

## Concentration Studies on Chromite Tailings by Multi Gravity Separator

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**ABSTRACT:** In this study, a representative sample was obtained from Uckopru mine in Türkiye in order to beneficiate fine-sized chromite tailings. Physical and chemical analyses showed that while the whole tailings contained 12.80%Cr<sub>2</sub>O<sub>3</sub> (100% by weight), the particle size fraction of minus 38 microns contained 25.20%Cr<sub>2</sub>O<sub>3</sub> (33.20% by weight) and the particle size fraction of plus 38 microns contained 6.64%Cr<sub>2</sub>O<sub>3</sub> (66.80% by weight). The mineralogical investigations revealed that the sample contained chromite and serpentine group minerals as its main components. For concentration purposes, a Multi Gravity Separator was used for chromite fines in the experiments. The best results using the MGS device for the sample of minus 38 microns were obtained under the following conditions: angle, 2°; frequency, 5.7 cpm; amplitude, 15 mm; and drum speed, 230 rpm. These conditions gave a chromite grade of 47 %Cr<sub>2</sub>O<sub>3</sub> with fairly high recovery of 72%.

### 1 INTRODUCTION

It is a well-known fact that Türkiye is one of the major chromite producers in the world. Approximately a million tons of chromite ore are mined and processed for further metallurgical treatment and use in the country. Large amounts of fine-sized chromite tailings naturally occur during production and processing, and this causes severe environmental hazards as well as source losses due to the high chromite content.

There have been numerous research studies, Guney (1990), Guney et al. (1991), (1992), (1993), Ozdag et al. (1993), (1994), Ucbas and Ozdag (1994), Guney et al. (1994), Gui et al. (1995), Cicek et al. (1998), Sönmez and Turgut (1998), Gence (1999), on the beneficiation of these tailings in recent years. The Uckopru Mine of Eti Holding in particular was thoroughly investigated with regard to roughly a million tons of fine-sized chromite tailings that have been stored there for about a 100 years, and several treatment techniques have been developed for fine tailings, such as column flotation and gravity concentration devices.

For the reasons given above, beneficiation experiments were carried out on samples of fine-sized chromite tailings from Eti Holding's Uckopru Mine by the Mining Engineering Department of Istanbul University.

### 2 MATERIAL AND METHODS

In this study, about 120 kg of representative sample was obtained from Eti Holding in order to evaluate fine-sized chromite tailings. It was determined by physical and chemical analyses that while the whole tailings sample contained 12.80% Cr<sub>2</sub>O<sub>3</sub> (100% by weight), the particle size fraction of minus 38 microns contained 25.20% Cr<sub>2</sub>O<sub>3</sub> (33.20 % by weight) and the particle size fraction of plus 38 microns contained 6.64% Cr<sub>2</sub>O<sub>3</sub> (66.80 % by weight). The sample preparation flowsheet is given in Figure 1 in detail. The complete mineralogical investigations showed that the sample contained chromite and serpentine group minerals (crizotile, antigorite, olivine, pyroxene and tremolite) as its main components. The results of the complete chemical analyses according to particle size classification in a 38-micron sieve are also given in Table 1. Moisture analysis showed that the sample contained roughly 8 % moisture in the form it was obtained and that it could be dried and lose its moisture in a 24-hour period. In order to determine the particle size distribution of the sample prior to concentration, a screening analysis was performed and the results are shown in Table 2.

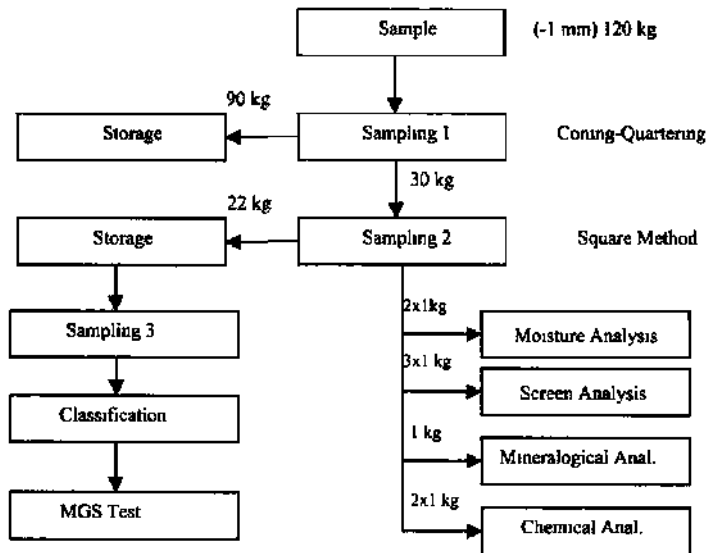


Figure 1. Sample preparation flowsheet.

Table 1. Complete chemical analysis results according to particle size of the sample

Component %	$Cr_2O_3$	$Fe_2O_3$	$SiO_2$	$Al_2O_3$	$MgO$	$CaO$	Weight %
+38 microns	6.64	15.60	28.03	1.51	45.07	0.35	66.80
-38 microns	25.20	14.10	19.80	5.40	31.60	1.10	33.20
<b>Total</b>	<b>12.80</b>	<b>15.10</b>	<b>25.30</b>	<b>2.80</b>	<b>40.60</b>	<b>0.60</b>	<b>100.00</b>

Table 2. Results of screening analysis

Aperture (mm)	Weight (%)	Cumulative Under Size Weight (%)	Cumulative Over Size Weight (%)	$\Delta d$	Normal Dist % W./ $\Delta d$
-1 +0.5	25.48	100.00	25.48	0.500	50.96
-0.5 +0.3	11.82	74.52	37.30	0.200	59.10
-0.3 +0.212	12.25	62.70	49.55	0.088	139.21
-0.212 +0.150	5.03	50.45	54.58	0.062	81.13
-0.150 +0.106	3.76	45.42	58.34	0.044	85.46
-0.106 +0.075	3.01	41.66	61.35	0.031	97.10
-0.075 +0.053	2.72	38.65	64.07	0.022	123.64
-0.053 +0.038	2.73	35.93	66.80	0.015	182.00
-0.038	33.20	33.20	100.00	0.038	873.68
<b>Total</b>	<b>100.00</b>	-	-	-	-

### 3 EXPERIMENTAL STUDIES

As a method, a Multi Gravity Separator (MGS) was used for concentration purposes. The MGS is an efficient device that can easily separate two minerals from each other provided that there is a reasonable difference between their specific gravities. The MGS is generally used for treatment of fines with a maximum particle size of about 100 microns.

A laboratory type of MGS with a length of 0.6 m

and radius of 0.5 m was used in the experiments. The MGS is made up of a slightly tapered open-ended drum that rotates in a clock-wise direction, producing 6-24 g of gravitation, and is shaken in a sinusoidal form in an axial direction. The parameters affecting the efficiency of separation of the MGS are the drum speed (130-280 rpm), tilt angle (0-9°), shaking amplitude (10-25 mm), shaking frequency (4-6 cps), amount of wash water (0-10 litres per minute) and feed pulp density (20-50% solid by

weight) (Chan et al. 1990, Gence 1999, Yüce 1994).

A Mozley C-705 model hydrocyclone was used to determine and optimize the vortex diameter, apex diameter and feed pressure for classification purposes, while the solid-liquid ratio was fixed at 30% during all experiments. Prior to the concentration experiments, the sample was classified according to particle size by means of a hydrocyclone in regard to several parameters in order to categorize the sample into two different particle size fractions, i.e., plus 38 and minus 38 microns.

The concentration experiments failed for the plus 38-micron particle size, whose weight was found to be about 67% of the whole sample, due to an inadequate degree of liberation, and this fraction was stored for further size reduction and concentration studies.

The MGS device gave fairly promising results for the chromite tailing samples at particle size fractions of minus 38 microns due to the fact that there was an appropriate degree of liberation and rich chromite content.

Several experiments were carried out to optimize the parameters of the MGS device for the sample at the particle size fraction of minus 38 microns, and the stable amplitude and frequency values were 15 mm and 5.7 cpm, respectively. The best results using MGS for the particle size fraction of minus 38 microns were obtained under the following conditions; an angle of 2° and drum speed of 230 rpm. These conditions gave a chromite grade of 47% Cr<sub>2</sub>O<sub>3</sub> with fairly high recovery of 72%.

The graphs below (Figures 2 and 3) show the results of the optimization studies for comparison of the conditions. All experiments showed that before the application of any concentration method dependent on gravity, such as MGS, the particles should be thoroughly classified by hydrocyclone and the parameters for different cut sizes for hydrocyclone should be optimized. It is recommended that different fine particle size fractions, which could be obtained by changing the hydrocyclone parameters, should be tested with MGS for further beneficiation studies.

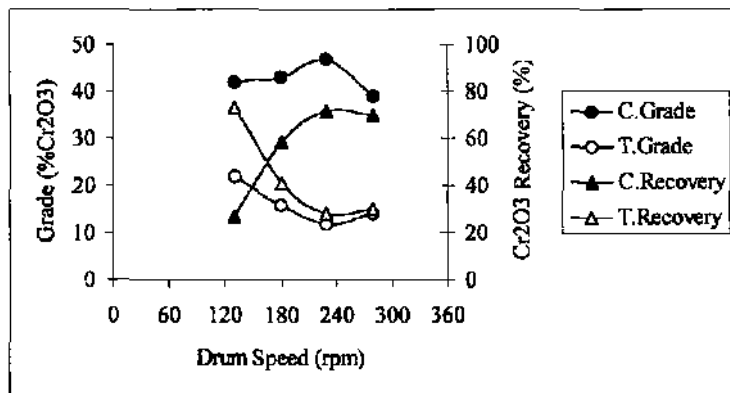


Figure 2 Results of MGS experiments according to drum speed at an angle of 2°.

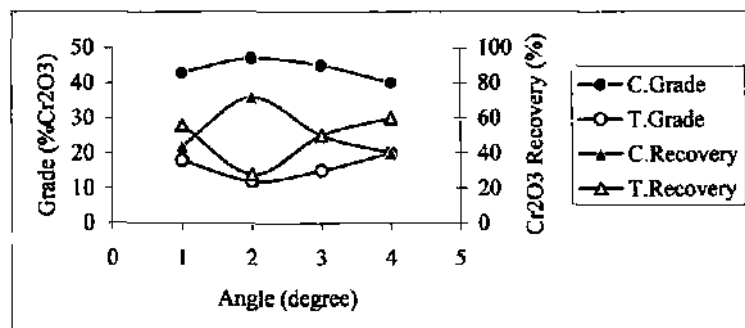


Figure 3. Results of MGS experiments according to angle at a drum speed of 230 ipm.

#### 4 DISCUSSION AND CONCLUSION

Beneficiation experiments were carried out on samples of chromite tailings from Eti Holding's Uckopru Mine. It was determined by chemical analyses that while the whole tailings sample contained 12.80 % Cr<sub>2</sub>O<sub>3</sub>, the particle size fraction of minus 38 microns contained 25.20 % Cr<sub>2</sub>O<sub>3</sub> and the particle size fraction of plus 38 microns contained 6.64 % Cr<sub>2</sub>O<sub>3</sub>. The complete mineralogical investigations showed that the sample contained chromite and serpentine group minerals (crizotile, antigorite, olivine, pyroxene and tremolite) as its main components.

For classification purposes, a Mozley C-705 model hydrocyclone was used in the present study. The cycloning tests were used to optimize the vortex diameter, apex diameter and feed pressure, while the solid-liquid ratio was fixed at 30 % during all experiments.

For concentration purposes a MGS device was utilised, and this separator gave fairly promising results for the chromite tailing samples at particle size fractions of minus 38 microns due to the presence of an appropriate degree of liberation and rich chromite grade.

The best results using MGS for the particle size fraction of minus 38 microns were obtained under the conditions: angle, 2°; frequency, 5.7 cpm; amplitude, 15 mm; and drum speed, 230 rpm. These conditions gave a chromite grade of 47 % Cr<sub>2</sub>O<sub>3</sub> with fairly high recovery of 72 %.

When the tests were performed for plus 38-micron fractions, the results were considerably lower than the test results for the minus 38 microns; therefore, the coarse fractions were stored for future evaluations after size reduction.

Finally, all experiments showed that before the application of any concentration method dependent on gravity, such as MGS, the particles should be thoroughly classified by hydrocyclone and the parameters for different cut sizes for hydrocyclone should be optimized. It is recommended that different fine particle size fractions, which could be obtained by changing the hydrocyclone parameters, should be tested using MGS for further beneficiation studies.

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