IMPROVING GRADE OF INDIAN CHROMITE ORES BY HIGH–GRADIENT MAGNETIC SEPARATION

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Abstract

Investigations were carried out to improve the chromium–to–iron ratio of two off–grade chromite samples from Orissa, India, having different physical natures. The results of these investigations indicated that the chromium–to–iron ratio could be improved from 1.85 to 3.0 with around 10% to 30% recoveries by high–intensity magnetic separation of the washed ores. A common flowsheet is suggested for processing of these two ores.

INTRODUCTION

The major portion of the Indian chromite ore reserves are located in Sukinda–Naushai belt of Orissa, and belong to the lateritic iron group ores group. Approximately 40% of these reserves are suitable for metallurgical use, 33% for refractory making and 27% for chemical industries [1]. The purpose for which a given ore can be used depends on the chromium–to–iron ratio besides the Cr_2O_3 content. Ores having chromium–to–iron ratio above 2.8 are considered suitable for metallurgical purposes and those with the ratio between 2.8 and 1.8 for charge chrome/refractory uses, while the rest with ratio below 1.8 are used for production of chemical [1].

Statistical review [1] reveals that metallurgical industry accounts for about 77% of the total annual consumption of chromite ore in India. The refractory industries

consume around 15% and the rest is used for producing chemicals. Now there is a heavy demand for chromite ore due to increase in the installed capacity of plants. In addition to this, many new ferroalloy plants are coming up in the country. Due to a sudden increase in the demand for the consumption of high-grade ore containing chromium-to-iron ratio above 3.0 by metallurgical industries, and the limited reserves of such high-grade ore resources, it has become necessary to improve the quality of medium-grade ores.

Investigations were, therefore, carried out on two ore samples selected from different mining localities of Orissa (India). These are similar in chemical characteristics but distinctly different in their mineralogical and physical characteristics. The results of these investigations are discussed in this paper.

MATERIALS AND METHODS

Ferruginous chromite ore samples of Orissa region having chromium-to-iron ratio 1.9 and 1.8 were supplied by M/s Misrilal Mines Pvt. Ltd., Chaibasa [2] and m/s The Orissa Mining Corporation Ltd., Bhubaneswar [3], respectively. These samples were designated as A and B.

Representative samples of A and B were stage crushed to pass through crushing rolls set to 1.5 mm gap. Each crushed product was subsequently ground at different time intervals in a batch ball mill of 300x300 mm size, with mill feed at 40% filling. The sample as received and each mill product were size analysed by wet screening. All size fractions were analysed for chromium content. The fractions below 50 μm were considered as slimes.

Based on these results, large-scale continuous scrubbing and washing studies were carried out on both A and B samples using spiral classifier 225 mm dia x 1800 mm long (M/s Mineral Processing Equipment, Bombay), at a rate of 80 kg/h of ore, and 250 ℓ /h of water.

The washed products of samples A and B from the classifier were subjected to magnetic separation at currents of 1.0 A and 1.5 A by using dry belt magnetic

separator (Boxmag Rapid, single-disc type, model Log 1.4), at a rate of 70 kg/h. The other variables of the magnetic separator were maintained constant at the following levels:

- disc speed: 30 rpm
- belt speed: 0.1 m/s
- gap: 2 mm.

Mineralogical studies were carried out by x-ray diffraction and elemental analysis for chromium and iron were carried out by wet methods.

RESULTS AND DISCUSSION

The physical, chemical and mineralogical characteristics of the two samples are shown in Table 1. Results of laboratory and large-scale continuous washing tests are shown in Tables 2 and 3, respectively. Results of magnetic separation on washed products after crushing at 1.5 mm set roll crushers are shown in Table. 4. Summary of the results from continuous washing followed by magnetic separation are shown in Table 5.

It is observed from the data presented in Table 1 that both the samples A and B do not differ significantly in Cr_2O_3 content, but are physically distinct in nature. Sample A is hard, lumpy and rich in Cr_2O_3 content, and sample B is friable, fine and soft ore. Further, it can also be seen that sample A is associated with $\text{FeO}(\text{Cr},\text{Al})_2\text{O}_3$ — Ferran type chromite and sample B is with $\text{Fe}(\text{Al},\text{Cr})_2\text{O}_3$ chromite type mineral.

From the data in Tables 2 and 3, it can be seen that the chromium content can be significantly improved by simple washing. It is also concluded from the data in Table 2 that further grinding of the samples will cause a loss of Cr_2O_3 in the fines. These observations are confirmed by the results of large scale continuous scrubbing tests made on these samples shown in Table 3. The chromium content improved from 47% to around 52%. However, the chromium-to-iron ratio, 2.2, obtained in both products of samples A and B is still not suitable for some metallurgical industries.

Table 1 Characteristics of chromite ores

Details	Sample A	Sample B
Mine lease	M/s Misrilal Mines Pvt. Ltd. Chaibasa	M/s Orissa Mining Corp. Bhubaneswar
Location	Sukinda Valley, Orissa	Sukinda Valley, Orissa
Nature	Lumpy, hard, ferruginous	Fines, soft, friable, ferruginous
d80, passing size of ROM ore [mm]	6.5	2.5
Mineral constituents	Chromite [FeO, (Cr,Al) ₂ O ₃ ferran type] Goethite, hematite, magnetite, hydroxides of chromium, iron aluminium silicates, quartz	Chromite (Fe,Al,Cr) ₂ O ₃ and MgCr ₂ O ₃ Picrochromite, goethite, hematite, magnetite, hydroxides of chromium, iron, aluminium silicates, quartz
Cr ₂ O ₃ content	48.3%	47.3%
Cr/Fe	1.91	1.85

Table 2 Grade and recovery of Cr₂O₃ in batch washing

	Sample A		Sample B	
	Grade [%]	Recovery [%]	Grade [%]	Recovery [%]
Original feed	48.3	100	47.3	100
Washed material	55.8	93	53.9	95
Ground and washed material				
Time of grinding				
0 min	57.1	86	54.9	88
3 min	58.1	78	55.2	84
5 min	58	73	55.9	74

Table 3 Results of continuous washing tests

Sample	Details	Weight %	Cr ₂ O ₃ %	FeO %	Cr/Fe
A	Feed	100	48.3	22	1.91
	Product	87	52.2	20.5	2.22
	Slimes	13	22.4	31.6	0.62
B	Feed	100	47.3	22.3	1.85
	Product	85.5	51.5	20.8	2.16
	Slimes	14.5	22.9	30.9	0.65

Feed rates: chromite: 80 kg/h, water: 250 l/h

Table 4 Results of magnetic separation tests on washed products

Sample	Details	Weight %	Cr ₂ O ₃ %	FeO %	Cr/Fe
A	Feed	87	52.2	20.5	2.22
	Mags 1(*)	46.4	51.5	24.1	1.86
	Mags 2 (#)	29.1	55.4	15.3	3.15
	Non-mags	11.5	48.2	17.2	2.45
B	Feed	85.5	51.5	20.8	2.16
	Mags 1 (*)	47.9	50	22.6	1.93
	Mags 2 (#)	28.5	53.6	19	2.46
	Non-mags	9.1	53.4	15.6	2.99

Feed rate: 70 kg/h

* Magnetic product at 1.0 A

Weakly magnetic product between 1 and 1.5 A

Table 5 Summary of results

Detail	Sample A			Sample B		
	Feed	Product [P2]	Product [P1+P3]	Feed	Product [P3]	Product [P1+P2]
Cr ₂ O ₃	48.3	55.4	50.8	47.3	53.4	51.3
FeO	22.1	15.3	22.7	22.3	15.6	21.3
Cr/Fe	1.91	3.15	1.95	1.85	2.99	2.1
Yield [%]	100	29	58	100	9	76
Recovery [%]	10	33	61	100	10	83

The results of high-intensity magnetic separation tests on the washed ore samples given in Table 4 indicate that a product having chromium-to-iron ratio of around 3.0 can be obtained from both these samples. However, in the case of sample A, the weakly magnetic product is the desired one, while in the case of sample B the non-magnetic fraction is the desired one.

The probable reason for such a difference in the response to magnetic separation of these two ores is that samples A and B are associated with two different structural chromite minerals such as Fe(Al,Cr)₂O₃ and FeO(Cr, Al)₂O₃, respectively (Table 1). Such variations in structure influence the magnetic properties and separation characteristics. These views are supported by other studies [4 to 8]. Thus, from the data presented in Table 5 it is seen that chromite concentrates having chromium-to-iron ratio 3.0 can be obtained with 33% and 10% recoveries from samples A and B, respectively. The other material is suitable for making charge chrome. A common flowsheet shown in Figure 1 is suggested for both these ores.

CONCLUSIONS

Desliming of the two chromite samples studied gave almost the same grade of product in spite of differences in physical and mineralogical properties.

High-intensity magnetic separation of these washed chromite samples yielded fractions having chromium-to-iron ratio around 3.0. A common flowsheet involving high-intensity magnetic separation of crushed and washed chromite material is proposed to upgrade both types of the ores to products having chromium-to-iron ratio around 3.0.

Fig. 1 Schematic flowsheet for upgrading Cr/Fe ratio of ferruginous chromite ores.

Products of Cr/Fe = 3.0 for samples A(*) and B(#).

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