PILOT SCALE BENEFICIATION OF ZHOB VALLEY AND MALAKAND CHROMITE ORES

K. Hussain, N. Sheikh and A. A. Qureshi

PCSIR Laboratories, Lahore - 16

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Low grade chromites of Zhob Valley, containing 30-35 % Cr_2O_3, and of Malakand area having 12-35 % Cr_2O_3, were upgraded to concentrates assaying upto 48 % and 47 % Cr_2O_3 respectively. In the beneficiation sequence Humphry's spirals were used for roughing operations and the final concentrates were produced on Wilfley Tables. Test variables, optimized on the laboratory stage, were used to run the pilot plant tests. Testing was based on 30 tonnes of the ore samples and the test results were found to be reproducible with an overall recovery of 55 to 83 % Cr_2O_3. Chemical analysis of the concentrates confirms their suitability for the chemical and metallurgical operations.

Key words: Table and spiral concentration; Recovery; Grade.

INTRODUCTION

Chromite bearing ultramafics are exposed sporadically in the form of fairly large bodies over extensive areas in Zhob, Kharan, Las Bela and North Waziristan districts of Pakistan. The best known of these is the famous Zhob Valley ultramafic complex outcropping at Saplaitorghar, Nisai and Jangtorghar and extends to Khanozai [1].

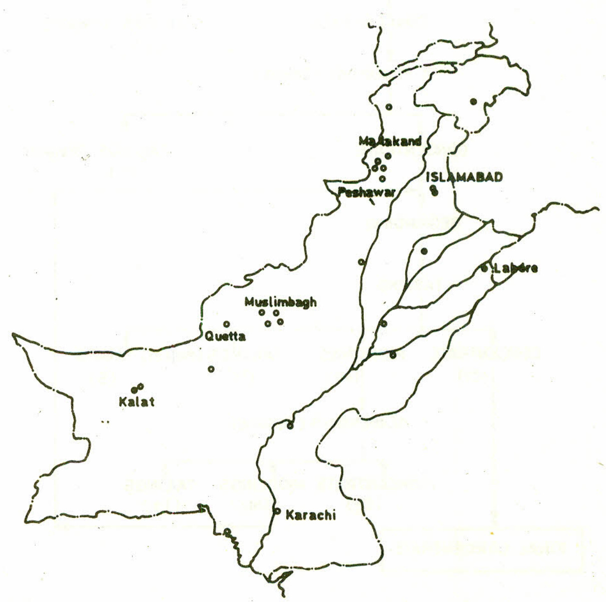
The other major chromite reserve is located in the Malakand area situated in Dargai ultramafic complex in the east-west extending mountain ranges emerging from alluvial plains west of Sakhakot and Dargai (Location Map) [2].

A considerable part of the chromite deposits of Zhob Valley [3] and Malakand [4] areas are of low grade. The prevelant practice of selective mining and hand-sorting of the better grade chromite also results in the accumulation of the low grade ore, which has no commercial value. The chromite mining in the country is limited and is mainly export oriented. This practice is not likely to be continued for long due to the fast depletion of the high grade ore. In addition, the imported chromite based products such as ferrochrome, chrommagnesite refractories, and chrome chemicals must be produced within the country from the indigenous ores. But this obviously cannot be achieved unless the low grade ores are beneficiated and utilized.

The work reported here was undertaken with a view to increase the production of chromite by utilizing the low grade chromite reserves for the export market and chromite-based industries.

Collection of samples. A composite sample, weighing 15 tonnes, representing ten mines in the Muslimbagh mining district of Zhob Valley was collected. Two samples weighing 5 and 10 tonnes from Bajrokanri and Badasar (Malakand area) respectively, were also collected. These samples varied in physical appearance, texture, grade and chemical composition.

Mineralogy. Mineralogy plays an important role in the processing of ores and minerals. In the present case mineralogical studies have revealed that the various chromite samples can be processed to desired grades of concentrates at fairly coarser sizes with favourable recoveries of the valuable component. The mineralogy of each ore sample in relation to processing has been amply discussed later in



Location map of Chromite Deposits in Pakistan.

this paper. The chemical analysis of the different samples have been given in Table-1.

EXPERIMENTAL

The feed for the pilot scale tests was prepared through jaw crusher, crushing rolls and the rod mill. The Bajrokanri ore, containing 12.5 % Cr_2O_3, was ground to 30 mesh and subjected to three successive spiral operations in the following manner (Fig. 1):

Table 1. Chemical composition of the chromite ore samples

Constituent	Bajrokanri	Badasar	Muslimbagh
Cr_2O_3	12.66	31.65	34.92
Fe_2O_3	12.80	14.00	15.95
SiO_2	31.00	19.24	17.30
Al_2O_3	2.60	16.00	13.00
MgO	34.86	15.57	11.20
L/I	6.00	2.96	7.00
Cr : Fe	0.96	2.20	2.14

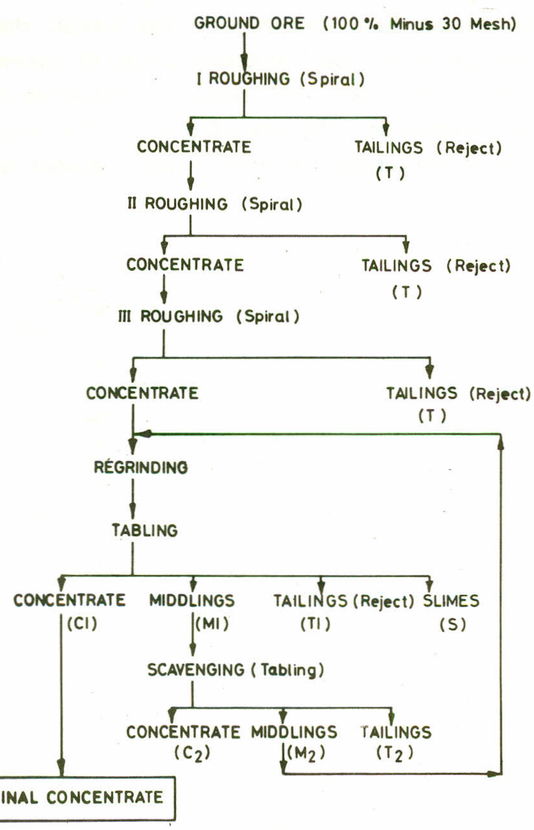


Fig. 1. Flowsheet for the processing of Bajrokanri ore.

Test samples, weighing 100 kg each, were run on the spiral at the feed rate of 1.25 tonnes per hour with 18 % solids and the pulp flow rate of 100 litres per min.

The spiral concentrate, produced from the Bajrokanri ore, was further ground to 60 mesh for processing on the Wilfley tables. The processing of Muslimbagh and Badasar ores could not be carried out on the spiral concentrator as it entailed loss of about 20 % material in the slimes. It is generally recognised that a closely sized feed exhibits better separation by gravity based processes. In this study it was observed that over 80 % of the chromite grains were liberated in the range of 40 to 60 mesh. The feed was, therefore, split into three possible fractions, i.e., -40+60, -60+85 and -85 mesh. Below 85 mesh, although the liberation was more enhanced, yet it involved significant loss of chromite due to fineness of size. Three fractions were separately treated on the tables to produce the final concentrates.

Each tabling operation was carried out at a feed rate of 15-20 kg/hr with 15 liters/min. wash water. The deck inclination was fixed at 4^{o} with a stroke length of 7 mm. All these tests were performed in batches and the operating parameters were kept almost identical with those of the laboratory scale operations.

RESULTS AND DISCUSSION

In the Bajrokanri ore sample, the chromite grains existed in the disseminated form throughout the serpentine-dunite matrix. Here the objective of the initial coarse grinding and roughing by spiral concentrator was to discard maximum bulk of the gangue. Though fairly large volume of free gangue was removed in this way, yet the concentrate obtained contained a sizeable fraction of middlings alongwith unlibrated chromite grains. The grinding of the spiral concentrate to 60 mesh liberated chromite to the optimum limit and it was subsequently processed on the tables. Table 2 represents the results of these operations whereas the process sequence is shown in the flowsheet (Fig. 1).

The Badasar ore was massive in nature and had a coarse texture. The gangue was found intimately associated with the chromite grains. The microscopic examination revealed weak fracture zones in the ore. This character caused an abundant generation of fines during comminution. Controlled crushing and grinding was, therefore, adopted to avoid excessive production of fines. 85 mesh size was established as the grinding limit for this ore for optimum recovery.

Following the standard procedure for the gravity based operation, the closely sized fractions were seperately treated. The ground ore was classified into three fractions, i.e., -40+60, -60+85 and -85 mesh. Each fraction, when processed on the tables, produced concentrates containing 47-48 % Cr_2O_3 with an overall recovery of around 80 %. Flowsheet (Fig. 2) represents the procedure followed for the treatment of the ore fractions and Table-3 shows the compiled results.

Table 2. Metallurgical balance for Bajrokanri ore

Products	Weight %	Cr_2O_3	Recovery %
Table concentrate (C1 + C2)	13.7	47.00	51.49
Table middlings (M2)	3.76	32.8	9.86
Table tailings (T1 + T2)	17.32	7.6	10.52
Table slimes (S)	8.34	20.3	13.54
Spiral concentrate (C)	43.02	24.82	85.41
Spiral tailings (T)	56.98	3.2	14.58

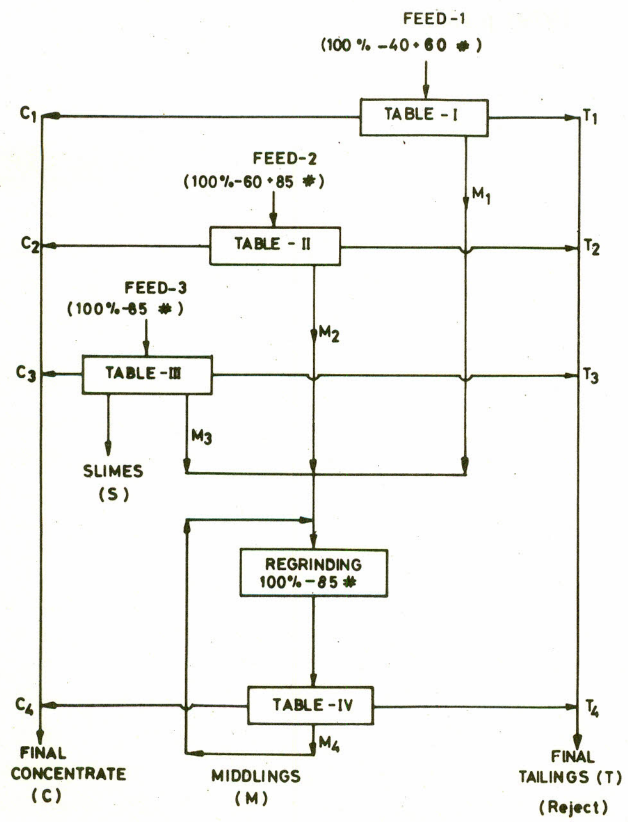


Fig. 2. Flowsheet for the processing of Muslimbagh and Badasar ore.

The Muslimbagh ore contained samples collected from ten different mining areas of the Zhob Valley. This composite mostly contained low grade disseminated-serpentinized, banded, layered and grapeshot types of ores. The gangue, present in the bulk sample, consisted mainly of serpentine, dunite with a small quantity of harzburgite. As the major portion of the composite ore sample consisted of massive as well as disseminated ores, so the processing scheme applied to Bajrokanri ore (disseminated ore) could not produce proper grade of concentrate. The high grade fines resulting from the massive ore were lost with the spiral tailings. To overcome this difficulty the ore was given similar processing treatment that was followed with the Badasar ore. The results of the tabling operations are given in Table-4:

CONCLUSION

The indigenous metallurgical, chemical, refractory and foundry grades of chromite have tremendous projected demand-potential both in the local and foreign markets. But the fast depletion of the rich ores may create alarming

Table 3. Metallurgical balance for the Badasar ore

Mesh size/ products	Weight %	Cr_2O_3	Recovery %
Concentrates			
-40 +60 (C1)	9	46.25	13.39
-60 +85 (C2)	11	47.15	16.68
-85 (C3)	26	47.50	39.73
-85 (C4) (from reground middlings)	6	45.67	8.82
	52	47	78.62
Tailings			
-40 +60 (T1)	5.2	8.83	1.47
-60 +85 (T2)	7.4	8.35	1.98
-85 (T3)	9.7	8.75	2.73
-85 (T4) (from reground middlings)	5.5	7.95	1.42
	27.8	8.5	7.60
Slimes			
-150 #	20.2	21.2	13.77
Calculated heads	100.00	31.09	99.99

Table 4. Metalurgical balance for the Muslimbagh ore

Mesh size/ products	Weight %	Cr_2O_3	Recovery %
Concentrates			
-40 +60 (C1)	10	47.00	13.49
-60 +85 (C2)	12	48.37	16.67
-85 (C3)	30	49.00	42.23
-85 (C4) (from reground middlings)	8	46.82	10.76
	60	48.25	83.15
Tailings			
-40 +60 (T1)	3.0	9.30	0.80
-60 +85 (T2)	5.0	8.91	1.28
-85 (T3)	8.6	9.00	2.22
-85 (T4) (from reground middlings)	3.4	7.75	0.78
	20.0	8.86	5.08
Slimes			
-150 #	20	20.5	11.77
Calculated heads	100.00	34.82	100.00

problems. The situation necessitates the urgent development of appropriate processing technologies for up-grading the low grade ores, which are abundantly available. An attempt on beneficiation of the low grade ores with Cr_2O_3 content ranging from 12 to 30 % for producing industrially acceptable chromite concentrate strongly points to the fact that setting up of the beneficiation plants will appreciably reduce the imbalance between the future supply and demand positions of this mineral. It may be pointed out that the cost of processing a tonne of the ore at the pilot plant scale comes out to be Rs. 300-400 depending on the nature of the ore. This cost, however, does not include the cost of the ore.

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