ALLOY STEEL INDUSTRY IN INDIA — HISTORICAL

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Abstract

Perhaps the most significant development in India in the ferrous metallurgical field during the last World War was the making of alloy and tool steels for strategic military and civilian uses. Unfortunately progress in this department has not continued. This is, in fact, a department of the steel industry in India where the general advances characterizing the period since independence have not so far been reflected. An attempt is made to visualize the present and future quantitative requirements in respect of alloy and special steels in India, and to indicate the steps which require to be taken to meet the expected demands.

STEEL-MAKING in India goes back to early times, and a modern steel industry has flourished for nearly fifty years thanks to the lead given by J. N. Tata. In view, however, of the relatively little developed state of Indian engineering industries, in the years before the war, of a sorts which might consume alloy steels and the almost total dependence at that time on importations of engineering machinery and related equipment from U.K., only small demands had been felt for alloy and special steels prior to the outbreak of hostilities. No official statistics are available, but the total demands were estimated by the Tata Iron & Steel Co. Ltd. as around 3000 tons per annum of alloy and special steels (mostly tool steels), with the following breakdown:

	Tons
High-speed steels	250-300
Alloy steels	300-500
Stainless steels	100
Hollow drill steels	400 (approx.)
Carbon tool steels	1500 (2000)

These figures are far below the levels needed to sustain a special steel industry. It is accordingly small wonder that up to the war, India's steelworks had confined themselves to the production of plain-carbon steels. The ordnance factories and certain other plants with electric furnaces did, however, make small quantities of alloy and tool steels, mostly to meet demands within the industry, together with spring steels for the Indian railways. So far as the Tatas were concerned, the major contribution at this period was the production of low-alloy high-tensile plate and sheet steels, for bridge building (TISCROM) and railway coaches (TISCOR).

Amongst notable applications to date of alloy steels in India was the construction of the Howrah Bridge in which Tatas' Tiscrom, a chromium and copper-containing steel, was extensively used. This steel was chosen partly for its increased corrosion resistance, about three times that of mild steel, and also because of its higher strength which allowed lighter design; it also had the merit of ready availability in India. Steels of this type which can be used in slender sections straight from rolling have many attractions to the civil engineer. They become especially attractive when high strength and corrosion resistance are accompanied by unimpaired or scarcely impaired weldability as compared with mild steel.

The most significant metallurgical development in India during the last World War was the making of the alloy and tool steels required for defence purposes and important civilian uses. When in 1940-41 India was virtually cut off from the Allied nations, the General Staff found it next to impossible to obtain armour plating required for armoured carriers for the Eastern campaigns. The Tatas rose to the occasion and met the demand by supplying bullet-proof plating which stood the most searching tests. Thus, it became possible to produce as many as 5000 armoured vehicles in India known as 'Tata Nagars', on chassis imported from Canada.

Limitations of equipment and experience were counteracted by ingenuity and enterprise, sometimes at the expense of rather wasteful use of raw materials, but without disadvantage in the product. Absence of oil-hardening facilities caused an air-hardening steel to be chosen against the trend elsewhere, while in the absence of adequate soaking-pit facilities to prevent hair-line cracking in such a highly hardenable steel, alternative methods of slow-cooling had to be improvised.

Initially the production of these alloy steels came to about 250 tons per month, but rose to 500 tons early in 1941. In 1942 production reached a maximum of 1000 tons per month. Not only bullet-proof armour plates, but special alloy steel rivet bars and a special welding electrode used with these were made by the Tatas. Production of armour-piercing shot was then taken up and at the same time special alloy steel plates were made for the proofing of armour-piercing shot. Composite plates to withstand the attacks of 2-pounder shot, etc., were also made. Other war-time achievements in steel-making were Admiralty 'D' steel for shipbuilding, high-speed steel for tooling up machine tools, high-carbon steels for the manufacture of mint-dies, and other types of plain-carbon steels for high explosive shells and a special alloy steel for parachute harness, nickel steel plates for gun carriages, and the special high-alloyed nickel-manganese non-magnetic steel for use in the manufacture of service helmets, while stainless steels for surgical instruments were made for the first time in India.

About the middle of 1943, the Tatas installed a half-ton high-frequency furnace on behalf of the Government of India. This furnace, together with their two 5-ton electric furnaces, was used for the making of special alloy and tool steels. A ferro-alloy plant with 4 electric arc furnaces for the production of ferro-tungsten was also started in April 1943 and 48 tons of ferro-tungsten were produced in 1943-44.

For meeting the requirements of ferro-vanadium, essential for the manufacture of certain grades of tool and alloy steels, a plant for the extraction of vanadium from the indigenous vanadium-bearing iron ores was established by the Tatas.

Similarly, the Mysore Iron & Steel Works made alloy steels in war time including high-speed tool steels for their own use and that of other State departments.

At these centres, alloy steel production continued in the years following the war and the attainment of independence. The following figures, which relate to this period, are of interest.

Metal & Steel (Ordnance) Factory, Ishapur

	April 1947 to March 1948	April-December 1948
	Tons	Tons
Alloy steels	480	247
Tool steels	32	252
Special steels	22	88

Production Figures (in tons)

The Tata Iron & Steel Co. Ltd.

	1946-47	1947-48	1948-49
High-speed	25	30	89
Stainless and heat-	27	22	20
resisting steels			1766
Other alloy steels	217	600	—

	1949-50	1950-51	1951-52 (April-July)
High-speed	79	79	6
Stainless and heat-	27	5	9
resisting steels	1330	2017	289
Other alloy steels	—	—	—

Mysore Iron & Steel Works Ltd.

	1946	1947	1948	1949	1950
Austenitic Mn steel	68	94	32	26	27
Low-alloy steel	1	4	27	15	43
High-silicon acid-resisting steel	$\frac{1}{2}$	1	5	2	2
Heat-resisting steel	—	—	1	1	2
High-speed tool steel	1	1	2	3	3
Ni-Hard pig iron	—	—	—	—	25

The change in Governmental policy during the war period towards encouragement of Indian self-sufficiency had resulted in an increase in engineering industry and a consequent appreciable increase in the demand for alloy and special steels. In the years immediately after World War II, the Tata Iron & Steel Co. Ltd. made the following estimates of the Indian demand. It will be seen to be approximately three times that made about seven years earlier. Nevertheless, the figures still remained too low to justify a special steel industry in India and the Tatas eventually decided to shut down their production and disperse their stocks.

Steel	*Post-war annual demand within five years or so* *Tons*
High-speed steels	300-350
Carbon tool steels	3000-4000
Alloy steels	2000-3000
Drill steels	1000
Stainless steels	200-300

The detailed circumstances leading to the post-war shut-down of most alloy steel production in India (in fact, all except silicon sheet steel, silico-manganese spring steel and alloy steel castings) are not known to the authors and might in any case be beyond the scope of the present paper, but it is suggested that the following were amongst the pertinent issues: (i) The estimated demand did not give a stable basis for the industry. (ii) Production of alloy steels needs to rest on a firm foundation of ferro-alloy manufacture, but the war-time efforts at ferro-alloy production had not concerned the alloys mainly required and did not themselves rest on a very firm foundation. Where ferro-alloy manufacture has been firmly established (i.e. ferro-silicon), the alloy steels related to this ferro-alloy have continued and prospered in manufacture. (iii) In the works where alloy steel manufacture was attempted, the plant was mainly intended for other purposes and the furnaces specially installed were not at the immediate disposal of the steelworks, being Government property. The same applied to alloy stocks. (iv) In many ways, production had been improvised and especially: (a) the soaking-pit capacity needed for alloy steels was short, so that difficulties often arose in finding ways of dispensing with its use; (b) the works were not in possession of facilities for supplying materials regularly as heat-treated; (c) the payment systems, based on tonnage production of mild steel, could not easily be adapted to an alloy steel programme. (v) The steelworks were sanguine of completing licence agreements with overseas producers which would involve a fresh start and saw no reason to continue to war-time arrangements. (vi) A period ensued, during the Korean war, when world alloy shortages were intensified as compared with those during World War II, and allocation schemes were launched which gravely discouraged alloy steel production except where already well established.

In expansion of the remarks at (ii) above, it is pointed out that the production of special alloy and tool steels requires the use of a large number of special alloying elements, the chief of which are aluminium, manganese, chromium, cobalt, nickel, molybdenum, tungsten, titanium and vanadium. Apart from the alloying elements, the base metal itself should be of the highest quality. With regard to alloying elements, except for manganese, titanium, silicon and to a lesser extent vanadium and chromium, there are no occurrences of any importance in the country. Under the present conditions, India will have to depend upon other countries for the supply of nickel, cobalt, molybdenum and tungsten. With regard to vanadium, certain Indian magnetite ores contain about 1·5-2·5 per cent of vanadium pentoxide. Though this can be extracted in the country, with the small quantity contained in the available ores, it is very probable that the cost of extraction would be higher than that of imported ferro-vanadium.

Such considerations make it evident that an Indian alloy steel industry must be integrally planned, with composition rationalized in terms of available source materials.

The main applications for alloy steels relate to mechanical engineering, for which the combinations of strength, ductility and toughness given by steels in the as-rolled or normalized condition are relatively unattractive. Better combinations of these properties are given by hardened and tempered steels. Hardening and tempering are, however, only of limited application to plain-carbon steels for two reasons: (i) all plain-carbon steels have only limited hardenability (depth of hardening) and can only be properly hardened in small sections and then by severe quenching, e.g. high-carbon steels can be hardened throughout in 1 in. bars by water-quenching, but no larger section can be through-hardened by any means; (ii) the conditions of severe quenching and high carbon content needed to give reasonable depth-hardening in plain-carbon steels lead to cracking, which whether on a macro or micro-scale is very detrimental. A steel with a suitable combination of alloying elements has greatly increased hardenability. For example, a 6 in. bar of a 3 per cent chromium-molybdenum alloy steel may be fully hardened by air-cooling from its hardening temperature. Heat-treatable alloy steels thus allow the engineer to use large sections with high specific stressing and thus to effect great economy in steel.

The engineering industry of a country must, however, develop to certain quantitative and qualitative levels before an insistent demand is felt for the alloy constructional steels. An earlier demand was felt, in fact, for certain special purpose steels in India. This included silicon sheet steel, under regular production here by the Tatas since the last 10 years, and stainless steel.

The All-India Non-ferrous Metalware Manufacturers' Association have urged in a memorandum submitted that it would be in the interest of the country to manufacture adequate quantities of stainless steel, since 3200 tons are imported annually involving foreign exchange equivalent to Rs. 2 crores. They suggest that one of the three steel plants should manufacture a minimum of 6000 tons of stainless steel. The following import figures for stainless steel in tons are given: 819 (1951), 1143 (1952), 1286 (1953), 3087 (1954), 1619 (January-June 1955).

The total alloy and special steels, including stainless steel imports, as revealed by the official statistics, have been indicated as follows:

1952 — 5138 tons including 26 per cent of stainless steel

1953 — 3930 tons including 36 per cent of stainless steel

1954 — 7554 tons including 43 per cent of stainless steel

1957 — Estimated demand by the Iron and Steel Controller of alloy and special steel is 9158 tons including 4265 tons of stainless steel.

In the above, the phrase 'as revealed by the official statistics' is used to indicate a degree of doubt. It is not suggested that these quantities were not imported; rather the doubt is whether much larger quantities were not imported in the guise of machinery and equipment components. The figures clearly do not include constructional steels.

First and Second Five Year Plans

Under the First Five Year Plan the subject of setting up of an integrated alloy and steel plant was not given the consideration it deserved, even though the economics of the alloy steel production is of considerable potential. This can be realized from the position that in England out of the total production of about 19-20 million tons of steels including 1 million alloy steels, the total value of the former is equivalent to that of the latter.

In the Second Five Year Plan some attempt has been made to rectify the omission and numerous statements have been made that the Mysore Iron & Steel Works is to accommodate the future alloy, tool and special steel industry of this country.

The Planning Commission's Steering Committee that met recently in Delhi has approved the inclusion, during the Second Five Year Plan, of a ferro-alloy and tool steel plant at the Mysore Iron & Steel Works. This is based on the recommendations of the American consultants, Messrs Ramseyer and Miller, and also on the needs of large-scale capital goods industries envisaged in the Second Five Year Plan. Rupees 17 crores are to be spent on its development to produce alloy and tool steels in the Second Five Year Plan.

Targets of 76,000 tons of commercial steel, 2000 tons of spring steel, 15,000 tons of stainless steel, 2000 tons of alloy and tool steel and 5000 tons of wire and wire products have been established. The output of ferro-alloys is to be stepped up from 4000 tons to 30,000 tons.

In the authors' view this scheme is too limited to meet India's full needs. It altogether omits the most important class of alloy steels, alloy constructional steels. Moreover, it attaches the stainless steel industry to a firm without sheet-rolling facilities or experience. It has already been mentioned that India imports a considerable tonnage of stainless steel. The demand is virtually certain to increase quite considerably for both industrial and domestic applications. There appears to be room in India for the establishment of a stainless steel industry on the scale of some 30,000 tons per annum at this stage, mainly in the form of sheets. In view of the nickel position, it will be necessary to concentrate on producing nickel-free or low-nickel types, e.g. 12 per cent chromium steel, 18 per cent chromium-iron, 18 per cent chromium - 2 per cent nickel steel (S 80) and 18 per cent chromium-manganese (nickel) types of austenitic steels. In the last-named range, the compositions suitable for combating atmospheric corrosion under Indian conditions cannot be defined without further research, though there are indications that a chromium-manganese-nickel steel should meet most requirements. There may also be room for the development in India of special varieties of such steels for high-temperature applications, as in the sheet metal components of gas turbines.

Alloy steel production in India in either the high-tensile structural category or the heat-treatable constructional range is very limited, and considerable imports are being made of special and alloy steels. It does not seem unlikely that, in a few years, the demand for alloy steels in India will be in the same proportion to the total steel production as in other steel-producing countries, where the figure ranges from 5 to 15 per cent of total production. On the basis of a 6-million ton steel capacity, one may anticipate at least 300,000 tons per annum of alloy steels. The preponderance will obviously belong to the two categories referred to above, but there will also be large needs for stainless steels and considerable, though smaller, needs for tool steels.

Such an alloy steel programme would place large demands on alloy source materials and it seems important that whatever can be done to supply these needs indigenously should be done. The main alloy demands will be for chromium and for manganese. It is easy to envisage a demand for at least 10,000 tons per annum of 75 per cent ferro-chrome; this would be provided from Indian ores once the extraction plant was set up. The reduction could be along normal electric furnace lines or could make use of the finding of the National Metallurgical Laboratory that a serviceable grade of ferro-chrome can be made from fairly low-grade chromite by reduction with ferro-silicon plus aluminium in the electric furnace.

In this connection, and in relation to Government plans to increase production of ordinary steels in India to 6 million tons per annum, sight must not be lost of the need to employ resources to the best advantage. If modifications of practice in existing steel plants can increase the yield of finished steel per ton of ingots, can make efficient local use of scrap which has formerly been sold abroad, or can economize in the weight of finished steel used to build an engineering structure, the advantage will be tremendous.

If India is to take her rightful place in the comity of nations as a powerful modern and heavily industrialized republic, as justified by her mineral potential and reserves, it will be, in our opinion, better to err on the higher side than accept a low demand estimate so far as alloy and special steels are concerned.

It should not be overlooked that India can be a potential exporter of alloy and special steels to South-Eastern Asian countries, East Asian and Far-Eastern countries, including Australia, where such products should prove valuable bargaining counters for the resources of which India is short. In our opinion, it would not be at all reckless if plans were to be drawn up for setting up, during the term of the Second Five Year Plan, a $\frac{1}{3}$ million ton unit for alloy and special steel plant capable of later expansion to 1 million ton, in addition to implementing the Mysore programme and encouraging small producers to use their electric furnaces for alloy steels within their capacity. The new plant should employ modern innovations like oxygen lancing for the production of low-carbon austenitic stainless and continuous casting of alloy steel ingot. The National Metallurgical Laboratory and the proposed alloy and special steel plant should be closely linked, as the press told us a year or two ago in connection with a separate department for alloy and special steel production which was supposed to be set up at Hindustan Steel Plant at Rourkela.

The $\frac{1}{3}$ million ton alloy and special steel plant should include a potential of 30,000 tons of stainless steel sheets, castings, etc., so that India can go in for stainless steel stream-lined railway trains, aim to provide a stainless steel kitchen in every home, make extensive use of stainless steel decorations for architectural purposes, expand her chemical and fertilizer industry (as has been proposed ' three Sindris during the Second Five Year Plan '), expand her aircraft industry along modern lines and progress along a multitude of other engineering industries.

Possession of an alloy and special steel industry on these lines would be of great importance to maintain the progress of India's advance. It would be especially valuable if an emergency arose which concerned or isolated India. It has been observed that whenever there is an international tension or war emergency, India's position relating to her requirements of alloy and special steels becomes most unbalanced and precarious. In the last full-scale emergency the situation could be met by improvisation. With the greatly increased demands which industrial development has brought, improvisation could not be relied on in any future emergency. The situation calls for a bold and vigorous solution such as has been proposed in this short review.