23 Chromite

Chromite is an oxide of chromium and iron. The chemical composition of chromite is $FeO.Cr_2O_3$ or $FeCr_2O_4$. Chromite contains 68% Cr_2O_3 and 32% FeO with Cr : Fe ratio of about 1.8 : 1. Chromite is the only commercial source of chromium. It occurs as a primary mineral of ultrabasic igneous rocks and is normally associated with peridotite, pyroxenite, dunite and serpentinite. World-wide, high-alumina chromite, largely from podiform deposits is used in refractory applications while iron-rich ores, largely from stratiform deposits are utilised in metallurgical and chemical applications.

RESOURCES

As per UNFC system, total resources of chromite in the country as on 1.4.2005 are estimated at 213 million tonnes, comprising 66 million tonnes reserves (31%) and 147 million tonnes remaining resources (69%). More than 95% resources of chromite are located in Orissa, mostly in the Sukinda valley in Cuttack and Jajpur districts. Minor deposits are scattered over Manipur, Karnataka, Jharkhand, Maharashtra, Tamil Nadu and Andhra Pradesh.

Gradewise, charge-chrome grade accounts for 26% resources followed by ferro-chrome grade and beneficiable grade (20% each) and refractory grade 2%. Low, others, unclassified and not known grades together account for 32% (Table-1).

EXPLORATION & DEVELOPMENT

Directorate of Geology, Orissa conducted regional geo-chemical sampling during 2006-07 in areas of Mahagiri range viz, Kakudia, Giringamali, Ragada in Jajpur district on a 250 m grid interval. About 54 cu m excavation was also done. Analytical results were awaited. The Orissa Mining Corporation, a State Government Undertaking during 2007-08, explored areas in the Bangur and South Kaliapani leases and established measured reserves of 60,000 tonnes having a cut off of 10% Cr_2O_3 in Bangur area. In Kathakata - Sankatpalli areas of Keonjhar district the exploration could not locate any occurrences of chromite.

In Rajasthan, DMG conducted regional mineral survey in 2007-08 for nickel-chromium bearing minerals in areas; viz, Machind-Gaongurha, Ghata in Rajsamand district. About 50 samples were collected. Analytical results are awaited.

The DGM, Nagaland continued exploratory test drilling for base metals in 2007-08 in Ziphu area where along with copper, some traces of chromium, PGE, cobalt and gold were detected (Table 2)

PRODUCTION, STOCKS & PRICES

The production of chromite at 4,799 thousand tonnes during 2007-08 decreased by 9 % as compared to that in the previous year owing to gradual reduction in demand.

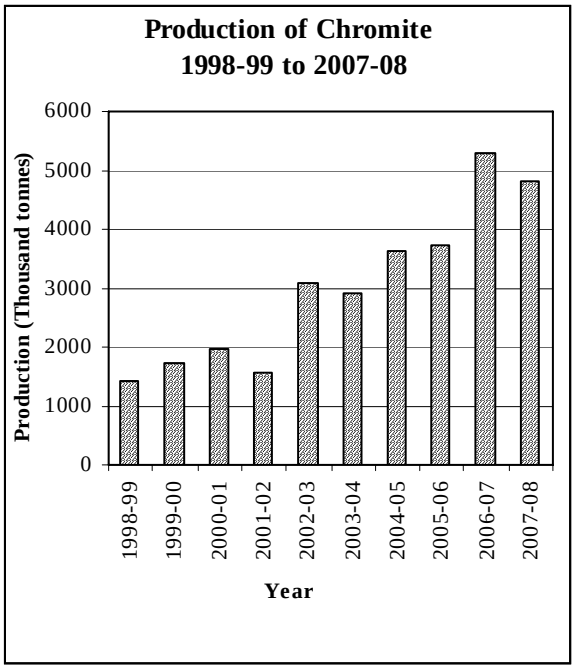

Table - 1 : Reserves/Resources of Chromite as on 1.4.2005
(By Grades/States)

(In '000 tonnes)

Grade/State	Reserves				Remaining resources							Total resources (A+B)
	Proved STD111	Probable		Total (A)	Pre-feasibility		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
		STD121	STD122		STD221	STD222						
All India : Total	**30892**	**10217**	**25019**	**66128**	**1191**	**2286**	**39673**	**30701**	**47235**	**25849**	**146935**	**213063**
By Grades												
Refractory	425	-	1541	1966	-	-	15	240	1940	-	2195	4161
Charge-chrome	10706	5981	7084	23771	625	1358	8981	5958	14468	-	31390	55161
Low	70	-	27	97	-	-	360	-	513	-	873	970
Beneficiable	9104	2652	5872	17628	443	749	14604	1129	8128	-	25053	42681
Ferro-chrome	6074	1584	10495	18153	123	178	13257	3426	7497	-	24481	42634
Others	-	-	-	-	-	-	-	15	-	-	15	15
Unclassified	4513	-	-	4513	-	-	2456	1778	14528	25849	44611	49124
Not known	-	-	-	-	-	-	-	18156	161	-	18317	18317
By States												
Andhra Pradesh	-	-	-	-	-	-	-	15	172	-	187	187
Jharkhand	-	-	-	-	-	-	15	98	623	-	736	736
Karnataka	470	-	620	1090	68	41	-	20	571	-	700	1790
Maharashtra	5	-	-	5	-	-	42	67	418	-	527	532
Manipur	-	-	-	-	-	-	-	529	6052	-	6581	6581
Orissa	30417	10217	24399	65033	1123	2245	39609	29972	39124	25849	137922	202955
Tamil Nadu	-	-	-	-	-	-	7		276		283	283

Figures rounded off.

Table -2 : Details of Exploration Activities for Chromite, 2006-07 and 2007-08

Agency/ State/ District	Location/ Area/ Block	Mapping		Drilling		Sampling (No. of samples)	Remarks
		Scale	Area (sq km)	No.of bore-holes	Meterage drilled		
2006-07							
Diretorate of Geology							
Orissa							
Jajpur	Kakudia, Giringamali, Ragada	1:25000	40	-	-	120 (Geochem)	Analytical results revealed Cr_2O_3 content of 71% in few samples. Reserves not estimated.
Keonjhar	Kathakata Sankatpalli area	1:25000	53	-	-	69	No chromite occurrence was found
FACOR							
Dhenkanal	Kathpal Chromite mine	1:2,000 1:500 1:200	113.3 (Hec.)	82	1651.5	88	Activity was for knowing geometry of orebody. Total mineable reserves of chromite as on 31.3.2007 are estimated at 0.82 million tonnes containing 44% Cr_2O_3.
	Ostapal Chromite mine	1:2,000	72.84 (Hec.)	5	394.6	115	Activity was for knowing existence and extension of orebody. Total reserves as on 1.4.2007 are estimated at 53.94 million tonnes containing 37.8% Cr_2O_3
2007-08							
DMG							
Rajasthan							
Rajsamand	Machind-Gaongurha Ghat	1:50000 1:10000 1:4000	100 10 1	-	-	50	Resources not estimated.
DGM,							
Nagaland	Ziphu	-	-	-	109.25	-	Traces of chromium found.
OMC, Orissa							
Keonjhar	Bangur	1:200	5 (Hec.) (Under-ground)	3	343	333	Measured resources of 60,000 tonnes with cut off at 10% Cr_2O_3.
- do -	Baniaponk	1:2000	50 (Hec.)	2	41.50	-	Significant exposures not encountered.
Jajpur	South Kaliapani chromite mine	1:2,000	40 (Hec.)	16	1104	100	Reserves of measured category estimated at 1,20,000 tonnes at 10% Cr_2O_3 cut off in band II.
FACOR							
Dhenkanal	Kathpal Chromite mine	1:2,000 1:500 1:200	113.3 (Hec.)	9	562.95	64	Total reserves as on 1.4.2008 were estimated at 2.2 million tonnes containing 49.8% Cr_2O_3.
- do -	Ostapal Chromite mine	1:2000	72.84 (Hec.)	7	766	116	Total reserves estimated at 52.8 million tonnes containing 37.8% Cr_2O_3.

The number of reporting mines was 21 in both the years. Six principal producers operating 12 mines together accounted for 90% of the total production during the year. The contribution of 13 mines, each producing more than 20,000 tonnes per annum, was 99.70 % of the total production.

The share of public sector in total production was 30% in 2007-08 as compared to 31% in the previous year. About 30% of the total production was reported from captive mines in current year as compared to that of 26% in the previous year.

Orissa continued to be the major producing State of chromite, accounting for 99.85% of the total production during 2007-08 and the remaining 0.15% was reported from Karnataka.

Gradewise analysis of production during 2007-08 reveals that above 52 % Cr_2O_3 both lumps and fines accounted for 15% (Lumps nominal and Fines 15%), 40%-52% Cr_2O_3, for 38% (Lumps 3% and Fines 35%) , below 40% Cr_2O_3 for 31% (Lumps 4% and Fines 27%) and chromite concentrates 16 percent of the total production (Tables - 3 to 6).

Mine-head stocks of chromite at the end of 2007-08 decreased by 1% to 2,236 thousand tonnes as compared to 2,260 thousand tonnes at the beginning of the year. Out of the total stocks, about 99% was held at the mines in Orissa (Tables - 7 (A) and 7 (B).

The average daily employment of labour in chromite mines during 2007-08 was 5,371 as against 6,157 in the previous year. Domestic prices of chromite are furnished in Table - 8.

Table – 3 : Principal Producers of Chromite 2007-08

Name & address of producer	Location of mine	
	State	District
Tata Steel Ltd Bombay House, Homi Mody Street, Mumbai – 400 001 Maharashtra.	Orissa	Jajpur
The Orissa Mining Corporation Ltd 'OMC House' Post Box No.34 Bhubaneswar-751 001 Orissa.	Orissa	Dhenkanal and Jajpur
Balasore Alloys Ltd Balopalpur Balasore –756 020 Orissa.	Orissa	Jajpur
Indian Metals & Ferro Alloys Ltd Bomikhal, P.O. Rasulgarh, Bhubaneswar – 751 010 Orissa	Orissa	Jajpur and Keonjhar
Ferro Alloys Corporation Ltd Shree Ram Bhawan, Tumsar , Dist. Bhandara (Maharashtra)	Orissa	Jajpur and Keonjhar
IDCOL Ferro Chrome & Alloys Ltd Jajpur Road 755 020 Dist-Jajpur, Orissa.	Orissa	Jajpur

Table - 4 : Production of Chromite, 2005-06 to 2007-08 (By States)

(Qty. in tones; value in Rs. '000)

State	2005-06		2006-07		2007-08 (p)	
	Qty	Value	Qty	Value	Qty	Value
India	**3714284**	**10929529**	**5295551**	**14501689**	**4798515**	**20201550**
Karnataka	8696	34718	7715	43387	7257	43843
Orissa	3705588	10894811	5287836	14458302	4791258	20157707

Table – 5 (A) : Gradewise Production of Chromite, 2006-07
(By Sectors, States and Districts)

(Quantity in tones; value in Rs.'000)

State / Distric	No. of mines	Production by Grades: Cr_2O_3 Content							Total	
		Below 40%		40% - 52%		52% & Above				
		Lumps	Fines	Lumps	Fines	Lumps	Fines	Concen-trates	Quantity	Value
India	**21**	**258852**	**1304439**	**85700**	**2210075**	**6223**	**519264**	**910998**	**5295551**	**14501689**
Public sector	8	2275	190234	8138	838911	-	362073	214971	1616602	4204488
Private sector	13	256577	1114205	77562	1371164	6223	157191	696027	3678949	10297201
Karnataka	**2**	**978**	**25**	**5588**	**1124**	**-**	**-**	**-**	**7715**	**43387**
Hassan	2	978	25	5588	1124	-	-	-	7715	43387
Orissa	**19**	**257874**	**1304414**	**80112**	**2208951**	**6223**	**519264**	**910998**	**5287836**	**14458302**
Dhenkanal	2	2724	2938	7334	1431	5577	-	-	20004	106799
Jajpur	13	227091	1301476	24325	2178414	-	519264	883250	5133820	13975706
Keonjhar	4	28059	-	48453	29106	646	-	27748	134012	375797

Table – 5 (B) : Gradewise Production of Chromite, 2007-08 (p)
(By Sectors, States and Districts)

(Quantity in tones; value in Rs.'000)

State / Distric	No. of mines	Production by Grades: Cr_2O_3 Content							Total	
		Below 40%		40% - 52%		52% & Above				
		Lumps	Fines	Lumps	Fines	Lumps	Fines	Concen-trates	Quantity	Value
India	**21**	**171509**	**1334322**	**121430**	**1700237**	**12567**	**702351**	**756099**	**4798515**	**20201550**
Public sector	8	5784	158764	3948	693925	163	430870	148788	1442242	10055296
Private sector	13	165725	1175558	117482	1006312	12404	271481	607311	3356273	10146254
Karnataka	**2**	**4126**	**44**	**2139**	**898**	**-**	**-**	**50**	**7257**	**43844**
Hassan	2	4126	44	2139	898	-	-	50	7257	43844
Orissa	**19**	**167383**	**1334278**	**119291**	**1699339**	**12567**	**702351**	**756049**	**4791258**	**20157706**
Dhenkanal	4	497	4424	12607	1754	9143	-	-	28425	223520
Jajpur	13	141307	1329854	52470	1660288	-	702351	731374	4617644	19452599
Keonjhar	4	25579	-	54214	37297	3424	-	24675	145189	481587

Table – 6 : Production of Chromite, 2006-07 and 2007-08 (By Frequency Groups)

(In tonnes)

Production group	No. of mines		Production for the group		Percentage to total production		Cumulative percentage	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Total	**21**	**21**	**5295551**	**4798515**	**100**	**100**	**100**	**100**
Upto 1000	04	03	998	20	0.02	0.00	0.02	0.00
1001 - 5000	01	04	3847	8782	0.07	0.18	0.09	0.18
5001 - 10000	01	01	6737	5639	0.13	0.12	0.22	0.30
10001 - 20000	02	-	30933	-	0.58	-	0.80	-
20001 - 40000	03	02	76064	67142	1.44	1.40	2.24	1.70
40001 and above	10	11	5176972	4716932	97.76	98.30	100.00	100.00

Table -7 (A) : Mine – head Stocks of Chromite, 2007-08 (At the Beginning of the Year)

(In tonnes)

State	Stocks by Grades: Cr_2O_3 Content							Total
	Below 40%		40% -52 %		52% and above			
	Lumps	Fines	Lumps	Fines	Lumps	Fines	Concentrates	Quantity
India	**17958**	**1755721**	**24314**	**224043**	**713**	**75120**	**161162**	**2260031**
Karnataka	3511	41	8938	1787				14277
Orissa	14447	1755680	15376	222256	713	75120	161162	2245754

Table -7 (B) : Mine – head Stocks of Chromite, 2007-08 (p) (At the End of the Year)

(In tonnes)

State	Stocks by Grades: Cr_2O_3 Content							Total
	Below 40%		40% -52 %		52% and above			
	Lumps	Fines	Lumps	Fines	Lumps	Fines	Concentrates	Quantity
India	**18527**	**1729171**	**19561**	**205135**	**723**	**64680**	**198158**	**2235955**
Karnataka	4794	44	46	218	-	-	-	5102
Orissa	13733	1729127	19515	204917	723	64680	198158	2230853

Table - 8 : Prices of Chromite, 2005-06 to 2007-08
(Domestic Markets)

(In Rs. per tonne)

Grade	Market	2005-06	2006-07	2007-08 (P)
Chromite				
Below 40%	Ex-mine Cuttack	570	670	1240
+40-52% Cr_2O_3	Ex-mine Cuttack	2190	7250	6710
+40-52% Cr_2O_3	Ex-Jajpur Rd (Orissa)	5500	4850	9522
+52% Cr_2O_3	Ex-Jajpur Rd (Orissa)	4500	4363	8356
28-30% Cr_2O_3	Ex-mine MML (Karnataka)	1350	1830	5580
+44% Cr_2O_3	Ex-mine MML (Karnataka)	4000	5800	8780
+46% Cr_2O_3	Ex-mine MML (Karnataka)	4600	6125	9180
Concentrate	Ex-mine MML (Karnataka)	850	1830	2020

MINING & TRANSPORT

Chromite is mined mostly by opencast method in the country. In OMC's opencast mines, the bench height is less than 6 m and the bench width is more than 10 m in mechanised quarry. The bench height and width is 1.5 m and 2 m, respectively, in the manual quarry. The mining machinery deployed in OMC mines include I.R. & wagon drills for drilling 100 mm dia holes, escavation by Poclain of 1.00 m^3 to 3.70 m^3 capacity, dozers of 15' blade, loader excavator of 1.70 m^3 and dumpers of 16-18 m^3 capacity. In some quaries tippers and pay loaders are used in addition to manual means. The motive power is provided by electric generators of 75-160 KVA and portable diesel generators of 5 KVA capacity. In South Kaliapani (quarry D) mine of OMC, the 14 m wide main haulage road was proposed to align with a circular path. The haulage road for removing overburden from quary face to dump was also to be partially aligned. The altered position will be permanent.

Underground mines are confined to Byrapur in Karnataka and Boula and Kathpal mines in Orissa. A proposal was under consideration to convert Nausahi chromite mines of Indian Metals and Ferro Alloys Ltd. (IMFA) into an underground mine. For this purpose, development of inclines from the existing quarry bottom was started. Tata Steel was also contemplating to convert a part of Sukinda chromite mine into an underground mine for which rock mechanics studies by South African consultant have been carried out. Chromite ore body extending to 300 m depth is mined by underground method since 1967 at Byrapur in Hassan district of Karnataka. Here cut-and-fill method of stoping is practised. In Sukinda valley, chromite has been mined to a maximum depth of about 63 m by open-cast method. The maximum overburden to ore ratio is 15:1. In the two underground mines in Orissa-one at Kathpal of M/s Ferro Alloys Corporation Ltd and other at Bangur of IMFA - sub-level stoping with parallel/ring hole blasting with delayed firing is practised. Construction of cement concrete barrier has been planned to provide a base for the fill material at 30 m interval in the dip direction. In Sukinda area, deposits of chromite lying below 100 m depth may have to be exploited by highly specialised underground mining techniques.

OMC was also developing underground mine near Bangur in Baula-Nuasahi chromite belt close to IMFA mining operations. Though positive results were obtained from drilling, systematic exploration was yet to be taken up. OMC's chromite mines at Kaliapani, Sukrangi, Kalarangi, Kathpal and Bangur, all in Orissa, make it one of the leading chromite producers of the country. Chrome ore of very high grade (+58% Cr_2O_3) is produced here. The chrome ore beneficiation plant at Kaliapani with a total production capacity of 84,000 tonnes concentrates is designed to upgrade low-grade ore below 33% Cr_2O_3. Keeping in view the increasing demand for chrome concentrates, OMC is in the process of doubling the capacity of this plant.

Transportation of the ore from mines to railway sidings is done through trucks and from railway sidings to various consuming centres by railway wagons. In South Kaliapani mine of OMC, the width of haul road was more than 3 times the width of tipper/dumpers plying in the quarry and in some places one way traffic was provided as and when needed. Important loading stations for chromite in the country are Jajpur-Keonjhar Road in Orissa and Tiptur in Karnataka. Export of

chromite is through Paradip port. However, small quantities of lumpy chromite ore are imported to meet the needs of ferro-alloys industry in the country.

Research and Development

Plant audit conducted by the Institute of Minerals & Material Technology (IMMT), Bhubaneswar (CSIR) at the 10 t/hr chromite beneficiation plant of Jindal Steel Ltd, Bhubaneswar indicated that the yield can be improved to > 40Wt% by introducing minor modifications in the current circuit. For this a chromite grade of ~ 48% Cr_2O_3 was studied to improve the yield and to oversee the performance improvement of the plant.

Beneficiation studies were carried out on middlings generated at the Chromite ore beneficiation plant of Balasore Alloys to suggest suitable flow sheet to recover the chromite values. It is possible to recover good grade chromite by simple combination of hydrocyclone & tabling.

Studies were also initiated for Jindal Stainless Ltd, Bhubaneswar to develop a commercially viable flow sheet to recover chromite values from chromite ore beneficiation plant tailings containing ~ 20% Cr_2O_3 and also from another low grade ferruginous chromite ore containing ~ 15% Cr_2O_3. IMMT conducted laboratory investigations and completed the detailed project report.

Environmental Problems

Management of waste dump in Sukinda valley is the major environmental concern. These overburden dumps modify the land topography, affect the drainage system, prevent natural succession of plant growth resulting in acute problems of soil erosion and environmental pollution.

Normally, waste dumps are maintained up to height of 20-30 m with 30 m terrace width and slope angle of 25 to 35°. Toe-wall, garland drain, terracing, plantation along the slope are some common measures being adopted for waste dump management. Neem, Chakunda, Accacia, Mahul, Sal, Mango, Cashew, Arjuna, Babul, Amla, Bahada, Jamun, etc. are the species used in afforestation over dead dump slopes, dump terrace, along the haul roads and safety zones in the mines.

The major source of environmental pollution in Orissa is the hexavalent chromium generation, especially in case of friable ore. The hexavalent chromium contamination of the local water bodies is a major concern because of its carcinogenic properties. The pumped out water from the mine needs to be doused with ferrous sulphate solution before being discharged. This converts hexavalent chromium to trivalent chromium.

Environmental problems related to chromium processing are limited. Chromium, in its trivalent (Cr^{3+}) oxidation state as found in chromite and other natural minerals, is an essential nutrient. Its principal function is to maintain normal glucose metabolism. Chromium deficiencies can lead to problems in insulin circulation as well as possible risk of cardiovascular disease. Hexavalent form of chromium (Cr^{6+}) which is used widely in chemical compounds has been implicated in skin rashes and lung cancer.

CONSUMPTION

The reported consumption of chromite in the organised sector increased by 6% from 1,784,800 tonnes in 2006-07 to 1,889,400 tonnes in 2007-08. It was mostly in ferro-alloys/charge-chrome industry. A continuous growth in consumption can be observed in this industry since 2005-06. In addition to above, chromite in substantial quantities is also consumed in small-scale ferro - chrome units for which information is lacking. Data on consumption of chromite and ferro-chrome from 2005-06 to 2007-08 are given in Tables - 9 and 10, respectively.

Table - 9 : Reported Consumption of Chromite 2005-06 to 2007-08 (By Industries)

(In tonnes)

Industry	2005-06(R)	2006-07	2007-08(p)
All Industries	**1,345,400**	**1,784,800**	**1,889,400**
Chemical	4,800(2)	4,800(2)	4,800(2)
Ferro-alloys* (including charge-chrome)	1,319,000(13)	1,756,900(18)	1,860,500(18)
Refractory (including iron & steel)	21,100 (23)	22,500(24)	23,500(24)
Others (foundry, ceramic, glass, electrode)	500(16)	600(7)	600(7)

Figures rounded off. Data collected on non-statutory basis. Figures in parentheses denote the number of units in the organised sector reporting consumption.

** Besides, a number of small-scale units produce ferro-chrome, consumption data for such units are not available.*

Table - 10 : Reported Consumption of Ferro-chrome 2005-06 to 2007-08 (By Industries)

(In tonnes)

Industry	2005-06(R)	2006-07	2007-08(p)
All Industries	**149,600**	**150,100**	**150,600**
Alloy steel	34,900(16)	34,900(16)	34,900(16)
Electrode	++(5)	++(5)	++(5)
Foundry	700(20)	700(20)	700(20)
Iron & steel	114,000 (9)	114,500(10)	115,000(10)

Figures rounded off .
Data collected on non-statutory basis.
Figures in parentheses denote the number of units in the organised sector reporting consumption.

USES

In metallurgy, chromite is used in the manufacture of chromium metal and various alloys with iron, nickel, cobalt, tungsten, molybdenum, etc. Chromium imparts additional strength, hardness and toughness to its alloys. It also shows resistance to corrosion to steel abrasion, reduces oxidation and flow of electricity. Stainless steel, high-speed tool steel, corrosion and heat-resistant steel are some important varieties of chromium steel. Ferro-chrome is of two types: (i) high carbon (containing 4-8% carbon) and (ii) low carbon (containing up to 2% carbon). The amount of chromium used in steel varies with the purpose. Low chromium steels (less than 5% chromium and small amount of nickel) are used in rails, automobiles, armour plates, armour piercing projectiles, etc. Intermediate chromium steels (3-12% Cr and small amounts of W, Mo or Si) are used in high-speed tools, valves for engines and other equipment requiring resistance to abrasion, corrosion and oxidation. Chromium steels include stainless steels (12-18% Cr) and super-stainless steels (12-30% Cr and 7-10% Ni) which are used for cutlery and cooking utensils and in aircraft and high-speed trains, respectively. Chromium (17%) with iron (83%) is also used as ferritic stainless steel to manufacture coins.

Chromite is used in refractory industry because of its resistance to corrosion, high temperature and ability to withstand sudden temperature changes, and its chemically neutral character. The ore is used in the form of lumps, bricks or cement in linings, specially of steel furnaces.

Chromite is used for manufacturing important chromium compounds like chromates and bichromates of sodium and potassium, chromium pigments like chromic oxide green and chromic acid which, in turn, are used in chromium-plating solution.

SUBSTITUTES

Development of substitutes of chromium tends to be deterred by cost performance or the customer appeal of the chromium. There are no substitutes in the stainless steel or super-alloys. Boron, manganese, nickel and molybdenum can be substituted in alloy steels and cast irons. Base metal alloys can sometimes be used in place of stainless steel. Dolomite is an alternative for some

Table - 11 : IS Specifications of Chromite for Metallurgical Industry (IS : 10818-1984) (Reaffirmed in 2003)

Sl. No	Characteristic (on dry basis)	Grade (%)			
		Low carbon ferro-chrome	High carbon ferro-chrome	Silico-chrome	Charge-chrome
1.	Cr_2O_3 percent, min	48	48	48	44
2.	Total iron percent, max. (as FeO)	15	16	15	18
3.	Al_2O_3 percent	13	13	13	10
4.	SiO_2 percent, max	5	8	10	12
5.	CaO percent, max	5	5	5	5
6.	MgO percent, max	14	16	14	12
7.	Sulphur* (as SO_3) percent, max	0.1	0.1	0.1	0.14
8.	Phosphorus* (as P_2O_5) percent, max	0.005	0.02	0.02	0.2
9.	Cr:Fe, min	3:1	2.8:1	3:1	1.6:1
10.	MgO : Al_2O_3	-	1:4	-	-

**Sulphur* (as SO_3) *and phosphorus* (as P_2O_5) *may be determined as agreed upon by the supplier and the purchaser.*

refractory bricks. Cadmium yellow is one of the several alternative pigments. However, it is not environmentally acceptable and nickel and zinc are possible substitutes for the protection of decorative coatings.

SPECIFICATIONS

The specifications of chromite vary for different end-use industries. The Cr:Fe ratio is one of the important factors to be considered before deciding the end-use of the mineral. The IS specifications for metallurgical, refractory and chemical industries are given in (Tables - 11 to 13).

Table - 12 : IS Specifications of Chromite for Refractory Industry (IS : 10819-1999) (First Revision)

a) Chemical

Sl. No.	Characteristic (on dry basis)	Grade - I (percent by mass)	Grade - II (percent by mass)	Grade - III (percent by mass)
1.	Loss on ignition	1.5 max	1.5 max	1.5 max
2.	Cr_2O_3	52 min	50 min	48 min
3.	Total iron (as FeO)	16 max	18 max	18 max
4.	SiO_2	3 max	7 max	9 max
5.	MgO	15 max	15 max	15 max

b) Physical

All the refractory grades of chromite are hard, massive, fine-grained, serpentine-free lumpy ores and in the size range -50 mm to (+) 50 mm.

Table - 13: IS Specifications of Chromite for Chemical Industry (IS : 4737-1982; First Revision, Reaffirmed in 2003)

Sl. No.	Characteristic (on dry basis)	Requirement %
1.	Chromic oxide (as Cr_2O_3), percent by mass, min	44.0
2.	Total iron (as FeO), percent by mass, max	20.0
3.	Alumina (as Al_2O_3), percent by mass, max	14.0
4.	Silica (as SiO_2), percent by mass, max	7.0
5.	Lime (as CaO), percent by mass, max	3.0
6.	Magnesia (MgO), percent by mass, max	14.0

INDUSTRY

Chromite is used chiefly in metallurgical industry for manufacture of ferro-alloys; e.g., ferro-chrome, charge-chrome and silico-chrome which are used as additives in making stainless steel and special alloy steel. Ferro-alloys are the essential ingredients for the production of high quality special alloy steel as well as mild steel. The demand for ferro-alloys is associated with the production of alloy steel.

The total combined capacity of chrome alloys (ferro-chrome and charge-chrome) in the country was around 1.30 million tonnes. Production of ferro-chrome/charge-chrome was mainly reported by Ferro Alloys Corp. Ltd, Industrial Development Corporation Orissa Ltd, Tata Steel Ltd, VBC Ferro-alloys Ltd, Indian Charge- chrome Ltd. and Indian Metals & Ferro-Alloys Ltd. As per the Indian Ferro Alloys Producers' Association, ferro-chrome/charge-chrome of 801,138 tonnes in 2006-07 and 948,366 tonnes in 2007-08 was produced in India. The production of low carbon ferro chrome was 235 tonnes in 2007-08 as compared to 230 tonnes in 2006-07. Tata Steel Ltd, Ferro Alloys Corporation Ltd, and Indian Charge-chrome Ltd were amongst the major producers of charge-chrome having a total capacity of 1,62,500 tpy. The charge-chrome contains 50 to 60% chromium and 6 to 8% carbon. Hard lumpy chromite is used for high-carbon ferro-chrome while friable ores and fine briquettes are used for low-carbon ferro-chrome. Briquette fines along with lumpy ores were also consumed in charge-chrome plants.

The important plants which produce chromite-based refractories were Tata Steel Ltd (formerly OMC Alloys), Tata Refractories Ltd, Orissa Industries Ltd, Burn Standard Co. Ltd, Bhilai Refractories Ltd, Joglekar Refractories and Ceramics (P) Ltd, and Associated Ceramics Ltd. The demand for chromite in refractory industry is gradually decreasing.

There were two units producing chromium chemicals in small quantities in the organised sector; namely, Tamil Nadu Chromates and Chemicals Ltd and Krebs & Cie (India) Pvt. Ltd.

Plantwise specification of chromite in respect of major user industries are given in Table - 14. For information on ferro-alloys industry, the review on ferro-alloys may also be referred.

Table - 14 : User's Specifications of Chromite in Major Consuming Industries

Industry/Name and location of plant	Specifications of ore consumed
FERRO - CHROME/CHARGE-CHROME	
Andhra Pradesh	
Andhra Ferro Alloys Ltd, Kothavalasa, Dist. Vizianagram.	NA
Ferro-Alloys Corp. Ltd, Shreeram Nagar, Dist. Vizianagram.	Lumps : Cr_2O_3 46% SiO_2 : 10% Cr: Fe_3 : 3 Fines : Cr_2O_3 42% SiO2 : 7% Cr : Fe : 2.6
Jindal Stainless Steel Ltd, Jindal Nagar, Dist. Vizianagram.	Lumps : Cr_2O_3 38% Cr:Fe : 2.9
Nav Bharat Ferro Alloys Ltd, Paloncha, Dist. Khammam.	Lumps : Cr_2O_3 28-42% Fines : Cr_2O_3 48-50%, 52-54%
GMR Vasvi Industries Ltd, Ravivalasa, Dist. Srikakulam.	NA
VBC Ferro Alloys Ltd, Rudragram, Dist. Medak.	Lumps : Cr_2O_3 36-52%
Chhattisgarh	
Jindal Steel & Power Ltd, Raigarh.	Lumps : Cr_2O_3+38% Cr:Fe : 2.9 Fines : Cr_2O_3+52% Cr:Fe : 2.6
Deepak Ferro Alloys Ltd, Urla, Dist. Raipur.	Lumps : Cr_2O_3 36-40% Fines : Cr_2O_3 48-52%
Orissa	
Balasore Alloys Ltd, Balgopalpur, Dist. Balasore.	NA
FACOR, Charge Chrome Division, Randia, Dist. Balasore.	Lumps : Cr_2O_3 41% Fines : Cr_2O_3 46% Friable : Cr_2O_3 42%
IDCO Ferro Chrome & Alloys Ltd, Jajpur Road.	Cr_2O_3 : 42-52% Cr:Fe : 3.0, SiO_2 6% max
Indian Charge Chrome Ltd, Choudwar, Dist. Cuttack.	Cr_2O_3 : 40-48% SiO_2 : 15% max
Indian Metals & Ferro Alloys Ltd, i) Theruballi, Dist. Koraput. ii) Choudwar, Dist. Cuttack	NA
Tata Steel Ltd, (Formerly OMC Alloys Ltd,) Bamnipal, Dist. Keonjhar	NA
West Bengal	
Rohit Ferro Tech Ltd, Bishnupur, Dist. Bankura.	NA
Shri Vasavi Industries Ltd, Dist. Bankura.	NA

(Contd.)

Table - 14 (Concld.)

Industry/Name and location of plant	Specifications of ore consumed
REFRACTORY	
Chhattisgarh	
Bharat Refratories Ltd, Bhilai Refractories Plant, Durg.	Friable/lumps : Cr_2O_3 : 46-54%
Vishva Vishal Engineering Ltd, Bhilai, Durg.	Cr_2O_3 : 50% SiO_2 : 4.5% max Fe_2O_3 : 8%
Jharkhand	
Associated Ceramics Ltd, Chirkunda, Dist. Dhanbad.	NA
Maithan Ceramics Ltd, Dhanbad.	NA
Maharashtra	
Joglekar Refractories & Ceramics (P) Ltd, Rabale, Dist. Thane	NA
Orissa	
Orissa Industries Ltd, Lathikata Works, Sundergarh.	Cr_2O_3 : 52-54% Fe_2O_3 : 15-18% max SiO_2 : 3-5%
IFGL Refractories Ltd, Kalunga, Dist. Sundergarh.	Cr_2O_3 : 52% min
Tata Refractories Ltd, Belpahar.	Cr_2O_3 : 48-50% min SiO_2 : 5-9% min
Tamil Nadu	
Burn Standard Co. Ltd, Salem.	Cr_2O_3 : 52-54% min SiO_2 : 3-5% max Fe_2O_3 : 15-18% max
CHEMICALS	
Orissa	
Krebs & Cei (India) Ltd, Kalma, Dist. Mayurbhanj.	Cr_2O_3 : 48-55%

TRADE POLICY

The Ministry of Commerce and Industries, Department of Commerce, had come out with the new Foreign Trade Policy (FTP) for the period 2004-09 on 31.8.2004. The policy came into force from 1 September 2004. As per the Export-Import Policy effective from 1.4.2008, the imports of chromium ore lumps, friable ores and concentrates are freely allowed. The export policy on chromite is as follows:

Item	Policy	Nature of restriction
(a)	Chrome ore other than (i) beneficiated chrome ore fines/concentrates (maximum feed grade to be less than 42% Cr_2O_3); and (ii) those categories of chrome ores mentioned as permitted through STEs (State Trading Enterprises)	Restricted	Exports permitted under licence other than categories given below
(b)	Beneficiated chrome ore fines/concentrates (maximum feed grade to be less than 42% Cr_2O_3)	STE	Export through MMTC
(c)	Chrome ore lumps with Cr_2O_3 not exceeding 40%	STE	Export through MMTC
(d)	Low silica friable/fine ore with Cr_2O_3 not exceeding 52% and silica exceeding 4%	STE	Export through MMTC
(e)	Low silica friable/fine chromite ore with Cr_2O_3 in the range from 52 to 54% and silica exceeding 4%	STE	Export through MMTC

WORLD REVIEW

World resources of shipping-grade chromite are more than 12 billion tonnes, sufficient to meet conceivable demand for countries. About 95% of world's chromium resources are concentrated in Kazakhstan and southern Africa. US chromium resources are mostly in Stillwater complex in Montana. Other countries which possess sizeable quantities of resources are Finland, India, Russia, Turkey, Brazil and Albania. The world resources of chromite are shown in Table - 15.

The world production of chromite increased from 19.8 million tonnes in 2006 to 24 million tonnes in 2007. South Africa was the leading producer, contributing about 40% to the total world production, followed by India (20%) and Kazakhstan (15%). Other significant producers were Finland, Russia, Turkey, Brazil and Zimbabwe (Table - 16).

Table - 15 : World Resources of Chromium (By Principal Countries) (Shipping Grade)

(In '000 tonnes)

Country	Reserve base
India*	57000
Kazakhstan	470000
South Africa	270000
USA	120

Source: *Mineral Commodity Summaries, 2008.*

* *India's total resources of chromite as per National Mineral Inventory as on 1.4.2005 are 213 million tonnes of which 66 million tonnes are under reserves category.*

Table - 16 : World Production of Chromium ores and Concentrates (By Principal Countries)

(In '000 tonnes)

Country	2005	2006	2007
World : Total	**19200**	**19800**	**24000**
Brazil	617	563	628
Finland	572	549	556
India*	3714	4096	4821
Kazakhstan	3581	3366	3687
Russia	772	966	777
South Africa	7503	7418	9647
Turkey	859	1060	1679
Zimbabwe	615	700	664
Other countries	967	1082	1541

Source*: World Mineral Production, 2003-2007.*

* *Production of chromite in India in 2005-06, 2006-07 and 2007-08 was 3.71 million tonnes, 5.29 million tonnes and 4.80 million tonnes, respectively.*

The sharp recovery of contract prices of charge chrome in last quarter of 2006 reflecting recovery in world stainless steel production and cutbacks by ferro-chrome producers, was also seen in higher production of chromite reaching 19.2 million tonnes in 2006. China became a major producer of stainless steel and ferro-chrome in the world, though it has to depend on imports of chrome ore/ferro-chrome as its domestic production is low.

South Africa

With a rising trend, the exports of metallurgical grade chrome ore nearly tripled in 2007 from about 320,000 tonnes to an estimated 870,000 tonnes. However, the government took steps to ensure that the ore has to be beneficiated before export. However, the weakend exchange rate against the doller resulted in reduced exports of chrome ore. In addition, China entered into joint venture with South African ferro-chrome producer Samancor to secure future supplies to its domestic industry.

In September 2006, Xstrata Commissioned 364,000 tpy capacity Lion ferro-chrome project in Mpumalanga Province. International Ferro Metals Ltd (IFM) commissioned two furnaces at its smelter at Mooinooi in North West Province in January 2007 with a total 267,000 tpy capacity. Based on imported ore from India and Iran. Tata Steel Ltd has started building a ferro-chrome smelter at Richards Bay in South Africa for an annual capacity of 135,000 tonnes. The high power cost in India was the main reason for the Indian company to shift its smelting operations to South Africa.

FOREIGN TRADE

Exports

Exports of chromite dropped 25% to 906,575 tonnes in 2007-08 from 1,203,060 tonnes in the previous year. Out of total chromite exported in 2007-08, bulk share of about 95% was of chromite concentrate while chromite lumps and other chromite together accounted for merely 5%. Exports were mainly to China (86%), Japan (6%) and Australia (3%). In 2007-08, about 37 tonnes of chromium & alloys and scrap was exported mainly to Nigeria, Australia and Germany (Tables - 17 to 21). The exports of ferro-chrome are covered in 'Ferro-Alloys' review.

Imports

Imports of chromite increased substantially to 121,001 tonnes in 2007-08 from 4,800 tonnes in the previous year. Out of total quantity of chromite imported in 2007-08, lumpy chromite accounted for 61% while other forms accounted for remaining 39%. Imports were mainly from Oman (56%), South Africa (24%) and UAE (15%). Imports of chromium & alloys and scrap also increased in 2007-08 to 498 tonnes from 349 tonnes in the previous year. Imports were mainly from Russia (47%), UK (21%) and South Africa and France (6% each) (Tables - 22 to 26). The imports of ferro-chrome are covered in 'Ferro-Alloys' review.

Table - 17 : Exports of Chromite : Total (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**1203060**	**7936861**	**906575**	**12230975**
China	1060745	7023704	781734	10762792
Japan	91616	647370	58214	669189
Australia	-	-	30034	398239
Netherlands	-	-	17356	244951
Korea, Rep. of	1589	14698	14240	116146
Brunei	-	-	2000	20666
Singapore	-	-	538	8317
Malaysia	-	-	280	4929
UAE	38457	162594	2063	3912
Indonesia	10220	85310	-	-
Other countries	433	3185	116	1834

Table - 18 : Exports of Chrome Ore Lumps (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**48515**	**216050**	**1058**	**18965**
China	48492	215833	1058	18963
Poland	23	217	-	-
USA	-	-	++	2

Table - 19 : Exports of Chrome Ore Conc. (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**736237**	**4767109**	**860157**	**11776035**
China	594355	3857137	738033	10321915
Japan	91616	647370	58214	669189
Australia	-	-	30034	398239
Netherlands	-	-	17356	244951
Korea, Rep. of	1589	14698	14240	116146
Brunei	-	-	2000	20666
Malaysia	-	-	280	4929
Indonesia	10220	85310	-	-
UAE	38457	162594	-	-

Table - 20 : Exports of Chrome Ore (Others) (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**418308**	**2953702**	**45360**	**435975**
China	417898	2950734	42643	421914
Singapore	-	-	538	8317
UAE	-	-	2063	3912
Poland	-	-	51	963
Egypt	-	-	38	801
Baharain	20	143	26	58
Oman	-	-	1	8
Nepal	10	24	-	-
Qatar	20	386	-	-
Thailand	360	2415	-	-
Other countries	-	-	++	2

Table - 21 : Exports of Chromium & Alloys and Scrap (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**4**	**2243**	**37**	**8453**
Australia	-	-	12	2863
Germany	-	-	2	2448
Nigeria	-	-	20	1724
UK	-	-	++	454
Malaysia	-	-	2	289
UAE	1	608	++	257
Indonesia	++	284	++	104
Kenya	++	88	++	91
Saudi Arabia	1	364	-	-
Sweden	2	806	-	-
Other countries	++	93	1	223

Table - 22 : Imports of Chromite : Total (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**4800**	**67817**	**121001**	**1064129**
Oman	-	-	67966	497095
South Africa	4496	62777	29375	344756
UAE	-	-	17824	163323
Iran	-	-	2768	24212
Turkey	-	-	1964	24070
Albania	-	-	1001	8533
China	7	754	26	975
Korea, Rep. of	28	605	-	-
Malta	180	2355	-	-
Philippines	58	785	-	-
Other countries	31	541	77	1165

Table - 23 : Imports of Chrome Ore Lumps (By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**1828**	**25310**	**73792**	**567112**
Oman	-	-	66071	481979
South Africa	1768	24554	1845	25928
Turkey	-	-	1964	24070
Iran	-	-	1990	18822
Albania	-	-	1001	8533
UAE	-	-	834	6564
USA	-	-	40	492
China	-	-	20	355
Malta	60	756	-	-
Unspecified	-	-	27	369

Table - 24 : Imports of Chrome Ore Conc. (By Countries)

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	**63**	**924**	-	-
South Africa	63	924	-	-

Table - 25 : Imports of Chrome Ore (Others)
(By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**2909**	**41583**	**47209**	**497017**
South Africa	2665	37299	27530	318828
UAE	-	-	16990	156759
Oman	-	-	1895	15116
Iran	-	-	778	5390
China	7	754	6	620
Belgium	11	284	-	-
Korea, Rep. of	28	605	-	-
Mali	20	257	-	-
Malta	120	1599	-	-
Philippines	58	785	-	-
Other countries	-	-	10	304

Table - 26 : Imports of Chromium & Alloys and Scrap
(By Countries)

Country	2006-07		2007-08	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	**349**	**174004**	**498**	**202283**
Russia	129	38810	236	78813
UK	112	43811	107	38327
Germany	35	34935	19	19875
USA	11	24767	9	17321
Japan	10	10866	24	16573
France	12	4554	30	10810
China	36	14442	22	8320
Netherlands	++	185	11	5179
UAE	3	882	7	2555
South Africa	-	-	31	2500
Other countries	1	752	2	2010

FUTURE OUTLOOK

An Expert Committee constituted by the Ministry of Steel, Government of India has recommended the need of detailed exploration in all the potential areas in Orissa, Karnataka and ophiolite belt of North-Eastern region with a view to prognosticate resources to a depth of 500 m in Sukinda belt and estimation of resources in all other potential areas.