Study on the possibilities of effective use of basalt

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Abstract. This article presents research on the possibilities of creating value-added unconventional materials, functional fabrics and products from local basalt and basalt roving. Basalt fiber, i.e. roving, is used to make knitwear and heat-insulating cord. The thermal insulation cord was tested in the "SNOL 15/1200" electric furnace in the laboratory of the "Mega invest industrial" LLC joint enterprise and its durability up to +980ºC was determined.

1. Introduction

Basalts are the most common on Earth and on other planets of the solar system. Basalt is a igneous volcanic rock that belongs to the basalt family and is the main component of the normal alkaline series. This term comes from the Greek language. The word basalt is also used as "bselt" or "bsalt", "boil", "stone containing iron".

Basalt is the raw material necessary for the production of basalt fiber, which currently makes up one-third of the igneous rocks that make up the earth's crust [1].

Basalt deposits are the product of lava flows formed during volcanic eruptions. Basalt is the most common of all hard rocks. The history of the name basalt comes from the Greek word "basanon" which means iron stone. Their mineral composition consists of apatite, graphite, dialag, magnetite, etc. [2].

In-depth study of the physical-mechanical and physical-chemical properties of basalt rocks expands the possibilities of their targeted use. For example, R.K.Rashidova, in her research under the leadership of A.A.Kurbanov, theoretically substantiated the possibility of obtaining a new heat-resistant product based on the raw materials of the "Aydarkol" basalt mine of our Republic. Among them are "Basalt FTM" bricks, which are used for the inner side of metal melting furnaces in the metallurgical industry based on the new composition (Fig. 1, a).

a *b*

Fig. 1. External view of "Basalt FTM" brick (a) and basalt fiber (b)

Shevchenko in his work on the topic "Creation of basalt fiber production technology based on raw material minerals of the Republic of Uzbekistan" [3] showed that concentration intervals based on basalt, limestone, phosphorous components obey the fundamental laws of the formation of difficult-to-dissolve eutectics in silicate systems, the quantitative change of solids when adding additives and found that there is a direct relationship between the viscosity of the solution. In addition, he justified the possibility of using the mineral raw materials of the Republic of Uzbekistan for the industrial production of high-quality basalt fiber.

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At this point, we considered it appropriate to provide information about short fibers, i.e., "fibras", which are obtained by cutting a roving of basalt fiber, rope or other fibrous materials to a certain length. "Fibra" (eng. "fibra") means pieces of fiber (Fig. 1, b). Fibers with their unique properties are widely used in various sectors, including industry, construction and road construction. For example, polypropylene, glass, metal and basalt fibers are used in construction to increase concrete strength [4].

Since 2017, the joint enterprise "Mega Invest Industrial" in the Jizzakh region of our country has launched a basalt fiber production enterprise, which is considered a valuable innovative material in modern construction, and produces a basalt fiber, which is used for making fittings and composite mesh, and produces innovative construction material.

"Geobasalt" LLC was established in December 2020. Corrosion-resistant, durable geonet is produced at this enterprise from basalt roving (600, 1200, 2400 tex). Unlike metal mesh, the new geogrid has corrosion resistance and does not require a dry place, it lies flat on the surface, it is safe to use, it is easy to cut with construction shears, it does not lose the strength of alkaline concrete, it conducts less heat, it provides high adhesion when using special solutions, and it allows to separately strengthen the layers of blocks [5].

In addition, heat-insulating wrap coverings made from basalt mineral fiber, "sandwich panels" are now widely used [6]. "Sandwich panels" can be formed according to the customer's requirements with appropriate sizes and parameters (thickness: up to 50 - 150 mm; length: up to 1 - 13 meters; coating thickness: up to 0.35 - 0.50 mm). These "sandwich panels" resistant to high temperature, non-flammable, compressive strength - 110 kPa, density - 105-125 kg/m^3, shear strength - 100 kPa.

Today, one of the main reasons why local basalt roving chemical treatment is being more seriously focused on its processing is to reduce the brittleness of these fibers, to obtain new textile products from them that replace imports, and to create composite materials for various purposes [7, 8].

2. Materials and Methods

The international and local experience in this area was studied in order to increase the integration of the field, higher education, science and production innovation cooperation to a new level, and to obtain new textile products that replace imports and create composite materials for various purposes, using local basalt raw materials effectively. The methods of comparison, analysis, logical thinking, scientific abstraction, information grouping, analysis and synthesis, induction and deduction were widely used. Physico-mechanical and other operational characteristics of local basalt piles (roving) were studied. In order to reduce the brittleness of basalt roving fibers, their modification with surfactants (SFM), experimental studies of weaving were conducted and alternative solutions were found.

3. Results and Discussion

According to the information of the State Geological Committee of the Republic of Uzbekistan, the reserve of known basalt minerals in our country is approximately equal to 243 million m^3.

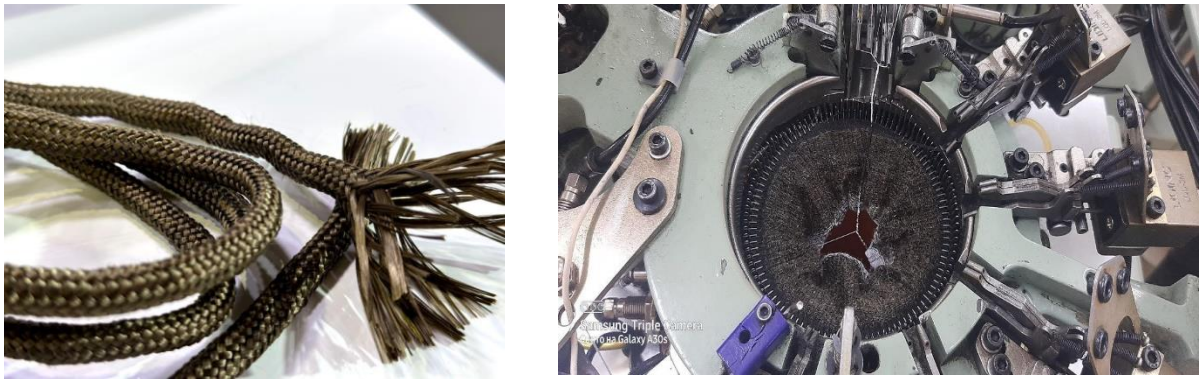
Table 1. Physico-mechanical parameters of twisted basalt threads

String structure	Linear density, tex	Durability, N	Relative strength, mN/tex
Complex yarn МБ9 - 15	15	9,1	607
Twisted threads: МБ9 – 15*1*2 (75)	30	15,1	503
МБ9 – 15*1*3 (75)	45	23,0	511
МБ9 – 15*1*4 (75)	60	29,0	483
МБ9 – 15*1*5 (75)	75	39,0	520
МБ9 – 15*1*6 (75)	90	46,0	511
МБ9 – 15*1*7 (75)	105	53,0	505
Roving МБ9 – 45	45	25,3	562
Twisted rovings: МБ9 – 45*1*2 (75)	90	47,5	528
МБ9 – 45*1*3 (75)	135	70,2	520
МБ9 – 45*1*4 (75)	180	96,0	511
МБ9 – 45*1*5 (75)	225	126,3	561
МБ9 – 45*1*6 (75)	270	145,0	537
МБ9 – 45*1*7 (75)	315	162,1	515
Twisted threads: МБ9 – 13,5*1*8 (100)	106,4	59,7	559
МБ12 – 80*1*3 (75)	240 ± 45	-	230
МБ12 – 160*1*2 (75)	320 ±50	-	300

Annual production of basalt mineral fiber heat-insulating wrap coverings in the whole world is 5 million tons, and basalt fibers are about 1 million tons [9].
Physico-mechanical parameters of basalt complex thread, pilik (roving) and twisted yarn obtained on the basis of pilik (roving) are presented in Table 1.
As mentioned in the study of foreign literature [9], the peculiarity of obtaining tissues from basalt threads is that it mainly uses twisted complex basalt threads. The number of twists in basalt threads was 75 and 100 per meter. After relatively long-term heat exposure of 450 and 500^{0}C, the residual strength of the fabrics formed from twisted threads is 30-63%.
Cords and ribbons made of super thin, pure basalt thread on cord weaving machines (Fig. 2) are widely used as thermal insulation elements in heat distribution systems, heat aggregates, melting and heat treatment furnaces and drying cabinets of various sectors of the national economy of a number of foreign countries [10].

Fig. 2. Cord and ribbons from super fine basalt thread

Also, basalt cords are used in the insulation of various pipe bends in shipbuilding, aviation, energy, engineering and construction. Basalt cord contains 0.1% moisture, it does not burn, does not rot, is free from the effects of various rodents and microorganisms, and is a sound insulating material. It is free of defects, environmentally friendly, does not release radioactive and toxic substances, is stable in acidic and alkaline environments, and has a working temperature of -200^{0}C +900^{0}C. The technical conditions of such basalt cords have also been developed [11].
Taking into account the above, within the framework of the cooperation agreement No. 2021-5 between "Mega invest industrial" LLC and Jizzakh Polytechnic Institute dated March 2, 2021, preliminary research was conducted in the direction of using basalt rovings in textiles. The technology of making heat-insulating cord resistant to fire and high temperature from local basalt rovings was created. In this case, local basalt rovings were first modified with SFM or covered with thin synthetic threads in a special weaving method.



a *b*

Fig. 3. Basalt insulating cord (a) and knitting process (b)

With the improvement of basalt roving technology in the conditions of "Mega Industrial" LLC enterprise, basalt rovings of traditional linear density and relatively thin were obtained (Table 2). In “Jizzax eso textile” LLC, local heat-insulating cord (Fig. 3, a) resistant to fire and high temperature, as well as basalt roving in sock weaving machines, as well as elastane, polyamide, polyester yarns are produced in various options sleeve of knitted fabric (Fig. 3, b) were taken [12].

In order to ensure the legal protection of the heat insulating cord obtained by these methods, a utility model application was submitted [10].

Table 2. Physico-mechanical properties of relatively thin local basalt rovings processed by SFM

Composition of SFM	Sample	Breaking strength, N	Regarding elongation, %	Relative breaking strength, mN/tex	Elastic modulus, N/tex
Collagen, PAA, Glycerin, water	1-1	15.8	1.8	439.0	37
	1-2	13.0	1.5	360.7	30
	1-3	10.2	1.2	282.8	28
	1-4	9.4	1.2	261.1	33
	1-5	12.9	1.4	357.1	40
	average	12.3	1.4	340.1	28
Acrylic emulsion, PAA, Glycerin, water	1-1	19.7	2.5	465.1	25
	1-2	19.1	2.6	483.9	25
	1-3	18.6	2.5	491.5	21
	1-4	17.4	2.5	486.8	26
	1-5	17.5	2.6	522.2	22
	average	18.5	2.5	489.9	24
DBF, PEG-4000, OS-20	1-1	17.2	2.0	485.1	22
	1-2	16.8	1.8	468.7	26
	1-3	10.3	1.8	417.4	22
	1-4	12.4	1.8	450.5	23
	1-5	13.2	1.9	463.7	24
	average	13.9	1.9	457.1	23

In our republic, the scope of use of heat-insulating cord is very wide, it is heat-resistant for stoves and fireplaces, heat-insulating cord is necessary for installing stove fittings, fireplace doors and protective screens, and for closing the intersections of chimneys with building structures. We hope that the use of knitted fabrics as a reinforcing element in the formation of various cylindrical polymer composites will lead to further improvement of the quality indicators of these products.

Heat-resistant bricks made of minerals, basalt fiber products, when used as specified in the relevant technical conditions, they ensure the implementation of environmentally friendly, air-permeable, various toxic additives and waste-free processes. One of the best qualities is that under the influence of fire basalt structural fibers stick together, partial melting limits the effect on subsequent fibers. Because basalt fiber can withstand temperatures from -200 to $+980^0$C, similar to glass fiber in structure, it is considered acceptable in thermal insulation [13, 14, 15]. When heated, basalt cords do not emit toxic or radioactive substances into the air, which ensures the safety of workers.

Heat insulating cord obtained from basalt fiber, i.e. roving, was tested in the "SNOL 15/1200" electric furnace in the laboratory of the "Mega invest industrial" LLC joint enterprise, and it was determined that it had a resistance of up to $+980^0$C.

4. Conclusions

a) According to the review of the literature on basalt and its use, its advantages such as high temperature, corrosion, chemical resistance, and resistance to the effects of aggressive environments, salts, acids, alkali solutions, and the prospects of obtaining functional products from it were studied.

b) Deep scientific analysis of the composition of local basalt minerals, research of the assortment of fibrous materials obtained from it in cooperation with science, higher education and practical experts, improvement of the technology related to increasing the types of fiber and pile (roving) linear density, obtaining reinforced basalt yarns that meet the requirements of the textile industry possibilities were explored.

c) Local basalt materials, especially "Aydarkol" basalt, are relatively hard in composition, and its melting temperature is 250÷300ºC higher than that of other regions, i.e. 1450÷1550ºC, based on practical experiments conducted at the joint venture of "Mega invest industrial" LLC.

d) Based on the analysis of relative breaking strength of rovings obtained from SFM of various composition, samples of rovings treated with SFM were taken at the joint enterprise of "Mega Invest Industrial" LLC.

e) Experiment-test samples of knitted skirts and cord without filler and with filler were obtained at Jizzax eso textile LLC using basalt rovings obtained by physico-chemical modification at the joint enterprise of "Mega invest industrial" LLC.
f) heat resistance It was proved that basalt fiber cord can withstand heat resistance of 980^0C during tests in the furnace available at the joint enterprise "Mega invest industrial" LLC.
g) Local heat insulating cord was tested in the "SNOL 15/1200" electric furnace in the laboratory of the "Mega invest industrial" LLC joint enterprise and its durability up to $+980^0$C was determined.

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