ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 7, Issue 4 , April 2020

Development and Research of Properties of Nonwoven Materials Based on Basalt Fiber

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ABSTRACT: This article presents the development and study of the properties of non-woven materials based on basalt fiber, as well as the purpose of basalt fibers: continuous fibers - the production of reinforcing and composite materials and products, fabrics and non-woven materials; staple short fibers - production of heat-insulating materials for mats and plates; superthin fibers - production of heat and sound insulation materials of high quality.

KEYWORDS*:* basalt fiber, basalt continuous fibers, staple short fibers, composite materials, non-woven materials, basalt homogenization, fiber drawing.

I. INTRODUCTION

Basalt fiber - produced from basalt rocks by melting and converting the melt into fibers.

Basalts are rocks of igneous origin, natural raw materials. The main energy costs for the preparation of basalt raw materials for fiber production - enrichment and initial melting of basalt raw materials are made in natural conditions.

Basalt continuous fibers, staple short fibers and superthin fibers are produced and applied. Purpose of basalt fibers: continuous fibers - production of reinforcing and composite materials and products, fabrics and non-woven materials; staple short fibers - production of heat-insulating materials for mats and plates; superthin fibers - production of heat and sound insulating materials of high quality, materials for filters.

The production of basalt fibers is based on the choice of basalt rocks suitable for the production of fibers, melting of basalt raw materials and the production of fibers from the melt through spinneret feeders, or fiber-forming devices [1].

The use of basalt raw materials, the initial melting and preparation of which was performed in natural conditions, allows the production of basalt fibers with low energy consumption.

The production of continuous basalt fiber is carried out on modular and feeder furnaces and plants [2]. Patents The extraction of basalt continuous fibers from the melt is carried out through platinum rhodium spinneret feeders by winding spindle machines. Further processing of basalt continuous fibers into reinforcing, composite materials, fabrics and non-woven materials is carried out using "cold technology" with low energy consumption.

Currently, industrial technologies and equipment for the production of basalt continuous fibers have been developed, factories of basalt continuous fibers and production of materials of basalt continuous fibers have been created [3].

The production of superthin fiber is carried out according to a two-stage technology - the melting of basalts, the extraction of primary fibers from the melt and the blowing of primary fibers into superthin with a high-temperature jet of hot gases from the blowing chamber.

The production of staple thin fibers is carried out by melting basaltic rocks in melting furnaces of a bathtub or cupola type, supplying melt to fiber-forming devices — rolls, or blowing heads.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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II. SIGNIFICANCE OF THE SYSTEM

The production technology of continuous basalt fibers is a one-stage process: melting, basalt homogenization and fiber drawing. Basalt is heated only once, which allows to obtain the desired product - continuous basalt fibers. Further processing of basalt continuous fibers into materials is carried out using "cold technology" with low energy consumption.

Basalt fibers used in modern industry are divided into two categories:

- continuous
- discrete

Continuous fibers are a very long length, which can reach 30 km or more. They have excellent characteristics, which allows you to use them with almost no restrictions. The manufacturing technology of such products consists not only of one stage: basalt radiation, after processing and without any intermediate solutions, immediately turns into fiber.

Unlike the previous type, the fiber length varies from several mm to several cm. They have excellent performance in a wide temperature range, have excellent vibration resistance, are resistant to deformation, chemically inert and fire resistant. An insignificant advantage is that their service life is 100 years, and the material does not contain harmful substances, compounds, and also helps to alleviate the effects of radiation.

The production process of basalt fibers consists of the following main stages:

Preliminary, rough, processing of crushed stone from basalt rocks, which includes its crushing, washing and drying;

The melting process of the obtained basalt chips in special smelting furnaces;

The formation of fiber, depending on its type;

Weaving fibers to obtain fabric, or the manufacture of products of a different shape, based on the scope of its further use.

III. LITERATURE SURVEY

These, as well as other points, require special swimming stoves that allow you to maintain the temperature of the substance in a certain, identical, level, throughout the entire production process. In this case, vertical swimming technologies are used, using, at the final stage, other methods and technologies, in many respects similar to those obtained in the manufacture of textile fabrics and threads.

Basalt fibers are made from basaltic rocks of magmatic origin. This determines the high chemical resistance of the fibers to alkalis, acids and chemically active environments; the possibility of long-term operation of the fibers under the influence of the environment, moisture and sea water; incombustibility and high thermal resistance of fibers[4].

During the drawing process, continuous fibers from basalt melts acquire rather high strength characteristics. The tensile strength of basalt continuous fibers is from 2800 to 4800 MPa[5].

Basalt staple short and especially thin fibers have good thermal and sound insulation characteristics. The temperature range of long-term use of basalt fibers is from - 200 to + 6000 ° C. Basalt fibers from acidic basalt rocks have higher application temperatures up to + 750, ... + 8000C.

The combination of the properties and characteristics of basalt fibers provides the possibility of producing a wide range of materials and their wide application in the construction industry, road construction, industry and energy[6].

IV. METHODOLOGY

Basalt fibers are highly resistant to chemically active environments (acids, alkalis, salt solutions), high temperatures and open flame. The resistance of basalt fibers to water and sea water is 100%, to alkali 96% and acid 94% [7]. The chemical resistance of basalt fibers allows them to be used for reinforcing concrete and asphalt concrete, the production of pipes, tanks for the chemical and petrochemical industry, composites for hydraulic engineering, coastal and marine construction.

Basalt fibers are non-combustible and fire-resistant, withstand fire and temperatures +900, ... + 10000C in case of fire. Heat-insulating and fire-resistant materials based on staple and superthin fibers withstand a standard fire, do not emit smoke when heated and exposed to a flame. The hygroscopicity of basalt fibers is 6 times lower than that of glass fibers. Only heat and sound insulating materials based on superthin basalt fibers are used in the aviation and shipbuilding industries, since they do not accumulate excess moisture [8].

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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Table 1

	Basalt continuous fibers	E-glass	E-glass	Carbon fiber
Tensile strength, MPa	3000~4840	3100~3800	4020~4650	3500~6000
Modulus of elasticity, g Pa	79.3~93.0	72.5~75.5	83~86	250~450
Elongation at break,%	1.5 - 2.1	4.7	5.3	1.5~2.0
The diameter of the primary fibers, microns	6 - 21	6 - 21	6 - 21	5 -15
(weight in grams of roving)	60 - 4200	40 - 4200	40 - 4200	60 – 2400
Application temperature, ° C	-260 +600	-50 +350	-50 +300	-50 +400
Cost of prom. production USD / kg	0.9 – 1.2	1.1 – 1.5	2.5 – 3.0	15 – 25
Cost of sales, USD / kg	2.6 - 3,0	1,5 – 2.0	3,5	25 – 50

The cost of industrial production of basalt continuous fibers is determined by the low cost of basalt raw materials and the use of energy-saving technological equipment of the third and fourth generations[9].

The strength characteristics of basalt continuous fibers exceed the characteristics of E-fiberglass, are close to special and carbon fibers, while having a low production cost. According to its strength characteristics, basalt continuous fibers occupy an intermediate position between fiberglass and carbon fibers. Given the full range of characteristics, basalt continuous fibers have several advantages compared to glass, carbon and chemical fibers, as well as the best ratio of characteristics [10].

Basalt fibers created from rocks of magmatic origin, unlike artificial glass, carbon, mineral fibers, are the only fibers that are made from natural raw materials of magmatic origin.

V. EXPERIMENTAL RESULTS

Continuous basalt fibers are the only fibers, in contrast to artificial glass, carbon, chemical fibers, which are produced exclusively from natural raw materials - basic basalt rocks.

The theoretical basis for the production of basalt continuous fibers, accumulated experience, laboratory equipment, experimental industrial equipment, basalt continuous fibers and methods for researching basalt rock deposits, allow us to assess the degree of their suitability for industrial production of basalt continuous fibers and determine the technological parameters of melting and characteristics of melts, to obtain primary continuous fibers and evaluate their characteristics.

Characteristics of basalt continuous fibers are of great interest from the market for reinforcing and composite materials.

Main advantages:

- Basalt fibers have a high natural resistance to environmental and aggressive environments, flame and high temperatures, resistance to vibration. Fibers are resistant to mold and other microorganisms. This determines the durability of the application of basalt fibers and based materials in the construction industry, in the automotive and aviation industries, shipbuilding and energy.
- Good electrical and thermal insulation characteristics, long service life and. This property allows the use of basalt fibers for the production of heat-resistant materials, as well as fire retardant and fire-resistant material.
- Increased chemical resistance in acid and alkaline environments, in sea water compared to E-glass. This property of basalt fibers opens up wide prospects for their application for structures operating under the influence of moisture, salt solutions, chemical and alkaline media. Allows consumers to replace metal structures and parts that are subject to corrosion by light, strong and corrosion-resistant materials made of basalt fiber under the influence of chemically active environments.
- The chemical resistance of basalt fiber is one of the defining competitive advantages for the production of filters in the chemical and metallurgical industries, and for the production of containers and pipes for the chemical industry and public utilities.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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- Ecological purity of the material. Full compliance with the REACH program. The finished product does not contain harmful substances and fully complies with the REACH protocol and all hygiene standards.
- High durability. The service life of the materials is 50 years. The use of such materials allows to achieve savings due to durability and enhances the safety of operation of industrial facilities.
- Low price compared to the cost of special fiberglass.

Materials based on basalt fiber have the following important properties: porosity, temperature resistance, vapor permeability, and chemical resistance.

• The porosity of basalt fiber can be 70% by volume or more. If the pores of the material are filled with air, then with such porosity it is characterized by low thermal conductivity.

• Temperature resistance is a very important property of heat-insulating materials, especially when used for insulation of industrial equipment operating at high temperatures. The temperature resistance of materials is characterized by the technical temperature of application at which the material can be operated without changing the technical properties.

• Vapor permeability is the ability of a material to pass water vapor through its pores. If there are interconnected pores in the materials from basalt fiber, they pass the same amount of steam as air. Due to the high vapor permeability, these materials are almost always dry during operation; steam condensation occurs mainly in the next layer, on the colder side of the fencing.

• Chemical resistance. Basalt fibers have good resistance to the action of organic substances (oil, solvents, etc.), as well as to the effects of alkalis and acids.

Due to these properties, basalt fiber and materials based on it are finding wider application today for such purposes as:

- heat and sound insulation and fire protection in residential and industrial buildings and structures, baths, saunas, change houses, etc.;
- thermal insulation of power units, large diameter pipelines;
- thermal insulation of household gas and electric stoves, ovens, etc.
- insulation of reconstructed buildings with installation both inside and out;
- insulation of flat roofs;
- insulation of oxygen columns;
- insulation of low-temperature equipment in the production and use of nitrogen;
- in industrial refrigerators and refrigerators, domestic refrigerators;
- in three-layer sandwich construction panels;

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