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INVESTIGATION OF CONTENT OF TECHNOGENIC PRODUCTS OF CHEMICAL WATER TREATMENT OF HEAT AND ELECTRIC POWER PLANTS IN CLINKER CERAMIC MATERIALS

ИССЛЕДОВАНИЕ СОДЕРЖАНИЯ ТЕХНОГЕННЫХ ПРОДУКТОВ ХИМИЧЕСКОЙ ВОДОПОДГОТОВКИ ТЕПЛОЭЛЕКТРОЦЕНТРАЛЕЙ В КЛИНКЕРНЫХ КЕРАМИЧЕСКИХ МАТЕРИАЛАХ

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ABSTRACT

CERAMIC TILES, MAN-MADE PRODUCTS, CHP CHEMICAL WATER TREATMENt

The article presents the results of a study of the content of man-made products of chemical water treatment used at combined heat and power plants in clinker ceramic materials. The results of the research showed the possibility of using man-made products water treatment used at combined heat and power plants (CHP) in the production of clinker ceramic materials and the range of rational values of the content of inorganic waste in the composition of the ceramic mass and the temperature of sintering.

АННОТАЦИЯ

КЕРАМИЧЕСКАЯ ПЛИТКА, ТЕХНОГЕННЫЕ ПРОДУКТЫ, ХИМИЧЕСКАЯ ВОДОПОДГОТОВКА ТЭЦ

В статье приведены результаты исследования содержания техногенных продуктов химической водоподготовки ТЭЦ в клинкерных керамических материалах. В результате проведённых исследований установлена возможность использования техногенных продуктов химводоподготовки ТЭЦ в производстве клинкерных керамических материалов и определена область рациональных значений содержания неорганических отходов в составе керамической массы и значение температуры спекания.

The rational use of natural resources is currently of particular importance. Technogenic products are waste (sludges) of various types of production, suitable in their qualitative and quantitative composition for further industrial use [1]. One of the directions of their processing is the use of waste as man-made raw materials in the production of construction products. At present, Obolsky Ceramic Plant is expanding its product range by producing ceramic clinker products using man-made products of chemical water treatment of combined heat and power plants (CHP).

Clinker, or clinker brick, is a brick that is fired until the shard is completely sintered without glazing the surface and signs of deformation. Depending on the field of application, there is road clinker, construction, facing, and clinker for hydraulic structures. Of all its varieties, road clinker was the most widely used, which was primarily associated with the idea of this material as a construction material. The history of clinker began in Denmark in Bokhorn borough in 1743 with the appearance of a workshop for firing bricks (stones) for paving roads. In Russia, the first clinker plant was built in 1884 in Topchiivka village near Chernigov. In the framework of the project "Innovative, resource-saving production technology of paving slabs using industrial waste", carried out on the instructions of the state scientific research program "Physical materials science, new materials and technologies", Department of Ecology and Chemical Technologies jointly with Obol Ceramic Plant study the possibility of using man-made products and energy complex (sludges of chemical water treatment at the CHP) as an additive in the manufacture of ceramic paving materials.

A preliminary analysis of the literature sources showed that there is no information about the use of man-made products of chemical water treatment of the CHP as an additive in the manufacture of clinker ceramic materials. The studied precipitation of chemical water treatment of the CHP in its natural form is a wet mass of dark brown color [2]. The oxide composition of man-made products of chemical water treatment of the CHP was determined in the testing center of the state enterprise "Institute of NIISM" [3]. Table 1 shows the oxide composition of sludges of chemical water treatment of thermal power plants.

Table 1 – Oxide composition of sludges of chemical water treatment of the CHP

Component	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	P_2O_5	CaO	MgO	Loss on ignition	SO_3	Na_2O	K_2O
Wt, %	0,24	0,64	1,77	2,85	0,03	н.о.	47,66	2,26	44,15	н.о.	0,20	0,08

In accordance with the requirements of STB 1450-2010 "Technological documentation. Technological specification. General requirements for the development" the formulation and composition of raw materials for the manufacture of prototypes of ceramic clinker paving slabs using precipitation of chemical water treatment of thermal power plants (Table 2).

Table 2 – Composition of the mixture for forming ceramic clinker tiles with additives of sludges of chemical water treatment precipitation of the CHP

Components	Mixing ratio, %		
	№ 1	№ 2	№ 3
Clay raw material at Rudnya-2 deposit	30	25	20
Clay raw material Latnensky deposit	40	40	40
Clay raw material Zapolye deposit	25	30	35
Shamotte	2	3	4
Sludges of chemical water treatment of the CHP	3	2	1

When preparing studies to optimize the ratio between waste and sintering temperature in the composition of ceramic mass for molding ceramic clinker tiles, the following task was set: to determine the most rational values of the content of inorganic waste generated during water treatment at the CHP and the sintering temperature that provide the required physical and mechanical properties of the tile. To conduct experimental studies at Obolsky Ceramic Plant, experimental samples of ceramic clinker paving slabs (ceramic clinker bricks) with additives of man-made products of the energy complex (chemical water treatment sludges) were made in accordance with the developed recipe (Table 2). Mixing of all raw materials and forming of ceramic clinker tiles (ceramic clinker bricks) was carried out using a mechanical stirrer. After mixing the components, a homogeneous plastic mass was obtained with a moisture content of 18 %. In the course of the experiment, samples of ceramic clinker tiles were formed. The final firing of products was carried out in a muffle furnace at temperatures of 1100, 1150, and 1200 ^{o}C. The total duration of the heat treatment and firing processes was 36 hours, including the holding time at a maximum temperature of 4 hours. In the production laboratory of Obolsky Ceramic Plant studies of the physical and mechanical properties of experimental samples of ceramic clinker tiles were carried out [4]. When preparing studies on optimization, the following indicators were used as input parameters: X_1 – sintering temperature, ^{o}C; X_2 – content of man-made products of chemical water treatment, %. The levels and intervals of variation of the input factors are presented in Table 3.

Table 3 – Levels and intervals of variation of input factors

Input factor name	Designation	Variation levels			Variation interval
		–1	0	+1	
Sintering temperature, ^{o}C;	X_1	1100	1150	1200	50
Content of man-made products of chemical water treatment, %.	X_2	1	2	3	1

The following indicators were used as output parameters: ***Y1*** – Compressive strength, MPa; ***Y2*** – Ultimate bending strength, MPa; ***Y3*** – Water absorption, %; ***Y4*** – Frost resistance, cycles. A full-factor experiment was carried out, realizing all possible combinations of varying the input parameters. After analyzing the combined graph of the dependence of optimization criteria on input factors and taking into account the restrictions imposed on them, the range of rational values of the content of inorganic waste in the ceramic mass (2–3 %) and the sintering temperature – 1150 ^{o}C is determined

Studies of physical and mechanical properties of experimental samples of ceramic clinker tiles conducted at Obolsky Ceramic Plant show the possibility of using man-made products of the energy complex (sludges of chemical water treatment of the CHP) as an additive in the manufacture of general-purpose ceramic building materials. The range of rational values of the content of inorganic waste in the composition of the ceramic mass and the value of the sintering temperature is determined.

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