

## RECYCLING OF GYPSUM REFUSE LUMPS

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### ABSTRACT

The specific features of the kiln subjected gypsum as well as its relatively low price are rendering it suitable for variety of industries like construction, faience, machine construction etc. Significant amount of solidified gypsum in a form of a gypsum stones is accumulated in a form of technogenic waste which pose an environmental problems. An investigation in direction of recycling and secondary utilization of the gypsum lumps has been carried out aiming to transform the gypsum refuse into ground gypsum for construction industry. The technological flowsheet designed has involved the following principal processes: crushing, drying, vibration grinding and burning with the objective to alter gypsum granulometry and physico-mechanical properties. The influence of the temperature upon the gypsum refuse has been studied for the following temperatures 65, 110, 165 and 180 °C. After the vibration grinding, test bodies have been formed and the strength properties of the ground gypsum were measured.

By addition of 1 to 3 % inert mineral component during the vibration grinding process of dry waste gypsum thermally processed at 65 °C, it is possible to obtain construction gypsum having compressive strength exceeding 2.5 times the strength of the ordinary type gypsum.

### INTRODUCTION

Gypsum and anhydrite deposits are among the most abundant deposits met worldwide. Few places in the world are lacking of industrial deposits. The major decision influencing factors influencing the industrial fate of a given gypsum mine and its profitability are:

- the distance to the potential customers;
- the means of gypsum transportation.

Raw state gypsum presents a cheap source. Burned gypsum is a relatively cheap material also, having major consumers like:

civil engineering activities, when is used as void-filler, putties and fabrication of building and decorative materials;

machine manufacturing and porcelain-faience industry for forms and models making.

An investigation for recycling of useless and broken gypsum moulds rejected from china clay production has been performed. The aim was to use the obtained gypsum for production of cement, gypsum-based binders, gas-concrete materials etc.

### EXPERIMENTAL

#### Methods and materials

The studied material was obtained after crushing of porcelain industry gypsum moulds and has consisted of gypsum lumps sized under 100 mm. Material moisture was 0.21 % obtained at 50 °C.

The method of investigation has been designed in the following sequence:

- restoration of the granulometric composition of the burnt gypsum - source material for the gypsum pottery;
- thermal processing of the ground waste gypsum at given temperatures responsible for transformation of the different gypsum types;
- compressive strength studies by means of test bodies.

The granulometric composition restoration under lab scale conditions has been carried out following the flowsheet shown at Figure 1.

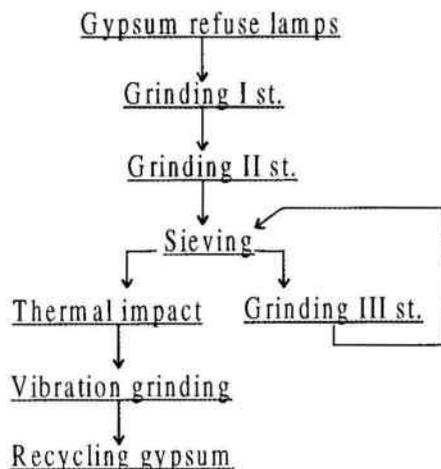


Figure 1 - Flowsheet for recycling of gypsum refuse lumps

The first grinding stage employs jaw crusher with 120x80 entry opening having grinding degree of 4. During the second stage, roller crusher is used with roll diameter 220 mm and grinding degree of 3. The 0.5 mm oversize is directed into third stage grinding in a KID type crusher having grinding degree of 10. The undersize reports into vibration grinding process. It is accomplished inside a vibration mill working at frequency of 25 Hz and 6 mm amplitude. The working chamber has 350 cm<sup>3</sup> volume and employs rods as working media. Vibration grinding with addition of 1,2 and 3 % inert mineral - thermally treated at 65 °C waste gypsum, has been carried out. Thermal impact duration was kept at 80 minutes. The influence of the thermal treatment on the waste gypsum was investigated at temperatures of 65, 110, 165 and 180 °C.

The compressive strength studies have been done on series consisting of 6 test bodies with the following dimensions: 36 mm dia and 26 mm height. The test bodies have been produced by mixing 100 grams waste gypsum with 60 cm<sup>3</sup> water. The compressive studies have been performed after test bodies were left for 15 days using a mechanical press.

## RESULTS

The degree of coarseness reached for the waste gypsum during the vibration grinding was as follows:

- for 5 min. vibration grinding - 9.6 % + 0.2 mm;
- for 10 min. vibration grinding - 0.3 % + 0.2 mm;
- for 15 min. vibration grinding - 14.5 % + 0.1 mm.

Figure 2 shows the results obtained concerning hardening time of the test bodies manufactured on the basis of vibration assisted ground waste gypsum for different temperature treatments - 110, 165 and 180 °C.

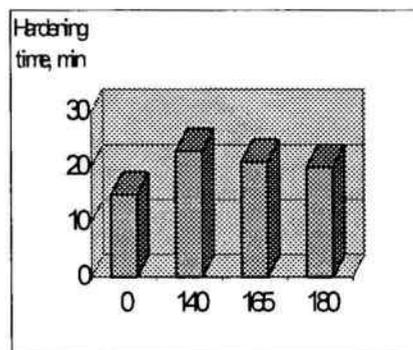


Figure 2 - Dependence between hardening time and temperature treatment of ground recycled gypsum

Table 1 presents the results obtained from the compressive strength tests of waste gypsum with and without thermal treatment.

Table I - Compressive strength tests

Thermal treatment °C	Compressive strength, kg/cm <sup>2</sup>	
	Minimum	Maximum
0	126	169
65	89	94
110	100	103
165	75	75
180	111	127

Table 2 below summarizes the mean values for the compressive strength for the thermo treated at 65 °C secondary obtained waste gypsum, vibro ground for 5, 10 and 15 minutes in the presence of inert mineral additive (1, 2 and 3 %).

Table II - Compressive strength for the thermo treated waste gypsum

Grinding time min	Compressive strength, kg/cm <sup>2</sup> (with mineral additive)		
	1 %	2 %	3 %
5	218	281	332
10	230	343	351
15	330	356	364

## DISCUSSION

The compressive strength figures obtained from the performed studies with by-product gypsum obtained from recycling of porcelain industry gypsum moulds are summarizing the influence of the granulometric characteristic and the temperature treatment upon its characteristics. The non-thermally treated recycled gypsum possesses the highest compressive strength - 126 - 169 kg/cm<sup>2</sup>. According to the results from Table 1, the thermal impact realized under the above range and time duration, has a negative impact. Since the non-thermally treated secondary gypsum possesses the highest compressive strength characteristics, one could presume that this material contains definite preserved quantity of semi hydrated gypsum responsible for the binding features of the gypsum when saturated with water. The differences in the obtained values for the mechanical strength of the thermally treated gypsum does not necessary indicate correlation. Owing to Figure 2 the hardening time for the test bodies made from secondary gypsum does not differ from that for the raw burnt gypsum.

It is interesting to note the inert mineral additive influence during the vibration grinding in producing secondary-type gypsum from the refuse lumps. According to the values in Table 1 and 2, compressive strength increases in order of 30 to 200 % when compared to the best results obtained with recycled gypsum. The presence of inert additive does not lead to worsening the gypsum quality which complies with the standards imposed by the BDS (Bulgarian National Standard System). It allows presence of up to 10 % additives for the best quality gypsum.

A characteristic differences in the structure of the test bodies made from recycled gypsum with inert mineral mixture were found out during the research course. The test bodies made from recycled gypsum have been uniformly cracked and destroyed smoothly when smashed under the press. However, the test bodies having mineral additive under compression have been destroyed with rock-blast type sound. The peculiarities in the structure of the test bodies having inert mineral additive suggest unambiguously a link between the gypsum and the additive which is chemically inert and does not react with water and organic solvents.

## CONCLUSION

The performed investigation aiming recycling of refuse gypsum lumps has suggested that the secondary obtained gypsum preserves to a significant extent its mechanical strength when used again. If required, its mechanical strength could be enhanced by introducing inert mineral additive during the grinding stage. The gypsum lumps recycling secures obtaining of a competitive secondary gypsum having lower production costs compared to the one obtained from ore calcination.

## REFERENCES

- Brukner H, Deiler E., Fitch G., Karcher G., Zigler H., Gypsum - Manufacturing and Application of Gypsum Based Building Materials. Stroyizdat, Moscow 1981 (in Russian)