

BENEFICIATION OF CHROMITES

Low grade chromite ore samples from Bihar, Orissa, Andhra Pradesh, Karnataka and Maharashtra States were tested in N.M.L. for their beneficiation studies to make them suitable as a raw material for either (1) ferro-chrome manufacture, (2) chrome-refractories or (3) chemical industry. Apart from beneficiation, agglomeration studies like sintering and pelletisation were also undertaken with chrome ore fines which were either concentrates or fines obtained from the mines. The specifications of chromite ore to be used for different industries have been dealt with in Volume I.

Mineralogy

Chromite was the chief ore mineral and the bulk of the gangue was formed of various silicate minerals present in the ore or mixed up from the host rock while mining. This type of ores may be classified as "Siliceous Ores". The other major gangue in the chromites was "Iron" contributed by the presence of hematite or magnetite and the samples containing high iron may be classified as "Ferruginous Ores". Some iron may also be present in chemical combination of the chromite mineral itself in the spinel structure. In addition to these gangue minerals, carbonates of calcium and magnesium and other aluminous minerals also may be present in the ores.

Beneficiation Problems

Low grade chrome ores required beneficiation by way of reduction of iron or silica contents or both from the ore for their utilisation in any of the above mentioned industries. Table 3.3, at the end of this chapter, gives the beneficiation test results of the different chromite samples investigated in condensed form.

Siliceous Ores

These ores contain high silica content than required thereby lowering the Cr_2O_3 content of the ore. As the chromite mineral is having higher specific gravity than any of the associated silicate or other gangue minerals present in the ore, they are separated by gravity methods like jigging, tabling etc. depending upon their liberation size. If the liberation of the minerals was at a finer size flotation also may be adopted.

Ferruginous Ores

The difference in the specific gravity of iron bearing minerals magnetite, hematite, goethite and chromite is little; gravity methods do not help in the processing of ferruginous chromites. If the iron is contributed by magnetite, the sample is crushed to required liberation size and then magnetite is separated by magnetic separation. If the iron mineral happened to be hematite or goethite the sample is roasted under low temperature conditions in a reducing atmosphere employing CO , or coke oven gas and then the product is subjected to magnetic separation wherein the iron oxides will be separated as magnetic fraction leaving chromite in the non-magnetic product.

A. CHROMITES FROM BIHAR STATE

M/s. Tata Iron and Steel Co. Ltd. sponsored investigation on some chromite samples from Kittaburu, Singhbhum district for beneficiation studies. The end product was expected to be used in the metallurgical industry.

- (i) The sample consisted of lumps from 100 mm + 10 mm size with minor amounts of fines. The ore mineral was chromite and the gangue was

composed of chlorite, talc, dolomite, magnesite, magnetite and limonite. Complete chemical analysis of the chromite r.o.m. ore sample is given as follows:

Constituent	Assay%
Cr ₂ O ₃	36.66
FeO	19.05
MgO	14.26
Al ₂ O ₃	4.70
SiO ₂	17.06
CaO	4.49
LOI	3.85

As the SiO₂ content of the ore was high, attempts were made to concentrate the chromite by gravity methods. Jigging tests with the sized -14+48 mesh and tabling with -48 mesh fraction mixed with crushed jig tails produced chromite concentrates analysing 48.3% Cr₂O₃, 20.84% FeO with 75.9% Cr₂O₃ recovery.

Tabling tests done with 65 mesh ground sample yielded a concentrate analysing 54.1% Cr₂O₃ and 22.4% FeO with 71.6% Cr₂O₃ recovery. When the table middlings were combined with the concentrate, the mixed concentrate analysed 51.7% Cr₂O₃ with 82.3% recovery. Flotation tests did not produce any remarkable effect on the grade of the concentrate.

(ii) Another sample from the same area marked as "Soft Ore" assaying 37.2% Cr₂O₃ treated by the Humphry's spiral at 65 mesh size produced a concentrate analysing 48.95% Cr₂O₃ and 22.42% FeO, with 80.4% Cr₂O₃ recovery. With similar treatment "Mixed Ore" analysing 33.2% Cr₂O₃ produced a concentrate assaying 46.67% Cr₂O₃ and 21.38% FeO with 80.0% recovery. These batch scale tests were also confirmed by the pilot plant scale studies where in similar results were obtained.

B. CHROMITES FROM ORISSA

(i) Gunjag Area—Cuttack District

The chromite received from this area was ferruginous in nature. The chief ore mineral chromite was found embedded in the base of limonitic material and the grains were of fine nature. The sample in its as received state analysed as follows:

Constituent	Assay%
Cr ₂ O ₃	41.4
FeO	8.8
Fe ₂ O ₃	28.2
MgO	8.6
Al ₂ O ₃	7.9
SiO ₂	1.2
LOI	4.1

Magnetic separation of the ore after crushing it to 35 mesh size yielded a non-magnetic concentrate analysing 50.6% Cr₂O₃, 28.3% FeO with 56.2% Cr₂O₃ distribution. As the recovery was low, further tests were conducted after roasting the 3 mesh crushed ore in a reducing atmosphere followed by magnetic separation produced a concentrate (non-magnetic) with 60.5% Cr₂O₃, 13.6% FeO and 53.8% Cr₂O₃ distribution in it. When the intensity of the magnetic field was slightly reduced, the non-magnetic concentrate analysed 60.0% Cr₂O₃, 15.1% FeO with 81.2% Cr₂O₃ distribution in it. Reduction roast and magnetic separation test with washed sample did not produce any better results.

(ii) Nausahi Area—Keonjhar Dist.

The sample consisted of 75 mm to 12 mm sized lumps with small quantity of fines. The sample was siliceous in nature and contained chromite followed by siliceous gangue and minor carbonates in the sample. Complete chemical analysis of the sample is as follows:

Constituent	Assay%
Cr ₂ O ₃	42.52
FeO	16.62
Fe ₂ O ₃	1.28
Al ₂ O ₃	7.98
MgO	15.44
CaO	0.89
SiO ₂	14.24
P	0.051
LOI	1.68

The sample was ground to 35 mesh size and then sized in a hydro-classifier. The coarser portion analysed 53.24% Cr₂O₃ with 58.4% distribution. The medium and finer fractions when treated on shaking table, the medium portion produced a concentrate assaying 55.9% Cr₂O₃ and a middling with 44.71% Cr₂O₃. The finer portion also produced a table concentrate assaying 56.2% Cr₂O₃ and a middling with 47.55%

Cr_2O_3 . The combined coarser fraction, table concentrates and middlings analysed 53.51% Cr_2O_3 , 19.26% FeO (Cr/Fe 2.4) with 91.6% Cr_2O_3 distribution. When the sample was ground to 65 mesh size and treated on tables after sizing to coarse and finer fractions, the coarse fraction produced a concentrate of 57.11% Cr_2O_3 grade and a middling with 47.51% Cr_2O_3 grade. The finer fraction yielded a concentrate and middling assaying 56.43% Cr_2O_3 and 48.31% Cr_2O_3 respectively. The combined concentrates and middlings analysed 55.4% Cr_2O_3 , 19.4% FeO (Cr/Fe ratio =2.5), 3.2 SiO_2 with 91.7% Cr_2O_3 distribution in it. Humphry's spiral tests conducted at 65 mesh size also yielded similar grade of concentrate.

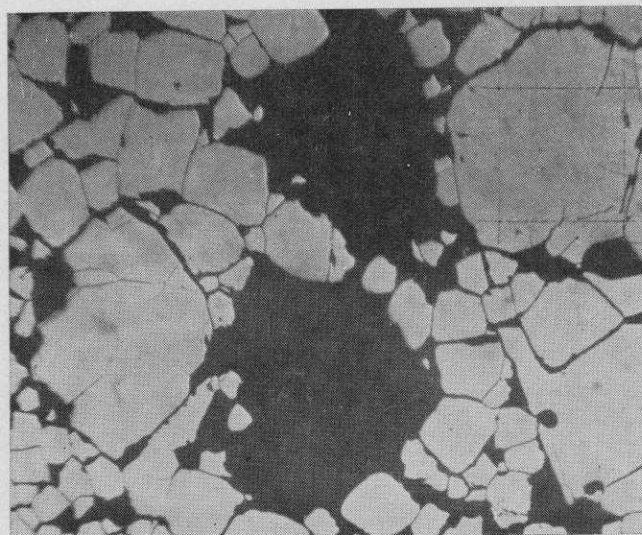
Flotation studies conducted at 65 mesh size produced a concentrate assaying 51.9% Cr_2O_3 , 18.27% Fe (Cr/Fe=2.5) with 85.2% Cr_2O_3 recovery. At a finer grind the flotation concentrate analysed 53.31% Cr_2O_3 , 18.97% FeO, (Cr/Fe=2.5) with a higher Cr_2O_3 recovery of 91.2%. Fatty acids as well as petroleum sulphonate can be used for chromite flotation.

Magnetic separation tests after removing the highly magnetic portion at 35 mesh and 65 mesh respectively yielded 54.25% and 55.08% Cr_2O_3 grade non-magnetic concentrates with 84.9% and 79.3% Cr_2O_3 distribution. It may be concluded from the test results that the Cr/Fe ratio cannot be improved due to the presence of iron in chemical combination within the chromite mineral.

(iii) Chromite from Boula Mine-Keonjhar Dist

The chromite sample in its "as received" state composed of 75 mm lumps, and compact in nature. The gangue chiefly composed of talc, serpentine and anthophyllite. Chromite grains were liberated at about 35 mesh size. Chemical composition of the sample is as follows:

Constituent	Assay%
Cr_2O_3	44.70
FeO	17.18
MgO	15.33
SiO_2	13.48
Al_2O_3	7.90
CaO	0.55
P	0.04
LOI	1.23
Cr/Fe ratio	2.3



Coarse grained chromite (white) and gangue (Black). The square represents 35 mesh aperture X44. Reflected Illumination. Boula Mines, Nausahi, Keonjhar, Orissa.

Tabling tests were conducted with 35 mesh and 48 mesh grinds. The 35 mesh material was sized in hydrosizer and the coarse fraction left untreated. The medium and fine portions were treated on tables and the concentrate and middlings were mixed with the untreated coarse portions. The mixed concentrate obtained with roll-crushed product analysed 53.2% Cr_2O_3 , 19.71% FeO with a Cr_2O_3 recovery of 84.9%. The ball mill grind under similar conditions produced a concentrate analysing 53.87% Cr_2O_3 , 20.16% FeO with 90.4% Cr_2O_3 recovery.

Tests with 48 mesh grind prepared in a roll crusher gave a mixed concentrate (mixed product of the concentrates and middlings sized) analysing 53.59% Cr_2O_3 , 20.74% FeO with 86.5% Cr_2O_3 distribution. The mixed concentrates from the rod mill grind analysed 53.56% Cr_2O_3 , 20.10% FeO with 90.4% Cr_2O_3 distribution.

Humphry's spiral test with rod mill ground to 48 mesh size produced a combined concentrate (conc. & middling) analysing 54.11% Cr_2O_3 , 20.52% FeO with 79.6% Cr_2O_3 distribution.

Magnetic separation tests at 48 mesh size after removing the highly magnetic matter, feebly magnetic and non-magnetic matter yielded a product analysing 54.69% Cr_2O_3 and 20.33% FeO with 87.9% Cr_2O_3 recovery.

Flotation tests with a feed ground to 65 mesh using sodium sulphonate yielded a concentrate assaying 55.5% Cr_2O_3 , and 20.34% FeO with 80.3% distribution. Tests with petroleum sulpho-nate yielded concentrate assaying 54.39% Cr_2O_3 , 20.16% FeO with 84.5% distribution. But in all the cases the Cr/Fe ratio did not improve beyond 2.4 level thereby making the concentrate not useful for metallurgical industry.

C. CHROMITES FROM KARNATAKA

(i) Chrome Ore from Talur

The sample was sent by M/s. Tata Iron and Steel Co. Ltd. for investigating the possibility of producing metallurgical grade of chromite. The sample consisted of lumps from 12 mm to 45 mm in size. The chief ore mineral was chromite and the gangue constituted of magnesite, calcite, serpentine, augite, olivine, hypersthene and horn-blende and chromite was liberated at 48 mesh size. Complete chemical analysis of the sample was as follows:

Constituent	Assay%
Cr_2O_3	35.21
FeO	18.90
CaO	1.95
Al_2O_3	9.20
MgO	18.34
SiO_2	7.74
LOI	8.53

Tabling tests with 48 mesh sized (coarse and fine) feeds produced coarser concentrate analysing 47.6% Cr_2O_3 and 23.1% FeO with 44.1% recovery. The combined concentrate analysed 47.87% Cr_2O_3 , 79.6% Cr_2O_3 distribution in them.

Another test conducted with sized 65 mesh size material under similar conditions produced concentrates of 48.4% Cr_2O_3 and 23.1% FeO with 51% Cr_2O_3 recovery and 49.0% Cr_2O_3 and 23.6% FeO with 25.8% Cr_2O_3 recovery in them. When both of these concentrate and middling from the coarse fraction (39.29% Cr_2O_3) were combined, the product analysed 48.07% Cr_2O_3 with 81.2% Cr_2O_3 distribution.

Tests with 48 mesh feed in Humphry's spiral produced a concentrate of 45.34% Cr_2O_3 with 77.6% recovery, with further treatment of this product to 47.27% Cr_2O_3 with 65% of Cr_2O_3 recovery (w.r.o.) only. Flotation tests produced

only 44.3% Cr_2O_3 grade of concentrate with 68.5% distribution of chromite.

(ii) Arsekare Chromite

The sample consisted of lumps from 12 mm to 75 mm in size. Chromite was the chief ore mineral and the associated gangue was composed of antigorite, chlorite, talc and anthophyllite. The sample as received analysed 29.47% Cr_2O_3 and 17.65% FeO.

Tabling tests conducted with 48 mesh ground ore produced a concentrate of 46.01% Cr_2O_3 grade with 75.4% recovery. When the sample was ground to 65 mesh and treated after classification, the combined coarse and fine concentrate analysed 47.45% Cr_2O_3 with 74.3% Cr_2O_3 recovery. At 100 mesh grind the table concentrate analysed 47.97% Cr_2O_3 with 75.6% recovery.

Humphry's spiral test conducted with 65 mesh grind yielded a chromite concentrate assaying 43.6% Cr_2O_3 with 64.5% recovery. Further treatment of the spiral concentrate on shaking table has improved the grade of the concentrate to 47.2% Cr_2O_3 with 60% recovery only. Magnetic separation of the table conc. did not show any improvement of the grade

Flotation tests using oleic acid emulsion produced a concentrate assaying 46.46% Cr_2O_3 with an overall recovery of 67.0% Cr_2O_3 in it.

(iii) Dodkatur Chromite

Chromite sample received from Dodkatur area consisted of lumps from 12 mm to 75 mm in size. Chromite was associated with serpentine, bastite, calcite, tremolite and quartz. The chromite was fairly liberated at 65 mesh size. The ore as received analysed as follows:

Constituent	Assay%
Cr_2O_3	26.29
FeO	20.42
CaO	1.93
MgO	19.23
Al_2O_3	11.25
SiO_2	11.51
LOI	9.18

Tabling tests conducted with the sized sample stage-crushed to 65 mesh size produced a combined concentrate of 38.36% Cr_2O_3 grade with

76.1% recovery. Tests conducted with 100 mesh sized feed, produced a concentrate of 40.34% Cr_2O_3 grade with 66.9% distribution. Humphry's spiral tests and flotation tests did not give any better results. The chromite as such may be useful to refractory industry but not for the metallurgical and chemical industries due to the unfavourable Cr/Fe ratio.

(iv) Chrome ore from Byrapur Area, Hassan Dt

The sample consisted of lumps in size from 25 mm to 75 mm in size with a small quantity of fines. The chromite was liberated at about 65 to 100 mesh size. Magnesite and serpentine formed the bulk of the gangue and present as matrix for the chromites. Small amounts of quartz and ochre were also present. Complete analysis of the r.o.m. sample was as follows:

Constituent	Assay%
Cr_2O_3	36.74
FeO	22.93
MgO	15.47
CaO	0.65
SiO_2	12.36
Al_2O_3	6.22
LOI	4.84
Cr/Fe	1.4

Tabling tests conducted with sized 48 mesh ground product produced a combined concentrate of 50.76% Cr_2O_3 with 58.4% Cr_2O_3 recovery. At 65 mesh size, the test yielded a concentrate of 51.52% Cr_2O_3 with a recovery of 60.7%. When the middlings were combined with conc. the recovery increased to 88.9% but the grade would lower to 49.11% Cr_2O_3 . When the combined table middlings and concentrate were magnetically separated, a feebly magnetic concentrate of 49.98% Cr_2O_3 grade with 78.5% (w.r.o.) recovery was obtained.

Tabling tests conducted with 100 mesh material yielded a concentrate of 52.11% Cr_2O_3 , 31.72% FeO with 77.3% recovery of chromite. Humphry's spiral test at 48 mesh size followed by the cleaning of spiral middlings on shaking table yielded a concentrate of 47.78% Cr_2O_3 with 61.5% recovery.

Magnetic separation tests with deslimed 65 mesh sample produced 49.08% Cr_2O_3 and 29.18% FeO grade concentrate with 90.6% Cr_2O_3 recovery. Reduction roast followed by magnetic separation

tests at -65 mesh size yielded a magnetic concentrate analysing 44.2% Cr_2O_3 with 91.4% Cr_2O_3 distribution. Magnetic separation tests with an oxidizing roast followed by reduction roast yielded a concentrate of 46% Cr_2O_3 and 31.2% FeO grade with 81.9% Cr_2O_3 distribution in it. The over all test results indicated that Cr_2O_3 content of the ore may be improved but Cr/Fe ratio cannot be improved due to the chemical association of iron with chromite.

D. CHROMITES OF ANDHRA PRADESH

(i) Chromite from Erukonda area, West Godavari Dist.

Chromite was associated with orthopyroxenes, feldspars, followed by minor amounts of antigorite, ilmenite, goethite and biotite; liberation of chromite from the gangue was observed at 65 mesh size. Complete chemical analysis of the chromite r.o.m. sample was as follows:

Constituent	Assay%
Cr_2O_3	38.00
FeO	26.20
Sol.Fe	1.36
SiO_2	8.30
Al_2O_3	15.40
MgO	10.30
CaO	1.90

Tabling tests conducted with 48 mesh sized feed yielded concentrate of 42.48% Cr_2O_3 (coarse) 41.75% Cr_2O_3 (Medium) and 42.11% Cr_2O_3 (fine) grade with 73.8% recovery; when all the three concentrates and middlings from the coarse portion (36.16% Cr_2O_3) were combined, the product analysed 42.01% Cr_2O_3 , 28.6% FeO with a recovery of 76.8% Cr_2O_3 . When the feed was ground to 65 mesh size and treated on shaking table after sizing, the coarse concentrate analysed 45.31% Cr_2O_3 , 29.80% FeO while the fines concentrate assayed 45.10% Cr_2O_3 and 29.80% FeO; when the two concentrates were combined with middlings (fine) the product analysed 44.61% Cr_2O_3 , 29.65% FeO (Cr/Fe=1.32) with 74.6% Cr_2O_3 distribution in it. Tests conducted with 100 mesh ground feed did not show any further improvement.

Flotation tests with 85% -100 mesh grind produced a concentrate of 43.7% Cr_2O_3 and 29.61% FeO (Cr/Fe=1.31) with 85% recovery of Cr_2O_3 . Magnetic separation tests produced a feebly

magnetic chromite concentrate of 45.00% Cr_2O_3 , 29.8% FeO with an over all recovery of 54.8%.

The sample could not be beneficiated for metallurgical purposes due to the chemical association of iron with chromite.

(ii) Chrome ore from Garividi, Srikakulam Dist

Chromite sample was 12 mm to 75 mm in size and was to be up-graded for metallurgical use. Chromite was the chief ore mineral, associated with metallic minerals like hematite and goethite. The non-metallic gangue composed of orthopyroxenes, feldspars, micas, antigorite etc. The gangue minerals and chromite were liberated at 48 mesh size. Chemical analysis of the R.O.M. ore was as follows:

Constituent	Assay%
Cr_2O_3	43.80
FeO	21.52
SiO_2	14.21
Al_2O_3	8.31
CaO	1.04
MgO	10.98

Tabling tests conducted with a feed size of 28 mesh produced coarse, medium and fine concentrates of 51.1% Cr_2O_3 , 50.1% Cr_2O_3 and 49.5% Cr_2O_3 grade respectively. The combined concentrate analysed 50.6% Cr_2O_3 and 24.1% FeO (Cr/Fe=1.85) with 83.5% Cr_2O_3 recovery. Tests conducted with 48 mesh sized feed produced coarse and fine concentrates of 52.5% Cr_2O_3 and 51.7% Cr_2O_3 . The combined concentrate analysed 52.4% Cr_2O_3 with 77.1% Cr_2O_3 distribution.

Reduction roast followed by magnetic separation of the sized feed after removing the highly magnetic portion and the non-magnetic portion produced feebly magnetic concentrates of 52.0% Cr_2O_3 in each case of coarse and fine products and the combined concentrate analysed 52.0% Cr_2O_3 , 27.85% FeO with an overall recovery of 60.7% Cr_2O_3 distribution. Metallurgical grade chromite concentrate could not be produced from this sample due to the chemically associated iron with the chromite.

E. CHROMITES FROM MAHARASTRA

(i) Low grade chromite from Vagda/Maharashtra

The sample consisted of fines and lumps upto

38 mm in size. Chromite was associated mainly with olivine followed by chlorite and minor amounts of hypersthene, magnetite and ilmenite; chromite and the gangue were fairly liberated at 65 mesh size. Complete chemical analysis of the sample was as follows:

Constituent	Assay%
Cr_2O_3	33.14
Total Fe as FeO/	21.51
Soluble Fe	1.03
MgO	14.50
SiO_2	14.74
Al_2O_3	11.00
CaO	2.24
LOI	2.13

Tabling tests with a feed ground to 35 mesh size produced a coarse grained concentrate of 46.5% Cr_2O_3 , medium grained concentrate of 36.8% Cr_2O_3 and a fine concentrate of 33.9% Cr_2O_3 . The combined concentrate analysed 43.5% Cr_2O_3 , 28.5% FeO with 66.4% Cr_2O_3 recovery. Similarly, table combined concentrates obtained at 48 mesh and 65 mesh sizes were respectively analysing 46.4% Cr_2O_3 and 26.4% FeO with 78.2% Cr_2O_3 distribution and 47.4% Cr_2O_3 and 26.2% FeO with 75.2% Cr_2O_3 distribution.

Flotation tests and magnetic separation tests did not show any improvement in the grade of the concentrates. The concentrate may be used for chemical and refractory industries.

(ii) Chromite from Kankauli, Ratnagiri Dist.

Chromite was 35 mm in size in its as received state. Microscopic examination of the sample indicated the presence of hematite as the single metallic gangue while chlorite followed by serpentine, talc orthopyroxenes and mica formed the non-metallic gangue. Fair liberation of chromite was observed at 65 mesh size. The r.o.m. ore sample analysed as follows:

Constituent	Assay%
Cr_2O_3	34.73
FeO	21.50
Al_2O_3	14.74
SiO_2	9.60
MgO	17.21
CaO	2.00
Soluble Fe	0.76

Tabling tests at 48 mesh and 65 mesh ground feed produced combined (coarse and fine) concentrates analysing 49.6% Cr_2O_3 , 28.72% FeO with 91.2% Cr_2O_3 distribution and 49.86% Cr_2O_3 , 28.09% FeO with 87.4% Cr_2O_3 distribution respectively. In both the cases the Cr/Fe ratio was poor.

Humphry's spiral tests conducted with 65 mesh size produced a concentrate of 47.75% Cr_2O_3 , 26.93% FeO grade with 80.8% Cr_2O_3 distribution in it.

Magnetic separation tests conducted with 48 mesh and 65 mesh ground material, after discarding the highly magnetic and non-magnetic portions resulted in a feebly magnetic concentrate analysing 49.35% Cr_2O_3 , and 27.8% FeO with 75.4% Cr_2O_3 distribution in it.

Flotation tests yielded a concentrate of 41.6% Cr_2O_3 grade with 77.3% Cr_2O_3 distribution. Because of the high iron content in the concentrates, it may be used in the chemical and refractory industries.



Fig. 3.6 Chromite grains with gangue inclusions octahedral planes and surrounded interstitial chlorite serpentine gangue X112. Reflected Illumination Kankauli, Ratnagiri Dist., Maharashtra.



Fig. 3.7 Chromite grains showing very little gangue inclusions and with idiomorphic outlines. Interstitial gangue is chlorite serpentine X112. Kankauli, Ratnagiri Dist., Maharashtra.

TABLE 3.3—BENEFICIATION RESULTS OF CHROMITE ORES

State & Locality	% ROM Cr ₂ O ₃	Assay FeO	Beneficiation Method	Conc. Cr ₂ O ₃	Assay % FeO	Recovery Cr ₂ O ₃ %	Remarks
Bihar							
(1) Kittaburu (Soft)	36.66	19.05	Tabling at 65 mesh	51.7		82.3	Siliceous ore
(2) Kittaburu (Soft)	37.2		Tabling at 65 mesh	48.95	22.42	80.4	Siliceous ore
(3) Mixed ore (Soft+ Hard)	33.2		Tabling at 65 mesh	46.67	21.38	80.0	Pilot Plant scale tests conducted.
Orissa							
(4) Gunjag area	41.4	8.8	Reduction roast and magnetic separation	60.0	15.1	81.2	Ferruginous ore Cr/Fe=3.3; used for metallurgical industry Cr/Fe=2.5
(5) Nausahi area	42.52	16.62	Magnetic separation	55.08		79.3	
(6) Boula Mine	44.70	17.18	Tabling at 65 mesh	55.40	19.4	91.7	
			Flotation	54.39	20.16	84.5	
			Tabling at 48 mesh	53.56	20.10	90.4	
Karnataka							
(7) Talur	35.21	18.9	Tabling with sized 65 mesh feed	48.07		81.2	
(8) Arsekare	29.47	17.65	Flotation	46.46		67.0	
(9) Dodkatur	26.29	20.42	Tabling at 100 mesh	47.97		75.6	
			Tabling with 100 mesh feed	40.34		66.9	Cr/Fe ratio unfavourable
(10) Byrapur	36.74	22.93	Desliming and magnetic separation with 65 mesh feed	49.08	29.18	90.6	Cr/Fe ratio unfavourable
Andhra Pradesh							
(11) Enukonda	38.00	26.20	Flotation with 100 mesh	43.7		85.0	Cr/Fe=1.31
(12) Garividi	43.8	21.51	feed tabling at 65 mesh	44.61	29.65	74.6	Cr/Fe ratio=1.32
			Tabling with 48 mesh feed	52.4		77.1	Cr/Fe ratio=poor
Maharashtra							
(13) Vagda	33.14	21.51	Tabling with 45 mesh feed	46.6	26.49	78.2	Cr/Fe ratio=1.5
(14) Kankauli	34.73	21.5	Magnetic separation	49.35	27.8	75.4	
			Tabling at 48 mesh	49.60	28.72	91.2	Cr/Fe ratio poor

F. AGGLOMERATION STUDIES WITH CHROMITE FINES

Mining of ores (iron ore, chrome ore, manganese ore etc) by mechanised methods results in production of fines which go as waste if not made as lumps by way of agglomeration. Further in most of the cases of the final beneficiation products (fine concentrates) they are to be agglomerated before using them as raw materials in industry. As such agglomeration is essential for the use of ore fines in the metallurgical and other mineral-based industries. Sintering, pelletizing and briquetting are the three common agglomeration methods. Sintering and pelletization studies were taken up on chromite fines and the details of the studies are given below :

(i) Sintering

Sintering studies were taken up on the chromite ore fines received from M/s. Orissa Industrial Development Corpn., coke and limestone samples used in the tests were received from Hindustan Steel Ltd. and TISCO Ltd. respectively. Complete chemical analysis of the raw materials are as under :

	<i>Chromite</i>	<i>Coke</i>	<i>Limestone</i>
Cr ₂ O ₃	58.48	—	—
FeO	12.50	—	—
SiO ₂	3.52	12.5	8.33
Al ₂ O ₃	9.75	6.4	1.65
CaO	Trace	1.0	45.90
MgO	13.94	0.5	3.60
F.C	—	71.9	—
Ash	—	24.9	—

Tests were conducted varying moisture/water

content in the sinter mix, coke (solid fuel) and the return fines which are normally added to the sinter mix. The test results indicated that the best results were obtained with 6% of moisture, 7% of coke and 20% of return fines. Self fluxing sinters were also prepared by adding limestone fines to the sinter mix varying the basicity ($\text{CaO} + \text{MgO}/\text{SiO}_2 + \text{Al}_2\text{O}_3$) from 1.0 to 1.60 and it was observed that at all basicity values, the sinters were quite alright in relation to the shatter index etc.

(ii) Pelletization Studies

Pellets were prepared in a laboratory drum pelletiser. The ore fines in their "as received state" were too coarse for pelletising and studies were conducted employing different grinds of the ores (70% — 325 mesh optimum) and a binder. Apart from these, pellets were heat hardened to withstand the handling operations at various points.

Pellets without any binder were very poor in strength when dry, but after firing at 1200°C developed a crushing strength of 67.3 kg/pellet. When 0.1% of sodium silicate was added the crushing strength of the hardened pellet increased to 82.5 kg/pellet. Bentonite also improved the strength of the pellet whereas cement and flourite did not; tests conducted with 0.5% sodium silicate and 1.0% limestone also produced a crushing strength of 138 kg/pellet when fired at 1200°C.

With organic binders also good pellets were produced but the initial drying was critical owing to the fast decomposition of the binders. Firing at 1000°C gave good results. Combination of organic binders with inorganic binders and fluxes were tried, but without success.

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