The Development of Iron and Steel Industry in India's Five Year Plans

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MANY thousands of years separate us from the historic Iron Age when man first learned how to smelt iron from ore and shape it into tools and weapons. Since then, the number of metals and alloys developed by man for his needs has been greatly extended, but still iron and steel hold the unchallenged supremacy as can be seen from the fact that during the first quarter of the present century the quantity of iron and steel produced and used throughout the world was much more than that of any other metal. In the reconstruction and economic development of any country, whether it relates to greater industrial production or increased development of water and power resources, transport and agriculture or development of cottage industries, it is the iron and steel industry that forms the backbone and provides scope for maximum employment of ever increasing population.

It is a common knowledge that a nation's economic progress can be aptly judged in terms of the quantity of steel produced. The United States[1], the most highly industrialised country in the world, produced 113 million tons of steel in 1957. In Soviet Union, the development of Iron and Steel Industry has proceeded at a remarkable pace. In 1955, Soviet Industry produced 33 million tons of pig iron and 45 million tons of steel[2], whereas in 1913, production of iron and steel amounted to only 4·2 million tons each. The iron and steel industry is continuously expanding in the Soviet Union and the Sixth Five Year Plan[2] calls for the production of 53 million tons of pig iron and 68·3 million tons of steel per year by 1960. In Germany the total steel production before the year 1955 was much below that of United Kingdom, but within a year or two, Germany's production exceeded that of U.K. which in 1957 was 26 million tons and 24 million tons respectively.

In the Far East, China[3] has already crossed the level of 11 million and she is now regarded as the 7th largest steel producer in the world.

Japan, inspite of the great handicap due to the shortage of coking coal and iron ore, is the largest producer of steel[1] in the Far East with a production of nearly 14 million tons of steel during 1957.

All these mean only one thing : that the key to industrial production lies in steel. The year 1957 can best be regarded in the history of iron and steel as the turning point from the standpoint of production and profitable operation as new records have been set for the blast furnace and steel production, the latter having reached an all time record of 322 million tons. If the tempo of steel production is maintained at the present level of increase, it is quite likely that the world's annual production[4] may even exceed 500 million tons by 1975–80, to be shared as follows :

U.S.A.	150	million tons
U.S.S.R., Eastern Europe and China	150	,, ,,
Commonwealth countries ...	40	,, ,,
Western Europe including U.K. ...	155	,, ,,
Others	25	,, ,,
Total ...	520	million tons

Towards the later half of this century, spectacular developments in the iron and steel technology have taken place such as, increased use of oxygen in almost all the processes of iron and steel making, L-D oxygen converter process, Cyclo-steel process, the Kaldo and Rotor processes, developments in continuous casting, metal working and fabrication techniques involving remote control instrumentation, mechanisation and use of automatic machinery and equipment and the use of processed raw materials for iron making.

Historical background

Sufficient evidence exists to show that in India, since antiquity, iron and steel have been in existence and the historic iron pillar in Delhi bears testimony to the high degree of skill and craftsmanship in iron making of our ancestors. There are evidences that the aborging of Central India and neighbouring areas have had the knowledge of smelting iron in small quantities in primitive furnaces with the aid of wooden bellows. It was in 1799 when first recorded attempts in this country were made to manufacture iron by Motee and Farquhar[5]. In the year 1830, Josiah Marshall Heath showed remarkable enterprise in starting the production of iron at Porto Novo in South India. Followed by repeated attempts of making iron at various places, the real beginning of India's present iron and steel industry was made in 1875 when the first blast furnace was established in Kulti in West Bengal, 145 miles West of Calcutta. Jamshedji Tata became the pioneer in putting the

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iron and steel industry on a firm foundation in the eightees of the last century and the era of steel making in India could truly be said to have dawn only at the beginning of the present century when in 1912 the first ingot of steel was rolled by Tata Iron and Steel Co.[5] In 1918 the Indian Iron and Steel Co. started operation at Hirapur situated at 140 miles from Calcutta. In the year 1923, Mysore State erected their charcoal blast furnace designed to produce 20,000 tons of pig iron per year.

The two world wars gave stimulus for further expansion and by 1939 the production of saleable steel[5] rose to 800,000 tons per year and touched the peak level of production at 839,000 tons in 1942. During the second world war even special steels like armour plates, welding rods for fabricating armour cars, stainless steel for surgical instruments, high speed steels for tools, etc. were made to the extent of 3 million tons[5] by Tata Iron and Steel Co. Besides, a pilot plant was also put up for the production of ferro-tungsten and other ferro-alloys to meet the exigencies of war. In 1947 India attained independence and since then the policy of the Government was directed towards the one objective, i.e., industrialisation of the country to raise the standard of living, i.e., per capita income.

In 1948 the Government of India[6] appointed three firms of consulting engineers to study and make recommendations for expanding the iron and steel industry and this marked the era of State enterprise in iron and steel. In march 1950, the Planning Commission came into being and plans were drawn to formulate the First Five Year Plan with a total outlay of rupees 2,356 crores in the Public Sector. As far as allocation of industry and mining is concerned the total amount set apart was only 179 crores, i.e., 7·6 per cent of the total outlay, as the emphasis was more on the fuller utilisation of capacity already in existence and to set comparatively modest target for new investment in the industrial field. In 1951 Tata Iron and Steel Co. in keeping with the spirit of the Government of India's policy embarked on the expansion and modernisation scheme for raising the production capacity of saleable steel to 931,000 tons[7]. Likewise the Indian Iron and Steel Company initiated the expansion scheme to raise the target[7] of saleable steel to 700,000 tons and pig iron to 400,000 tons or alternatively to 620,000 tons of saleable steel and 500,000 tons of pig iron by the end of 1957. The Mysore Iron and Steel Works planned for the expansion of its capacity to 100,000 tons of finished steel by 1956.

The investments on the expansion and modernisation schemes[7] in the private Sector during 1951/56 were estimated at Rs. 43 crores as against the overall investment of about Rs. 70 crores and of the Mysore Iron and Steel Works at Rs. 2·8 crores.

In short the first Five Year Plan truly laid the foundation for the larger tasks lying ahead and also evoked widespread public interest, creating an insistent urge for rapid industrialisation.

RAW MATERIALS

Before going into details of the development of iron and steel industry in the Five Year Plans it will be interesting to have a survey of our raw materials resources since raw material account for nearly 80% of the cost of pig iron and 60% of the cost of finished steel.

For manufacturing one ton of finished steel we would require the following quantities of raw materials[8] as shown in Table I.

TABLE I

Raw Material	Estimated consumption per ton of finished steel
Coking coal ...	1·565 tons
Iron ore (Hematite) ...	1·913 ,,
Manganeferous ore and manganese ore ...	0·130 ,,
Blast furnace flux ...	0·509 ,,
Open hearth flux ...	0·057 ,,
Ferro alloys ...	0·017 ,,
Raw dolomite ...	0·090 ,,
Burned magnesite ...	0·009 ,,
Refractory bricks ...	0·026 ,,
Other refractories ...	0·017 ,,
Steam coal ...	0·365 ,,

To meet the needs of 6 million tons of steel as envisaged in the Second Five Year Plan, the minimum additional quantities of the principal raw materials[5] that we would require per annum are :

7 million tons of iron ore
7 million tons of coking coal
4 million tons of limestone
0·2 million tons of refractories

Iron ore

India is not lacking in the essential raw materials for her iron and steel industry. Her iron ore reserves are classic in quality and quantity and her reserves[9] are estimated at 21,000 million tons approximately. Some of the richest iron ore deposits of the world exist in Singhbhum belt in Bihar where the average iron content of the ore is between 60 to 69 per cent as compared[8] to 50 per cent in the United States and 40 per cent in Europe.

Iron ore in India can be conveniently divided into three groups namely Hematite, Magnetite and Limonite ores. The largest deposits of the hematite variety occur in Bihar, Orissa, Madhya Pradesh, Mysore and Bombay. The magnetite ores occur in Madras, Mysore, Orissa and Himachal Pradesh. Extensive reserves of limonite ores associated with its spathic ores are present in West Bengal.

The production for 1956 was of the order of 4·86 million tons and in 1957 it touched the level of 5·02 million tons. At the end of the Second Five

Year Plan the target of production will go up to 12·5 million tons.

Coal

The expert Committee on metallurgical coal investigated the position in 1950 and gave an assessment at 2,000 million tons[10] of good quality coking coal mostly in Jharia and Raniganj coal fields. It was further stated that only 60 per cent of the total reserves can be put into actual use and that measures for conserving the same are to be taken in hand forthwith. At the present time for production of 1·3 million tons of finished steel we would be requiring 1·4 million tons of hard coke which amounts in terms of unwashed coal to 2·6 million tons. By the end of the Second Five Year Plan our steel plants will require about 5·6 million tons of sized hard coke for which we should produce 10·34 million tons of coking coal from the mines. By 1975 it is felt that our iron and steel industry may require up to 40 million tons of hard coke[11]. The demand in respect of metallurgical coke by 1961 for the existing and proposed steel plants that are fast coming up are given in Fig. 1. The ash content in the Indian coals are fairly high, ranging between 15/24 per cent and the answer to utilise the high ash coals and to supplement our reserves of coking coal lies in adopting the modern coal washing techniques. Already a step in the right direction has been taken by the National Coal Development Corporation by setting up a coal washery at Kargali designed to supply 1·1 million tons and 0·5 million tons for the new steel plants at Rourkela and Bhilai respectively. In the private sector the Tata Iron and Steel Co. has put up a coal washing plant at Bokaro and another at Jamadoba. These two washeries after certain improvements can supply 1·5 million tons of washed coal. The washery at Lodna of the Indian Iron and Steel Co. can supply 0·22 million tons of washed coal.

In the public sector also the steel plants have included in their project suitable coal washing plant to meet their requirements. By 1961 the public sector will have another 4 washeries with a total washing capacity of more than 2,000 tons per hour for upgrading the metallurgical coal[12] (Fig. 2). There is besides a proposal for installing a 500 tons per hour washery at Korba[12] for upgrading high ash non-coking coal of Jatraj seam in Korba coalfield. The present position of coal washing installations in India—existing and under construction—is given in Table II.

In order to ulilise the high ash middlings and/or sinks coming out of these washeries, schemes for establishing thermal power stations in close proximity to these washeries have also been given due consideration. In this connection the findings of the Central Fuel Research Institute on the suitability of washed coal from the new Kargali washery for the production of metallurgical coke, published recently, will be of great interest :

"Tests carried out by the Institute in its multi-oven pilot plant have now confirmed earlier results that blendings of washed Bokaro and Kargali coals yield a coke suitable for steel plants and it is further improved by mixing Jharia coal with it. It has also been established that selective crushing to reduce the charge to 100% below 3 mm can improve the coke properties even when Kargali seam coal is being used. It has been further observed that a mixing of coke dust in the charges improves the physical properties of the coke. Pilot plant tests with blends of Ghordawa coal, with Jharia or Kargali coal show that up to 20% of the non-coking coal could be used satisfactorily.

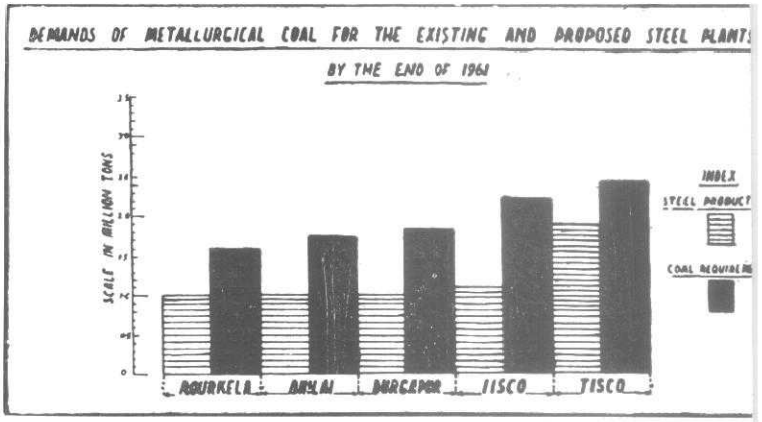

Fig. 1.

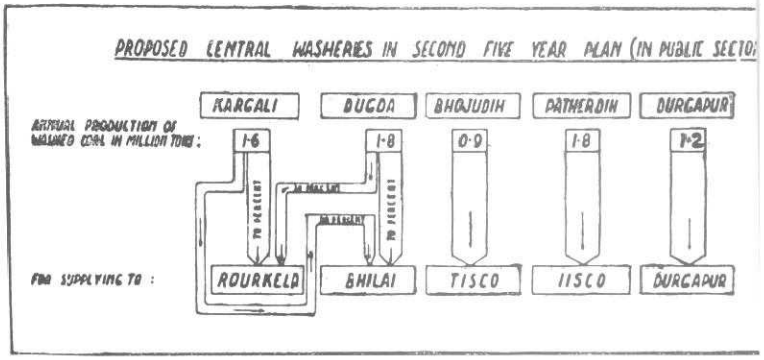

Fig. 2.

Manganese ore

Coming to manganese ore, India is the second largest producer of manganese ore next to Russia and her deposits are estimated at nearly 200 million tons[13]. Manganese ore deposits occur in many parts of the country such as Bihar, Orissa, Madhya Pradesh, Bombay and Mysore, the most important of them

TABLE II

Coal washeries in India. Existing and under construction.

	Existing			Under construction	
Location	Jamadoba	West Bokaro	Lodna	Karagali	Nowrazbad
Owned by	Tisco	Tisco	Turner Morrison (IISCO)	N.C.D.C. (P) Ltd.	A.C.C. (P) Ltd.
Type	Chance	Chance	Feldspar Jig	Composite H.M.S. and Jig	Humboldt H.M.S.
Installed capacity in tons per hour	300	130	70	525	120

being Singhbhum district of Bihar ; Keonjhar, Bonai and Bolangir districts of Orissa; North Kanra, Belgaum, Bellary (Sandur Taluk), Chitaldrug, Chikmaglur, Shimoga and Tumkur districts of Mysore ; Nagpur and Bhandara districts of Bombay State and the Balaghat and Chindwara districts of Madhya Pradesh.

Manganese ore production[14] during 1955, 1956 and 1957 is as follows :

1955	...	...	1,583,538 tons
1956	...	...	1,686,609 tons
1957	...	...	1,602,000 tons

Most of the indigenous consumption is at present met from Keonjhar and Singhbhum districts. The domestic demand is likely to increase with the expansion of iron and steel and ferro-manganese industries. During the Second Five Year Plan, when the steel ingot production is to be stepped up to 6 million tons, we would be requiring nearly 120,000 tons[15] of manganese ore.

Limestone

So far as fluxing materials are concerned limestone is one of the basic requirements of iron and steel industry. Although limestone is abundant in the country, the quality varies widely particularly the available base (lime) which determines the usefulness of flux.

A typical analysis of limestone used in the open hearth practice in India by the Tata Iron and Steel Co. from their Birmitrapur quarries is given below in Table III.

TABLE III

Analysis of Birmitrapur limestone

SiO_2	...	...	4·05%
Al_2O_3	...	...	1·11%
Fe_2O_3	...	...	1·06%
CaO	...	...	48·86%
MgO	...	...	3·77%

It will clearly indicate the high silica content of the indigenous variety as compared to the British and American ones where it is seldom more than 2% of silica. However, it is encouraging to note that the investigations conducted by the Indian Bureau of Mines have shown that the deposits[16] located at Durg and Raipur districts of Madhya Pradesh would meet the entire requirements of our future iron and steel industry.

Fluorspar

As regards fluorspar, workable deposits occur in the districts of Durg and Jabalpur in Madhya Pradesh, but the indigenous production has been insufficient to meet the demands and in 1957, we had to import 7,896 tons[17].

With the expansion of iron and steel industry, our requirements may go up to 15 to 20 thousand tons per annum. In this context it is gratifying to note that extensive deposits of fluorspar have been discovered recently in Rajasthan which is hoped to meet our demands to a great extent.

Refractories

As far as refractories are concerned, much of our requirements are being imported from abroad, and the Planning Commission has fixed the target at nearly 1,000,000 tons[7] out of which nearly 600,000 tons of refractories alone will be required annually for the 6 million tons ingot steel going to be produced by the various plants by 1960-61.

In keeping with the increased demands of refractories for steel plants, the expansion of existing refractory plants has already been initiated, and more plants are being put up to augment the supplies. Amongst the new plants to come into operation soon, the Belpahar Refractories Co.[5] is a joint venture by the Tata Iron and Steel Co. and Didier Werke of Germany. This company will have two plants, one at Karuppur near Salem for calcining magnesite and chrome-magnesite and the other at Belpahar for making finished bricks of all kinds ranging from fire bricks to basic bricks. This plant will have an initial capacity of 40,000 tons fire bricks, 12,000 tons silica bricks, 15,000 tons basic bricks per annum and this enterprise will meet the requirements of refractories for the two

million tons plant that has just been completed at Jamshedpur.

A detailed and informative report has already been compiled by the National Metallurgical Laboratory at the request of the Adhoc Committee of the Planning Commission. As per this report four additional fire brick plants of 17,000 tons capacity and one silica brick plant of 40,000 tons capacity and three basic brick plant of 20,000 tons have been recommended to be installed in suitable regions to meet our present as well as future requirements.

Ferro-alloys

Any aspect of iron and steel industry, is incomplete without reference to ferro-alloys which are so vital in producing steel to specification for meeting the ever increasing demands in various fields. Of the various ferro-alloys, ferro-manganese and ferro-silicon are required to a large extent. As for example, for the production of a million ton of steel, we need about 10,000 tons of ferro-manganese and 1,500 tons of ferro-silicon.

The indigenous production, being insufficient, we have been importing major portion of ferro-alloys to the extent of Rs. 37 to 46 lacks[18], as shown in Table IV.

The requirement of ferro-manganese for iron and steel industry by 1960–61, has been estimated at 60,000 tons.

Enough scope also exists for export of ferro-manganese to foreign countries to the extent of 1,00,000 tons by 1960-61, particularly to U.S.A. which imports to the extent of 75 to 80% of her requirement of ferro-manganese in shape of raw manganese ore.

This will earn foreign currency to the extent of 8 crores by export at current prices. Bearing this in view the Government of India has already issued licences to a number of firms[7].

Out of these, four plants are already in operation at Dandeli in Bombay, Garivadi at Andhra Pradesh, Raygada and Joda in Orissa. Thus when all the plants are completed we will produce 171,800 tons (now estimated at 201,800 tons per annum) which will meet out indigenous requirement and leave surplus for export.

The development programme of ferro-manganese industry[7] has been summarised in Table V.

TABLE V

Development programme of ferro-manganese industry.

	Unit	1955-56	1960-61
Number of plants	...	..	...
Installed capacity (by electric process ...	Tons	...	171,800
Production	Tons	Nil	160,000
Domestic consumption	Tons	23,000	60,000
Exports	Tons	Nil	100,600

The present production of ferro-silicon is in the neighbourhood of 5,000 tons. To meet the increasing demand of iron and steel industry in the plan period, steps have already been taken to expand the production to 20,000 tons per year, for which the Mysore Iron and Steel Co. has got the sanction of Rs. 1·5 crores for setting up the plant with the help of a Norwegian firm.

As regards ferro-chrome, at present there is no plant in India for the manufacture of ferro-chrome regularly to meet the indigenous demands although Mysore Iron and Steel Co. has been producing small quantities as and when required. In the second quarter of 1958 the indigenous production was only of the order of 77 tons and it is anticipated that the demand for standard ferro-chrome of 60% Cr for the next few years will be of the order of 200–250 tons per annum[19]. But if stainless steel plants come into operation our requirements will increase more.

In India, high grade chromite ores occur in Cuttack and Keonjhar districts of Orissa, Hassan and Mysore districts of Mysore, Singhbhum district of Bihar and Krishna district of Andhra Pradesh amounting to 900,000 tons. Nearly 87% of the entire output of the country comes from the above sources.

As regards the other ferro-alloys like ferro-tungsten, ferro-vanadium, ferro-titanium and ferro-boron we are not lacking in the technique as will be evidenced from the fact that in World War II the Tata Iron and Steel Company successfully produced these ferro-alloys on a pilot plant scale in electric furnaces.

It will, therefore, be evident that a ferro-alloy industry should be developed *pari passu* with the fast growing needs for alloys and special steels and the National Metallurgical Laboratory has taken up a major research programme to set the monopoly of

TABLE IV

Import of ferro-alloys

	1953–54		1954–55		1955–56	
	Tons	Rs.	Tons	Rs.	Tons	Rs.
Ferro-chrome ...	70	1,59,670	66	47,778	216	3,01,609
Ferro-manganese ...	3,447	33,82,632	3,567	33,37,679	287	4,13,231
Ferro-silicon ...	9	20,797	444	3,67,941	145	1,39,236
Others ...	319	1,75,885	511	3,04,770	343	2,50,624
	3,851	37,38,984	4,588	46,58,168	991	11,04,691

Indian raw materials for the production of low carbon ferro-chrome and other carbon-free ferro-alloys.

IRON AND STEEL INDUSTRY IN OUR FIVE YEAR PLANS

First Five Year Plan

Before the Second World War, India was producing about 1,750,000 tons of pig iron and 750,000 tons of steel per annum[20]. It reached a maximum[8] of 2 million tons of pig iron in 1941 and 1·13 million tons of finished steel in 1943. The level of production, however, went down in the subsequent period because of the intensive use of plant and machinery during the war and lack of adequate replacements. This downward trend was arrested in 1948 and since then the production has once again recorded an increase.

When the First Plan was being prepared, it was estimated that the requirements[20] of steel will rise from 2·1 million tons to 2·8 million tons by 1957, and as regards the future demands[20] for steel it was calculated at 4·5 million tons by 1960-61 taking about 300,000 tons for export. The indigenous production being behind the demand, the gap had to be filled by imports from abroad. In the First Five Year Plan, although the main emphasis was laid on agriculture and allied fields, a sum of Rs. 76 crores[7] was allotted for the development of the iron and steel industry, particularly for modernisation of the old machinery worn out due to war production and to bring the existing plants to full capacity. It was also realised that since the relatively small output of the iron and steel industry affected the progress of a series of industries which are dependent upon iron and steel for raw materials, the State in future should be responsible for further development excepting to the extent of cooperation from private sectors considered necessary from time to time. The Plans were therefore accordingly formulated to put up the first integrated steel plant[7] in the public sector at Rourkela in Orissa at an installed capacity of 800,000 tons of pig iron and 350,000 tons of steel. During the later half of the Plan period necessary preliminaries were also initiated for the installation of the second and third integrated steel plants[7] of one mlllion tons steel capacity each, one at Bhilai and the other at Durgapur in West Bengal, the former in collaboration with the Government of the U.S.S.R. and the latter with the help of a Consortium of leading industries from U.K.

The private sector responded splendidly in modernising their plants to utilise the full capacity and also increased their production. The Tata Iron and Steel Company invested nearly 34 crores[7] in 1951–56 and completed during the above period a new Simon Carves battery of coke ovens, re-building of their D Blast Furnace completely engineered and built by their staff without any outside technical assistance and raised their production capacity to 931,000 tons of saleable steel. The Indian Iron and Steel Company raised their production of pig iron and saleable steel to 700,000 tons and 400,000 tons respectively and invested nearly 15·27 crores[7]. Mysore Iron and Steel Works also embarked on an expansion scheme and invested Rs. 1·39 crores[7] by the installation of, amongst others, two 13,200 kVA Tysland-Hole electric furnaces with a rated capacity of 60–65 thousand tons per annum. Their pig iron production has nearly trebled during this period. The total output of pig iron and saleable steel by the three main producers, namely, Tisco, IISCO and Mysore Iron and Steel Works for the periods 1951–56 is given in Table VI.

It can, therefore, be seen that the First Five Year Plan truly laid the foundation for the iron and steel industry, especially for the State enterprise, in this important branch of industry and also indicated the various directions in which planned action was necessary to achieve the objective of incresed production potential.

The Second Five Year Plan

Planning requires a continuous watch on current or incipient trend, systematic observation and adjustments of the programme in the light of new requirements. In this context, the Second Five Year Plan can be best regarded as a continuation of the development effort put in the First Plan with a shift in the priority to iron and steel, for which a sum of Rs. 462 crores[7] out of a total outlay of 1094 crores for industrial expansion, representing nearly 43 per cent, was allocated. Of course, the amount to be actually spent will exceed much more than 500 crores due to increased cost, etc. During this period, concerted efforts are being made to bring the three steel plants in the public sector, namely, at Rourkela, Bhilai and Durgapur to commission in various stages and also to complete the expansion of the existing

TABLE VI

Output of pig iron and saleable steel (in 1,000 tons)

Year	TISCO		IISCO		Mysore Iron and Steel Works		TOTAL	
	Pig iron	Steel	Pig iron	Steel	Pig iron	Steel	Pig iron	Steel
1951–52	1,129	799	694·1	264	23·0	30·5	1,846·1	1,093·5
1952–53	1,153	790	627·0	311	36·9	23·6	1,816·9	1,130·6
1953–54	1,150	780	579·4	291·7	52·5	32·0	1,781·9	1,103·7
1954–55	1,128	783	715·6	461	50·3	26·6	1,893·9	1,270·9
1955–56	1,156	797·8	707·0	452·9	52·4	35·0	1,915·4	1,285·7

steel plants so that the target of 6 million tons of ingot steels to yield about 4·5 million tons of saleable steel by 1960–61 could be realised.

In the private sector the existing capacity of 0·9 million tons of the Tisco has already been expanded to produce 2 million tons of ingot steel. The Indian Iron and Steel Co. will produce 0·9 million tons by expanding their present capacity of 0·5 million tons and the Mysore Iron and Steel Works will produce 0·1 million tons thus bringing the total of 3 million tons from the existing plants.

The three steel plants put up in the public sector, one at Rourkela, another at Bhilai and the third at Durgapur will each contribute 1 million tons and thus bring the total steel production to 6 million tons of ingot steel.

Tata Iron and Steel Company

In the private sector the Tata Iron and Steel Company, the pioneers in the iron and steel development in India, as far back as 1951 embarked on the modernisation and expansion of their works, and now they have nearly completed their 2 million tons production programme at an overall cost of 81·4 crores[10].

The salient features of the 2 million tons expansion programme embrace practically every phase of production ranging from the mining of the ore and other raw materials to the finishing stage including the service units dealing with electrical distribution, water, fuel, etc. The main items of interest are two new batteries of 26 coke ovens each, the rebuilding of the three old batteries ; a sintering plant of 5,000 tons a day capacity to utilise iron ore fines, a new blast furnace with a 28 ft. hearth diameter and designed for high top pressure operation with a capacity of 1,650 tons of pig iron per day which can deal subsequently with 2,250 tons[21] of pig iron per day when operated on 100% sinter ; seven new 200-ton open hearth furnaces and three 32-ton Bessemer converters for the new steel melting shop and three new rolling mills comprising of a 46″ blooming mill, with soaking pits, a medium and light structural mill and a sheet, bar and billet mill. Ancillary works relating to the above consist of improvements and additions and include the construction of a new ferro-manganese plant located at Joda near the manganese ore mines, a new refractories plant of 60,000 tons capacity per year, a ferro-sulphate washing plant for treatment of waste pickle liquor and a plant for the recovery of scrap from slag by the Hecket process.

The blowing in of Tata's giant blast furnace on 10th October 1958, the sixth in the series and the key unit of their two million-ton programme can be said to mark the beginning of the end of the era of the iron and steel shortage in India. This furnace equipped for high top pressure operation, a production technique employed for the first time in India, has a capacity of 6 lakhs tons of pig iron per year. This capacity can be increased by 20% when sinters are used. A 5,000-ton sinter plant to feed this giant furnace is nearing completion.

Several other major items of the two million-ton programme planned in 1955 have also since been completed. The first to be commissioned in 1956 was the 3·65-crore skelp mill. Early in 1958 a new 26-coke oven battery and the rebuilt No. 2 battery were brought into operation. Later the ferro-manganese plant at Joda, with an initial capacity of 36,000 tons a year, was commissioned. On the steel making side, two Bessemer converters were commissioned in September 1958 and a third one on the same day as a giant blast furnace. All the seven 200-ton open hearth furnaces have already come into operation. The new 46″ blooming mill was completed in August 1958. The other two mills, the bar and billet mill and the medium and light structural mill are also nearing completion.

Indian Iron and Steel Company

The Indian Iron and Steel Company also initiated their expansion programme in 1953 at an overall cost of 45·61 crores[10] which is also proceeding according to schedule. Two new blast furnaces have gone into operation, one on 30th January 1958 and the second on 11th October 1958 together with a 350-ton open hearth furnace, the largest of its type in India. Extensive additions to the Bessemer plant of one converter and one mixer have also been nearly completed so that the IISCO plant can now produce its full capacity of 1 million tons of ingot steel per annum.

As regards the coke oven batteries, the first of the new coke ovens was lit on 6th November 1957, whereas the second battery was lighted on 5th August 1958. Regarding open hearth furnaces two furnaces of 250-tons capacity have been added. The ancillary plants comprising of ore handling plants, casting machines, scrap gantry, etc. have also been completed in the scheduled time.

Simultaneous extensions have also been made at the company's ore mines at Gua where the old methods of mining have been replaced by modern methods employing most up to date machinery and handling equipment including crushing plants and full lengths of belt conveyors from the mine site to the screening plant near the rail head.

On completion of the programme in the two steel plants in the private sector the level of production of saleable steel is anticipated to be as given in Table VII.

TABLE VII

Anticipated production during 1956–1961

Year	Tisco	IISCO
1st year 1956-57	800,000 tons	300,000 tons
2nd ,, 1957-58	900,000 ,,	375,000 ,,
3rd ,, 1958-59	1,200,000 ,,	520,000 ,,
4th ,, 2959-60	1,500,000 ,,	640,000 ,,
5th ,, 1960-61	1,500,000 ,,	800,000 ,,
Total ...	5,900,000 ,,	2,635,000 ,,

The raw materials[7] that would be required in the two plants when completed are given in Table VIII.

TABLE VIII

Raw materials for TISCO and IISCO

Items	TISCO	IISCO	Total
Coal	3,500	2,467	5,967
Iron ore ...	3,200	2,180	5,380
Manganese ore ...	60	40	100
Limestone ...	900	650	1,550
Dolomite ...	90	40	130
Ferro-silicon ...	5	2·5	7·5
Sulphur ...	7·2	12	19·2
Spelter ...	6	5·4	11·4

Mysore Iron and Steel Works

The third existing steel plant which is the only plant in the Southern region has also embarked on an expansion programme to boost up its steel production from the present level of 35 thousand tons to 100 thousand tons per annum. Two 13,200 kVA Tysland-Hole electric furnaces with rated capacity of 60–65 thousand tons per annum have already been added up and a sintering plant for the utilisation of iron ore fines is also being got ready at a cost of 45 lakhs[7]. With the help of the Norwegian firm the capacity of the ferro-silicon plant is also being boosted up from the present level of production of 5 thousand tons to 20 thousand tons per annum at a cost of 1·5 crores by installing modern rotating furnaces. It is almost certain that L-D process of steel making is going to be adopted at this works. The future expansion programme[20] envisages installation of a tool and alloy steel plant, a stainless steel plant and a silicon sheet plant which are currently under the examination of the Government of India. The total amount envisaged to be spent in the Plan period is 6 crores[10] for the expansion schemes.

On completion of the programme the following are the raw materials, amongst others, that will be required by the Mysore Iron and Steel Works :

Coke ...	...	0·05 m tons
Iron ore ...	...	0·2 m tons
Electric power	...	98,800 kW

HINDUSTAN STEEL LTD.

Rourkela

The first integrated iron and steel plant in the public sector coming up at the confluence of the two rivers Sankh and Koel is going to cost Rs. 170 crores[22] excluding mines and the township. It will produce 1 million tons of crude steel to be rolled into 720 thousand tons of plates, sheets and strips with provision for expansion with a few additions to 1·3 million tons and enough scope also exists for ultimate expansion to 2 million tons.

Iron ore will be supplied from a new mine fast being developed at Barsua 45 miles away from Rourkela and till the mines are brought into full commission iron ore will be drawn from Gua and Naomundi areas. Coal will be transported from Bokaro, Kargali and Jharia fields in Bihar. Limestone will be supplied from Hathibari and Birmitrapur 15 miles away. This integrated iron and steel plant will have three batteries of 70 ovens each for carbonising 4,500 tons of dry coal per day to yield 1·6 million tons of coke and 3 blast furnaces of 1,000 tons capacity with a by-product plant for extracting useful products from the coke oven gas. The by-product plant will recover 200 tons of tar, 20 tons of sulphuric acid and 35 tons of benzol each day and other by-products like ammonium nitrate, etc.

The coal and coke will be handled by remote control and for carbonisation a mixture of Bokaro, Kargali and Jharia coals from the Kargali washery, now working, and the Dugda washery nearing completion, will be used. It will be of interest to record here that the first hard coke from the Rourkela coke oven plant has already been pulled out on 3rd December, 1958 and since then the plant is under continuous operation.

As this plant has been designed specially for the production of flat rolled products, it has been proposed to produce 750 thousand tons of steel by the L-D process, for the first time in this country, from the three L-D converters as it is known that L-D steel is ideal for flat rolled sections and means lower capital and operating cost. About 250 thousand tons of ingot steel will be made by the open hearth process in the four open hearth furnaces. The plant will have a separate tonnage oxygen plant and the nitrogen released in the process would be used for making fertilisers for which an unit to produce 580 thousand tons of calcium amonium nitrate a year is being put up. Other features of the plant are a dolomite plant and rolling mills for hot and cold rolling. The hot rolling mill plant comprises a blooming and slabbing mill, broad strip and heavy plate mills. When the cold rolling mill, the first of its kind in India, will be ready it will also have a tinning department. These mills altogether will produce 200 thousand tons of plates of 3/16″ and above, 300 thousand tons of hot rolled and 170 thousand tons of cold roll strips and 50 thousand tons of tin plates. A thermal plant is also being set up with a rated capacity of 75 mW and to meet the peak load power from Hirakud Project will be utilised.

The first blast furnace will start producing 1,000 tons of pig iron by February 1959 and the second by August 1959 and the third by November 1959. The open hearth furnaces are expected to be ready between May and July 1959 and the L-D converters are expected to go into operation by October or November 1959. The blooming mill and slabbing mill will be ready by September 1959 and the plate mills, the broad strip mill and the cold rolling mill will go into operation by 1960. On completion this plant will require 1·6 million tons of coal,[10] 1·7 million tons of iron ore, 0·112 million

tons of manganese ore, 0·523 million tons of limestone, 0·028 million tons of dolomite and 85,000 kW of electric power annually to produce 1·045 million tons of coke, 0·945 million tons of pig iron, 1 million ton of steel ingot, 0·720 million tons of finished steel, leaving a surplus of 0·03 million tons of pig iron for sale.

Bhilai

The second integrated iron and steel plant under erection at Bhilai in collaboration with the U.S.S.R., 165 miles from Nagpur on the main Bombay—Calcutta route. The plant has been designed for an initial capacity of 1 million tons of ingot steel to be rolled into 770 thousand tons of billets, rails and structural sections. The plant[22] alone is expected to cost Rs. 131 crores and has provisions to increase its capacity to 1·25 million tons with a few additions whereas the layout permits of its ultimate expansion to 2·5 million tons.

The Bhilai plant will draw its iron ore from Dhalli Rajhara deposits in the Durg area 60 miles away. The average iron content of this ore is of the order of 60 to 68%. A scheme for the mechanical handling of the iron ore has also been prepared at a cost of Rs. 6 crores and for this purpose 5 thousand tons of mechanical equipment have been imported from the U.S.S.R.

Coal will be drawn from the Bokaro and Kargali mines in Bihar initially and Korba coal fields in Madhya Pradesh has been kept as an additional source of coking coal and also for the supply of coal for power and steam generation. Limestone will be obtained from Nandini quarries 15 miles away from this plant. For manganese, Bhilai is fortunate in drawing its supply from the famous deposits of Balaghat and Bhandara mines. Water will be taken from the Tandula and Morada tanks and electricity will be available partly from the Korba generating station of Madhya Pradesh Government and partly from the plant's own thermal plant. The coke oven unit will have three batteries of 65 ovens each to correspond to the number of blast furnaces. A by-product plant, at a cost of Rs. 3 to 4 crores is being put up to recover the by-products namely, tar, ammonium sulphate and crude benzol.

Iron will be produced by 3 blast furnaces of 1,135 tons capacity each designed for high top pressure operation at about 1 atmosphere. Each blast furnace[23] has been provided with special air blowers capable of blowing 2 to 3 thousand cubic metres of air per minute with constant humidity and delivered to the blast furnace at a temperature of 900°C. Provision has also been made for moisturing the blast with steam up to 40 gms of moisture for 1 cubic meter of air according to the maximum atmospheric humidity in the area, to control the furnace operation.

There will be two sintering machines to produce a total of 1,000,000 tons of sinters[23] per year.

It is expected that the first blast furnace will start producing iron from 3rd February 1959 and the second and third blast furnaces will go into operation by the end of this year. For steel making there will be six open-hearth furnaces of 250 tons capacity each with provisions for increasing to 300 or more tons capacity to be operated with a mixture of blast furnace and coke oven gas and with provisions for oxygen enriched air up to 23 to 25 per cent.

The annual output of the open hearth furnaces is expected to be of the order of 1 million tons of plain carbon and low alloy rail and structural steel compositions of which nearly 70% will be rimming quality steel and the rest 30% killed type. The open-hearth furnaces in the Bhilai plant will have magnesite bricks for the roof and provisions have also been made to double their capacities up to 500 tons each by a special design of the lower part of the furnace including flue, gas and air mains. The rolling mill will comprise of a 1,150 mm two high reversing blooming mill, a 700–500 mm continuous billet mill, a 950–800 mm rail and structural mill and a 350 mm merchant mill.

The Bhilai steel plant, when completed[19], will require 1·79 m tons of coal, 1·94 m tons of iron ore, 0·009 m tons of dolomite and 50,000 kW of electric power to give about 0·770 m tons of finished steel as given in Table IX, leaving a surplus of 0·30 m tons of pig iron for sale.

TABLE IX

Items of production at Bhilai

		Tons per year
1.	Rails—Standard gauge ...	100,000
2.	Rails—Narrow gauge ...	10,000
3.	Railway sleeper bars ...	90,000
4.	Standard and broad flanged beam channels, angles and other light and heavy structural sections (beams with section height up to 24″) ...	284,000
5.	Rounds from $\frac{7}{8}$″ to 3″ dia. and squares with sides from $\frac{7}{8}$″ to 3″	121,000
6.	Flats from 2″ to 5″ wide ...	15,000
7.	Billets for rolling at outside rolling mills from 2″ to 3″ × 3″ cross section	150,000
		770,000

Durgapur

The third integrated steel plant in the public sector is coming up at Durgapur about 110 miles from Calcutta at a cost of Rs. 138 crores[22] exclusive of the township, etc. The present capacity of the plant is 1 million tons of ingot crude steel, but with a few additions the same can be raised to 1·25 million tons whereas the layout provides for its ultimate expansion to 2·5 million tons.

Iron ore for this plant will be drawn from the well known deposits of Gua in Orissa. The coal to

be drawn from the Jharia coal fields will be washed and blended with the weakly coking coals of Barakar for carbonisation in the Durgapur batteries. Limestone will come from the Hathibari and Birmitrapur quarries, to start with, but prospecting is already going on to locate some source in close proximity to the works.

Durgapur plant is fortunate to have the Damodar river flowing along the sourthern side of the plant site and for electric power it is proposed to have a big thermal station constructed by the Damodar Valley Corporation close to the works, to be supplemented further by the 15,000 kW generated within the plant itself.

The salient features of the plant, the erection of which has been entrusted to a consortium of leading British steel and other allied interests, known as the Indian Steel Works Construction Co. Ltd., comprise[24] *inter alia* 3 blast furnaces each of 1,250 tons per day capacity, 7 open hearth furnaces of 200 tons capacity each and of 80 tons capacity for converting iron into steel, 3 batteries of coke ovens having two independently operated blocks of 39 ovens totalling 234 ovens capable of carbonising 5,200 tons of coal per day to deliver 3,900 tons of coke. The by-product plant will recover tar, sulphur, benzol, toulene, xylene and solvent naphtha. There will be a 60-ton capacity sulphuric acid plant for the manufacture of ammonium sulphate. The rolling mills comprise of a 42″–96″ blooming mill, a 32″–84″ intermediate mill, one continuous billet mill, one medium section mill, one sleeper plant capable of handling 1·25 million tons of standard size ingots and a wheel tyre and axle plant to meet the needs of the Indian Railways. In addition to this the plant will also have a tonnage oxygen plant of 50 tons per day capacity to meet the requirements of steel making processes. A central engineering and maintenance department and an iron and steel foundry with a production capacity of 20,000 tons of ingot moulds and 5,000 tons of other castings per year will also form part of the works.

This plant, when completed[10], will consume 1·83 million tons of coal, 1·94 million tons of iron ore, 0·064 million tons of manganese ore, 0·61 million tons of limestone, 0·4 million tons of dolomite and 40,000 kW of electric power to produce 1 million tons of ingot steel, i.e., 0·79 million tons of finished steel distributed as given below in Table X.

TABLE X

Items of production at Durgapur

1.	Heavy forging blooms ...	10,000	tons
2.	Merchant sections ...	240,000	,,
3.	Forging billets	60,000	,,
4.	Sleeper bars	60,000	,,
5.	Light sections	200,000	,,
6.	Forging blooms	30,000	,,
7.	Axles	12,000	,,
8.	Wheels and tyres ...	28,000	,,
9.	Billets for sale	150,000	,,
	Total	790,000	tons

Besides this about 350,000 tons of pig iron will also be available for sale. The construction work is fast progressing and by the end of this year one coke oven battery and one blast furnace will be brought into operation.

In Stage II by May 1960 the second coke oven battery and two blast furnaces[25], part of the steel plant comprising 3 open hearth furnaces and part of the rolling mills comprising a 42″–96″ blooming mill and a 32″–84″ intermediate mill and billet mills and the remainder of the power plant will be completed. In Stage III, by 1961, the remainder of the coke oven plant and the blast furnaces plant and rolling mill and the rest of the steel plant with 5 open hearth furnaces will be ready. In Stage IV the remainder of the steel plant and the wheel, tyre and axle plant will be brought into commission.

Thus we have seen that India's expansion programme to produce 6 million tons of steel is proceeding in the right direction and it is anticipated that the work cost[26] of 1 ton of ingot steel as calculated in the respective project reports will be Rs. 117/- per ton in Rourkela by the open hearth process and Rs. 98/- per ton by the L-D process while in the Bhilai plant it will be near about Rs. 112/- per ton by the open hearth process and in the Durgapur works it will be nearabout Rs. 104/- per ton by the Duplex process.

Due consideration has also been given to the type of finished products that will be produced in each works in relation to those that will be produced in the private sector and accordingly the plants have been designed. As for example in Rourkela the modern broad strip mill will produce only flat products, like flats, sheets and tin plates whereas in Bhilai rails and a heavy range of sections will be produced. Durgapur will manufacture relatively lighter sections besides wheels, tyres and axles. This will explain particularly the reason why there is a disparity in the cost of the three plants put up in the public sector.

Third Five Year Plan

In the Third Five Year Plan also this basic iron and steel industry is sure to receive proper support for its expansion. The target[27] of steel production in the Third Five Year Plan is expected to be fixed around 15 million tons.

To bring the steel production to 15 million tons, which will amount to an increase of 9 million tons over the target of the Second Five Year Plan, the authorities have in mind the further expansion of Tata Iron and Steel Company and Indian Iron and Steel Company, an increase of the production capacity of the steel plants in the public sector at Rourkela, Bhilai and Durgapur and also the establishment of a steel plant of 2·5 to 3 m. tons capacity at Bokaro in Bihar during the Third Plan period. For the location of this plant Rs. 50 lakhs has already been allotted to be spent in 1958–59 on preparatory work at site for the steel plant to

be established at Bokaro. Bokaro has many advantages as it is nearest to the coal fields of Kargali, Bokaro and Jharia although iron ore will be a little bit far away. But the authorities had taken into consideration that the wagon which will carry coal from Kargali and Jharia to Rourkela and Bhilai can bring back iron ore on their return journey.

With all the steel plants going into full production, we can confidently look forward with great optimism not only to meet our own demands but also to export our surplus to neighbouring countries.

References

1. "Developments in the Iron and Steel Industry during 1957" —Iron and Steel Engineer, Jan. 1958, pp. 139–189.
2. Lazar Roitburd "Soviet Iron and Steel Industry", p. 5.
3. China Today No. 1, 1959, Jan. 3rd, 1959, p. 7—Information Office of the Embassy of the People's Republic of China in India.
4. C. R. Wheeler—"Raw Material Supplies and the Future Development of Iron and Steel Industry", Journal of Iron and Steel Institute, pp. 101-102.
5. S. K. Nanavati—The Growth and Expansion of the Iron and Steel Industry—Presidential address at the Indian Institute of Metals, p. 2.
6. E. T. Warren—"Steel Industry in India, Yesterday, today and tomorrow"—Iron and Steel Engineer, Nov. 57. pp. 85.
7. Government of India, Planning Commission "Programme of Industrial Development" 1956–61, pp. 1.
8. Metallurgical Industries; Programme of Industrial Development 1951–56, p. 12.
9. "Iron Ore", Mineral Production in India, 1956, Ministry of Steel, Mine and Fuel; Indian Bureau of Mines, New Delhi, p. 70.
10. "Coal", India in Industries; Indian Market Research Bureau, p. 25.
11. A. Lahiri, A. Ghosal and N. C. Sinha; Hard Coke Requirements in India: Proceedings of National Metallurgical Laboratory, Symposium on "Foundry Technology".
12. G. C. Sarkar and S. K. Mitra—"Cleaning of Coal for the Industries"; Journal of Iron and Steel Review, Vol. 2, No. 6, p, 476.
13. S. K. Borooh, Director of Geology and Mining, Madhya Pradesh—"A short note on Manganese Industries in Madhya Pradesh".
14. Brochure prepared by Indian Bureau of Mines on the occasion of India 1958 Exhibition.
15. Manganese Ore; Mineral Production in India 1956, Indian Bureau of Mines, Ministry of Steel, Mines and Fuel. p. 88.
16. Limestone; Mineral Production in India, Indian Bureau of Mines, Ministry of Steel, Mines and Fuel, p. 83.
17. Monthly Statistics of Foreign Trade in India, Dec. 1957 Issue.
18. India's Mineral Wealth; Industrial Products Part IV, Ferro-Alloys, p. 9.
19. Nijhawan and Gupte; Manufacture of Ferro-Alloys; National Metallurgical Laboratory Symposium on "Alloy and Special Steel" proceedings, p. 122.
20. "Iron and Steel Industry"; Indian Engineering Industries, 1958 Edition, p. 275.
21. TISCO News, Oct. 10, 1959, Vol. 5, No. 16, p. 11.
22. Hindustan Steel Ltd. Brochure prepared at India. 1958 Exhibition.
23. M. N. Khanna, Metallurgical Aspects of Bhilai Steel Plant; Indian Construction News, Vol. 7, No. 6, June, 1958.
24. P. K. Banerjee; "Integrated Steel Project at Durgapur", Indian Construction News, Vol. 7, No. 7.
25. Indian Construction News, Vol. 7, No. 9, Sept. 1958, p. 80.
26. Journal of Industry and Trade, Oct. 1958, p. 1461.
27. "Steel in Third Plan"; Journal of Industry and Trade, Mar. 1958.