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Analysis of methods for processing and using by-products of the technological process of asphalt concrete component manufacturing

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Introduction. Currently, the problem of disposal and recycling of industrial waste is extremely relevant. The article analyzes the economically feasible and environmentally friendly ways of the processing or using waste generated during the production of the asphalt concrete component — enriched mineral filler.

Problem Statement. The aim of the study was to find the most economically feasible and environmentally friendly ways to process or use waste generated during the production of enriched mineral filler at one of the enterprises of the Rostov region.

Theoretical Part. The paper considers the composition of the enriched mineral filler as the main product of production and a source of by-products, the technological process of its manufacture, as well as the composition of the resulting by-products to be disposed. Based on the results of these studies, the assessment of probable ways of waste disposal was performed and the optimal method of recycling was selected.

Conclusion. The choice of the most appropriate method of waste disposal from the production of mineral filler allows you to reduce the total amount of waste at the enterprise and significantly reduce the negative impact of the enterprise on the environment. To implement the proposed technology of mineral waste disposal, the relevant technical conditions and regulations are being developed.

Keywords: industrial waste, recycling, mineral filler, environmental safety.

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Introduction. The problem of recycling municipal and industrial waste is urgent and acute now as never before. Many industrial enterprises are gradually switching to closed production cycles, actively developing low-waste and non-waste technologies in order to reduce the burden on the environment and improve the situation in the field of waste management [1-5]. In the village of Zhirnov, Rostov region, there is a production enterprise Karbonat AO, which actively implements environmentally safe production cycles in its economic activities, while focusing on modern alternative methods of recycling the resulting waste [6].

Problem Statement. The enterprise Karbonat AO has a technological line for the production of mineral filler, which is then subjected to enrichment, and then used in the manufacture of asphalt concrete and other road surfaces. The implementation of this production process is accompanied by the release, primarily into the atmospheric air, of a number of by-products officially classified as industrial waste, which are subject to mandatory disposal [7-9]. The purpose of this work was to find the most economically feasible and environmentally friendly ways to process or use the waste generated during the production of the enriched mineral filler at Karbonat AO.

Theoretical Part. The solution to these tasks is in the study of the mineral-enriched filler as the main product of production and the source of the by-products formation, the technological process of its manufacture, and composition of the formed by-products (waste), recyclable. The results of these studies are the basis for evaluating the likely ways of waste disposal and selecting the most appropriate one.

The raw material for the production of the enriched mineral filler at Karbonat AO is a crushed natural material-limestone of the 0-5 mm fraction extracted from an open pit. Limestone is a sedimentary rock consisting mainly of calcite $CaCO_3$, which includes CaO (56%) and CO_2 (44%) [7, 8].

Limestone has the following physical and mechanical properties [7]:

— average density — 2.6–2.75 t/m^3;

— water absorption — 0.0–2.07 %;

— porosity — 0.37–4.76 %;

— the limit of compressive strength in dry state — 57.6–145 kPa;

— compressive strength in the water-saturated state — 51.4–139.8 kPa;

— degree of fragmentation — 1.733.

In the process of mineral filler enrichment, petroleum bitumen is added to it — a combustible solid substance that is obtained by oxidation of tar (a residual product of oil refining) with atmospheric air. In addition, during enrichment, an adhesive additive (in other words, a surface active compound) is added to the mineral filler, which is a dark brown homogeneous mobile mass, non-volatile, non-explosive and non-toxic [10]. The addition of surface active compounds or materials including them to the filler is made in order to improve the performance properties of the mineral filler and, as a result, extend the service life of the road surface, the component of which the filler becomes in the future [11].

In general, the technology for the enriched mineral filler production consists of drying the original natural raw materials (limestone), crushing it, screening out the desired fraction, subsequent application of petroleum bitumen, surfactants and thorough mixing of the resulting mixture.

It is at the stage of crushing natural limestone on the crushing and sorting equipment that limestone dust is formed, which enters the air environment and is captured by the dust and gas cleaning unit located in the crushing department and accumulates in its receiving hopper. In accordance with the Federal Classification Catalog of Waste (FCCW) [12], the captured dust is classified as "Waste of limestone, dolomite and chalk in the form of powder and dust of low hazard". This waste is accumulated on the territory of Karbonat AO in special containers and is subject to further export to the disposal sites.

It should be noted that a similar situation occurs when grinding sandstone is used as a raw material for the production of crushed stone at the enterprise in question. When implementing this technology, waste is collected in the receiving hopper of the dust and gas cleaning plant, which is classified in accordance with the FCCW as "Crushed stone gas cleaning dust" [12]. After removal from the hopper, this dust also accumulates on the territory of the enterprise with subsequent removal for disposal [1, 7].

Conclusion. The disposal of the above-mentioned types of by-products (waste) of the production of asphalt concrete components can be carried out in several ways.

The simplest and most often used way in such a situation is the removal of waste with its subsequent disposal at a specialized landfill. This way is currently used by Karbonat AO, while paying for the disposal of waste. The following methods of disposal of these wastes can be an alternative to disposal [7, 13]:

— separation of useful fractions during waste sorting and their further processing;

— secondary consumption (at the same enterprise in other production cycles);

— re-use in the same production.

The proposed disposal options will reduce the total amount of waste generated at the enterprise and received at landfills, and, of course, will give a tangible economic effect to the enterprise [14]. Thus, the secondary consumption and / or reuse of limestone and crushed stone dust will allow Karbonat AO not to pay for the disposal of waste at the

landfill, which is currently about 18,800 rubles per year: the volume of formation of these wastes is about 27 tons and 20 tons per year, respectively, the fee for the disposal of 1 ton of waste at the landfill is 400 rubles.

Thus, in order to reduce the volume of waste from the production of enriched mineral filler and reduce the harmful impact on the environment, the company can recommend the waste classified as "Low-hazard limestone, dolomite and chalk waste in the form of powder and dust" and "Crushed stone gas cleaning dust" to be used as secondary raw materials, adding them as additives to the main commercial product — the enriched mineral filler. The origin, chemical composition and other qualitative characteristics of these wastes indicate that their addition will not affect the properties of the resulting mineral filler and will not worsen its quality. In addition, the recommended reuse of limestone and crushed stone dust in the same production as secondary raw materials (47 tons per year) will give Karbonat AO an additional economic benefit of about 30,550 rubles per year, since the initial raw materials for the production of mineral filler (natural limestone) are purchased by the company at an average price of 650 rubles per 1 ton. It follows that the total economic effect of the implementation of the proposed solutions at 2020 values will be approximately 49,350 rubles per year (18 800 + 30 550).

To use these types of waste in the production of the enriched mineral filler, it is necessary to develop technical specifications (TS) and technical regulations (TR) for mineral filler, which will include the above-mentioned waste. The first step in this direction is the study of various technical specifications and technical regulations, on the basis of which it will be possible to develop similar documents for mineral filler with the proposed modernized composition in the future [10].

Thus, in the course of the work, the analysis was carried out of cost-effective and least dangerous to the environment methods for recycling by-products of the manufacture of the asphalt concrete component — the enriched mineral filler. The choice of the most appropriate method of waste disposal will reduce the total amount of waste at the enterprise, as well as significantly reduce the negative impact of the enterprise on the environment. To create the technology for the disposal of the considered mineral waste, it is necessary to develop appropriate technical specifications and regulations.

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V. V. Ozeryanskaya — formulation of the main concept, goals and objectives of the study, analysis of the research results, formulation of conclusions; A. A. Repinskaya — definition of research objects, preparation of the theoretical part; R. R. Lazurenko — analysis of literary sources, revision and correction of the text; M. Yu. Seregin — consultations on technology and regulatory documents.