

On the issue of disposal of waste sorption material as an additive in new products' manufacturing

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Abstract. Sorption is currently a promising method for purifying wastewater from organic and inorganic substances. The authors have developed a technology for obtaining a granular composite sorbent (GCS), on the basis of large-tonnage production waste - tobacco dust. However, as a result of sorption purification of highly concentrated wastewater from food industry enterprises, a significant amount of waste sorbent is formed, the regeneration of which is economically inexpedient. This article presents the laboratory studies' results, on the basis of which methods of GCS disposal were developed, exhausted its sorption resource for the new products' manufacturing in construction industry.

1 Introduction

In recent years, the problems associated with the water basin pollution have become aggravated. Discharge of untreated waste water (WW) in surface water bodies leads to a decrease in biodiversity and even the disappearance of life in ecosystems. One of the solutions to the environmental protection problem is the development and implementation of waste-free and low-waste technologies for cleaning industrial WW.

The most promising direction in the creation of effective environmentally friendly technologies for the processing of industrial WW is adsorptive cleaning [1,2]. One of the industries characterized by the formation of highly concentrated WW are the tobacco industry enterprises that are a part of food industry for which the method of sorption additional purification of substandard waters is the most economically justified and effective [3-5].

The authors of the article studied the adsorption processes of pollutants that make up WW enterprises of the tobacco industry in the Russian Federation using granular composite sorbent (GCS), the method of obtaining which was developed by the staff of the department

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"Water supply and sewerage" VolgSTU [6,7]. At the stage of adsorption purification of the designated production highly concentrated effluents, a significant amount of waste sorbent is formed, containing organic pollutants that are part of the WW - COD and BOD_{full}, anionic surfactants (AS) and chlorine ions, in this regard, the question arises related to the GCS waste disposal [8,9]. The article presents the laboratory studies' results, on the basis of which the methods for the disposal of waste sorbent as a secondary raw material in the construction industry were proposed.

After using GCS sorption-filtering material for WW post-treatment enterprises of the tobacco industry in the Russian Federation from pollution, the concentration of which is many times higher than the permissible values even after electrochemical treatment (see Table 1), it is proposed not to regenerate it due to the economic inexpediency of this process due to the need to use a significant amount of water, but to recommend directions by the alternative methods GCS waste disposal as: a porous addition to the clay mass in the ceramic products manufacture [10-12] and one of the components of dry building mixtures for flooring [13-15].

Table 1 The composition of the WW contaminating components enterprises of the tobacco industry in the Russian Federation, the concentration of which exceeds the permissible values

No.	Component name	Concentration	Permissible concentrations, in accordance with the Administration Decree of Volgograd No. 3229 from 24.10.2011.
1	BOD _{full}	178-180 mg·O ₂ /dm ³	34.44
2	COD	204-210 mg·O ₂ /dm ³	51.66
3	AS	0,9-1,2 mg/dm ³	0.42
4	Active chlorine	940-1000 mg/dm ³	72.3

2 A porous addition to the clay mass in the manufacture of ceramic products

The moisture content of the filtration sludge in the form of waste GCS, formed during the post-treatment of WW multicomponent, is about 75%. In order to dispose the spent sorbent and eliminate the ingress of pollutants that make up the effluent of the tobacco factory (TF) into the environment, as well as to prevent the withdrawal of land from agricultural use, occupied by the storage of sediments resulting from wastewater treatment, in this work it is proposed to use waste GCS as a porous addition to the clay mass in the manufacture of unglazed tiles for cladding floors inside buildings.

According to the literary sources [10-15], the approximate composition of the mass that is used in the production of tiles for facing the floor surface inside the building is as follows: kaolin (5-10%), clay (25-70%), feldspar raw materials (13-25%), quartz sand (10-15%), carbonate raw materials (0-10%) and broken products (5-10%). Previous studies to determine the GCS composition also confirm the presence of most of the above-listed component ingredients required for the production of unglazed floor tiles.

Based on GOST 6787-2001 "Ceramic tiles for floors. Technical conditions "tiles intended for flooring are produced by the method of semi-dry pressing, using the wet method for the raw materials' preparation. Therefore, large pieces of clay must first be crushed in roller mills or runners. Then the raw materials (clay, sand, fluxing agents, GCS) crushed together in ball mills in water until a homogeneous suspension (slick) with a

particle size of less than 0.1 mm and a moisture content of 35-50% is obtained. Pressed workpieces are cleaned and dried mainly in vertical roller dryers. The drying temperature varies, depending on the technology used, from 120 to 350 °C. The residual moisture content of the semi-finished product should not exceed 1%. At the final stage, the tiles are fired for 0.5-1 hours at temperatures of 950 - 1200°C, after which they are sorted and packaged.

The proposed scheme for the unglazed tiles' production for cladding floors inside the building using waste GCS is shown in Fig. 1.

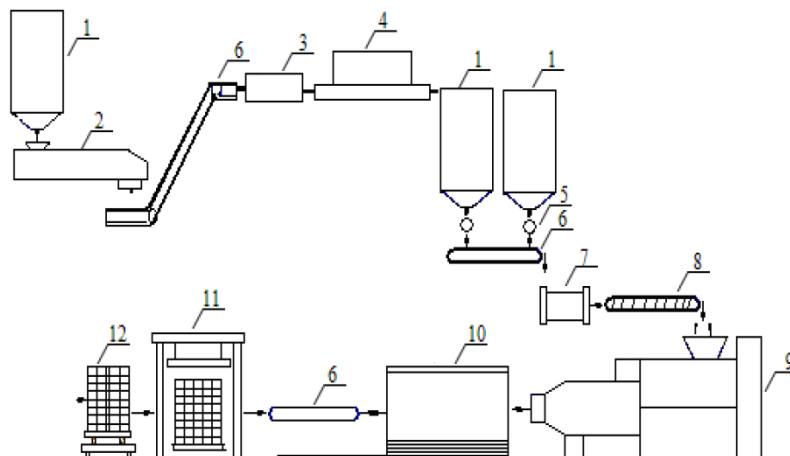


Fig. 1. Scheme of the production of unglazed tiles for cladding floors inside the building using GCS waste: 1 – bunker; 2 – siezing screen; 3 – edge mills; 4 – sieves; 5 – dispensers; 6 - belt conveyor; 7 - mixer; 8 - screw conveyor; 9 - press; 10 - vertical roller dryer; 11 - kiln; 12 - ready-made prudence.

In laboratory conditions, firing of the molded samples - tiles of size 15×15 cm and a thickness of 4 mm after drying in a drying oven at a temperature 120...130 °C was carried out in a muffle furnace at a temperature 1020-1080 °C within 60 minutes.

Since the composition of the used GCS CaCO₃ and adsorbed multicomponent contaminants are included, then during the clay mass sintering, the reaction with the gaseous substances release is possible, which will promote pore formation in the body of the ceramic mass, which can lead to a decrease in the strength of the finished ceramic products and improve their heat and sound insulation properties. The results of determining the physical and mechanical parameters of the prototype using the GCS waste, obtained in laboratory conditions are presented in Table. 2.

Table 2. Physical and mechanical properties for unglazed tiles used for facing floors inside a building

No.	Indicator name	Values for unglazed tiles	
		according to GOST 6787- 2001	when adding GCS waste
1	Water absorption, %, no more	3.5	2.5
2	Flexural strength, mPa, not less, for the tiles with a thickness of up to 9.0 mm inclusive	28.0	32

3	Wear resistance (on quartz sand), g/cm ² , no more	0.18	0.15
4	Frost resistance, number of cycles, not less	25	50

The test results presented in Table 2, indicate that when using GCS waste as an additive in the production of unglazed tiles, the established strength standards in accordance with GOST 6787-2001 are not reduced, which means that the resulting ceramic products can be used for finishing floor coverings inside buildings.

3 Dry building mixtures for flooring

Spent GCS, after post-treatment of waste liquid, is also proposed to be used as a water-reducing additive for the manufacture of dry building mixtures, which can be used as a leveling sub-base for flooring.

The water-reducing effect affects the solution workability, which in turn allows to reduce the water-cement ratio, as a result of which the mechanical strength increases without changing the consistency, as well as the tendency of stratification and water separation of the finished leveling mortar mixture decreases.

Technology for obtaining additives from GCS waste dry mix used in the construction of floors consists in drying the waste GCS in vivo, grinding it to a powdery state (particle size less than 0.1 mm), heat treatment at a temperature 300 – 400 °C for 30 minutes to remove bound moisture. In the future, the resulting additive is mixed with the main components of the dry building mixture in the proportions given in table. 3.

Table 3 The composition of dry building mixtures

no.	Functionality	Brand	Composition by weight with a cement grade of at least 400		
			Cement	Sand	GCS waste-based additive
1	For floor screeds	150	1	3	0.3
		200	1	2.8	0.35
2	For leveling the coating	300	1	2.4	0.4

Thus, based on the results obtained, presented in Table 3, it can be argued that a dry mixture mixed with water with an additive from GCS waste with a constant water-cement ratio, transforms into a super-plastic solution, without reducing the final mechanical strength and gives a possibility to obtain a structure with an improved surface quality, devoid of pores and cells.

Laboratory tests carried out in accordance with 8.2 GOST 30459 - 2008 "Additives for concrete and mortar", as well as a comparative analysis of technical specifications TS 5745-001-00000-2016 "Dry building mixes for flooring", with the results obtained in the study of the samples made with the GCS waste addition for compliance with technical requirements. The results are presented in Table 4.

Table 4. Test results for leveling mortars

No.	The name of indicators	The value of indicators for brands of dry mixtures floor leveling according to TS	Mix for the floor construction with an additive based on GCS waste
1	2	3	4
1	Dry mix moisture, no more, %	0.5	0.5
2	Granulometric composition, sieve residue No. 1.25, no more, %; No. 0.63, no more, %	5 10	0 5
3	Mobility, immersion cone depth, cm	4-5	4-5
4	Water-holding capacity of the mixture, not less, %	95	98.3
5	Solution spreading diameter, cm - not less - no more	9 12	12 15
6	Solution viability, min, not less - 20	20	30
7	Setting time start, not earlier, min end, not later, min	40 180	40 180
8 9	Ultimate strength, at the age of 28 days, not less, MPa: - under compression	20	18
10	Adhesion strength to the base at the age of 28 days, not less, MPa	0.3	0.5
11	Frost resistance, not less than cycles	35	35
12	Shrinkage, no more, mm / m	1.0	1.5

The results of the research showed that the proposed dry building mixtures with the addition of GCS waste meet the requirements TS 5745-001-00000-2016 "Dry building mixes for flooring" and can be used for flooring as a water-reducing additive.

4 Conclusion

Thus, the presented results confirm the possibility of using the GCS waste as a secondary raw material in the manufacture of products in construction industry:

- 1) it is possible to use GCS waste as an additive in the production of unglazed tiles for interior flooring;
- 2) spent GCS can be used as a water-reducing additive for the production of dry mortars, which can be used as a leveling base for flooring

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