DEVELOPMENT OF A SEPARATION PROCESS FOR GYPSUM-CONTAMINATED CONCRETE AGGREGATES

Schnellert, T. (1), Kehr, K. (1) and Müller, A. (1)
(1) Bauhaus - University Weimar, Chair of Mineral Processing of Building Materials and Reuse, Germany

1. INTRODUCTION

Gypsum is a finishing building material. The gypsum building materials are easily workable and light. Besides a comparatively low energy is required for the production, which leads to ecological and economic advantages. These aspects contribute to the fact that the production of gypsum materials around years has been higher than any other building materials [1]. Gypsum content in building materials increased for 3% in the year 2000, much higher than 1% of the year 1985 [2]. The gypsum amount referred to the produced concrete amount has increased for decades.

Moreover, apart from the expected increase of the gypsum amount in construction materials, a substantial portion of gypsum was used to build sanitary room walls and anhydrite gypsum into floor in 2.15 million apartments of precast concrete buildings (slab method) in the area of the new Federal states in Germany. In the end life, the entire buildings were demolished resulting a gypsum contaminated concrete aggregates, without possible reuse. The content of leachable sulfate found was higher than that permitted for the use in road or earthworks.

In construction & demolition (C&D) sites or C&D recycling plants, a process capable to separate the gypsum materials of the other materials is necessary for reuse or use of C&D aggregates. The available process is to abort the contaminated C&D waste masses in recycling process, redirecting probably for a landfill that is an illogical solution in terms of economic and environmental aspects. In future, the increase of gypsum amount in C&D materials will clearly become a problem for the usual recycling process.

So, the separation from gypsum from the remaining building materials represents a challenge at the recycling technology. In the wet gravity separation criterion, the density variation of the individual materials due to water absorptivity must be considered. When the effective densities of particles are similar, the separation is not efficient anymore requiring a modified set technology that uses asymmetrical strokes [11]. In this contribution the separation between concrete and gypsum materials is demonstrated by the use of the modified set technology.
2. MATERIALS AND METHODS

Principles of jig technology and new model description

The separation by jig technology is based on density of material. The technology is well-known processing route. The use of jig started in 1556 with Agricola for ore production. Today the technology serves for the processing of coal, ores, gravel and other raw materials. This technology is also inserted in recycling market for production of valuable material.

The separation is based on the setting phenomena of the particles with different sizes and densities in a fluid bed. The feed particles are sent upward through of a fluid flow pulse and the heavy particles drop and the light particles go upward. This separation phenomena usually generated by a harmonic stroke is represented in the figure 1.

![Figure 1. Separation phenomena of jigging [10]](image)

A feedings
L light particles
S heavy particles
FL fluid
K field
St stroke

So, a stratified bed of different density particles is formed because no friction forces occur between the individual particles with similar density during the upward and downward flowing water movements generated by external energy supply.

With the new model jig machine of AGS GmbH it is possible to obtain asymmetrical strokes during the formation of stratified bed. According to own preliminary tests this induced particle movements are suitable to separate particles with small density variations [11]. The pilot scale jig was installed at the building waste recycling center in Erfurt Schwerborn.

The jig consists of a tank, a drainage filter, and Linatex 80 pump; capacity of processing of 5-7 t/h. The jig bed has the dimensions 400 x 1000 mm². The process consumes approx. 50 m³ of per hour in the cycle; but, most of water can be recycled in an industrial process.

Materials

The materials were collected at the building waste recycling center of the SWE GmbH, Erfurt, Germany. Three types of materials (Figure 2) were individually collected and crushed into sizes lower than 60 mm. These materials are 100% pure, without any contamination, in order to assure the real measurement of jig efficiency process.
Concrete
OD density(*): 2.40 g/cm³

Gypsum floor material
OD density: 1.56 g/cm³

Gypsum bath cell
OD density: 1.89 g/cm³

(*) OD density is the oven-dry density, determined using ASTM C 127 (1993).

Figure 2: Materials.

100 kg of each material was taken for characterization essay. For pilot jig test, 500 kg mixtures between concrete and each gypsum type (floor or batch cell) were produced in the following gypsum concentrations (%-in mass): 0; 5; 10; 15 and 20. The total quantity of material was 5 t approximately. 10 types of gypsum contaminated concrete aggregates were then produced, submitted to pilot scale jig separation. The output heavy and light products were, then, characterized.

Characterization methods

The output heavy and light products are characterized according to:
- Mass balances of the different materials, dried at temperature of 40 °C until the mass constant achieved between 24 and 48 h.
- Particle size analysis of dried materials by sieving at 2/4, 4/32 mm sieve sizes.
- Building material composition analysis by hand sorting

3. RESULTS

The heavy fractions represent the cleaned concrete aggregates. The light fractions represent the enriched gypsum material that may be use in gypsum industry depending of its purity. The mass balances of heavy and light fractions are shown in figure 1. Similar mass yields of light fractions were obtained independently of the input gypsum content in the aggregates. As a result the compositions of the enriched gypsum materials were very different.
The gypsum contents in light fractions depend of the input gypsum contents of the contaminated aggregates (figure 2 and figure 3). They are slightly higher when the aggregates are contaminated with sanitary room gypsum that has oven-dry density of 1.56 g/cm³.

To evaluate the quality of jig separation mass yields and composition should be evaluated absolutely in connection. For all heavy products, the mass yields were high as well as the contents of concrete were high achieving good quality product in terms of density. However, the gypsum contents in heavy fractions also depend of the input gypsum contents of the contaminated aggregates (figure 2 and figure 3). Contrarily to that observed to the light fractions, these contents are slightly higher when the aggregates are contaminated with floor screed gypsum that has oven-dry density of 1.89 g/cm³.
Over of 0.6-1.0 M-% of gypsum in input contaminated aggregates the output cleaned concrete aggregates presented more than 0.2 M-% of gypsum surpassing the limit established by DIN 4226-100. In this case, the use of cleaned aggregates is not possible in concrete anymore.

Regarding the particle size distributions of the light and heavy fractions a positive effect of jig processing can be the fact that fine aggregates were recovered only in the light fractions (Figure 4).

4. SUMMARY

To abort the contaminated C&D waste masses in recycling process redirecting probably for a landfill is an illogical solution in terms of economic and environmental aspects. A process capable to separate the gypsum from the remaining building materials is relevant.

The jig processing with asymmetrical strokes is able to reduce the content of gypsum in cleaned concrete aggregates, making possible to achieve the limit of 0.2 M-% established by DIN 4226-100 for the reuse in concrete. Due to restriction of near 1 M-% of gypsum in the input contaminated aggregates for achieving the required limit in the cleaned concrete aggregates, multiple stages will be probably necessary since there is occurrence of slab construction waste with 2 - 4 M-% of gypsum contents inside.
Apart from the composition requirement for the cleaned concrete aggregates, the jig processing may reach a secondary advantage due to the density increase and the separation of fine aggregates.

REFERENCES