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ENRICHMENT OF MAGNESITE ORE

Nermin GENCE

ABSTRACT : *In this study, the possibility of concentration of calcined magnesite ore by multi gravity separator was investigated. The best results were obtained in the concentration of magnesite which was calcined at 800^0C, by multi gravity separator. The optimum operation parameters determined for the concentration of calcined magnesite ore were as follows; a washwater flow rate of 3 lt/min., shake amplitude of 15 mm, shake frequency of 4.8 cps, tilt angle of 4^0 and drum speed of 200 rpm. The results of concentration experiments showed that, the saleable concentration containing 78.14% MgO was obtained with 66.58% recovery.*

KEYWORDS : *Magnesite, multi gravity separator*

MANYEZİT CEVHERİNİN ZENGİNLEŞTİRİLMESİ

ÖZET : *Bu çalışmada, kalsine manyezit cevherinin multi gravite separatör ile zenginleştirilebilme olanakları araştırılmıştır. En iyi sonuçlar 800^0C'da kalsine edilen manyezit multi gravite separatör ile zenginleştirildiğinde elde edilmiştir. Optimum deney koşulları; yıkama suyu: 3 lt/dk, genlik: 15 mm, çalkalama hızı:4,8 cps, açı:4^0 ve tambur hızı:200 rpm olarak belirlenmiştir. Zenginleştirme çalışmalarının sonuçları %78,14 MgO içeren satılabilir konsantrenin %66,58 MgO verimle elde edilebileceğini göstermektedir.*

ANAHTAR KELİMELER : *Manyezit, multi gravite separatörü*

Anadolu Üniversitesi Bozüyük Meslek Yüksekokulu, Bozüyük, BİLECİK

I. INTRODUCTION

Magnesite, $MgCO_3$, contains theoretically 47.8% MgO and 52.2% CO_2. Magnesite is an important economic nonmetallic mineral since it is the main source of magnesium oxide, which is widely used as a refractory raw mineral. Magnesite almost never occurs pure enough to be used directly in any significant deposit. Magnesite ores contain a variety of gangue minerals, mostly other carbonates, silicates and oxides. Therefore some kind of beneficiation is required. The most commonly used beneficiation methods for magnesite ores are the heavy medium separation, hand sorting, magnetic separation and flotation. [1-2].

Due to the fact that magnesite and dolomite have similar physical, chemical and physico-chemical properties, physical and chemical beneficiation methods are not effective in the selective separation of these minerals. Physico-chemical properties of dolomite and/or magnesite should be changed. Magnesite can be calcined in the less temperature than calcite and dolomite. If the magnesite ore, which contains dolomite, is calcined at the calcination temperature of magnesite, dolomite and magnesite have different hardness and/or specific gravity after calcination, and magnesite can be separated from calcite and dolomite by gravity concentration methods. During the calcination, magnesite has a porosity structure because of removing CO_2 and H_2O. The specific gravity of calcined magnesite ranges are between 1.3 and 1.9 g/cm^3, whereas the value of dolomite is 2.9 g/cm^3 [3].

The Multi Gravity Separator (MGS) is able to separate two minerals from each other, as long as there is a reasonable difference between them in specific gravity. The MGS is suitable for the treatment of fines with a maximum particle size of approximately 0.5 mm. Typical applications include the scavenging of precious metals or valuable minerals from tailings or slimes streams; pre-concentrating heavy mineral sands or industrial minerals (anatase, barytes, chromite, coal etc); concentrating base metal oxides, sulphides, uranium etc. from primary ores; treatment of alluvial ores in general [4-5].

In this paper, the possibility of concentration of calcined magnesite ore, which contains high dolomite, low iron and siliceous gangue was investigated by Multi Gravity Separator.

II. EXPERIMENTAL

2.1 Sample, Equipment and Method

The magnesite sample used for MGS studies was ground to minus 0.150 mm before calcination. The chemical composition of the raw magnesite sample is presented in Table 1. The sieve analysis and the content of MgO along with the distribution of MgO are given in Table 2.

Table 1. The chemical analyses of the raw magnesite sample

Content, %							
MgO	CaO	SiO_2	Fe_2O_3	Al_2O_3	Na_2O	K_2O	L.O.I
44.87	3.10	0.50	0.30	0.10	0.01	0.01	51.11

Table 2. The sieve analysis of the calcined magnesite

Particle Size (mm)	Weight, %	MgO, %	CaO, %	SiO_2, %	Distribution of MgO %
-0.150+0.106	19.26	64.37	3.31	0.51	18.47
-0.106+0.075	26.91	69.74	3.16	0.53	27.95
-0.075+0.053	38.79	72.83	2.98	0.50	42.08
-0.053	15.04	51.36	3.70	0.70	11.50
TOTAL	100.00	67.14	3.20	0.54	100.00

The sample (250-g) has been put in the oven at the room temperature and it was held in the oven for two hours after oven's temperature comes to the desired degree. The sample was agitated in every half-hour. The magnesite, which is calcined at 500^0C-800^0C, was used in the multi gravity separator tests.

A series of batch tests was run in order to determine the optimum operational parameters and to obtain maximum concentrate grade and magnesite recovery. The operational variables are the washwater flowrate, shake amplitude, shake frequency, tilt angle and rotational speed of the drum.

A laboratory / pilot MGS of type C900 was used in the tests. The MGS consists of a slightly tapered open-ended drum that rotates in a clockwise direction 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 (100 to 300 rpm), tilt angle (0^0 to 9^0), shake amplitude (10/15/20mm), shake frequency (4.0/4.8/5.7cps), amount of washwater (0 to 10 liters per minute) and feed pulp density (10% to 50% solids by weight) [6-7-8].

Feed slurry is introduced continuously midway onto the internal surface of the drum via a perforated ring. Washwater is added via similar ring positioned near the open end of the drum.

The dense particles migrate through the slurry film to form a semisolid layer against the wall of the drum as a result of the high centrifugal forces and the added shearing effect of the shake. The scrapers towards the open end of the drum convey this dense layer where it discharges into the concentrate launder. The less dense particles are carried by the flow of washwater into the tailing launder at the rear end of the drum.

The shake amplitude and frequency, drum speed, tilt angle and amount of washwater were adjusted, and the MGS was operated.

A sample bucket was placed under the tailing discharge pipe, another under the concentrate discharge pipe and another one was placed under the center spillage discharge pipe. 500 grams of dry sample was mixed with one liter of water, giving a feed density of 33% solids by weight. The solids were kept in suspension during the test by manual stirring. The pulp was poured into the MGS feed vessel at a steady rate of 1.2 liters / minute, giving a feed rate of 40 kg / h of dry sample whilst stirring continuously.

In the all tests, the total feeding time was 45 seconds. At the end of the feeding period, the separator was kept running until the material flow was finished and the washwater was allowed to run for a further 2 or 3 minutes. The washwater was turned off and the MGS was stopped.

Scraper or conveyed product, which collected via the front launder during the feeding and the washing period were referred to as concentrate. Another product, which collected during the feeding period was referred to as Tailing 1, and another product, which collected during the washing period was slightly higher in grade and was referred to as Tailing 2.
These samples were dried at 105^{0}C, weighed and analyzed in order to determine the magnesite grade and recovery. Throughout the tests, Middling and Tailing 2 were combined with concentrate and Tailing 1, respectively.
In order to determine the effects of operational parameters several variables were tested.

III. RESULTS and DISCUSSION

The washwater flowrate is reported to have important effects on separation. The effect of washwater flowrate on the separation was examined under the following conditions;

Experimental Conditions:

Drum speed	: 220 rpm	Tilt angle	: 0^0
Shake amplitude	: 10 mm	Feed density	: 33 %, w/w
Shake frequency	:4.0 cps	Feed rate	: 40 kg/h

As it can be seen from Table 3, as washwater flowrate increases, the grade of the concentration increases. However, the recovery of the concentration decreases. In the experiments, washwater flowrate was varied from 2 to 6 l/min. and the highest concentrate grade and recovery were obtained at 3 l/min.
Shake amplitude and shake frequency are the most important variables of the MGS. Shake amplitude can be adjusted between 10 mm and 20 mm while shake frequency is adjustable between 4.0 cps and 5.7 cps. The separation of the particles in the drum takes place under the effects of shearing forces. An increase in amplitude and frequency causes an increase in the shearing action on the particles, which effects the separation significantly. It was reported in the literature that there is an optimum combination of shake amplitude and shake frequency for the given mineral mixtures [4-5-9]. A high shake frequency is used with a small amplitude, whereas lower frequencies necessitate larger amplitudes. With increased amplitude concentrate grade increases whilst recovery is reduced. An increase in

the shake frequency, therefore decreases the weight of concentrate and increases the grade. A series of MGS experiments were carried out to determine the optimum combination of shake frequency and shake amplitude at the same conditions, given above and washwater flowrate was set as 3 l/min. The results given in Table 4 and Table 5 showed that the highest concentrate grade and recovery were obtained at 15 mm shake amplitude and 4.8 cps shake frequency.

Table 3. The effect of washwater flowrate

Washwater (l/min)	Products	Weight %	Assay MgO%	Distribution of MgO%
2	Concentrate	58.75	69.41	60.74
	Tailing	41.25	63.91	39.26
3	Concentrate	63.70	70.25	66.65
	Tailing	36.30	61.68	33.35
4	Concentrate	56.30	71.17	59.68
	Tailing	43.70	61.94	40.32
5	Concentrate	51.80	71.93	55.50
	Tailing	48.20	61.99	44.50
6	Concentrate	45.10	72.25	48.53
	Tailing	54.90	62.94	51.47
	TOTAL	100.00	67.14	100.00

The angle of tilt can be adjusted between 0 and 9 degrees. Fine and/or low-density minerals will require a smaller tilt angle; coarse and/or high-density minerals will require a larger tilt angle, that is, the angle used will depend on the nature of the material treated. Increasing tilt angle will increase throughput a little but too large an increase will tend to reduce heavy mineral recovery. In the experiments, the angle of tilt was varied between 0^0 and 8^0 while other conditions was kept constant, but the shake frequency and shake amplitude combination was set as 4.8 cps and 15 mm. The results given in Table 6 showed that the best results were obtained at a tilt angle of 4^0.

Table 4. The effect of shake amplitude

Shake amplitude (mm)	Products	Weight %	Assay MgO%	Distribution of MgO%
10	Concentrate Tailing	63.70 36.30	70.25 61.68	66.65 33.35
15	Concentrate Tailing	62.14 37.86	72.76 57.92	67.34 32.66
20	Concentrate Tailing	55.79 44.21	73.10 59.62	60.74 39.26
	TOTAL	100.00	67.14	100.00

Table 5. The effect of shake frequency

Shake frequency (cps)	Products	Weight %	Assay MgO%	Distribution of MgO%
4.0	Concentrate Tailing	62.14 37.86	72.76 57.92	67.34 32.66
4.8	Concentrate Tailing	59.02 40.98	73.98 57.29	65.03 34.97
5.7	Concentrate Tailing	51.24 48.76	75.10 58.78	57.31 42.69
	TOTAL	100.00	67.14	100.00

The rotational speed of the drum is the most dominant operational parameter. Depending on the nature of the material treated, drum speeds of between 160 rpm and 300 rpm, giving “g” forces at the drum surface of 6.5 to 24 g, are required. The drum speed affects the operation of the MGS in two ways. An increase in speed results firstly in an increase the flowrate of the slurry in an axial direction towards the tailings end of the drum. Secondly increases the intertial mass of the mineral particles, reinforcing their tendency to pin to the drum wall and form a solid layer. In the experiments, the drum speed was varied between

180 rpm and 240 rpm while other conditions was kept constant. The tilt angle was set as 4^0. The results are summarized in Table 7. The highest concentrate grade and recovery were obtained at 200 rpm. A significant increase in the recovery rate of concentrate and a decrease in grade were obtained by increasing the rotational speed of the drum.

The best results obtained in the following conditions are summarized in Table 8.

Experimental Conditions:

Washwater flowrate : 3 lt/min

Shake amplitude : 15 mm

Shake frequency : 4.8 cps

Tilt angle : 4^0

Drum speed : 200 rpm

Feed density : 33 %, w/w

Feed rate : 40 kg/h

Table 6. The effect of tilt angle

Tilt angle (^{0})	Products	Weight %	Assay MgO%	Distribution of MgO%
0	Concentrate	59.02	73.98	65.03
	Tailing	40.98	57.29	34.97
4	Concentrate	56.98	77.17	65.50
	Tailing	43.02	53.86	34.50
6	Concentrate	50.00	76.80	57.19
	Tailing	50.00	57.48	42.81
8	Concentrate	47.89	76.15	54.32
	Tailing	52.11	58.86	45.68
	TOTAL	100.00	67.14	100.00

Table 7. The effect of drum speed

Drum speed (rpm)	Products	Weight %	Assay MgO%	Distribution of MgO%
180	Concentrate	50.80	75.64	57.23
	Tailing	49.20	58.36	42.77
200	Concentrate	57.21	78.14	66.58
	Tailing	42.79	52.43	33.42
220	Concentrate	56.98	77.17	65.50
	Tailing	43.02	53.86	34.50
240	Concentrate	69.50	67.21	69.57
	Tailing	30.50	66.98	30.43
	TOTAL	100.00	67.14	100.00

Table 8. The best results

Products	Weight %	ASSAYS, %			Distribution of MgO%
		MgO	CaO	SiO_2	
Concentrate	57.21	78.14	1.51	0.55	66.58
Tailing	42.79	52.43	5.46	0.53	33.42
TOTAL	100.00	67.14	3.20	0.54	100.00

III. CONCLUSIONS

1. The results obtained from the experiments indicate that it is possible to enrichment the calcined magnesite ores by using multi gravity separator.

2. In the enrichment experiments carried out by using multi gravity separator, a 78.14 % MgO grade concentrate was obtained from –0.150mm particle size ore with a recovery of 66.58 %. Grade of CaO was decreasing from 3.20 % to 1.51 %, and grade of SiO_2 was 0.55 (Table 8). The optimum operation parameters determined for concentration of magnesite ores are as follows; washwater flowrate: 3 lt/min, shake frequency: 4.8 cps, shake amplitude: 15 mm, Tilt angle: 4^o and drum speed: 200 rpm.

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