Gypsum binders based on ceramic industry waste

Mamurjon*, Bakhromjon, Shoirjon*, Bakhodir, Adkhamjon, Zokhidjon

1 Fergana Polytechnical Institute, 150107 Fergana, Uzbekistan
2 Namangan Institute of Engineering and Construction, 103106 Namangan, Uzbekistan

Abstract. A tense situation is emerging in Uzbekistan regarding the supply of high-quality natural raw materials to the gypsum production industry. Consequently, many industrial made wastes containing gypsum compounds are disposed of in landfills. These wastes, which are harmful to the environment, are valuable raw materials that can be used in the production of gypsum binders in many cases. The use of man-made waste in the production allows to achieve great economic efficiency in the production of gypsum binders and various construction materials and products based on two important problems - prevention of environmental pollution.

The article describes the results of scientific research on obtaining gypsum binders from waste molds used in ceramic industry enterprises producing porcelain and sanitary-technical products. Waste molds of "EKOKERAMA" LLC (Fergana city, Uzbekistan) were used in the research. Waste mold pieces were treated with isothermal heat under "thermal shock" conditions. Due to the increase in the amount of α-modification of gypsum in the resulting product, gypsum binders whose physical and mechanical properties meet the requirements of GOST 23789-2018 were obtained.

1 Introduction

In our republic, there is a tense situation regarding the supply of high-quality natural raw materials to the gypsum production industry. Not every region has gypsum deposits, which requires the transportation of raw materials or finished binders from other places. This, in turn, leads to an increase in transport costs. In addition, even where there are natural gypsum reserves, it does not always meet the quality requirements. Today's existing mines require modernization and reconstruction, which requires large capital expenditures. Consequently, disposal of waste containing gypsum compounds is one of the main problems in the present era, when great attention is paid to environmental protection [1]. Man-made waste that is harmful to the environment is a valuable raw material that can be used in the production of construction materials in many cases. The use of man-made waste in the production allows to achieve great economic efficiency in the production of gypsum binders and various construction materials and products based on two important problems - prevention of...
environmental pollution. The analysis of the literature on the use of waste containing gypsum compounds in the construction materials industry shows that many scientists of the world have conducted research in this area. In particular, Russian researchers Potapov Yu.B. [2], Shchukina E.G. [3], Mikheenkov M.A. [4], Chistov Yu.D.. [5], Semenov N. [6], Petropavlovskaya V.B. [7], Otakoziev T.A., one of the scientists of our republic. [8], Iskanderova M.I.[9], Nigmatov S.S. [10], Boydadaev M.B. [11] and others conducted research on the factors affecting the properties of gypsum binders obtained from industrial waste and the improvement. Their main focus is on improving the quality of binders obtained from chemical industry waste containing gypsum compounds (phosphogypsum, borogypsum, citrogypsum, etc.). Many composite materials and products are produced on the basis of these binders. However, gypsum molds used in ceramic industry enterprises producing porcelain and sanitary-technical products are neglected. After these molds are used 40-60 times, they become unusable and are thrown away as waste. For example, only “EKOKERAM A” LLC (Fergana city, Uzbekistan) generates up to 10 tons of gypsum mold waste per day. A lot of money is spent on collecting them and transporting them to landfills. However, in terms of phase and chemical composition, unlike most gypsum wastes, they correspond to high-quality natural gypsum stone. However, until now, this secondary product is not used in the production of building materials.

2 Materials and research methods

The principle of obtaining gypsum binders is based on the ability of calcium sulfate dihydrate to dehydrate when heated, accompanied by a change in the structure of the crystal lattice [11]. During heating, α and β modifications of calcium sulfate hemihydrate are formed. The α and β modifications of the resulting gypsum are characterized by the same type of crystal lattice. The first of them has large, perfectly structured crystals, and the second consists of defective, small crystals. As a result, products made of a-gypsum have much better properties than products made of b-gypsum in terms of strength and moisture resistance [12]. However, despite this, the main volume of production of gypsum binders in our Republic corresponds to β-hemihydrate due to the simple and cheap production technology. In most cases, when obtaining α-modification of gypsum, methods of heat treatment of gypsum raw materials with saturated hot water vapor under pressure and in salt solutions at atmospheric pressure are used. The main disadvantage of these methods is that high pressure is required for technological processes and a large amount of water is used to wash off salt solutions from the product. In our research, we used the method of heat treatment of raw materials under “thermal shock” conditions in the production of gypsum binders from waste molds of “EKOKERAMA” LLC. [13]. This method involves heat treatment of raw materials in a certain temperature environment in the composition of the product based on increasing the amount of α-modification of gypsum.

The waste molds taken for testing were first crushed to a size of 3-6 cm, then placed in a muffle furnace heated from 1800°C to 2400°C for isothermal burning. The duration of burning was from 30 minutes to 4 hours. Burned samples were milled to a fineness of 0.2 mm in a planar mill, and normal thickness (NQ), bite times and strength limits were determined according to the requirements of GOST 23789-2018.
3 Results and discussion

Fig. 1. Dependence of the strength of gypsum binders on the temperature and duration of curing. The strength of plasters burned for 30 minutes at isothermal temperatures of 180 and 2100C has a minimum value, which indicates that their composition consists mainly of β-modification. Shortness of their solidification periods and high normal density index (S/G ratio) can be the basis for making such a conclusion.

Fig. 2. Dependence of the normal thickness of gypsum binders on the duration of casting. Increasing the burning time at such isothermal temperatures up to 4 hours makes it possible to increase the amount of α-modification of gypsum in the product composition as a result of the dehydration process of gypsum due to the pressure created inside the pieces of gypsum stone (“mini-autoclave”), and to improve its physical and mechanical properties. The resulting gypsum binder fully meets the requirements of GOST 125-2018, which is used for making molds in the ceramic industry that produces porcelain-technical products. Increasing the burning temperature from 2400C leads to complete dehydration of...
Increasing the burning temperature from 2400°C leads to complete dehydration of gypsum and increase of insoluble modification of $\text{CaSO}_4$ in the product. This process is not affected by the duration of burning.

Fig. 3. Dependence of the period of hardening of plaster binders on the duration of burning.

4 Conclusion

The analysis of the results of the conducted researches was carried out by burning from waste molds in isothermal conditions at a temperature from 1800°C to 2400°C, for 30 minutes to 4 hours, meeting the requirements of GOST 23789-2018 in terms of physical and mechanical properties, from G-4 to G-10 brands ($\text{R}_{	ext{siq}} = 4.2 - 11.5 \text{MPa}, \text{R}_{	ext{eq}} = 2.5 - 4.8 \text{MPa}$) showed that it is possible to obtain gypsum binders.

It is known that gypsum mold waste is produced in all porcelain and earthenware and sanitary-technical products manufacturing enterprises of the ceramic industry in the territory of our Republic. As a result of using the production of gypsum plasterboards from these wastes, these enterprises will reduce their need for plaster purchased from abroad for making molds, and will make it possible to earn additional income.

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