Summing up the article, we can note that there is a need to develop new methods for the rational water resources consumption as water is one of the main sources of life, which should be protected for contemporary and future generations.

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Production of high-strength ceramics from ash and slag waste

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Abstract

In the analytical part of the article, a review of domestic and foreign experience in the use of ash and slag waste (ASW) of coal-fired power plants in the manufacture of ceramic products was made.

The practical part provides information on the technology of extracting the ash fraction suitable for the manufacture of ceramic products from the dump ash of Primorskaya SDPP. A method for the manufacture of ceramic bricks with a 100% ash and slag waste content is described, some physical characteristics of the products obtained are determined, and the characteristics of the products obtained are compared in accordance with GOST 530-2012.

Keywords: ash and slag waste, recycling, microdispersed fraction, ceramic products, ecology.

Аннотация

В аналитической части статьи произведен обзор отечественного и зарубежного опыта по использованию золошлаковых отходов (ЗШО) угольных электростанций при изготовлении керамических изделий.

В практической части представлены сведения по технологии извлечения из отвальной золы Приморской ГРЭС фракции ЗШО пригодной для изготовления керамических изделий. Описан способ изготовления керамического кирпича со стопроцентным содержанием ЗШО, определены некоторые физические характеристики полученных изделий, проведено сравнение характеристик полученных изделий по ГОСТ 530-2012.

Ключевые слова: золошлаковые отходы, переработка, микродисперсная фракция, керамические изделия, экология.

Around 36% of all electricity in Russia is generated at thermal power plants, most of which use mineral fuel such as coal, shale, peat. As a result, at present about 2 billion tons of ash and slag waste have been accumulated in Russian ash dumps, with 40 million tons more being produced annually, and the level of their utilization is no more than 10%. Therefore, the use of waste from solid fuel combustion is closely related to the issues of environmental pollution [1, 2].

According to various studies, ash and slag waste can be used:

- in the production of building materials, including concretes, mortars, cements, ceramic products;
- road construction;
- in agriculture as additives that improve the structure of the soil;
- as a source of iron-containing concentrate for the metallurgical industry;
- as a technogenic source of valuable components, such as aluminosilicate microspheres, heavy concentrates, including precious metals, rare earth elements, etc.

In this article we're looking at use of ash and slag waste in the production of building ceramics, and specifically - the manufacture of ceramic bricks, since this is a product with a very large production and application volumes.

At the moment, the share of ceramic bricks in the structure of production of small-piece wall materials is about 65%. Reducing production costs, improving quality and expanding the range of products is a priority problem in brick production. One of the ways to solve the problem is to use industrial waste as a raw material for ceramic bricks. The issue of waste disposal stands at the junction of the problems of resource conservation, environmental safety, and the improvement of production technologies. [3]

A review of scientific works in the field of using ash and slag waste for the production of ceramic bricks in various regions of Russia and foreign countries was concluded. The purpose of the review was to get a general picture of the state of the use of ash and slag waste in the area under consideration.

First, a review of scientific literature from various regions of Russia was carried out, including: Ivanovo region, Samara region, Tomsk region, Kemerovo region, Republic of Tatarstan.

The list of reviewed foreign countries includes: India, China, Australia, Austria, Turkey, and USA.

The reviewed scientific works demonstrate the use of various techniques for the manufacture of ceramic products using ash and slag waste. The authors obtained ceramic products with different characteristics.

In the reviewed scientific works, the problem of making ceramic bricks using ash and slag waste was successfully solved. The authors used ashes from different energy and production facilities with different chemical composition. This indicates a wide potential for the use of ash and slag waste, provided that the specific composition of the ash and slag waste is taken into account.

It is worth noting that among the works of authors from Russia there are no examples demonstrating the manufacturing process of ceramic bricks with one hundred percent ash content, in which the samples have strength characteristics acceptable for use in construction.

The ash mixture for the manufacture of ceramic products from the ash of Primorskaya TPP was obtained in the course of an experiment on the extraction of heavy metals concentrate. For this purpose, underburning — particles of unburned coal — was removed from the ash by reagent-free flotation, and then iron-containing particles were extracted by magnetic separation. Small and light ash particles were removed from the remaining ash mixture by the elutriation method, since they impeded the operation of the centrifugal concentrator.

The elutriation was carried out as follows: a mixture of ash and water was intensively mixed using a pump in a container for 3-5 minutes. Then the mixture was allowed to settle for 15 minutes. After that, the aqueous part of the mixture with unsettled particles was poured into a separate container. The remaining precipitate was poured over with clean water and the elutriation was repeated. A total of 10 to 15 elutriation cycles were carried out. The aqueous mixture with small and light particles was settled, after which the water was decanted.

It was noticed that the sediment left after settling the mixture resembled in its consistency a highly plastic clay and was easily molded under compression. At the same time, the particles of the mixture were light enough to not be felt on a fingertip, which indicated their extremely small size.

The volume of the obtained microdispersed mixture was from 30 to 40% of the initial amount of ash, and the mixture itself was extremely plastic and the raw materials pressed from it had sufficient strength to withstand repeated movements in the technological line. It was decided to test the resulting ash fraction for the manufacture of ceramic products.

Using a 50-ton press and metal molds, 20 samples of raw bricks were made. The pressed samples were kept in air for a day, after which they were placed in an EKSP-300 muffle furnace for further drying. The drying procedure before firing is necessary in order to reduce the moisture content in the inner part of the brick, as high humidity increases the risk of cracking. Drying and firing were carried out according to the following regime:

1. Increasing the temperature to 100 degrees at a rate of 10 degrees per hour. At a temperature of 100 degrees, an isothermal pause of 1 hour was made.
2. Further, the temperature was increased again to 400 degrees with the same speed. When the temperature reached 400 degrees, a two-hour isothermal pause was made.
3. Increasing the temperature up to 1000 degrees within 8 hours. Upon reaching 1000 degrees, a two-hour isothermal pause was performed.
4. After that, the oven was turned off and the brick was left to cool for 24 hours with the oven closed.

10 samples of solid bricks and 10 samples of bricks with voids were made. For the test, 3 samples of solid bricks were selected.

Table 1

Flexural strength of samples

Sample №	Size, mm			Bending strength, MPa	Average value of flexural strength, MPa
	Width	Length	Height		
1	50	120	40	1,142851939	0,808266094
2	50	120	40	0,476436437	
3	50	120	40	0,805509905	

Table 2

Compressive strength of selected samples

Sample №	Size, mm			Compressive strength, MPa	Average value of compressive strength, MPa
	Width	Length	Height		
1	50	120	40	16,987	23,26890391
2	50	120	40	33,010	
3	50	120	40	19,810	

The results obtained show that it is possible to manufacture ceramic bricks from ash-and-slag waste with 100% ash saturation. However, the composition of the charges and the manufacturing process require some changes in order to increase the bending strength of products.

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