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DEVELOPMENT OF PRODUCTION TECHNOLOGY FOR FIBROUS, HEAT-INSULATING, FILTERING MATERIALS AND TECHNICAL PRODUCTS



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Abstract. *This article presents the results of research on the influence of external factors on the quality of processed materials from the "Qizilqum" basalt deposits. During the experiments, mechanical cleaning and assessment of the chemical properties of basalt rock samples obtained from three different deposits were carried out. The obtained results demonstrated the possibility of extending the service life and increasing the corrosion resistance of equipment by washing basalt rocks. The article offers suggestions for the use of basalts as thermal insulation materials and ensuring their environmental safety.*

Keywords: *basalt, thermodynamics, heating, pyroxene, crystal fiber, filtering material, fiber, melting, dry processing.*

РАЗРАБОТКА ТЕХНОЛОГИИ ПРОИЗВОДСТВА ВОЛОКНИСТЫХ, ТЕПЛОИЗОЛЯЦИОННЫХ, ФИЛЬТРУЮЩИХ МАТЕРИАЛОВ И ТЕХНИЧЕСКИХ ИЗДЕЛИЙ

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Аннотация. *В данной статье представлены результаты исследований влияния внешних факторов на качество перерабатываемых материалов на базальтовых месторождениях «Кызылкум». В ходе экспериментов проводилась механическая очистка и оценка химических свойств образцов базальтовых пород, полученных из трех различных месторождений. Полученные результаты показали возможность продления срока службы и повышения коррозионной стойкости оборудования путем промывки базальтовых пород. В статье представлены предложения по использованию базальтов в качестве теплоизоляционных материалов и обеспечению их экологической безопасности.*

Ключевые слова: *базальт, термодинамика, нагрев, пироксен, кристаллическое волокно, фильтрующий материал, волокно, разжижение, сухая обработка.*

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TOLALI, ISSIQLIK O‘TKAZMAYDIGAN, FILTRLOVCHI MATERIALLAR VA TEXNIK MAHSULOTLAR ISHLAB CHIQARISH TEXNOLOGIYASINI ISHLAB CHIQISH

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Annotatsiya. *Ushbu maqolada “Qizilqum” bazalt konlarida qayta ishlangan materiallarning sifatiga tashqi omillar ta’sirini tadqiq etish natijalari keltirilgan. Eksperimentlar davomida uchta turli konlardan olingan bazalt jinslari namunalarini mexanik tozalash va kimyoviy xususiyatlarini baholash amalga oshirildi. Olingan natijalar, bazalt jinslarini yuvish orqali uskunalarning xizmat muddatini uzaytirish va korroziyaga chidamliligini oshirish imkoniyatlarini ko‘rsatdi. Maqolada bazaltlarning termal izolatsiya materiallari sifatida qo‘llanishi va ekologik xavfsizligini ta’minlashga doir takliflar berilgan.*

Kalit so‘zlar: *bazalt, termodinamika, qizdirish, piroksen, kristall tola, filtrlovchi material, tola, suyuqlantirish, quruq ishlov berish.*

Introduction. It is known that basalt rock, due to its specific nature, forms a complex structure. The structure of basalt consists of numerous chemical elements that can form pyroxene, olivine, and plagioclase silicates during its processing. These silicates form the basis of the rock's mineralogical and chemical composition. This indicates that the basalt structure can significantly influence the processing method. Consequently, changes in the ratio of basalt's constituent chemical elements can dictate its further use and guide the development of a specific technology for processing this rock. Given the composition of basalts (from the deposits under consideration in the Kyzylkum), we deemed it expedient to develop a technology for processing the rock and design appropriate equipment for this purpose.

The results of theoretical research on specific aspects related to basalt, its processing, and the theoretical analysis of the behavior of products obtained from basalt rock serve as confirmation of this. The results of theoretical research on specific aspects related to basalt, its processing, and the theoretical analysis of the behavior of products obtained from basalt rock serve as confirmation of this.1

Basalt is a magmatic rock. Magmatic, or igneous, rocks are the products of solidified magma - the molten substance of the Earth. Depending on the composition of the original magma, its cooling conditions, and various factors related to its movement and interaction with surrounding rocks, magmatic rocks of diverse compositions and structures are formed.

Intrusive (deep) and extrusive (effusive) igneous rocks are distinguished. Intrusive rocks are formed in the Earth's interior. Here, the process of magma cooling and rock crystallization proceeds slowly, under high pressure and more favorable conditions, ensuring a fully crystalline structure. The intrusive rocks formed in this way will be completely crystallized. Extrusive rocks, which form closer to and on the Earth's surface, do not have time to fully crystallize before solidification, and therefore have an incompletely crystalline and glassy structure.

The degree of acidity plays an important role for igneous rocks. In deep ultrabasic rocks (olivinites and peridotites), the main mineral is olivine. The deep formation of these rocks is evidenced by the fact that their xenoliths are carried from deep (including mantle) centers of origin during volcanic eruptions and the formation of kimberlite explosion pipes. Two polymorphs of the same composition are known - olivine $(Mg, Fe)_2(SiO_4)$ and "spinel" $(Mg, Fe)_2 SiO_4$; possibly, the second modification exists even deeper in the mantle as a denser form. In basic, intermediate, and acidic rocks, isolated silicates play the role of accessory minerals - these include some garnets,

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zircon, and titanite. In granite pegmatites, perfect crystals of topaz are formed. In alkaline rocks, specifically in varieties containing nepheline, isolated silicates are characteristic minerals. These include zircon, titanite, rinkolite, and lamprophyllite.

The production of cast products based on basalts for various purposes utilizes igneous rocks: diabases, basalts, and their varieties such as pyroxenes, olivines, plagioclases, etc. Basalt-like igneous rocks have their own characteristics.

For instance, plagioclases enhance the crystallization ability of the melt but simultaneously raise its melting point. Olivine and pyroxene minerals improve the casting properties of the material, yet they also increase the brittleness of the final products and elevate the melting temperature. To reduce the melting temperature, fluxing agents such as 3% fluorspar are added to the mixture. To promote crystallization during the cooling of the melt, refractory materials like magnesite, chromite, and chromite ore are introduced — these act as crystallization nuclei (seeds). Zinc oxide, at a concentration of about 0.8%, is used to bleach the melt. Before being loaded into the furnace, the raw materials are crushed, sieved, and proportioned according to the required composition.

Smelting is carried out in shaft, bath, rotary, or electric furnaces, with bath furnaces being the most widely used. The melting temperature typically ranges from 1400 to 1500°C. During continuous casting, the molten material flows into storage tanks, where a reserve of homogeneous melt is maintained at 1180–1250°C. Cooling the melt before pouring into molds is essential for proper structural formation and to minimize shrinkage defects such as cracks or cavities. The melt is then poured into clay, metal, or silicate molds preheated to 600–700°C and allowed to cool gradually. Afterward, the products are annealed (slow-cooled), generally in tunnel or chamber furnaces at 800–900°C or in specialized annealing furnaces. This slow cooling increases ductility, relieves internal thermal stresses from cooling and crystallization, and improves resistance to mechanical impact.

A gradual decrease in temperature promotes the separation of the crystalline phase from the melt. Mineralizers added to the batch accelerate crystallization, while careful temperature control regulates the degree of crystallinity in the stone-cast material. The crystallization process can be further influenced by applying electric or magnetic fields, introducing vibration, or exposing the melt to X-rays or radioactive radiation.

When basalt melts are cooled to around 1250°C, small octahedral magnetite crystals start to form, clarifying nearby regions of the glassy matrix and encouraging further spontaneous crystallization. At 1200°C, isolated feldspar crystals of the plagioclase type appear. Around 1150°C, the number of plagioclase crystallization centers increases sharply, forming a fine network of tiny intergrown crystals. As the temperature drops further to about 1100°C, pyroxene crystals begin to form alongside continued separation of magnesite and plagioclase. The main minerals in cast stone include pyroxenes, plagioclases, olivine, magnetite, and others. The resulting cast stone products — such as pipes and tiles — possess a uniform fine-crystalline texture.

Their compressive strength ranges between 250 and 400 MPa. These materials exhibit high hardness, frost resistance, and acid resistance, which result from their high density (2900–3000 kg/m³) and very low porosity (1.0–1.5%) with closed pores. The wear rate of products made from stone diabase, granite, or cast stone is approximately 0.7 g/cm², which is 2–5 times lower than that of basalt.

Stone-cast materials are widely applied for lining bunkers, chutes, and flotation machine housings, among other uses. Stone-cast tiles effectively replace metal flooring in workshops exposed to aggressive environments and are also used in industrial floors and road construction. In chemical plants, stone casting is utilized as lining for etching baths and sedimentation tanks.

Production based on stone casting can follow two approaches. In the first, a refractory filler is combined with the molten material, molded, and - if necessary-pressed before being cooled to ambient temperature. In the second approach, the filler is mixed with cold, finely dispersed raw materials in a liquid medium. The molded pieces then undergo heat treatment, during which part of the material melts and, upon cooling, forms a glass-crystalline structure with cementing properties. This process stabilizes both the micro- and macrostructure of the stone-casting-based composite.

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The use of basalt casting at chemical and coke-chemical enterprises allows for lining the housings and traps of reaction tower equipment, coke ramps, settling tanks for generated acid, coils, distillation boilers, etching baths, acid pipelines, filters, liquid and oil collectors, tanks, mixers, cisterns, sinks, buckets, and exhaust systems for vapors, etc.

As mentioned above, basalt casting does not react chemically with aggressive environments, water of any quality, and consequently, possesses anti-corrosion properties. As a result, the petrurgical process laid the foundation for the development of petrurgical production worldwide. In all existing petrurgical industries, furnaces of similar design are employed, and natural gas serves as the primary fuel. This preference can be attributed to the fact that all high-calorific fuels — including fuel oil, coke, and natural gas — produce combustion products with nearly the same enthalpy when burned with a theoretical air supply, approximately 3500–3750 kJ/m³. Thus, under neutral combustion conditions, these fuels are considered to be energetically equivalent.

Basalt casting is also widely used in the mining sector of the national economy. Basalt is used to line drainage channels, troughs, funnels, chutes, classifiers, and other equipment. The use of basalt extends the service life of the aforementioned objects to up to 20 years, compared to 6-10 months when using metal materials. Manufactured basalt pipes can function underwater for up to 100 years without repairs. In cases where repair or restoration work is needed, the welding process does not require electrodes, as the basalt crack itself is sealed by melting the crack.

Primarily in the metallurgical and coal industries, basalt materials are used for lining coke funnels and bunkers. The application of basalt materials in the metallurgical industry reduces equipment wear by an average of 22.5%. In the coal industry, basalt casting is used to line separators, jigging machines, bunkers, pipelines, and other equipment. Basalt materials are effectively used for lining concentrate bunkers of scraper conveyors, screen rollers, and thickening funnels.

Currently, the technology for producing basalt fiber is of great practical and scientific interest. Basalt superfine fibers are in especially high demand in the national economy. The production technology for consists of the following processes:

1. Loading crushed basalt rock into the furnace;
2. Melting the basalt and homogenizing the melt in the furnace;
3. Extracting the basalt melt from the furnace feeder through a spinneret in the form of primary fibers;
4. Blowing the primary fibers into staple superfine fibers using a blowing torch;
5. Forming the mat on the receiving conveyor.

Results. Analysis showed that the technological process of production includes two relatively energy-intensive processes: basalt melting and blowing of primary fibers with a high-temperature flow. The latest developments by the company's specialists have made it possible to improve the production process and develop a new generation of low energy consumption installations.

Figure 1. shows the technological scheme for producing basalt fiber. Unlike the process of obtaining products in cast form through petrurgical production, in this case, after the melt is formed, the liquid basalt is directed to a spinneret, where the melt is transformed into a stream of fibers.

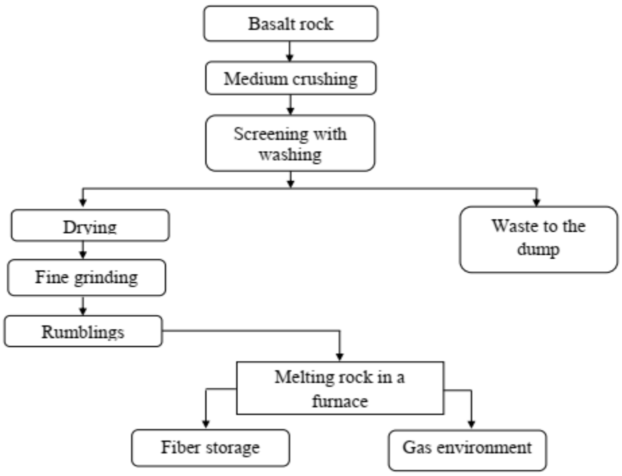

Fig.1. Technological scheme for the production of basalt fibers and fibrous thermal insulation materials.

Furthermore, a blowing apparatus has been added to the technological process, operating with the same hot air supplied under a pressure of 1-2 atm to support the flow of fuel gas entering the furnace. The process proceeds as follows. According to the proposed technology, the most effective method for carrying out the work is the process of obtaining basalt fiber according to the following plan:

- medium crushing is performed;
- screening of basalts with washing and removal of sludge;
- drying the product and obtaining granules with sizes ranging from 5 to 6 mm;
- preparing the furnace for operation, heating it to 800°C;
- feeding the basalt product into the furnace;
- preparing the melt to a temperature of 1400-1450°C;
- formation of continuous primary fibers using a spinneret feeder;
- blowing of primary fibers into secondary fibers;
- formation of the fibrous mat on the receiving drum.

The production of basalt thermal insulation material using this equipment involves 4 people: one operator, an equipment technician, an electrician, and a mechanical fitter. Basalt that has undergone initial processing enters a stone-melting furnace, where it is held until it reaches a fully liquid state. Afterward, the molten basalt from the furnace is transferred to a preheated bushing designed for preparing and drawing out the melt. Then, the melt from the bushing enters the bushing feeder to form the primary stream.

Heat-resistant spinnerets are designed for producing coarse, fine, and ultra-fine glass staple fibers from rocks according to TU 88023022-96 at temperatures up to 1350-1550°C [1.3.]. The spinneret plate is made of a heat-resistant alloy. Heat-resistant plates are manufactured in sizes of 290x90x12 mm and 420x80x12 mm.

Note that the streams from the combustion chamber are fed to the blowing head (in the blowing chamber), where a high-speed stream of compressed air pulls them into the fibers using the gravity of the fiber itself (of a certain diameter).

The produced fiber is deposited onto a conveyor and transported towards the receiving drum, where it is wound into rolls using an established technique. To eliminate excess impurities after the burning process, a chimney is built into the melting chamber, through which they are released into the open air.

In aggregate, the obtained basalt fibers form glass wool containing a small amount of "kings" (these are parts of the softened melt that do not have time to transform into fibers, have a dark brown hue, and a long-fibrous structure). This method of organizing the processing of basalt rock and production of heat-insulating basalt material improves working conditions, but leads to a reduction in the number of jobs due to the automation of the process.

Observations of the operation of the modernized stone melting furnace, as well as analysis of the basalt rock melting process and the stream of liquid mass extruded from the spinneret, allowed for measurements of energy resource consumption and melting time. These measurements were then used to conduct a comparative analysis with the results obtained from theoretical computer calculations.

Conclusion. The results demonstrated that by achieving the required temperature within 7÷8 hours through the modernization of existing furnaces (as opposed to 10÷12 hours in basalt processing plants), it is possible to reduce production costs by 30%, thereby increasing labor productivity and lowering the cost of thermal insulation materials. The developed computer program is protected by a certificate from the Intellectual Property Agency of the Republic of Uzbekistan.

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