Evaluation by Multi Gravity Separator (MGS) of a Low Grade Chromite Tailing From Yesilova-Burdur (Turkey)

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Abstract

In this study, concentrability by a Multi-Gravity-Separator (MGS) of the chromite tailings with content 23.84% Cr_2O_3 from Yeşilova-Burdur (Turkey) is investigated. Mineralogical analyses showed that the chromite tailings contain chromite and serpentine which formed as a result of alteration of serpantine group minerals such as olivines, chrysotile and talc. The tailings generated from chromite beneficiation plants in Turkey are generally concentrated by slime tables (Deister shaking tables) for producing the desirable saleable grade. However, slime tables are concentrating with low recovery for chromite minerals which are very fine particle size. MGS is an efficient method for separation of minerals by gravity at very fine particle size. In experimental studies, the effects of feed rate, washwater rate, drum speed and tilt angle, which are important for operating parameters of MGS observed for the low grade chromite tailings were investigated. As a result of the experimental studies performed, it was obtained a concentrate with saleable chromite grade and recovery from the tailings which is having size fraction under 0.075 mm.

Keywords: chromite, tailings, multi gravity separator, beneficiation, gravity

Introduction

Chrome is a metal important in especially stainless steel production. The most important ore in the production of chrome is chromite ore. The main mineral components of the chromite ore are chromite, olivine and serpentine minerals. It is desirable that Cr_2O_3 content is over 40% for saleable chromite ores in the market. If chromite content is under of 40% Cr_2O_3, then it must be beneficiated. In order to concentration the low grade chromite ores, it is important to liberate them by grinding to fine particle sizes. Low grade chromite minerals can be concentrated by many methods, but it is important to selection of the most economically method. Gravity, magnetic, electrostatic and flotation methods are generally used in beneficiation of low grade chromite minerals to get rid of the gangue minerals such as olivine and serpentine. In selection of beneficiation methods, knowing of physically, chemically and mineralogical properties of chromite ores are very important. In additional, reserve and grade of chromite ore are affected to selection of beneficiation methods (Deniz, 1992; Deniz et al., 2001).

In the concentration of chromite ores, gravity methods are commonly used in most of beneficiation plants based on differences in specific gravity between chromite and gangue minerals (serpentine, olivine etc.). Another reason for selection gravity concentration techniques is their simplicity, low operating cost easy to operate. In the coarse size (100–3 mm), sorting and jigging methods are applied, and in the fine sizes (3–0.1 mm), dry magnetic and gravity methods (shaking tables, spirals and cones) are applied. Flotation and wet magnetic methods are used in fine size (-0.100 mm).

Chromite production is carried out in various regions of Turkey, primarily Adana, Kayseri, Bursa, Elazig and Burdur-Yeşilova. There are more than 20 chromite concentrators in Turkey. Although, these concentrator plants use more gravity concentration methods such as jigs and shake tables, magnetic separators can be also used as less (Deniz et al., 2001; Guney et al., 2001). Recently, chromite ores concentration plants in Turkey are mostly limited by shaking table applications. Because of the fluctuations related to China's purchasing power in chromite prices, chromite companies tend to sell lump chromite ores.

In recent years, more researches have focused on beneficiation of chromite minerals from the tailings in terms of environment protection and economically. Low grade chromite tailings generated from the Turkish chromite concentration plants are concentrated industrial scaled in the Deister type tables for producing the desirable chromite grade. Multi gravity separator (MGS) has been studied as laboratory scaled for the up gradation of the chromite tailings, recently.

The loss of fines from different gravity plants in the World reaches millions of tons. Multi gravity separator (MGS) is very useful for an alternative solution. Chromite fine mineral tailings should be evaluated with high recoveries.

In the recent laboratory applications, fine size tailings (slimes) were effectively concentrated by using MGS. Especially, MGS was applied in fine chromite tailings (Ozdag et al., 1994; Kursun et al., 1994; Belardi et al., 1995; Sonmez and Turgut, 1997; Boci et al., 1996; Veglio et al, 1996; Cicek et al., 1998), desulphurisation from coal (Goktepe et al., 1996), celestite tailings (Aslan and Canbazoglu, 1996), fine sized graphite (Patil et al., 1999), barite tailings (Deniz, 2000), bastnaesite ore (Ozbayoglu and Atalay, 2002) and fine sized tungsten ore (Hosseini et al., 2016).

The multi-gravity separator (MGS) is one of machines using separation of fine particle minerals based on gravity. The parameters affecting MGS performance include drum

Tab. 1. Size distribution and fraction Cr_2O_3 grades of the chromite tailing
Tab. 1. Rozkład wielkości ziaren Cr_2O_3 z odpadów chromitowych

Sieve Size	Mass	Cr_2O_3	Distribution	Cumulative Over Sieve		
mm	(%)	(%)	(%)	Mass (%)	Cr_2O_3 (%)	Distribution (%)
-0.075+0.063	13.00	26.91	14.67	13.00	26.91	14.67
-0.063+0.045	14.25	26.41	15.79	27.25	26.65	30.46
-0.045+0.038	18.95	24.23	19.26	46.20	25.05	49.72
-0.038	53.80	22.28	50.28	100.00	23.84	100.00
Σ	100.00	23.84	100.00			

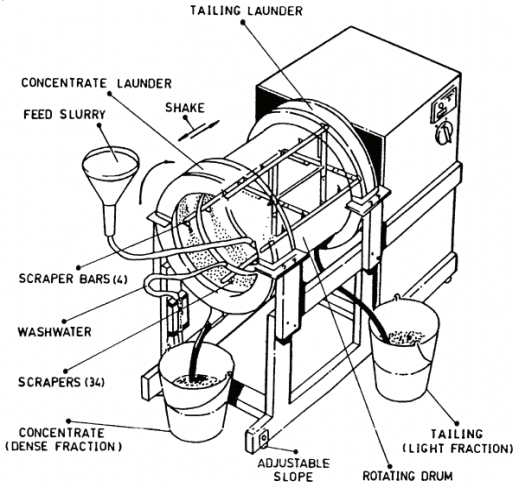

Fig. 1. Mozley Pilot Multi Gravity Separator (C900)
Rys. 1. Separator grawitacyjny Mozley Pilot Multi (C900)

speed, slope angle, shaking amplitude and frequency, pulp solid by weight, washwater and feed flow rates. A good separation of different gravity minerals by the MGS depends on the correctly choice of optimal operating conditions (Aslan, 2008).

In the present study, the influences on the enrichment ability of process parameters in the concentration by the multi gravity separator (MGS) of a low grade fine chromite tailing in Yesilova-Burdur were investigated.

Material and methods

Material

Chromite tailings are located in Yesilova town of Burdur (Turkey). The heap in this area with the amount of the 450 000 tons of slimes material was examined from the surface trough the 6 m of depth by the rotary drilling. Rotary drilling samples were taken from the heap and were mixed as a representative sample. This sample was analysed for the distribution and Cr_2O_3 grade in each fraction. The results of the test are given in Table 1.

Slime samples, taken from the storage, have been investigated texture of chromite mineral and gangue mineral from thin and polish sections by using Canada balsam. In the mineralogical analyses, the sample was fully serpentinised. Olivine remains could be determined as fine particles within the serpentine matrix. Sieve texture was developed dominantly within the serpentinised areas. Chromite grains were seen as cataclastic texture. The chromite tailing contains approximately 30–40% of chromite 50–55% of serpentine and 10–15% of olivine.

Method

With Taggart's "Concentration Criteria", it is theoretically possible to investigate whether or not each ore mass can be judged according to gravity separation. Specific gravity values of serpentine, olivine and chromite are 2.6, 3.3 and 4.6 g/cm³, respectively. In the investigation of "Concentration criterions" in the between of chromite, olivine and serpentine, there are 1.44 for olivine & serpentine, 1.56 for chromite & olivine and 2.25 for chromite & serpentine. Because of chromite mineral has higher specific gravity than olivine and serpentine minerals, concentration of the chromite mineral is easy. If gangue minerals are all together, then these have negative effective on beneficiation because it behaves as middling (Deniz et al., 2001).

In this study, firstly, material with a grade 23.84% Cr_2O_3 was prepared as 25% of pulp solid by weight in a feed tank of volume 50 m³. Later, pulp prepared which is kept at different the feed rates, was sent in the MGS by use of a pump to 3 minute. Some operational variables were adjusted and the MGS was operated. A series of pilot tests was run in order to determine the optimum operational parameters.

The operational variables are the washwater rate, the feed flow rate, the rotational speed and tilt angle of the drum. Constant parameters for each test are 15 mm shake amplitude, 4.8 rpm shake frequency and 25% pulp solid by weight. Then, samples were dried at 105°C, weighed and chemical analysed in order to determine the chromite content.

The Multi Gravity Separator (MGS)

MGS is suitable for the treatment of fines and ultra fines with a maximum particle size of approximately 500 microns

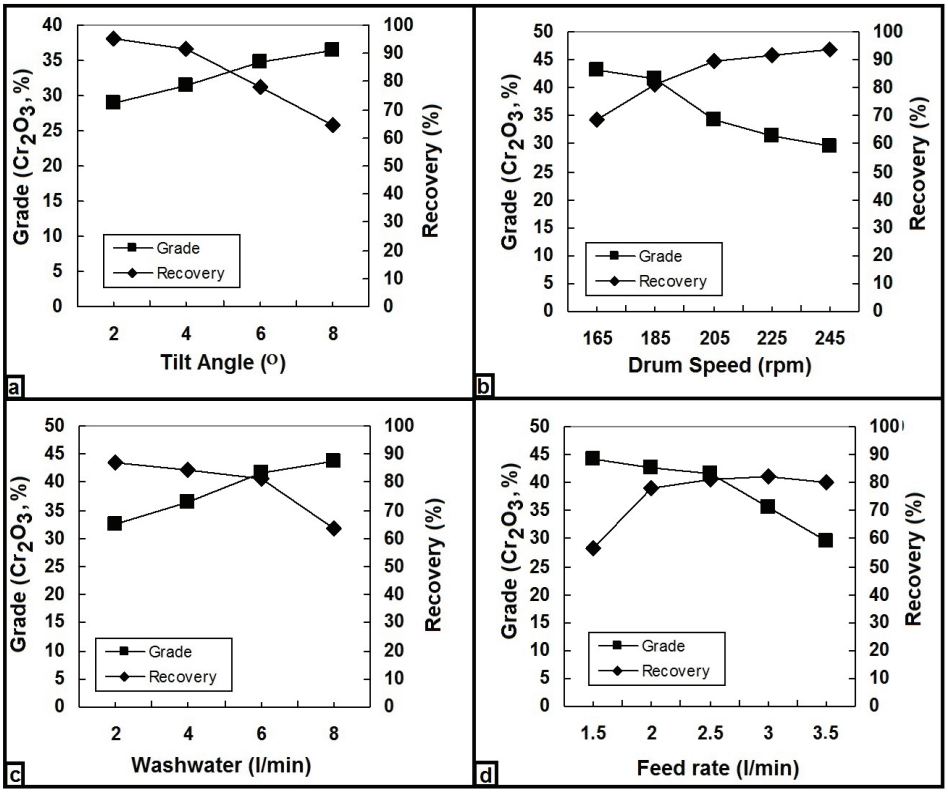

Fig. 2. Chromite grade-recovery trend with respect to some operating parameters
Rys. 2. Efekt odzysku chromitów w odniesieniu do niektórych parametrów operacyjnych

and lower limit of approximately 1 micron (Chan and Mozley, 1987; Deniz, 2000):

The MGS consist basically of a slightly tapered open ended drum that rotates in a clockwise direction and is shaken sinusoidally in an axial direction. Inside the drum is scraper assembly which rotates in the same direction, but a slightly faster speed. Feed slurry is introduced continuously midway onto the internal surface of the drum via an accelerator ring launder. Washwater is added via a similar launder positioned near the open and of the drum. As a result of the high centrifugal forces and the added shearing effect of the shake, the dense particles migrate through the slurry film to from a semisolid layer against the wall of the drum. This dense layer is conveyed by the scrapers towards the open end of the drum where it discharges into the concentrate launder. The less dense minerals are carried by flow of the washwater downstream to the rear of the drum to discharge via slots into tailings launder (Chan and Mozley, 1987).

Pilot model (C900) of MGS used for the tests has a mean capacity of 150 kg/h. The separator is an open ended drum in the diameter of 500 mm and in the length of 600 mm (Figure 1). The operating parameters of the MGS are given as follows: (Chan and Mozley, 1987);

The drum speed	: 100 to 300 rpm
Tilt angle	: 0–9°
Shake amplitude	: 10/15/20 mm
Shake frequency	: 4.0/4.8/5.7 cps
Washwater flow rate	: 0 to 10 L/min
Pulp density of the feed	: 10–50%
Feed capacity	: maximum 200 kg/h

Experiments

Experimental studies were conducted by a MGS separator to determine the possibility of beneficiation of low grade chromite tailings by high centrifugal forces. Firstly, MGS tests were applied for ascertaining the variable parameter values which are drum rotation speed, drum tilt angle, washwater and feed flow rate. The effects of parameters on the enrichment were determined by keeping invariable parameters constant (invariable parameters for each test are shake amplitude: 15 mm, shake frequency: 4.8 rpm, pulp solid by weight: 25%).

Feed, concentrates and tailings of experiments were analyzed to determine the grades and recoveries for each product. The experimental results of MGS studies gathered by differentiating the drum rotation speed, drum tilt angle, washwater and feed flow rate are given in Figure 2 as the graphical illustrations of each parameter.

Results and Discussion

The effects of the drum rotation speed, drum tilt, washwater and feed rate on the enrichment were analysed in the chromite tailings of the tests. Graphs for the effect of drum speed, tilt angle, washwater and feed rate on the beneficiation in the tests are given in Figure 2.

In the experiments, firstly, the drum tilt angle was changed from 2° to 8° by keeping of the other operating conditions constant. The results given in Figure 2a show that a tilt angle of 4° produced the best results. With increasing in the drum tilt angle, a significant decrease in the recovery of concentrate was obtained, while a significant increase in chromite content was obtained.

The drum speed for MGS separator is one of the most important parameters of operating conditions. Secondly, the drum rotational speed was changed from 165 rpm to 245 rpm, and the results as given in Figure 2b shown that there was the best result of drum speed of 185 rpm. With increasing in the drum speed, a significant decrease in the chromite content values of concentrate was obtained, while a significant increase in the recovery rate was obtained.

Thirdly, the washwater flow rate was varied between 2 L/min and 8 L/min by keeping the other conditions constant, and washwater rate of 6 L/min produced the best result as shown in Figure 2c. In the tests of the washwater rate, a similar situation is also observed with the experiments made for the tilt angle. It can be seen that Cr_2O_3 grade of concentrates increased when the washwater rate were increased, but Cr_2O_3 recovery of concentrates decreased.

Finally, the feed flow rate is the most important operational parameter for recovery. The feed flow rate was changed from 1.5 L/min to 3.5 L/min by keeping the other conditions constant. The results given in Figure 2d shown that there were produced of the best result with a feed flow rate of 2.5 L/min. With increasing in the feed flow rate, a significant decrease in the chromite content values of concentrate was obtained, while an increase in the recovery rate was obtained.

The beneficiation of low grade chromite tailings taken from Burdur-Yesilova of Turkey, which contains 23.84% Cr_2O_3, was investigated using MGS. The chromite concentrate having 41.72% Cr_2O_3 content was obtained with 81.34% recovery by using MGS.

Conclusions

From the result of tests, a saleable chromite concentrate from fine chromite tailings by the multi gravity separator (MGS) is possible obtained. Addition, with increasing the washwater flow rate and tilt angle lead to higher concentrate grades but lower recovery. On the other hand, with increasing the feed flow rate and drum speed, higher recovery but lower concentrate chromite contents are obtained.

For the best results by the MGS tests, the effects of drum speed, tilt angle, washwater and feed rate were examined. The best results were obtained at results of the test which used drum speed of 185 rpm, drum tilt angle of 4 degree, washwater flow rate of 6 L/min and feed flow rate of 2.5 L/min. The maximum achievable chromite content and recovery by the MGS were 41.72% and 81.34%, respectively.

It can be concluded that, due to fully liberation of the minerals and high density difference between chromite and serpentine, satisfactory results were gathered in experimentations on beneficiation of fine size chromite tailings by the MGS.

Further studies of cleaning and scavenging processes should be applied to determine whether the MGS is suitable for enrichment or not in beneficiation of fine size chromite tailings. In addition, the effect of other constant operating conditions (pulp solid by weight, shake amplitude and frequency) must be also investigated.

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Ocena za pomocą separatora grawitacyjnego (MGS) odpadowego chromitu niskiej jakości z Yesilova-Burdur (Turcja)

W artykule przedstawiono wzbogacalność w separatorze grawitacyjnym (MGS) odpadów chromitowych o zawartości 23,84% Cr_2O_3 z Yeşilova-Burdur (Turcja).

Analizy mineralogiczne wykazały, że odpady chromitowe zawierają chromit i serpentyn, które powstały w wyniku zmian minerałów z grupy serpenitu, takich jak oliwiny, chryzolit i talk. Odpady wytwarzane w zakładach wzbogacania chromitu w Turcji są na ogół wzbogacanie na stołach koncentracyjnych dla drobnych ziaren (stoły wytrząsające Deister) w celu uzyskania produktu nadającego się do sprzedaży. Jednak stoły koncentracyjne się charakteryzują się z niskim uzyskiem minerałów chromitowych o drobnym uziarnieniu. MGS to skuteczna metoda wydzielania grawitacyjnego bardzo drobnych cząstek. W badaniach eksperymentalnych zbadano wpływ prędkości podawania, prędkości wody do wzbogacania, prędkości bębna i kąta pochylenia, które są ważne dla parametrów operacyjnych MGS badanych odpadów chromitowych niskiej jakości. W wyniku przeprowadzonych badań eksperymentalnych uzyskano z odpadów o uziarnieniu poniżej 0,075 mm koncentrat chromitu o jakości handlowej.

Słowa kluczowe: chromit, odpady, separator wielograwitacyjny MGS, wzbogacanie, grawitacja