

Comparative Analysis of the Physical and Chemical Properties of Uzbekistan's Basalts and Ways of Solutions to the Problems of Choice of Raw Processing Directions

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Abstract

This article highlights the common use of petrographic processes in basalt processing. At present, basalt is being processed by liquefaction only. Heat fibers, tiles, cement, fittings, and nets are taken from the basalt. For this reason this article states that the range of products to be purchased is small. And to increase the assortment, it is proved by the fact that basalt basin should not be confined to liquefied processing. Chemical composition of basalt. Depending on the chemical composition of the basalt, the technology of their processing is selected and determined. The article is based on the same principle that the dry method of drying basalt without liquefaction is put forward. Below are the names of products that can be obtained on dry bases processing. This is justified by the fact that it increases the range of basalt products. However, it is advisable to follow two methods of basalt processing in the future. These methods, which are recommended by the authors, have undergone a production trial and received positive assessments; the test report has also been presented.

Keywords: raw materials, dry rock, ore, stocks, basalts, silicate, olive, pyroxene, decomposition, chemical, physical, mechanical, split

1. Introduction

1.1 Introduce the Problem

Currently, basalt products of Uzbekistan are produced mainly by melting. The experience of basalt processing enterprises shows that, in practice, there are practically no standard, established patterns of the influence of any factors on the melting temperature of basalts. It was found that the change in the melting temperature of basalts of different deposits is focused on the chemical and material components of basalts. There are various statements that the processing technology of basalts depends on the chemical composition of the rock. Since basalts have different chemical compositions in different deposits, the technology should also be different. [1].

For example: basalts of the Klyuchevskaya hill and the Hawaiian islands melt at a temperature of $1250 \div 1400^\circ\text{C}$; basalts of the Gavasay deposits at $1300 \div 1350^\circ\text{C}$, Asmansay at 1450°C , Aydarkul at $1500 \div 1550^\circ\text{C}$, Akhangaran at $1200 \div 1300^\circ\text{C}$ and Yanovo Valley $1300 \div 1350^\circ\text{C}$, etc. The differences in the melting points of the basalts considered in the five basalt deposits are approximately up to 250°C .

It is noted that if the melt has a high content of silica (more than 50–51%) or alumina, then it becomes excessively viscous, poorly fills the forms, it is difficult to melt and crystallizes. Oxides of calcium and magnesium, ferrous and oxide iron contribute to lowering the viscosity and improving the crystallization ability of the melts. In the case of a low silica content (between 40 and 50%), basalt melts at a temperature of $1280 \div 1350^\circ\text{C}$, the melt has a low viscosity, which is also bad because it quickly hardens with the formation of a glassy microstructure and cracking upon cooling.

2. Method

By well-known methods, the chemical properties of local basalts were investigated. It was experimentally established that the basalts of the Aydarkul deposit are a rare and finely porphyritic rock with an afyr, allotriomorphic granular structure. They consist, approximately, of an equal number of completely irregular grains of pyroxene and plagioclase. For this reason, the melting point of pyroxene is higher than that of olivine, i.e.

reaches values up to $1500 \div 1550^\circ\text{C}$. A characteristic feature of basalts is the content of plagioclases in them, which are expressed in the following forms: albite-Na [AlSi_3O_8] melting point 1250°C) and anorthite-Ca [$\text{Al}_2\text{Si}_2\text{O}_8$] melting point 1550°C). The main part of plagioclase is SiO_2 (from 44 to 67%) and the smallest proportion is Na_2O .

According to experts, the high SiO_2 content in plagioclase, like pyroxene, contributes to an increase in the melting temperature of basalts, and rocks of the Aydarkulskoye deposit can be attributed to them. The content of basalts (in%): Fe_2O_3 , TiO_2 , and MgO can also increase the melting temperature. Investigations of the basalts of the Asmansai deposit showed that the composition of the rock includes plagioclase, augite, and secondary minerals: calcite, epidote, zoisite, sphene, chlorite, ore, magnetite, leucoxene, and the structure is hyalopilite and inter-serum. The breed is fine-grained, finely and rarely porphyritic. The presence of augite contributes to the melting of the rock of the Asmansay deposit at temperatures $100 \div 200^\circ\text{C}$ lower than that of the Aidarkul basalts, i.e. at temperatures of $1400 \div 1450^\circ\text{C}$.

In both cases considered, the typical silicate compound formed in the basalt mineral is olivine - $(\text{Mg}, \text{Fe})_2 \text{SiO}_4$. The melting point of olivine is in the range of $1200 \div 1250^\circ\text{C}$. Therefore, manufacturers for the manufacture of basalt fiber materials often use basalts, of which olivine occupies the bulk. An increase in the melting temperature of basalts reduces the casting properties of the melt. An increase in the resistivity of the cast product to external shocks is observed. The content in the composition of basalt MnO_2 in the range $(0.09 \div 0.41)\%$ and FeO in the range $(2.6 \div 3.9)\%$, Fe_2O_3 in the range $(1.19 \div 2.5)\%$ and a low percentage ratio of Al_2O_3 and TiO_2 reduces the conductivity of the basalt casting. Thus, from the point of view of low electrical conductivity, the similarity of basalt glass-cast form with quartz glasses is confirmed.

The maximum permissible SiO_2 content in basalt is experimentally proved to be 43.7–49.3%, and is recommended as the most optimal option when choosing rock composition [2-4]. With such indicators, the basalts of all three of the considered deposits “Aydarkul”, “Asmansai”, “Akhanganar” and “Gavasai” can be successfully used for the manufacture of heat-insulating fibrous materials (melting temperature of basalts $(1350 \div 1400)^\circ\text{C}$).

According to tabular data, it follows that, unlike basalts used for the manufacture of insulators of different potentials, for the manufacture of heat-insulating fibrous materials, basalt rocks will be required, which contain (in%): SiO_2 –43 \div 47, 3 MgO up to 7, Al_2O_3 up to 20, CaO up to 10 and $(\text{K}_2\text{O} + \text{Na}_2\text{O})$ not more than 3.5.

It was established that the content of iron oxides ($\text{FeO} \cdot \text{Fe}_2\text{O}_3$) and TiO_2 in the composition of basalt does not affect the thermal conductivity of basalt fiber materials. However, it is necessary to take into account the content of MnO_2 , which determines the viscosity of the jets of liquid basalt that pass through the spinneret device. Basaltes of all three considered deposits possess such properties. Evidence of this is the use of the Aidarkul, Asmansai, Gavasay, and Akhangaran basalts by basalt processing plants. Basalts of the considered deposits are used exclusively for the manufacture of heat-insulating basalt fiber materials [4-6].

As noted above, an increase in the SiO_2 content of basalts by more than 50% contributes to a decrease in viscosity, casting properties of the melt and increases electrical conductivity, but at the same time reduces the hardness and density of the rock itself. The density of the rock decreases, and it becomes more suitable for crushing and grinding.

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The maximum permissible content of SiO_2 in the composition of basalt is experimentally proven is 43.7 \div 49.3%, and it is recommended as the most optimal option when choosing the composition of the rock [6]. With such indicators, the basalts of all three of the considered deposits “Aydarkul”, “Asmansai”, “Akhanganar” and “Gavasai” can be successfully used for the manufacture of heat-insulating fibrous materials (melting temperature of basalts $(1350 \div 1400)^\circ\text{C}$).

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which determines the viscosity of the jets of liquid basalt that pass through the spinneret device. These properties are possessed by basalts of all three considered deposits.

Evidence of this is the use of the Aidarkul, Asmansai, Gavasay, and Akhangaran basalts by basalt processing plants. Basalts of the considered deposits are used exclusively for the manufacture of heat-insulating basalt fiber materials [5]. Table.2 presents data on basalt products that can be produced by heat treatment, i.e., by the petrographic method, on the basis of melting and by dry processing, without melting.

Table 1. Comparative regions of the characteristics of the chemical composition of basaltic rocks of different globe

Comparative chemical composition and melting temperature of basalts of various deposits of the world (in%)									
Component connection	Klyuchevskoy Hills (Russia)	Hawaiian Islands	Bashkardas - than (Russia)	Yanovo Valley (Ukraine)	Mikuduksky (Kazakhstan)	Hawasai (Uzbekistan)	Asmansay (Uzbekistan)	Aydarkul (Uzbekistan)	Ahangaran (Uzbekistan)
SiO ₂	45.3÷52.4	44.1÷50.3	46.7÷51.0	44.2÷50.3	44.9÷55.9	45.7÷47.05	45.7÷53.3	43.7÷56.9	51.30÷54.9
TiO ₂	0.62÷0.79	1.4÷3.0	0.50÷0.92	1.1÷1.6	0.21÷0.41	1.01÷1.05	1.18÷1.21	1.5÷2.5	not detected
Al ₂ O ₃	13.2÷15.3	10.3÷12.9	19.2÷20.4	13.2÷15.3	17.4÷21.8	14.2÷15.7	9.2÷10.2	8.2÷9.3	16.3÷17.2
CaO	6.8÷8.0	8.9÷10.8	3.4÷4.5	8.8÷9.0	5.4÷6.2	1.16÷1.39	5.6÷8.9	4.6÷6.9	7.0÷7.2
MgO	8.8÷8.9	6.1÷8.1	2.1÷3.7	4.7÷5.1	0.81÷1.6	4.8÷5.4	1.1÷2.6	2.7÷3.8	3.2÷4.54
FeO	4.71÷4.75	6.4÷9.5	15.6÷18.9	6.6÷7.9	5.2÷11.4	1.16÷1.39	5.6÷8.9	4.6÷6.9	7.0÷7.2
Fe ₂ O ₃	1.8÷3.1	1.2÷1.5	12.8÷13.8	2.9÷15.5	6.19÷8.96	6.9÷7.4	2.9÷3.47	2.9÷3.0	7.2÷9.6
K ₂ O	0.29÷0.86	0.16÷0.46	0.81÷0.99	0.55÷0.71	0.37÷0.44	1.2÷1.4	0.21÷0.99	0.14÷0.19	1.16÷1.72
Na ₂ O	2.0÷2.7	2.1÷2.3	4.6÷5.6	2.8÷3.0	1.9÷2.8	2.8÷3.6	1.8÷2.6	2.8÷3.3	-
MnO ₂	0.17÷0.80	0.21÷0.31	0.1÷0.19	0.05÷0.09	0.22÷0.28	-	0.12÷0.41	0.09÷0.11	-
P ₂ O ₅	0.02÷0.10	0.10÷0.11	-	0.02÷0.03	0.05÷0.07	-	0.45÷0.73	-	-
Others	16.3÷2.1	18.9÷0.66	19.03÷0.31	26.95÷0.41	7.94÷8.34	7.9÷8.3	19.03÷0.31	26.95÷0.41	1.9-6.8
Melting temp. °C	1300÷1400	1200÷1300	1200÷1300	1300÷1350	1300÷1350	1300÷1350	1400÷1450	1500÷1550	1200÷1300
Liquidus temperature. °C*	1250÷1350	1150÷1250	1300÷1350	1300÷1350	1200÷1350	1200÷1350	1400÷1450	1500÷1550	1250÷1300

Table 2. Comparative characteristics of the chemical composition of basaltic rocks of different regions of the globe

Boundary criteria of physicochemical properties and composition of basalts						
The main components of the chemical components of basalts	The content of chemical components, % mass	Names of the medium for testing tiles for performance (acid)	Content of chemical components, % mass	Basalt products, °C	The content of chemical components, % mass	Dielectric constant ϵ (8,854x10 ⁻¹² , $\kappa^2/m^2 \times N$)
SiO ₂	50,3÷ 60,0		42,7÷ 47,3		43,7÷ 49,3	4,34
TiO ₂	0,63÷ 1,5		0,5÷1,51		0,8÷ 1,0	86,0
Al ₂ O ₃	10,22÷15,0	-B H ₂ SO ₄ -97	14,2÷20,2		8,7÷13	10,5-12,0
CaO	8,42÷13,0	- B HCl-85	7,2÷8,42		9,42÷12,0	3,0
MgO	2,7÷4,0	-B CH ₃ COOH-97,5	3,7÷6,0	Attemperatures from	5,7÷11,6	3,2
FeO	1,6÷2,9	-B HNO ₃ -95,5	2,6÷4,0	-270 to +800°C	5,6÷8,9	16,0
Fe ₂ O ₃	1,19÷2,5	- B H ₃ PO ₄ -95	3,1÷6,37		2,9÷3,47	11,6
K ₂ O	0,3÷ 0,99		0,2÷0,49		0,14÷ 0,99	16,0
Na ₂ O	1,80÷2,6		1,80÷2,60		1,1÷2,0	1,0
MnO ₂	-		0,09÷0,11		0,09÷0,41	13,0
P ₂ O ₅	-		-		0,45÷0,73	2323
Another	6,39		12,40		5,48	-
Total	-		100		100	-
Melting point °C.	-			1300÷1400°C		1450÷1550°C
Destination	Acid-resistant tiles, refractory and building materials, portland cement		Heat-insulating basalt wool, building materials, treatment belts and insulation tiles, Portland cement		Support-hardware insulators of different potentials, alkali resistant tiles, fittings, metal substitutes	
Field name						
Bazalts	Aydarkul, Hawasai, Asmansai and Akhangaran		Hawasai, Aydarkul, Asmansay		Asmansai, Aydarkul and Asmansay	

As noted above, an increase of more than 50% in the composition of basalts of SiO₂ contributes to a decrease in viscosity, casting properties of the melt and increases electrical conductivity, but at the same time reduces the hardness and density of the rock itself. The density of the rock decreases, and it becomes more suitable for crushing and grinding. The considered basalts from four deposits have a high SiO₂ content in the Aydarkul rocks, in which the SiO₂ content reaches up to 60% and TiO₂ up to 2.5%. It was experimentally revealed that basalts with such a SiO₂ content are difficult to melt and are easily crushed and milled. [7].

3. Results

Thus, it was found that the main factors on which the basalt melting temperature depends are: the percentage of olivine, pyroxene, and plagioclase in the rock, the mineralogical composition of the basalt rock, and the chemical properties of the rock. Basalts that are difficult to melt and require additional heat resources to melt them; also, for such basalts, the SiO₂ content reaches more than 50% are considered to be pipe melting.

The results of theoretical and experimental studies using samples of the considered basalt deposits: Aydarkul, Asmansay, Gavasay and Akhangaran found that all local basalts cannot be processed by heat treatment, that is, by melting. Because, with an increase in the content of basalts, the amount of SiO₂ rock becomes less solid and dense. Such basaltic rocks should be processed by crushing and grinding, excluding melting.

This technical solution allows you to open a new direction for the processing of basalts. This direction is based on dry processing of basalts, which allows you to organize production without the use of the melting method. This technical solution allows the production of new basalt products, which increases the product range and expands the use of basalt products. Such basalt products may include: acid-base resistant tiles, various bricks operating in aggressive environments, refractory bricks for various purposes, Portland cement, etc. This technical solution allows you to open a new direction for the processing of basalts. This direction is based on dry processing of basalts, which allows you to organize production without the use of the melting method. This technical solution allows the production of new basalt products, which increases the product range and expands the use of basalt products.

Such basalt products can be: acid-base resistant tiles, various bricks operating in aggressive environments, refractory bricks for various purposes, Portland cement, etc. This arrangement of the organization of basalt production allows you to develop a single production chain for the production of products for various purposes. The two types of basalt products processing directions that we proposed in this article in a single technological chain allow us to further increase the company's labor productivity, minimize technological and energy costs, and increase the product range.

References

- Kurbanov, A. A. (2010). On the problems of filtering gas, liquids and filter materials. Scientific, technical and production journal. Mountain Herald of Uzbekistan. *Navoi*, 1. S. 75-78.
- Kurbanov, A. A., & Abdurakhmonov, S. A. (2019). Scientific and practical basis for the complex use of diverse types of basalts in Uzbekistan. Navoi: Publ. Alisher Navoi., 238.
- Kurbanov, A. A., & Turaev, A. S. (2007). A brief overview of basalt and the resulting basalt materials. Scientific, technical and production journal Mountain Bulletin of Uzbekistan. *Navoi*, 3, 82-85.
- Kurbanov, A. A. (2009). Specific features of the Kyzyl Kum basalts. Tashkent: Fan., 160.
- Kurbanov, A. A., Abdurakhmonov S. A., & Turaev, A. S. (2010). Basics of processing of Kyzylkum basalts. Tashkent: Fan., 167.
- Mirzaev, P. A. (1964). Report on prospecting and appraisal work for 1965 Deposits of basic rocks, Belyauts I, II, etc. Funds of the State Committee for Geology of the Republic of Uzbekistan. T.
- The methodology for measuring the capture of harmful chemicals using basalt fiber filter material. MVI NMMC Ts-34.20-106: Methodology. *Navoi*, 2011, 8.

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