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BRIQUETTING OF IRAN-ANGOURAN SMITHSONITE FINES

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In conventional zinc carbonate ore processing, crushed ore is charged to Waelz furnace for the recovery of zinc through volatilization. When the feed size is fine which does not meet the requirements, briquetting is employed to convert the fines and dusts into chargable lumps.

The aim of this research was to determine the possibility of briquetting of Iran-Angouran zinc carbonate fines produced in Dandi concentration plant.

During the briquetting test, the effects of pressure, type and amount of binder, moisture, temperature, and fineness of the feed were determined. The quality of briquette was controlled in terms of the compressive strength, abrasion index and resistance to weathering.

The optimum briquetting result was obtained when the zinc carbonate fines was mixed with 6% water, 5% molasses and 1.5% lime at a briquetting pressure of 200 kg/cm^2 and drying at 105°C for 2 hours.

Keywords:Waelz furnace, zinc carbonate, briquetting, molasse

INTRODUCTION

Agglomeration which can be defined as any method of size enlargement of particle consolidation has become of fundamental importance in the utilization of fine material originated by the mineral industry due to their difficulty in handling, transportation and direct utilization. Iron oxide, magnesium oxide, lime, bauxite and alumina fines, phosphate and fluorspar concentrates are agglomerated and returned to the process. Recovery of dust materials increases the efficiency of the pyrometallurgical process and decreases environmental and disposal problems.

There are three methods of agglomeration of powder materials: pelletizing, briquetting and sintering. It can also be classified as agitation, compaction and heat treatment on the basis of agglomeration forces.

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All types of balling devices (e.g. pelletizers) are agglomerators by agitation. Briquetting, compacting, tableting and extrusion are examples of agglomeration by compaction. Agglomeration by heat treatment includes sintering and nodulizing.

Briquetting is one of the most widely used methods of agglomeration over many decades. It is defined as the formation of pillow, almond, cylindrical or other shaped pieces from finely divided solids by the application of external pressure. Roll type presses are most frequently employed. A number of physical and chemical mechanisms serve to bind solid particles together when they are compacted into a briquette. This is accomplished by matching moulds in the surface of the rollers whereby each essentially represents one half of the briquette volume. During this process the bulk density of the feed is increased. Suitable binders may assist in the formation of briquette and the development of their strength. Water often acts as a binder as well as providing lubrication. Mixing the fine solids with a higher content of a tacky viscous fluid provides a matrix which cements the particles when they are pressed together. Pitches, spent sulfite liquor, mixtures of molasses and lime, and other sticky fluids act as matrix binders.

Extensive research was conducted for the agglomeration of iron, coal, chromite etc, but research performed on the agglomeration of zinc oxide and zinc carbonate was limited (Planka, 1971, Göksel, 1980, Chaptykov, 1987, Lugscheider, 1989, Özbayoğlu, 1993).

The aim of this research was to determine the possibility of briquetting of Iran-Angouran zinc carbonate fines for the preparation of feed to Waelz furnace.

MATERIAL AND METHOD

To conduct briquetting tests, Angouran (İran) zinc carbonate fines were tested. The chemical analysis and particle size distribution of the representative sample are shown in Table 1 and 2.

Table 1. Chemical analysis of smithsonite fines

Element	%	Element or Comp.	%
Zn	27.72	Cl	0.070
Pb	5.06	Co	0.026
Cd	0.24	Mn	0.044
Fe	3.20	Bi	<0.0005
Cu	0.014	Ag	<0.0053
Ni	0.078	Al_2O_3	1.55
As	0.77	SiO_2	26.0
Sb	0.50	MgO	0.38

Table 2. Screen analysis of the sample

Screen Aperture (microns)	Wt, %	Cum.Wt.% Retained	Cum.Wt,% Passing
+417	2.30	2.30	97.70
+295	2.65	4.95	95.05
+208	2.76	7.71	92.29
+147	13.14	20.85	79.15
+104	15.35	36.20	63.80
+74	12.69	48.89	51.11
+53	12.54	61.43	38.57
+45	5.55	66.98	33.02
-45	33.02	-	-

In briquetting tests, a cylindrical shape, 39 mm in diameter and 39 mm in length steel mold was used. The test sample was premixed with predetermined amount of water and binder. The pressure was applied by a Tinius Olsen Standart Super L type hydraulic press with 200 tons capacity. The briquettes were dried in an oven at 105°C. The quality of the briquets was controlled by means of compressive strength test, tumbling test and weathering test on oven dried briquettes.

The compressive strength test which assess the ability to withstand the pressure of the burden in the storage is performed by compressing the briquette between two movable steel plates from the oblique surface. The crushing load in radial direction is used to express the tensile strength of a cyclindrical briquet according to the equation: $\sigma = \frac{2P}{DL}$ where σ=tensile strength, kg/cm^2, P=crushing load, (kg), D:diameter of specimen (mm), L=length of specimen (mm). Since D and L are constant, the crushing load may be used instead of tensile strength.

Tumbling (abrasion) test was performed to find out the resistance of briquettes to abrasion action during transportation and loading. A drum, with 20 cm in diameter and 30 cm in length, containing four lifters in 2 cm width was used for the determination of abrasion index. A 500 g sample was placed into the drum and rotated for 2 min at 30 rpm. The weight percentage of the dust finer than 850 μm was expressed as abrasion index.

The durability of the agglomerate at the outdoor stockpile was determined by weathering test. When the briquette was put into water, if it kept its original form at least for two hours, it was accepted as water resistant.

EXPERIMENTAL RESULTS AND DISCUSSIONS

In briquetting tests, the effects of pressure, type and amount of binder, moisture content, drying temperature and fineness of the sample on briquette quality were investigated.

THE CHOICE OF BINDER

The preliminary tests showed that the briquettes produced by the addition only water had no compressive strength. In order to improve the strength of the briquettes, various binders have been added into the briquet charge; their results are shown in Table 3.

Table 3. Effect of different binders on briquetting

Binder %	Crushing load(kg/briquet)
-	144
Molasses	434
Dextrin	561
Starch	209
Bentonite	143
Lime	141
Black cement	245
Na_2CO_3	193
NaCl	218
Na_2SiO_3	140
Polyvinyl acetate	297
Peridur XC3	266
CMC	141

Briquetting conditions: Binder: 5%, Moisture: 6%, Pressure: 200 kg/cm^2,
Drying temp.: 105°C, Particle size: original sample

As seen in Table 3, the briquets produced by the addition of dextrin and molasses showed higher compressive strength than the others; molasses was chosen as the binder, as it is much cheaper.

EFFECT OF AMOUNT OF BINDERS

Molasses has been added in various amounts into the briquette charges. The addition of molasses above 1,5 % was sufficient for the production of briquettes with compressive strengths above 100 kg. It was found that the increase in the binder amount increased the strength of the briquette.

Although, the briquette produced by the addition of molasses alone were sufficiently strong, their resistance to water was nil when they were brought in contact with it. In order to improve the resistance of briquettes to weathering, hydrated lime was added besides molasses. Table 4 shows the results of hydrated lime addition.

Table 4. Effect of amount of hydrated lime with molasses

Amount of Lime (%)	Crushing Load (kg/briquette)	Water Resistance
-	460	20 % disintegration in water
0,5	396	20 % disintegration in water
1,0	376	15 % disintegration in water
1,5	388	Water resistant
2,0	384	Water resistant

Briquetting conditions: Binder: 5% molasses, Moisture: 6 %,
Pressure: 200 kg/cm^2, Drying temp.: 105°C,
Particle size: original sample, briquettes were kept in water for 2 hours

As seen, hydrated lime addition improved the water resistant property of the briquettes when it was added above 1.5 % by wt. However, the compressive strength of the briquettes decreased by the hydrated lime addition.

There are two different proposals about the hardening mechanism of the briquets. One is that the hydrated lime added as binder react with carbon dioxide in air, producing calcium carbonate and water. Here, the molasses act as a catalyst and the calcium carbonate gives the briquette the required strength. Another theory is becoming more popular that the molasses taking part in the reaction to form calcium sucrates.

In order to find out the amount of molasses used in combination with hydrated lime, a series of tests have been performed by the use of molasses between 1 to 6 % by wt. As shown in Table 5, increasing the amount of molasses increased the crushing strength. By taking into consideration the water resistant properties of the briquettes, 5 % molasses addition was found sufficient for the production of water resistant briquettes.

Table 5. Effect of amount of the molasses used in briquetting

Amount of Lime (%)	Crushing Load (kg/brique tte)	Water Resistance
1.0	127	No resistance to water
2.0	163	No resistance to water
3.0	237	No resistance to water
4.0	287	15 % disintegration in water
5.0	366	Water resistant
6.0	514	Water resistant

EFFECT OF PRESSURE

At optimum molasses+hydrated lime addition, the briquettes were produced by applying different pressures whose results are shown in Table 6.

Table 6. Effect of pressure on briquette

Briquetting Pressure, kg/cm^2	Crushing Load (kg/briquette)	Water Resistance
100	184	20 % disintegrated in water
150	294	15 % disintegrated in water
200	386	water resistant
300	418	water resistant
400	486	water resistant
500	470	water resistant
600	294	water resistant

Briquetting conditions: Binder: 5% molasses+1,5% lime,
Moisture: 6%, Drying temp.: 105°C, Particle size: original sample,
briquettes were kept in water for 2 hours

As the pressure decreases the void spaces and increases the contacts between the particles,the crushing strength of the briquettes and their resistance to water improved. 200 kg/cm^2 pressure was found sufficient to achieve strong and water resistant briquettes.

EFFECT OF MOISTURE

The water was added between 1% to 8% to moist the briquette charge. The briquettes produced with the addition of more than 6% water, their water resistant properties were improved.

EFFECT OF FINENESS OF THE SAMPLE

In order to investigate the effect of fineness of sample on the strength of the briquets, various amount of minus 44 microns fraction was added to the original sample. As shown in Table 7, the effect of increasing fines in the briquette mixture was insignificant. In other words, the fines had no appreciable positive or negative effect on the quality of the briquette.

Table 7. Effect of fines on briquetting

-44 microns Fraction(%)	Crushing Load (kg/briquette)	Water Resistance
10	373	water resistant
20	362	water resistant
30	371	water resistant
40	375	water resistant
50	379	water resistant

Briquetting conditions: binder: 5% molasses+1,5% lime,
Moisture: 6%, Pressure: 200kg/cm^2, Drying temp.: 105°C,
briquettes were kept in water for 2 hours

CONTROL OF CALCINATION PROPERTY OF THE BRIQUETTE

In order to control the suitability of briquette size in calcination, it was calcined in the Gebr Rushtrat laboratory muffle furnace at 1100ºC for 2 hours. The calcinated briquette was analysed by XRD method, which is shown in Figure 1.

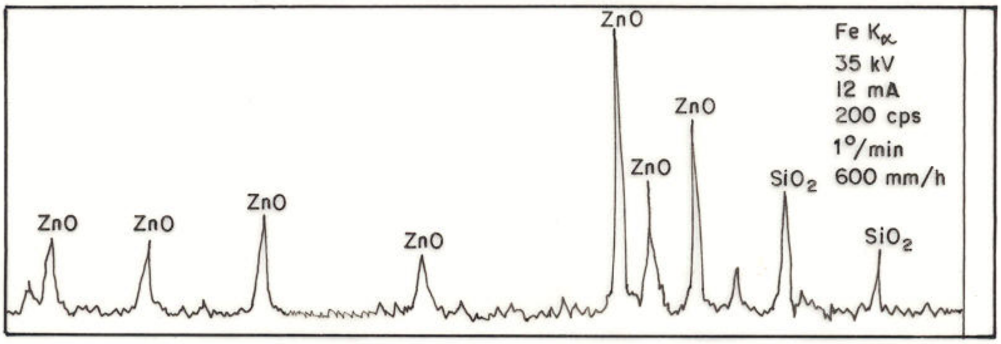

Fig. 1. XRD of zinc concentrate of iran after calcination

The chart of XRD test showed that no smithsonite was present in calcined sample due transformation of smithsonite to ZnO. It showed the suitability of the briquet size to calcination.

TUMBLING TEST ON BRIQUETS PRODUCED AT OPTIMUM CONDITIONS

Briquettes produced with 5% molasses and 1.5 % hydrated lime and with a briquetting pressure of 200 kg/cm^2, were fed to the tumbling drum, to determine the abrasion resistance. The tumbling test showed that the dust percentage was around 1%. It proves that the briquettes are very resistant to abrasion.

CONCLUSIONS

1. On the basis of briquetting tests, it was concluded that Angouran smithsonite sample could be successfully agglomerated by briquetting method.
2. During briquetting, binder addition was found essential. Among twelve organic and inorganic based binders, molasses was found suitable.
3. Although, the briquettes produced by the addition of molasses alone were sufficiently strong, they did not show any resistance to water. This was overcome by the use of hydrated lime with molasses.
4. The briquetting pressure had a significant effect on the strength and water resistant property of the briquettes.
5. The fineness of the sample had no appreciable effect on the quality of the briquettes.

6. Optimum briquets were produced by the addition of 5% molasses, 1.5 % hydrated lime, 6% water. The pressure and drying temperature were 200 kg/cm^2 and 105ºC, respectively. These briquettes showed above 300 kg crushing strength and around 1% abrasion index with no disintegration in water.

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Rudę zawierającą węglan cynku przerabia się w sposób tradycyjny w piecu Waelza, w celu odzysku cynku w wyniku procesu rozkładu termicznego. W przypadku, gdy nadawę do procesu stanowią drobne ziarna, musi być zastosowany proces brykietowania drobnych ziarn. Celem pracy było określenie warunków fizykochemicznych brykietowania drobnych ziarn węglanu cynku ze złoża Angouran w Iranie, które przerabiane są w zakładzie wzbogacania Dandi. W trakcie prowadzonych doświadczeń, badano wpływ ciśnienia, ilości cieczy mostkującej, wilgoci, temperatury i wielkości ziaren na proces brykietowania. Optymalne warunki brykietowania otrzymano, gdy drobne ziarna węglanu cynku były mieszane z 6% wody, 5% melasy oraz 1.5% wapna. Ciśnienie zastosowane do brykietowania wynosiło 200kg/cm^2, a temperatura suszenia 105^{0}C przez okres 2 godzin.