Reprinted from the Journal of the Institution of Engineers (India) vol 58 MM No. 2, November, 1977.

UDC 622.346.1

Resources, Conservation and Utilization of Chromite Ores in India

S Misra, *Non-member*
A Sarangi, *Non-member*
G K Roy. *Member*
K K Tripathy, *Non-member*

Chromite, being the primary source for manufacture of many industrially important alloys, chemicals and refractories, is a valuable and strategic raw material. The total chromite resources of India at present are estimated at about 17 mt. Orissa accounts for about 85% of the above reserves and about 99% of the present total annual production. In spite of this, India imports a substantial quantity of chrome finished products and exports a substantial quantity of chrome ores. With the present trend of export, the chromite deposit of India is estimated to fast only for about 50 years. This paper stresses the urgent need for conservation of this ore and highlights its proper and judicious utilization with reference to the present and future trend of consumption. Recommendations for proper utilization by way of establishing new industries have been made.

INTRODUCTION

The versatile use of chromite in metallurgical, refractory and chemical industries makes it a valuable raw material. Though the Indian chromite trade represents about *4%* of the international trade, the country has a modest chromite reserve. Furthermore, a consolidated account of the total Indian requirements of chromite and its exports (Table 1) shows that more than 50% of the ores produced are being exported at present because of lack of facilities . for proper indigenous utilization. If the present trend continues, it has been estimated that the total chromite deposits in the country will last only about 50 years, thus making its conservation and proper utilization essential.

In spite of the boom in the industrial production of metals and alloys after the independence, practically the entire requirement of chromium metal and its alloys needed in our industries was imported up to 1967.

Production of some of these items was started in the 1967-68, and it is envisaged that the country will attain self-sufficiency in this field by the end of the Fifth Plan. Keeping this in view, a decision to restrict further exports of chromite ores was taken by the Government of India in August 1975. Considering the continuous increase in the demand for chromium metal and its alloys in various industrial sectors in the country and our inability to afford their imports because of the country's vulnerable foreign exchange situation, it has

TABLE 1 CHROMITE REQUIREMENT OF INDIA UNDER VARIOUS HEADS, mt

Consuming Product	Production of Consuming Product			Chromite Consumption Norm Tonnes Unit	Chromite Required		
	1973-74	1978-79	1983-84		1973-74	1978-79	1983-84
*Ferro chrome	0.01	0.027	0.034	2.2	0.022	0.0594	0.0748
*Reftactories	1.25	2.000	3.000	0.04	0.050	0.0800	0.1200
Bichromates	0.01	0.015	0.020	1.70	0.017	0.0255	0.0340
Other uses	—	—	—	—	0.001	0.0015	0.0020
Export	—	—	—	—	0.198	0.2500	0.2000
Total					0.288	0.4164	0.4308

*Export figures included
**From material balance

S Mishra, A Sarangi, G K Roy and K K Tripathy are with Regional Engineering College, Rourkela.
This paper was received on January 18,1977. Written discussion on this paper will be received until January 31,1978.

TABLE 2 ESTIMATE RESERVE OF CHROME ORE IN ORISSA AGAINST ALL INDIA TOTAL (X 10^3 mt)

	LUMP	FINES	LUMP AND FINES	ALL ORISSA	% ALL INDIA	PROVED RESERVE
Cuttack	3 076.0	10 219	269.7	91.79%	78.56	3 860 (400 met grade)
Dhenkanal	64.8		187.6	1.71%	1.46	—
Keonjhar	218.6		740.6	6.50%	5.55	200 (all met grade)
Total Orissa	3 359.6	10 219	1197.9	14 776.7	85.57	—
Total India	3 585.8	10 369.9	3308	17 264	100.00	

been decided to find out methods and means for their indigenous production at the earliest, both in order to meet the internal requirements and to seek possibilities of exporting finished or semi-finished products in place of the raw ores.

ORE RESERVES

While the total resource position of chromite in India is 30 to 45 mt, the total proved and indicated reserves are estimated to be of the order of only 17 mt. This is insignificant compared to the total world reserve of nearly 3 000 mt The chromite reserves of Orissa, amounting to about 14.8 mt, represent about 85% of the all India figure and includes the entire quantity of metallurgical grade ore available in the country (Tables 2 and 3).

Orissa accounts for about 99% of the total production of chromite in the country (Fig 1).

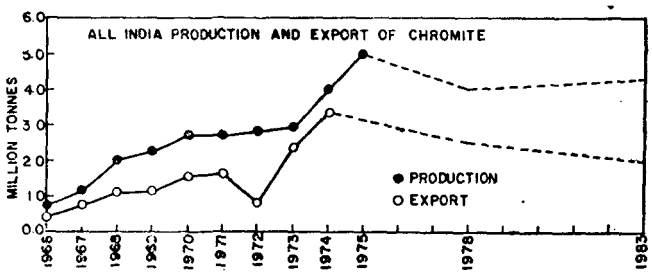

Fig 1

CONSUMPTION OF CHROMITE IN INDIA

Chromite consumption in India in order of magnitude can be broadly grouped under three categories, namely, metallurgical, refractory and chemicals. The present average relative consumption in these sectors is approximately 25%, 55% and 19%, compared *to* the USA figures of 65%, 25% and 10% respectively[3]. Other uses of chromite in India are very small and represent only about 1% of the total consumption. The annual requirement of chromite in the country (Table 1) has been arrived at on the basis of its different uses in various industrial sectors.

FERROCHROME

The most important application of chromite in metallurgical industries is in the form of ferrochrome which is the principal alloy addition used for the manufacture of tool, alloy and special steels containing chromium. Its widest application is in the manufacture of stainless and heat resisting steels in which the chromium content ranges from 12 *to* 28%. In the manufacture of alloy, tool and die steels the chromium content ranges from 1 to 12%.

Ferrochrome requirement of a country is generally assumed to be proportionate to steel production. The planning group of the Ministry of Steel and Mines, Government of India, have fixed this factor of proportionality at 0.15% for India* which is lower compared to 0.18% for the USA's. In terms of the total alloy steel consumption in the country, this factor is about 1.6%. The production, import and apparent consumption of alloy steels annually in India[3-5] are shown in Fig 2.

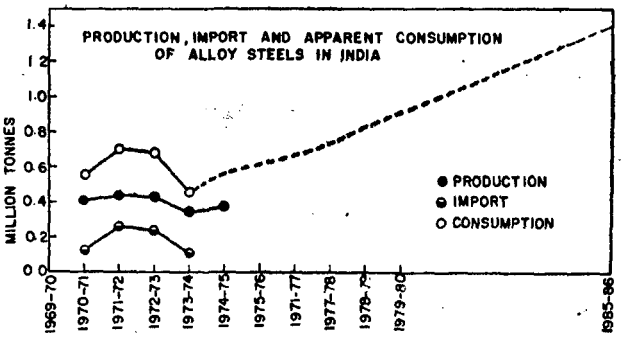

Fig 2

On the basis of the above criteria, the apparent annual consumption of ferrochrome in the country has been estimated (Fig 3) together with the annual production figures[6]. Out of the annual consumption of about 10 000t of ferrochrome, approximately 2 000t of the low-carbon variety is required for stainless and other low carbon alloy steel production. On an average about 1 500t of low-carbon ferrochrome is produced annually in the country, and the rest is imported to meet the requirement of these industries at present.

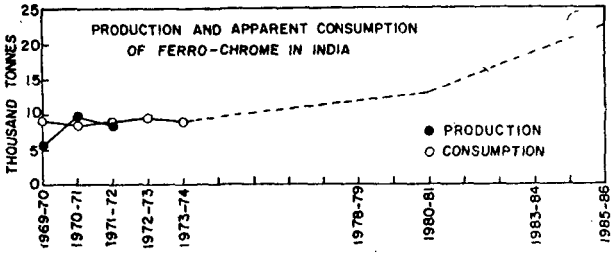

Fig 3

SILICO-CHROME

Silico-chrome is used as an alloy addition for making heat resisting steels. At present, about 50 t of silico-chrome is produced by Visvesvaraya Iron and Steel Limited, Mysore, on a captive consumption basis. It

TABLE 3 DISTRICT AND CATEGORYWISE RESERVES OF CHROMITE IN ORISSA STATE
(As on 1.1.1975)

District	Lease-hold	$\%Cr_2O_3$	Measured			Indicated			Inferred			Total		
			L	F	L+F	L	F	L+F	L	F	L+F	L	F	L+F
Cuttack	A	Above 45	—	92,632	—	65,572	290,064	269,725	110,468	239,990	—	176,040	622,686	269,725
		35—45	—	—	—	21,762	333,422	—	13,557	97,914	—	37,319	431,336	—
		Below 35	—	—	—	1,627	160,357	—	—	33,645	—	1,627	194,002	—
	B	Above 45	—	1,123,141	—	—	972,562	—	—	—	—	—	2,095,703	—
		35—45	78,213	398,864	—	1,000	227,445	—	—	—	—	79,213	626,309	—
		Below 35	78,831	125,000	—	230	78,750	—	—	—	—	79,061	203,750	—
	C		—	—	—	—	—	—	—	—	—	—	—	—
	D	Above 45	—	—	—	573,549	760,149	—	345,400	1,384,795	—	918,949	2,144,944	—
		35—45	—	—	—	1,189,000	499,300	—	425,000	1,061,034	—	1,614,000	1,560,334	—
		Below 35	—	—	—	290,000	759,700	—	—	1,089,670	—	290,000	1,849,370	—
Keonjhar	A	37—46	—	—	—	38,350	—	—	—	—	—	38,350	—	—
	B	40—55	—	—	—	—	—	53,331	—	—	416,968	—	—	470,299
	C	Above 45	—	—	—	—	—	—	—	—	32,385	—	—	32,385
		35—45	—	—	—	—	—	—	—	—	32,385	—	—	32,385
		All grades	—	—	—	—	—	—	—	—	205,511	—	—	205,511
	D	36—54	—	—	—	—	—	—	180,237	—	—	180,237	—	—
Dhenkanal	A	Above 40	—	—	—	—	—	—	—	—	26,584	—	—	26,584
	B	—	—	—	—	—	—	—	—	—	—	—	—	—
	C	All grades	—	—	—	—	—	—	37,000	—	161,075	37,000	—	161,075
	D	Above 40	34,795	—	—	42,000	—	—	27,858	—	—	104,653	—	—
			191,839	1,739,637	—	2,223,090	4,081,749	323,056	1,141,520	3,907,048	874,908	3,556,449	9,728,434	1,197,964

Note : *Leasehold*
A=Public Sector non-captive
B=Private Sector non-captive
C=Free hold
D=Private Sector captive

Total reserves of Orissa State : 14 482 847 t.

Chromite
L=Lump
F=Fine
L+F=Undifferentiated lump and fines.

is also manufactured by the ferrochrome plant at Jajpur, Orissa. The production figures in metric tonnes for the Jajpur plant are: 1580.2 (1970-71), 2546.55 (1971-72), 2418.97 (1972-73) and 693.2 (1973-74).

CHROMIUM METAL

Chromium metal is used as alloying element together with metals such as nickel and copper for the production of super-alloys and chromium bronze, etc. It is either produced electrolytically from solutions of chromium salts (chromium sulphate, chromic acid) or by aluminothermic reduction of chromium oxide. The metal, at present, is not produced in India in any appreciable quantity and the total annual requirement of 30 to 40 t is being met essentially by import.[8] With the commissioning of the super-alloy plant at Hyderabad, the demand for chromium metal will further increase.

REFRACTORIES

The manufacture of chromite refractories, which consist mainly of chrome, chrome-magnesite, chrome-aluminium and magnesite-chrome refractories, account for major chromite consumption (about 55% of the total consumption) in the country. In assessing the demand of chromite in refractory industry, it is assumed that the chromite requirement is about 4% of the total refractory requirement in the country.[4] The total quantity of chromite refractories produced in India is consumed in metallurgical industries and research laboratories. Considering the total requirement of 1.25 mt of refractories in the country[2] chromite requirement in refractory industry has been put at 0.05 mt in 1973-74, which is in fair agreement with the estimates made by the Task Force on Metallurgical and Refractory Minerals, Government of India.

CHROME CHEMICALS

Chrome chemicals find wide applications in tanning, dyeing, electrochemical, pigment, disingfectant, glass and ceramic industries. By far the largest quantity of chromite is used in the form of bichromate, primarily in the tanning industry. The present annual consumption of bichromate is about 10 000 t and the country is self-sufficient in bichromate production. The present annual consumption of chromic acid, which is mainly used in electroplating industry, is around 1 000 t. The use of other chrome chemicals in the country is comparatively small; their annual consumption[2] in terms of chromite being about 1 000 t.

CONSUMPTION TRENDS OF CHROMITE IN INDIA

FERROCHROME

Though the apparent consumption trend of ferrochrome in the past few years indicates an upward trend, the growth rate is not high since it is linked with the total alloy steel production in the country. Prior to 1967-68, the country was practically dependent on imports to meet its requirements of tool, alloy and special steels. The present apparent annual consumption of alloy steels in the country is around 0.6 mt and it is estimated that the pick up in its annual demand by 1978-79 and 1985-86 will be around[5] 0.8 and 1.4 mt (Fig 2) corresponding to an annual ferrochrome consumption of around 13 000 and 22 500 t respectively. The annual requirements of ferrochrome in the country by 1978-79 and 1983-84 will thus be around 12 000 t and 19 000 t respectively (Fig 3). The ferrochrome requirements in the country estimated by the Task Force of Steering Group of Iron and Steel, Government of India, and by the Indian Bureau of Mines are at variance by a wide margin.[7] The present estimates based on the total steel as well as the total alloy steel productions in the country are in close agreement with those of Indian Bureau of Mines. The estimates made by the above organizations together with the present estimates made by the authors are given in Table 4.

TABLE 4 TOTAL FERROCHROME REQUIREMENT OF INDIA (mt)

Estimate Made by Task Force of Steering Group of Iron and Steel		Estimate Made by Indian Bureau of Mines		Our Estimate	
1980	1985	1978-79	1983-84	1980	1985
68150	1 10 180	17 320	19 760	12 000	19 000

The present annual licenced capacity of ferrochrome production in India is 20 000 t and the Government has licenced a further capacity of 15 000 t per year earmarked exclusively for export.[9] The total annual production of ferrochrome in the country including the export figures will thus be around 27 000 t and 34 000 t by 1978-79 and 1983-84 respectively. However, the existing capacity for ferrochrome production in the country is much in excess of the internal demand and the industry will have to find an annual export market for about 15 000 t of ferrochrome by 1985 if it has to work on an economic basis.

CHROMIUM METAL

As mentioned earlier, the total quantity of chromium metal required in the country is almost exclusively imported at present. The super-alloy plant at Hyderabad will alone consume about 50 t of chromium metal by the end of Fifth Plan when it starts production. It is planned that the annual capacity of the plant will be doubled in the next five years.[10] Taking into account the present consumption, the country's total annual chromium metal requirements will be about 100 and 150 t by 1978-79 and 1983-84, respectively.

REFRACTORIES

The estimated annual consumption of refractories in the country is likely to increase to 2 and 3 mt corresponding to chromite requirements of 0.08 and 0.12 mt, by 1978-79 and 1983-84, respectively.[2] These figures are higher than the estimates made by the Task Force on Metallurgical and Refractory Minerals, Government of India and by the Indian Bureau of Mines. The Task Force's estimates of annual chromite requirements for refractories are 0.062 mt and 0.084 mt by 1979 and 1984 respectively, whereas the Indian Bureau of Mines puts these figures at 0.076 mt by 1983-84.

The lower demand projection of chromite for refractory use made by the above agencies is probably due to the assumption that the future steel plants will go in for the LD process of steel making which requires much less quantity of chromite refractories. However, the expansions and new installation of ferro-alloy and alloy steel units with the accompanying demand on chrome refractories is likely to justify the higher projection demand. Besides, the export possibility of chrome refractories can be explored.

A similar increase in the consumption trend of chrome chemicals is also expected.. The annual consumption of bichromate alone will be around 15 000 and 20 000 t by 1978-79 and 1983-84, respectively. Corresponding increase in the consumption of other chrome chemicals is also expected during the same period. Chromite requirement for other chrome chemicals and also for the production of chromium metal which is likely to be taken up is rather small and is included in the estimates for other uses of chromite (Table 1).

CONSERVATION

Chromite ore reserves are expected to last only 50 years. It is seen that the lumpy metallurgical grade reserves are only 0.23 mt, the demand for which is increasing continuously. Further, about 70% of the total chromite deposits occur as fines and in addition a substantial amount of fines are also produced (approximately 2 t of fines per tonne of lumpy ore) during mining operation. The high grade fines cannot be used in metallurgical industries unless they are agglomerated in the form of pellets or briquettes. At present, some of these fines are exported and the excess is dumped at the mine site. The price difference of about Rs 800 t between the lumpy ore and the fines is sufficient to justify the commercial viability of the agglomeration of chromite fines.*'

A major amout of the total Indian deposits of chromite is of non-metallurgical grade. Some of these can be benenciated to increase the Cr:Fe ratio for metallurgical and other uses. Thus, beneficiation and agglomeration constitute important aspects in the conservation of this strategic raw material. It is therefore necessary to evolve a material strategy for judicious conservation of country's limited high grade chromite ores and use the low grade ores to the maximum extent possible.

RECOMMENDATIONS

Considering the chromite consumption pattern and the restriction imposed by the Government on its export, the immediate future of chromite based industries does not seem to be very promising unless the export possibilities of either finished or semi-finished chromium products are substantially increased. The export of finished chromium products such as sophisticated special steels may not meet with much success since this is likely to be resisted by the industries in the developed countries. The penetration of export market at the initial stage through semi-finished products appears to be more promising.

In view of the above possibility together with the discussions made earlier, the following recommendations are put forward for better utilization of the chromite resources of the country :

1. There is better scope for production as well as possible export of pure chromium metal in the country at present. The entire chromium requirement of the country is now being imported and the super-alloy plant at Hyderabad will also import its requirements till it is produced indigenously. Adequate steps, therefore, may be taken to produce it as early as possible in the country. This may either be achieved by setting up of a new plant at a suitable site in Orissa or by making necessary provisions for its production in the existing ferrochrome plant at Jajpur by either of the standard techniques of aluminothermic reduction of electrolytic extruction. A plant with a production capacity of 200 t per year is suggested.

2. In Orissa, there are adequate resources for the production of alloy steels-especially nickel-chromium steel. The only source of nickel in India is in Sukinda which is likely to go into production in the near future. Since the pickup in the demand of alloy steels from 1980 to 1985 is estimated at 0.6 mt, an alloy steel plant with an annual capacity of 0.1 mt for the production of stainless and heat resisting steels may be set up in Orissa. This plant may also include the production of manganese steel and silicon steel since the raw materials for these are also produced in Orissa. Production of super-alloys need not be included in this plant since these will be produced by the super-alloy plant at Hyderabad. In view of the proximity of the ferrochrome plant at Jajpur to the nickel and chromite belt of Sukinda and availability of adequate power and water supply, locating of the alloy steel plant in this vicinity may be explored.

3. Necessary steps may be taken to increase the production of chrome refractories in the existing plants to meet the increasing demand. However, it may be worthwhile looking into the possibility of setting up of new refractory manufacturing units under medium scale industries scheme.

4. Similar steps are to be taken to increase the production of chrome chemicals to meet the increasing internal demand. Since the increase in demand for bichromate, the most important among the chrome chemicals, is estimated at about 5 000 t only between 1978-79 to 1983-84, this may conveniently be taken up under small scale industries scheme. There is also scope for producing chrome chemicals for laboratory uses.

5. Chromite is also finding its use in modern fields like solid-state and electronic industries. Fundamental research should be encouraged to find the scope of its utilization in these fields.

6. There seems to be little scope for increasing the ferrochrome production in near future other than that as envisaged at present. Low-carbon ferrochrome, however, should be manufactured exclusively indigenously to meet the internal demand. It is understood that there is an unused licensed capacity for the manufacture of ferrochrome to the tune of 10 000 t year. This capacity should be released to the existing plants. It is observed that the export market of ferrochrome, especially the high-carbon variety, shows a widely fluctuating trend. The low-carbon ferrochrome practically has no export market because of its high cost as well as the change in alloy steel production technology. This has to be kept in view while taking decisions *to* increase the ferrochrome production.

The authors have estimated the annual ferrochrome requirement in the country to be around 34 000 t (including 15 000 t earmarked for export) by 1985, which is consistent with the estimate of indigenous annual requirement of 19 760 to by 1983-84 made by the Indian Bureau of Mines.

The MECON recommendation for an annual production capacity of 50 000 t of ferrochrome over and above the existing production capacity will increase the foreign

exchange earning by exporting this intermediate product rather than the raw chromite fines, provided; the anticipated export is achieved. However, the recommendation made in this paper goes one step further, namely, to produce both finished and semi-finished products in the form of alloy and special steels, containing chromium. This would ensure the best and ultimate utilization, of chromite, both, in the shape of final finished products to meet the. internal: demand and' as semi-finished products for export' whose, exportability and foreign exchange earning capacity will be about five-fold;

7. The present annual production of chromite in India is of the order of 0:5 mt. Considering the present uncertain resource position of chromite. in the country and the Government of. India's decision to restrict further export of the raw ore, the present level of production should not be increased unless there is sufficient internal demand or a substantial increase in the export possibility of its various products. Since, the present consumption of chromite in the country is only about 25% of the total production, a complete ban on its export at this stage will only result in the closure of the mines and consequent unemployment of a large number of mine workers. In addition apart from the loss in foreign exchange earnings, it may not be possible to open these mines later and work them economically. Moreover, it may be worth considering that the present high price of chromite in the international' market is likely to slump once the user countries start importing the ore from Rhodesia and South Africa. The rise in export is, therefore, likely to be temporary and we should avail; this opportunity of earning valuable foreign exchange keeping however in mind the present resource position in the country. The present paper, therefore, envisages a proportionate decrease in the export of chromite with the increase in internal demand (0.25 and 0.2 mt by 1978-79 and 1983-84- respectively) in order that the mining industry does not become stagnant over a long period. Thus, with the gradual decrease in export as the internal demand picks up, the total annual production of chromite in the country may be stabilised around 0.4 mt until more details regarding the country's resource. position which is presently under investigation is known. The Government of India should; therefore, consider setting up of more chromite based' industries before considering a blanket ban on its exports.

REFERENCES;

1. C A Hampel (Ed): 'Rare Metals Handbook,' *Reinhold Publishing Corporation,* 1961.

2, M S, Balasundaram. *The Eastern Metal Review.* Annual Number, 1972; p 39.

3: A Mitra, *Steel' Furnace Monthly,* vol 10, no 8, 1975, p 317;

4. *Steel Furnace: Monthly,* vol.1 ; no 11, 1976.

5.. K Ramachandran. *Tool and Alloy Steels,* vol' 8: no 1; 1974; p.-32.

6. Statistics for Iron and'Steel;Industry, *Hindustan Steel Limited,* Ranchi; 1974.

7: Report of the Ferrochrome Plant, Jajpur, Orissa, 1975.

8: *Minerals and Metals Review,* vol 1, no 2-4; 1975.

9. G Lobo. *Eastern Metal Review,* Annual Number, 1972, p 61.

10: National" Committee on Science and Technology, Panel No 7; Mining, Steel and' Metallurgical Industry, August 1972: