...	30,000	Garividi, Andhra
Messrs Hari Ram Dina Nath, Bombay ...	18,000	Kanhan (M. P.)
B. F.	1,53,000	
Messrs Rungta and Sons Ltd., Bombay ...	18,000	In Bihar (adjacent to ore mines in Orissa and Bihar) Exact location not yet decided
Total ...	1,71,000	

Some aspects of Iron and Steel Industry in China

Along with coal and electrical power, iron and steel industry forms the sinews of a nation's industrial potential. No large scale industrialisation can be achieved without the concurrent development of a well-integrated metallurgical industry. The emergence of a modern iron and steel industry in China is a relatively recent phenomenon. Starting in 1907 with an iron and steel works with an annual capacity of less than 10,000 tons per year at Hanyan, the pace of subsequent expansion was very sluggish. During the last war the Chinese had pushed the production to 1·8 million tons of pig iron and 923,000 tons of ingot steel in 1943. The ingot steel production figures of China since 1943 are given below:

Year	Million tons
1943	0·923
1949	0·158
1952	1·349
1956	4·47
1957	5·24
1958 (original target) ...	6·25
1958 (revised target) ...	7·1

It will be thus seen that by 1952 the earlier annual production figures had been exceeded and remarkable expansion had since taken place during the following years. Production has been rising steadily since World War II and if, as seems likely, the expansion plans laid down in the Second Five Year Plan (1958-62) are fulfilled, China should become a major steel producing power of the world by the middle sixties.

At Anshan there are now 12 large blast furnaces with an annual capacity of 3 million tons of pig iron and several up-to-date steel mills turning out

300 types of carbon and alloy steels. China is now producing a large proportion of the high-quality steels required by the machine tool industry. In 1958, 100 new alloy steels will be manufactured based on manganese, vanadium, titanium, molybdenum, tungsten and boron as well as silicon and carbon steels. Contrasted with this, India has yet to establish an alloy and tool steel plant including the production of stainless steels. Apart from Anshan, new plants came into operation at Chungking, Penki, Shanghai and Taiyuan. Besides these, several large and medium scale projects will be completed during the Chinese Second Five Year Plan. Entirely new large integrated works are being established at Paotow and Wuhan. Wuhan should begin producing pig iron in October this year. Expansion is continuing on other major projects at Taiyuan, Shihchinghshan, Tunghwa, Chungking (scheduled to reach 700,000 tons ingot capacity this year), Kunming, Shanghai and Maanshan.

Chinese iron ore resources are now known to be better than was previously expected. Geological prospecting since 1949 has shown that resources measured and indicated by the end of 1957 totalled 4,700 million tons. Possible reserves are estimated at 15,000 million tons and new finds are continually being made. A previously unknown field has been discovered in Kiangsi with reserves estimated at 7,000 million tons with an iron content of 30%. Distribution of ores is also fairly widespread and there are large deposits in Kweichow, Szechwan, Shensi, Kansu, Shantung and Hupeh. The fact that coal is so widely dispersed is another natural advantage. Coal reserves are estimated at over 110,000 million tons. Iron and coal mines are located in almost all provinces. Manganese, fluxes, refractories are also plentiful to satisfy the expanding iron and steel industry.

The original target for 1958 for ingot steel production was 6·2 million tons or one million tons more than the previous year. This target was however raised to 7·1 million tons later in the year and even now it seems that steel production may actually touch 8 million tons. The main basis for this evaluation is the unprecedented increase in the number of small-scale iron and steel production units, which has been one of the main features of the new programme for promoting local industry. This programme is associated with the official policy of decentralisation and promotion of regional and local activity. Most provinces with deposits of iron ore are planning to install large numbers of small blast furnaces with very wide ranges in volume—anything from 3 to 22 cu. m. These are to be worked in association with medium and small side-blown Bessemer converter with an average production of 0·5 to 0·6 ton per blow. By the end of 1959 it is hoped that 200 mills would have been built. The main advantages of these small plants are : the low cost of installation ; ability to exploit relatively small and dispersed deposits of coal and iron ; and lower the cost of transport between the production unit and the consumer—a vital consideration since transport is a major bottleneck in any process of industrialisation. Agricultural implements, etc. will be one of the main consumers of locally produced iron and steel products with agricultural production undergoing almost a revolution. Wooden implements have yet to be replaced by iron and steel before even the process of semi-mechanisation can begin. The growth of local light industry will also create its own demand for iron and steel.

The original target for 1962 announced in 1956, was 10–12 million tons crude steel. At the end of 1957, this target was revised upwards to 12 million tons and early this year, revised again to 15–16 million tons. This was, however, before the big upsurge in local industry went into its strides. To all appearances the 1958 output and the 1959–60 annual rate of growth should both be somewhat higher than the latest forecasts. Production from large and medium-sized plants alone will be 15 million tons or more of crude steel in 1962 whilst an additional output from the small scale plants of 10 million tons by 1962 has been quoted. Even on the basis of the average rate of growth of 31·2 per cent in 1953–57, the extrapolation of the 1958 target of 7·1 million tons to 1962 yields a total output of 21 million tons and over.

Prospects for 1958

The original 1958 target for ingot steel announced in February was 6,240,000 tons or one million tons more than the previous year. This was raised two months later to 7·1 million tons in the light of the rapid progress already made. The attainment of this revised target would entail an increase of over 35 per cent, or somewhat more than the annual average rate of growth of 31·2 per cent of the previous five years. Even so, it now appears conservative, and it would not be surprising if output this year touched or even exceeded, eight million tons.

The main basis for the evaluation is the unprecedented increase in the number of small-scale iron and steel production units which has been an important feature of the new programme for promoting local industry. This programme is associated with, first, the official policy of decentralisation and promotion of regional activity and secondly, the dynamic release of productive energy which has rendered out of date so many planned targets in industry as well as in agriculture.

The five provinces of Hopei, Honan, Shantung, Anhwei, and Fukien are planning to complete 1,000 small blast furnaces each within the next 12 months. Honan is to construct 2,300 such furnaces with a capacity of one million tons of pig iron in the first year and 2·6 million tons in the second. Of 27 provinces and autonomous regions, 24 have already initiated iron and steel projects. All told, it is calculated, more than 13,000 small blast furnaces with a total capacity of 20 million tons of pig iron are to be built within the next year. Their volume will range from 3 to 225 cubic metres, and their average annual output will be 2,000 tons of pig iron.

Attention is also being concentrated on medium and small side-blown Bessemer converters with an average production of 0·5 to 12 tons of steel per blow. By the end of 1959, it is hoped that 200 such converters with a total annual capacity of 10 million tons of steel will be in operation. Some of them set up recently at Chekiang, Shansi, Shantung and Peking have already gone into operation.

Advantages of small plants

These small-scale iron and steel units have many advantages. First, they are cheaper and faster to erect per unit output than large-scale plants, and can be set up according to a few standard blueprints. In Szechwan, for instance, local sandstone is being used instead of firebrick for the upper part of the blast furnace; in Shantung, a locally designed and constructed converter, capable of turning out of 40 tons of steel in an eight-hour shift, costs about Rs. 55,000 to build.

These plants can exploit relatively small and lean deposits of coal as well as of iron ore which it might not otherwise pay to work. Third, the period of training for their labour force is short—in some cases as little as two or three weeks—in comparison with two or three years in the Anshan complex. Fourth, they serve as a training-ground for the labour force of larger-scale units. Fifth, they greatly reduce costs of transport both to point of production and to point of consumption. Finally, they raise the average technical level in the rural regions helping to bridge the gulf between rural and urban society. Naturally, such development in local industry presupposes that the necessary plant and equipment are forthcoming on the one hand, and that a ready market exists for its products, on the other. It would appear that in most cases, regional and provincial industries can manufacture the blowing engines, firebrick, and machinery; and, in any case, bigger machinery-manufacturing centres and allocating resources help to meet the demand. As for the market, in general the main emphasis in the development of local industry is on supplying the needs of agriculture and light engineering industries. In relation to local iron and steel production, it is clear that Chinese agriculture will provide the backbone of the market. Agricultural production is undergoing a revolution. This implies, in the first stage, replacing wooden implements with iron and steel components; introduction of new and efficient implements; and later, semi-mechanisation.

In addittion, the very process of gestation and development of local industries, including light industry as well as coal-mining and electricity, will create its own demand for iron and steel products. Therefore, the problem of outlets for increased capacity is not expected to be a stumbling block.

Steel production technique

The Chinese are producing about 15% of all their steel in side-blown converters, mainly in the works listed in Table IX. In addition, there are side-blown converters in plants at Chungking producing about 100,000 tons of steel per year. The use of side-blown converters in China originated during the Japanese occupation but was rapidly developed by the Chinese Peoples' Republic. The main reasons for the development of these small side-blown converters for steel-making were:

(*a*) insufficiency of scrap supplies for open-hearth production;
(*b*) the side-blown converter is independent of iron blast furnaces;
(*c*) successful operations with cupolas using up to 20% steel scrap and
(*d*) ready availability of iron ore suitable for producing low-phosphorus iron for subsequent steel-making in side-blown converters.

TABLE IX

	Shanghai plant	Ta Yi Works	Tien Shan Works
Number of converters	5	2	6
Capacity (each)	3·8 tons	1·5 tons	6 tons
Lining	Acid	Acid	Basic
Annual productions	100,000 tons	50,000 tons	200,000 tons

Today, the Chinese are using side-blown converters with basic linings so that they can work with normal open-hearth quality iron which is cheaper than Bessemer iron. These plants are all identical. Carbon steels of 0·06 to 0·10% carbon are produced and deoxidisers are added before tapping into the ladle (ferro-manganese, ferro-silicon and aluminium being used).

In 1952, the converters at the Tien Shan plant went over to using a basic refractory lining made locally by a special mixing process from dolomite and magnesite. The Tien Shan plant was worked by a Japanese textile company until 1945 and then had two electric furnaces and an acid 4-ton converter with two 8-ton per hour cupolas. After 1945, a duplex process was employed using an electric furnace. The plant now consists of six 6-ton converters and four 8-ton per hour cupolas operating at 16 tons daily total rate. The output in 1952 was 24,000 tons and in 1955, 200,000 tons. The iron used is mainly of high-manganese content, the remainder of the charge being coke and lime. The yield of steel from the charge does not exceed 75% due to the low temperature of the cupola iron, also on account of high-manganese contents of iron and pouring losses.

Small, basic side-blown converters are being developed in the Chinese Republic and the process will be improved upon by the technique of oxygen enrichment. There will also be a tendency to adopt the oxygen-enriched blast in bigger converters in conjunction with the use of the duplex (converter/electric furnace) process.

These experiments could be duplicated in India with considerable advantage and potentialities. There is only one such plant at the B.B. and C.I.R. Workshops at Ajmer. Establishment of these plants at various points in India should be considered. Active research and development is required on pilot scale production of steel by L-D process of oxygen injection in the light of Indian raw materials, particularly refractories. The success of L-D process of steel making is essentially the success of the refractories used. Considerable development work is required on refractories *inter se* L-D process of steel making. This may be undertaken on pilot plant scale similar to the Pilot Low Shaft Furnace put up by the National Metallurgical Laboratory along with Metals Committee of the Council of Scientific and Industrial Research. Similarly, experiments on balanced blast and hot-blast cupola are necessary. The technique of steel making as in Chinese side-blown converter practice needs to be closely studied and the possibilities of their adoption under Indian conditions of raw materials requires careful scrutiny. In India, setting up of small iron and steel production centres needs close examination and scrutiny from all angles including cost of production and operations—such as centres with production capacity of 3,000-5,000 tons of steel ingot per year, with small blast furnaces with production capacity of 8–15 tons per day coupled with basic lined L-D oxygen converters with capacity ranging from 2 tons upwards per blow. Such L-D converters can be designed and fabricated in India utilising Indian refractory basic linings. The products of such small iron and steel production plant will be small side ingots or billets which can be suitably forged in small drop-hammers, rolling mills and presses, etc. for the production of agricultural implements, small machine tools and a multitude of other small products utilised in light engineering industries, cycle industries, automobile industries, wire and wire products industries and so on.

DISCUSSIONS

Mr. B. S. Sharma, Mysore Iron and Steel Works: Dr. Nijhawan and Mr. Krishnan have referred to the Mysore Steel Works. I would like to add a few words about this only steel plant of South India. Dr. Nijhawan in his statement on the pattern of production in the country till 1961 showed that a certain quantity of billets is going to be produced by the major producers for feeding the re-rollers. He mentioned later that there is no need to start from a 5 or 10-ton steel ingot when what eventually it is required to produce is a screw-driver. This statement has very much appealed to me. The re-rollers, at least in this country, started their business from scrap and somehow the re-rolling mills have been established and they are to a certain extent contributing to our requirements. Now the problem is that, when sufficient steel is available in the country and there is no necessity to reroll from scrap, how to keep these re-rollers going? Is it necessary that the major steel producers should produce the billets for them? We are now only assessing the availability of coal, ore and other raw materials for the manufacture of steel. I would suggest that we should immediately take up a survey of the scrap availability in the country. As far as I know, we have got 40,000 to 50,000 tons of it in the southern parts, out of which only about 20,000 to 22,000 tons are being used at present. I feel electric furnaces should be installed in different parts of the country to produce small size ingots, which can be fed into the re-rollers and leave the major producers to manufacture big size sections; this, I think, would be the rational method, instead of rolling the billets somewhere in the north east and bringing them all the way to the south to feed the re-rollers and again re-roll into small rods or bars.

Dr. B. R. Nijhawan (Author): The subject of scrap versus electric melting is an important one and I believe increasing numbers of electric furnaces are being put up in different parts of the country to melt down the steel scrap and make small ingots. Whether the major producers should make the billets for the re-rollers is a point to be answered by the major producers themselves. But from what I can see, if the re-rollers are to be kept busy, they may not be able to get all their requirements from available steel scrap. Some of the billets are being imported from abroad to keep the re-rollers fully engaged. However, the point raised by Mr. Sharma is quite pertinent; instead of getting the billets from the north to the south, small plants could be installed on a regional basis in the south, so that they can meet the requirements of the local re-rollers some of which are small units with a very small capital outlay and probably cannot economically meet the transport costs of billets from long distances unless the State chooses to subsidise such costs. The point of making small ingots for making still smaller products is, I believe, quite sound. How small such an ingot should be is a point which will have to be examined in the light of further developments and perhaps in the Third Five Year Plan the question of putting up small ingots and steel plants may be examined.

Mr. A. A. Parish, B.H.P. Co. Ltd., Australia : I would like to ask Dr. Nijhawan as to what is known about the resource of refractories in India. It seems to be a matter of considerable concern and the major refractories of course will be silicon suitable for making silica refractories, alumina rich clays, and the basic refractories. I would be interested to hear about the known resources.

Dr. B. R. Nijhawan (Author) : As I have mentioned in my paper, the present installed capacity in India as on 1st January, 1958 totals 444,000 tons of different types of refractories per year. This is based on fireclay bricks and shapes to the extent of 320,000 tons, silica bricks 30,000 tons, basic refractories 9,500 tons, chromite bricks 500 tons, high alumina 10,000 tons, insulating bricks 4,000 tons, refractory cement and mortar 70,000 tons. The necessary raw materials required are available in India, and the production of refractories will have to be stepped up to the extent of 1·2 million tons and from what I have seen, except for some specialised items, there is no dearth of suitable refractory raw materials in the country. To produce about 60,000 tons of fire-bricks, 20,000 tons of silica bricks, 10,000 tons of magnesite, 12,000 tons of chromite and magnesite bricks annually, we would need 20,000 tons of quartzite, 20,000 tons of magnesite 10,000 tons of chrome ore, 10,000 tons of bauxite and about 75,000 tons of coal for firing, and these are available in the country. However, with some adjustments, substitution and further research and development, we should be reasonably self-sufficient in this respect.