Characterisation and response to beneficiation of ferruginous chromite ores

** R. Bhima Rao, * T. G. Charan and ** S. R. S. Sastri

INTRODUCTION :

Sukinda-Nausahi belt of Orissa, represent about 90% of the Indian chromite ore reserves. These ores are lateritic type in nature resulted by weathering of ultrabasic rocks. Metallurgical industries consume maximum chromite ores—around 50% followed by refractory and chemical industries which consume about 35% and 15% respectively. The utility pattern of chromite in industries is varying greatly. The variation in the demand could be due to limited market for medium and low grade chromite. Hence it is necessary to improve the chromium content for better utilisation and conservation of available resources.

Raw Materials :

Two different chromite ore dump samples of Kaliapani 1 & 2 and other dumps under the lease of M/s. Orissa Mining Corporation Ltd. and one medium grade chromite ore sample from M/s. Misrilal Mines Pvt. Ltd. have been received to assess the amenability for beneficiation.

Liberation Studies :

The liberation size and the possible grade recoverable from the ore are determined from (1) the texture of the mineralogical constituents present in the ore and (2) the assay value of each closely sized fraction of the ore or the products obtained from sink-float or magnetic separation of each closely sized fractions of different mill products.

Mineralogical studies were carried on the samples to find out the different constituents present and their liberation size. Physical and chemical characteristics of the samples as received were determined. All the ROM samples were size analysed and each fraction was analysed for chromium and iron. Based on these results, representative samples were stage crushed to pass through 1.5 mm open rolls. Each crushed product was further size analysed. Separate sink-float and magnetic separation tests were carried out on each of the closely sized fractions to assess the liberation and the type of concentrate recoverable either by gravity or magnetic separation (Fig. 1). An organic liquid of 2.83 specific gravity was used for sink-float studies. Each crushed product was subsequently ground for different time intervals in a batch ball mill of 1200 X 1200 mm in size with 25% ball charge. Each mill product was further size analysed to determine chemical constituents in each fraction and degree of liberation. Following the liberation studies bench scale beneficiation studies were carried out with or without combination of screen, hydro-cyclone, Diester table and Bartles-Mozley separator for enrichment of chromium content.

BENEFICIATION STUDIES :

Samples—D1 and D2

A representative sample was ground to optimum size as indicated in Fig. 2. A sample of 5 kg material was taken for each experiment and subjected to tabling with or without

** *Regional Research Laboratory (Council of Scientific & Industrial Research) Bhubaneswar - 751 013, Orissa.*

* *M. A. Sc., Mineral Processing, Gulbarga University.*

desliming by hydro-cyclone or pre-concentration on Bartles-Mozley separator. Experiments were also carried out on a deslimed product using a Bartles-Mozley separator. Representative samples of concentrates, middlings and tailings of each experiments were collected for chemical analysis. The optimum results obtained from different experiments are tabulated in Tables 2 & 3.

Sample-C1 :

A representative sample was washed and sized. Each size fraction was analysed for metal content. Based on the results, two tonnes of sample was washed over a double deck screen of 25 and 8 mm aperture and the washings as well as the fines below 8 mm were deslimed in a spiral classifier (225 mm dia X 1800 mm long) at a rate of about 75 kg/hr with 250 lit/hr water. The results are tabulated Table in 4.

Results and discussions :

Characteristics of the chromite ore samples are shown in Table-1. Sink-float separation and effect of particle size on crushed products related to liberation size are shown in Table-5 and Fig. 1. The results obtained from detailed beneficiation studies under optimum conditions are tabulated in 2a, 2b and 2c for sample D-1 and Table 3 and 4 are for sample D-2 and C-1 respectively. Schematic flow-sheets for the above ores are shown in Fig. 2 and 3.

It is observed from Fig. 1, the assay values of closely sized fractions of the samples, the liberation size is around 100 and 250 microns for sample D—1 and D—2 and Table-2 indicates, the sample C—1 is as such liberated. Based on these results, detailed investigations were carried out both on laboratory and large scale. A product is obtained from a feed sample D—1 on Diester table analysing 41% Cr_2O_3 with 72% metal recovery. But by desliming/pre-concentrating the feed sample D—1, by using hydro-cyclone/ Bartles-Mozley separator a better product is obtained, which analyses 43% Cr_2O_3 with 70% metal recovery. These results indicate that desliming or preconcentrating the feed prior to tabling, help in getting a better product and reduce the feed load and water requirements for tables.

Sample D—2 yielded a product after desliming analysed 40% Cr_2O_3 with 78% metal recovery. The product obtained from slimes on Bartles-Mozley separator is recirculated to the process. A common flow-sheet is obtained for sample D—1 and D—2, shown in Fig. 2. From Table—5 and Fig. 3, the sample C—1 yielded a product of 55% Cr_2O_3 with 94% metal recovery by desliming with spiral classifier.

Conclusions :

The possible libreration size of the dump samples D—1 and D—2 is around 100 and 250 microns and the possible grade recoverable from the ores is around 43% Cr_2O_3 is determined from the assay values of each closely sized fractions obtained from size analysis of the ore. A product assaying 43% and 40% Cr_2O_3 with 70% and 78% metal recovery is obtained from these samples on Diester table after desliming the feed. Sample C—1 is, as such liberated and a product containing 55% Cr_2O_3 with 94% metal recovery is obtained after desliming the feed using a spiral classifier. Accordingly suitable flow sheets have been suggested. It is concluded that these samples are amenable to gravity separation and the products are suitable for industries after suitable blending and agglomeration.

Acknowledgements :

The authors express their sincere thanks to Prof. P. K. Jena, Director of the Laboratory for his keen interest and encouragement in the work and for permitting to present this paper at "National Seminar on Mineral Processing", Jamshedpur. The authors also wish to thank Sri M. I. Ansari, Project Co-ordinator for his constant encouragement. Thanks are due to Dr. B. S. Acharya for X-ray diffraction studies and others involved in this project.

Table—1 : Characteristics of chromite ore samples

Sl. No.	Area/Mine	Nature of sample	Sample code	Cr_2O_3 % feed	Major mineralogical constituents
1.	M/s. OMC Ltd. Dump--1	Lumpy, friable, ferruginous low grade ores.	D—1	29.9	$Mg_2Cr_2O_4$, Hematite goethite, magnetite, quartz, serpentine and nickel oxide minerals.
2.	M/s OMC Ltd. Dump—2	Lumpy, friable ferruginous low grade ores.	D—2	26.5	Chromite, goethite, hematite, megnetite, quartz, serpentine and nickel oxide minerals.
3.	M/s. Misrilal Mines Pvt. Ltd. Chromite ore.	Lumpy, friable, ferruginous medium grade ore.	C—1	49.4	FeO $(Cr, Al)_2O_3$ Mg-Cr-Al-Silicate-hydroxide, goethite.

Table—2 : Sink-float separation on crushed product related to liberation

Sample No. C—1, Feed Cr_2O_3 % : 49.4

Sl. No.	Size in microns	Feed Wt. %	Heavies Wt. %	Feed Cr_2O_3 %	Heavies Cr_2O_3 %
1.	1000	38.9	37.8	51.4	53.0
2.	350	18.8	13.5	54.0	54.0
3.	150	21.8	21.6	57.9	57.3
4.	53	10.8	10.6	57.5	57.7
5.	B 53	14.7	—	27.8	—
	Head	100.0	83.5	50.4	54.9

Table—3 (A) : Results obtained from Diester table on D—1 sample

Sl No.	Sample	Weight, %	% of Cr_2O_3	
			Grade	Recovery
1.	Concentrate	53.84	41.59	72.0
2.	Middlings	23.08	23.71	18.0
3.	Tailings	23.08	14.87	10.0
	Head	100.00	31.29	100.0

Table — 3 (B) : Results obtained from cyclone and Bartles-Mozley separator on D—1 sample

Sl. No.	Sample	Weight %	% of Cr_2O_3	
			Grade	Recovery
I				
Desliming by hydro-cyclone	Concentrate	64.0	37.79	81.0
	Tailings	36.0	15.27	19.0
	Head	100.0	29.69	100.0
II				
Pre-concentrate by Bartles-Mozley separator.	Concentrate	70.97	35.70	85.0
	Tailings	29.03	15.53	15.0
	Head	100.00	31.29	100.0

Table—3 (C) : Optimum results obtained on sample D—1

Sl. No.	Sample	Weight %	% of Cr_2O_3	
			Grade	Recovery
I				
Desliming	Concentrate	64.0	37.8	81.0
	Tailings	36.0	15.3	19.0
	Head	100.0	29.7	100.0
II				
Diester table	Concentrate	49.0	43.05	71.0
	Middlings	10.0	24.37	8.0
	Tailings	5.0	13.20	2.0
	Tailings (deslimed)	36.0	15.27	19.0
	Head	100.0	29.69	100.0

Table—4 : Results obtained on sample D—2

Sl. No.	Sample	Weight %	% of Cr_2O_3	
			Grade	Recovery
I				
Screen (1.5 mm. open)	Coarse	4.39	20.26	3.0
II				
Diester table on	Concentrate	53.82	40.30	78.0
deslimed product	Tailings	13.46	13.85	7.0
III				
Bartles-Mozley	Concentrate	7.08	21.56	6.0
on slimes.	Tailings	21.25	7.82	6.0
	Head	100.00	26.63	100.0

Table—5 : Results obtained on sample C—1

Sl. No.	Unit	size (mm)	Feed %		Product %		Recovery %
			Weight	Cr_2O_3	Weight	Cr_2O_3	
1.	Screen	+25	4.6	48.9	4.2	52.9	4.0
2.	Screen	+ 8	18.1	51.5	16.9	51.5	17.0
3.	Spiral	- 8	77.3	50.7	64.4	55.5	71.0
4.	Spiral slimes		—	—	14.5	25.7	8.0
	Head		100.0	50.7	100.0	50.4	100.0

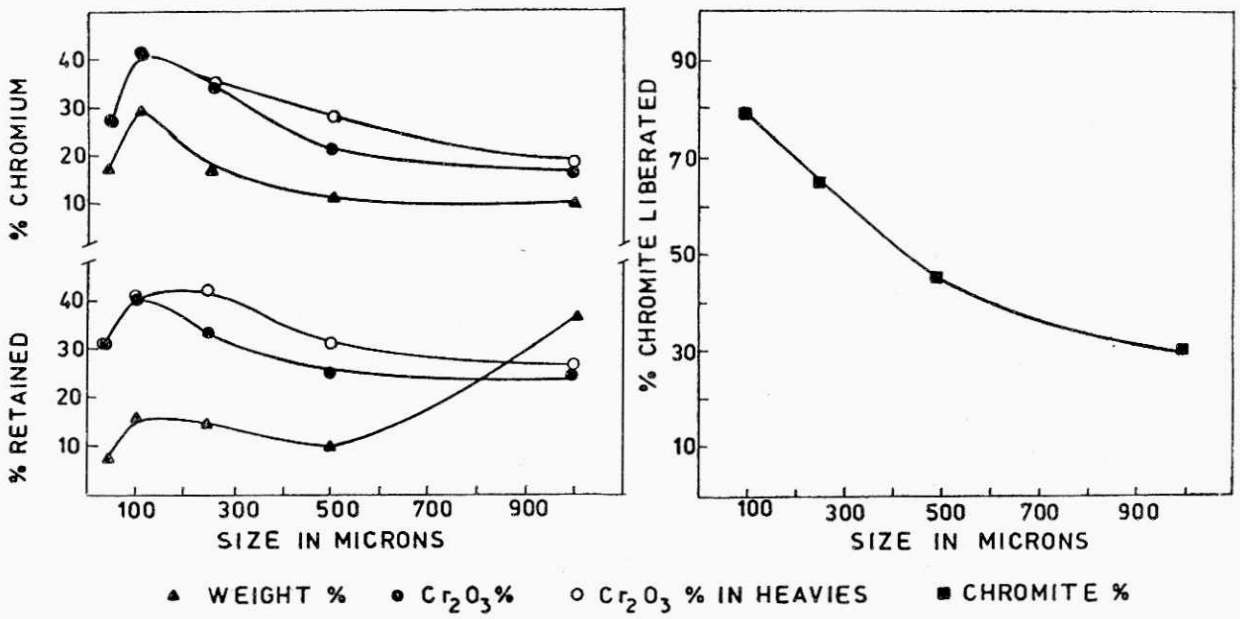
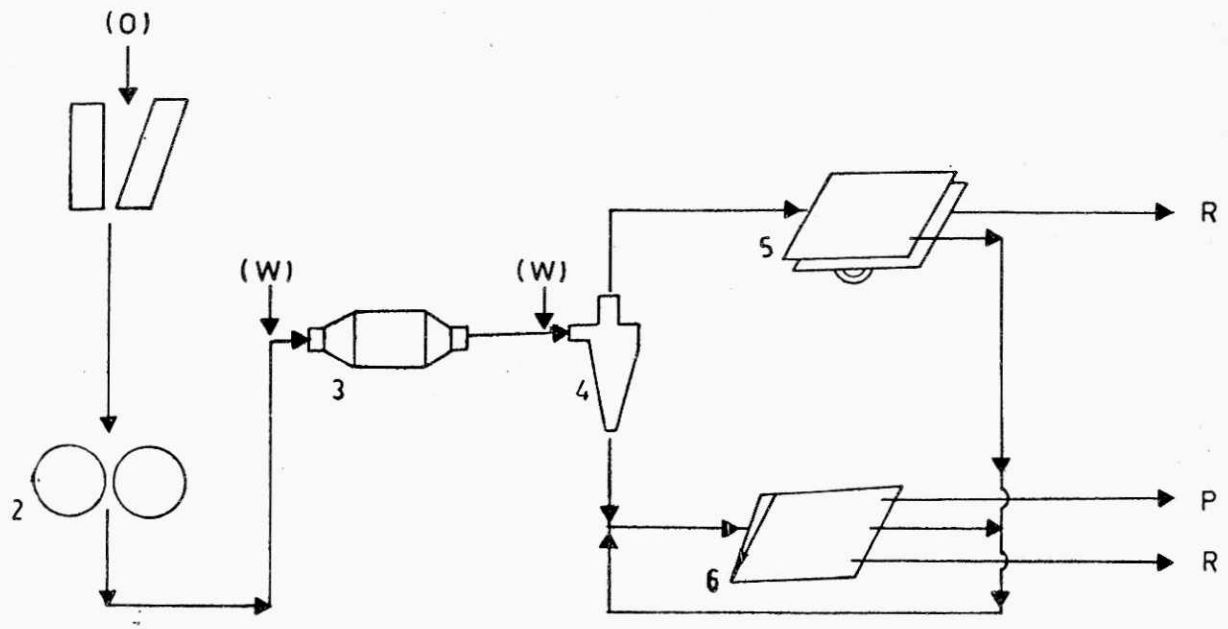


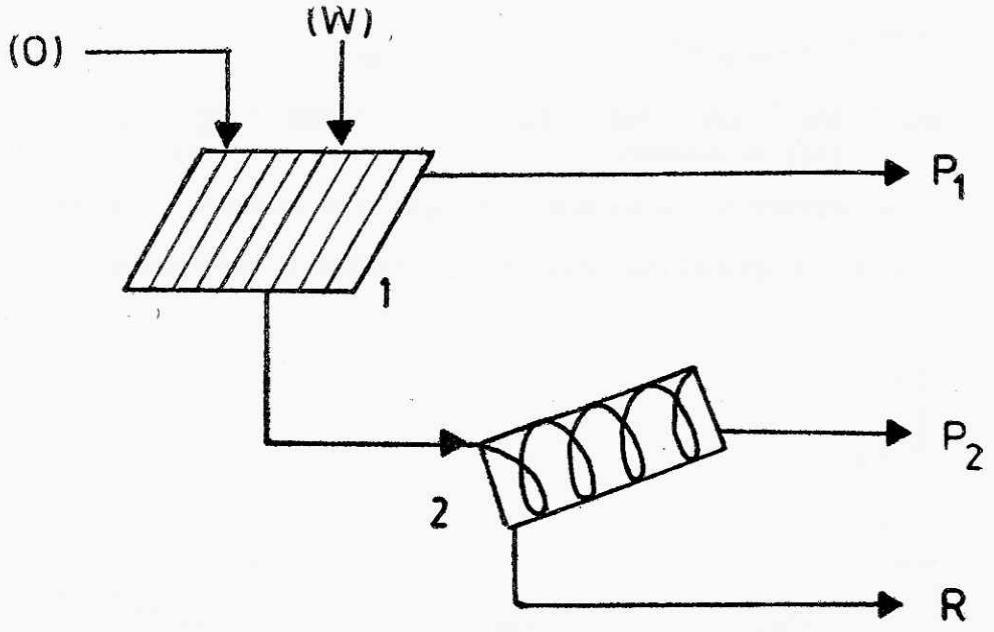
FIG 1 LIBERATION SIZE BY DIFFERENT METHODS..



(O) ORE (W) WATER (P) PRODUCT (R) REJECTS

1. JAW CRUSHER 2. ROLL CRUSHER 3 BALL MILL 4. HYDROCYCLONE
5. BARTLES-MOZLEY 6. TABLE

FIG.2 SCHEMATIC FLOW SHEET FOR BENEFICIATION OF SAMPLE D_1 & D_2



(O) ORE (W) WATER (P_1 & P_2) PRODUCTS
(R) REJECTS

1. SCREEN (VIBRATORY WITH 8 mm OPENING)
2. SPIRAL CLASSIFIER

FIG. 3 SCHEMATIC FLOW SHEET FOR BENEFICIATION OF SAMPLE - C_1.