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Recrystallization of Gypsum Particles

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ABSTRACT

This article explores the possibility of use of dynamic metamorphism processes for the synthesis of products from natural gypsum. The recrystallization of gypsum is described, i.e, the process of continuous growth of large crystals due to the dissolution of fine crystals in a polydispersed suspension called the "maturation" of crystals.

KEYWORDS

Gypsum, recrystallization of gypsum particles, dynamic metamorphism, compaction, calcium sulfate dihydrate

ARTICLE HISTORY

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Introduction

For the development of innovative building materials and technologies for their production it is necessary to use a variety of fundamental research, interdisciplinary and transdisciplinary approaches (Bazhenov, Demianova & Kalashnikov, 2006; 2012; Lesovik, Ginzburg & Volodchenko, 2014; Kaprielov et al., 2006).

It is known that building composites have analogues among the rocks: fine-grained concrete - sandstone, glass - obsidian, concrete on a large aggregate - a conglomerate, and so on (Bataiev, Chernysheva & Saidumov, 2015; Bazhenov & Falikman, 2001; Kaprielov, Sheinfeld & Kardumian, 2010; Lesovik, 2014; GOST P 56178-2014, 2014; Perianez, 2005).

One type of geological processes is metamorphism that occurs due to effects on the rocks (in particular, sedimentary ones) of high pressures and temperatures, and sometimes of high pressures alone, such as dynamic metamorphism (Gridchin, Pogorelov & Lesovik, 2000; Lesovik, Pogorelov & Strokova, 1999; Murtazaev et al., 2015a; 2015b).

The man-made analogue of dynamic metamorphism is compaction (Lesovik, 2015). This technology is used in the production of ceramic and concrete products,

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sand-lime bricks, etc. In this article we consider the use of such processes for the synthesis of products from natural gypsum.

From the literature it is known that a recrystallization phenomenon occurs in the wet gypsum samples (El-Didamony, El-Afi & Elwan, 2002; Erdogan, Demirbas & Gene, 2004; Rzeczycka et al., 2001; Singh, 2003; Olmez & Yilmaz, 1988). This process of the continued growth of large crystals, associated with the dissolution of fine crystals in a polydispersed suspension, is called the "maturation" of crystals.

The finest particles, such as the formed buds, are characterized by a large tendency to dissolution due to the surface tension. It is explained by the strong curvature of the surface, which leads in the conditions of constant surface tension to a higher internal pressure of the particles. Thus, fine particles have higher equilibrium solubility (Jarosinski, 1994; Singh, 2002; Al-Masri & Al-Bich, 2002; Altum & Sert, 2004; Arocena, Rutherford & Dudas, 1995).

In particularly reactive sites of the crystals (defects in a crystal lattice, corners and edges of crystals) the dissolution process proceeds more rapidly, which also causes the formation of a slightly supersaturated solution with respect to calcium sulfate dihydrate. Its ions [Ca2+] and [SO42-] join bigger hypsum crystals. The process of extension takes place.

In this regard, the question arises whether the hardening of densely packed particles of gypsum (calcium sulfate dihydrate) in a wet environment is possible.

Methodological framework

Methods are based on fundamental research on the theory of crystallization and solidification of natural gypsum and summarizes the advanced experience in the development and application of composite (filled) binders based on it.

Results and Discussion

The following samples were received (diameter: 40 mm, height: 40 mm) from ground natural gypsum by pressing. Production and storage under the following conditions:

- The weight ratio of moisture (water) to gypsum 4,0…7,0 %
- Plasticizer additive (in regards to gypsum) 0,0…0,1 %
- Pressure of compaction 50…100 MPa
- Waiting time of samples (recrystallization) 1…7 d
- Temperature of samples storage 5…20 º C

Figures 1 and 2 show the effect of the particle size and temperature on the solubility of calcium sulphate dihydrate.

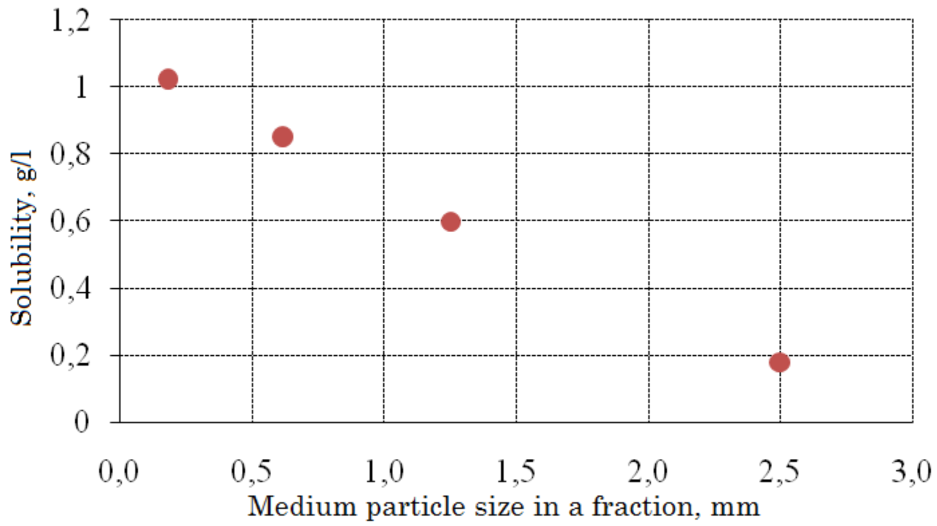

Figure 1. The dependence of the solubility of gypsum on particle size (Bazhenov et al., 2012; Lesovik, Ginzburg & Volodchenko, 2014)

The influence of various factors on the strength at compaction of gypsum samples is indicated in the following table.

Figure 3 clearly shows the dependence of the strength of the individual factors. The biggest effect among the five factors is caused by the pressure of compaction. At the same time, the bigger the pressure, the bigger the strength. The strength is also influenced, but to a lesser extent, by the ratio of water and gypsum and amount of the plasticizer in water. For these 2 factors it is characteristic that their strength increases with reduction. The time and temperature under these conditions do not significantly affect the process of hardening of gypsum particles. The mutual influence exists between the water-gypsum ratio and pressure of compaction.

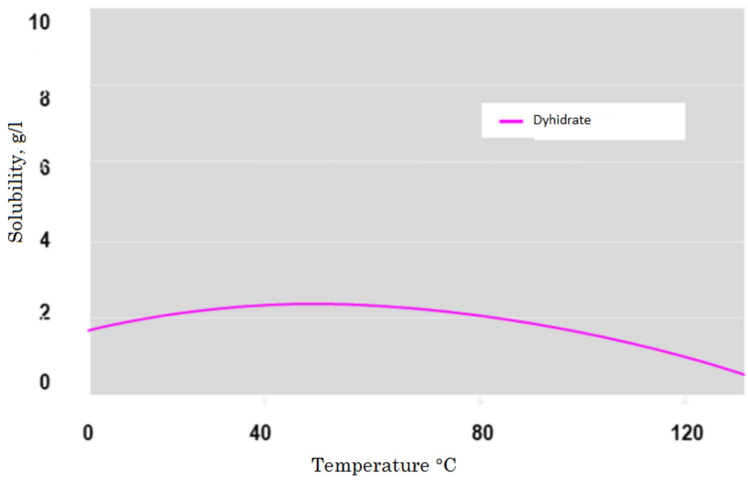

Figure 2. The dependence of the solubility of calcium sulphate dihydrate (gypsum) on temperature

Table1. Effect of various factors on the strength on the pressure of gypsum samples

№	Ratio water: gypsum [%]	Plasticizer content [%]	Pressure of compaction [MPa]	Time of storage [days]	Tempera-ture of storage [°C]	Strength under compaction [MPa]
1	7,00	0,00	50	1	5	11,3
2	7,00	0,10	50	7	5	10,5
3	7,00	0,10	50	1	20	10,0
4	4,00	0,10	50	7	20	12,7
5	4,00	0,00	100	1	5	21,2
6	4,00	0,00	50	7	5	13,0
7	7,00	0,00	100	1	20	15,2
8	7,00	0,00	50	7	20	11,6
9	7,00	0,10	100	7	20	13,5
10	4,00	0,00	50	1	20	12,2
11	7,00	0,10	100	1	5	14,1
12	4,00	0,10	100	7	5	19,4
13	4,00	0,00	100	7	20	21,5
14	4,00	0,10	50	1	5	11,1
15	4,00	0,10	100	1	20	18,2
16	7,00	0,00	100	7	5	16,9
-	A	B	C	D	E	-

Figure 3 clearly shows the dependence of the strength of the individual factors. The biggest effect among the five factors is caused by the pressure of compaction. At the same time, the bigger the pressure, the bigger the strength. The strength is also influenced, but to a lesser extent, by the ratio of water and gypsum and amount of the plasticizer in water. For these 2 factors it is characteristic that their strength increases with reduction. The time and temperature under these conditions do not significantly affect the process of hardening of gypsum particles. The mutual influence exists between the water-gypsum ratio and pressure of compaction.

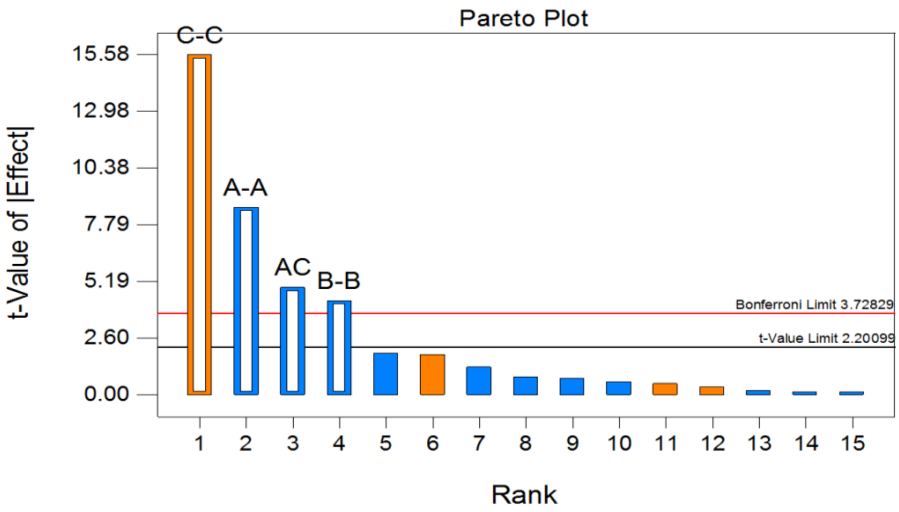

Figure 3. Pareto chart to identify significant factors

Figure 4 gives the possibility to predict the hardening of gypsum particles, depending on the pressure of compaction and water-gypsum pressure. In the above ranges the increase of strength is possible by almost two-fold: from 12 MPa to 20 MPa.

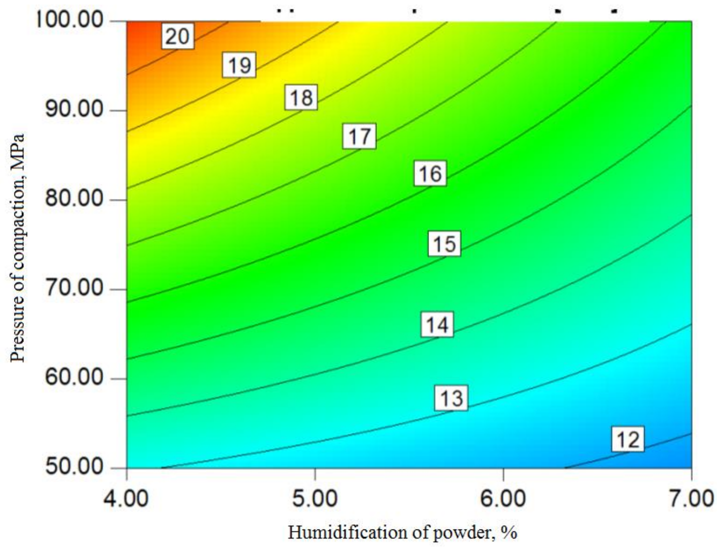

Figure 4. The strength at compaction of the samples from the pressed gypsum particles depending on the moisture content of the material and pressure of compaction (test conditions: storage temperature of samples: 20 °C, storage time: 7 days, without the use of a plasticizer)

Subsequent electronic and microscopic images (Figure 5) show the "merging" of certain gypsum particles that contribute to hardening of the samples.

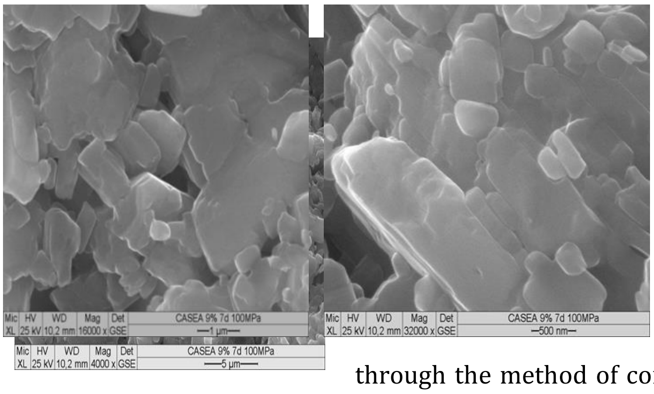

Figure 5. Merging of gypsum particles of the pressed samples (conditions: ground natural gypsum, pressure of compaction 100 MPa, water-gypsum ratio – 0,09, storage in closed containers – 7 days)

Conclusion

Thus, it is possible to get quite a strong structure through the method of compaction. Moreover, the higher the strength, the higher the pressure of compaction and the lower the humidity of the powder (in the examined range). The best results have been achieved at a pressure of 100 MPa and humidity of gypsum powder of 9%. Other studied factors do not have a considerable effect on hardening.

Disclosure statement

No potential conflict of interest was reported by the authors.

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