Investigation of thermal properties and composition on basalts of the Aydarkul deposit by methods DTA/DTG and X-ray diffraction

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Abstract. To study the applicability of the basalt fiber through various experimental works in thermal and chemical environments, lining heat-insulating materials basis on basalt of Aydarkul deposit were compared and discussed. The identification and study phase pert structures lining heat-insulating materials basis on basalt of Aydarkul deposit used X-ray diffraction analysis. The basalt fiber showed better strength retention than the glass fiber at relatively high temperature. The article studies the endothermic effects of the thermolysis process, which appear at a temperature of 80 ÷240 ^{0}C. They show the decomposition of clay impurities or the removal of hygroscopic water contained in rocks. The chemical and mineralogical composition of the basalts of the Aydarkul deposit has been studied by such modern methods as X-ray diffraction and differential thermal analysis methods. Keywords: basalt fi ber; thermal stability, differential thermal analysis, differential thermal gravimeter, derivatogram, X-ray diffraction, research method, Aydarkul deposit.

1 Introduction

Currently, for the processing of basalt rock, three methods are used in the world: the "petrurgical" method - melting the rock at high temperatures; dry processing method - a metallurgical method of processing basalts by force action on rocks without the intervention of thermal effects, a method of dissolving basalt rock in acid solutions [1-9,22].

At the same time, stone piece bricks cut from basalt rock recommended themselves well in the construction of special refractory buildings, structures, chimneys of houses and fortifications [10-12].

Lining heat-insulating materials from mineral materials for thermal insulation of houses is environmentally friendly, they have the ability to "breathe" (let air through), but only in cases where production is carried out strictly in accordance with GOST, without harmful impurities and additives. Another feature of basalt rock materials is their incombustibility. Upon contact with fire, only the gluing of the fibers occurs, preventing it from spreading further [13-17].

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Therefore, in this case, the high physical and technical properties of basalts are of scientific and practical interest, which make it possible to create the production of highly efficient construction, technical, heat and sound insulating, composite materials, heat insulating materials and products for various industries [18–20].

Studies show that an increase in the content of SiO_2, TiO_2, Fe_2O_3 in the composition of basalts increases their melting temperature and reduces the casting properties of the melt. The processing of basalt rock in the traditional way is accompanied by an increase in technological and energy costs. A particularly high content of SiO2 in the melt makes it more brittle, the density of the rock decreases, and it becomes more unsuitable for melting work. Density-2.3-2.7 g / cm3, hardness 5 on the Mohs scale. The compressive strength drops from 100 MPa. The porosity of basalts increases, and bubble and slag varieties develop on the casting surface. They acquire such a structure as a result of an increase in clay substances in basalts. Basalt becomes unsuitable for processing by smelting processes. The higher the content of SiO_2 in basalts, the basalt approaches alumina in composition and is more difficult to melt [21–24].

And the third method of processing basalts in Uzbekistan has not found practical application. As a basis for the specifics and the developed processing scheme, the dissertation work proposes a “dry method” of opening and separating rocks, the so-called “dry processing”. In the literature there is a large amount of information on the dry processing of minerals. These data are often found in metallurgy. Therefore, cast basalt breaks very easily [14-17].

The basalts of Uzbekistan arose as a result of uneven cooling of the rock after the eruption of marine volcanoes. Because of what, most often, basalts are found in the form of separate pieces. Therefore, the average diameter of basalt pieces ranges from 250÷300 mm, which are easily mined by an open method [6,15,17,19].

On fig. 1. deposits of basalts on the surface of the earth and fragmented samples of basalts are shown. Unlike smelting works, basalt is easily crushed and crushed. In basalts "Aydarkul" in comparison with such minerals of deposits "Asmansay" (Jizzakh region), "Gavasay" (Namangan region), "Akhangaran" (Tashkent region), the content of SiO_2 reaches from 55 to 63%. Whereas this indicator reaches in minerals: "Asmansai" from 48 to 53%, "Gavasai" from 45 to 47% and "Akhangaran" from 43 to 46% (Fig.1.)[6,12,15,19,21].

Fig. 1. Extraction and initial stage of processing of basalts from the Aydarkul deposit.

2 Experimental parts

2.1 Thermal method

In differential thermal analysis, the phase transformation and the interval of stability or change in the studied materials and prototypes with temperature changes were performed using differential thermal analysis, recorded on a derivatograph using an RLABSYSEvo-1A Setaram device (France), on which the differential curve was simultaneously recorded with

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curved changes in linear dimensions (shrinkage) and weight loss. Galvanometer sensitivity T-900, TG200, DTA-1/10, DTG-1/20, heating rate 10 deg/min in platinum crucibles. Recording was carried out under atmospheric conditions. Al2O3 was used as a reference.

Simultaneously, other samples from the material under study were recorded with a change in linear dimensions using a torsion balance, also with a mirror reading. Differential and temperature recording was carried out with a differential Pt-Pt-Rh thermocouple. The heating curves were taken at a sample size of 0.146-0.1645 g. At the same time, the change in linear dimensions was recorded on other samples of the material under study using a torsion balance, also with a mirror reading. The analysis of the obtained results was carried out using fundamental works on thermal analysis.

2.2 X-ray diffraction method

The phase composition of the investigated raw materials and experimental masses was determined by the X-ray method. Tables and reference books, as well as an Internet card file of minerals, were used in calculations and in the identification of phases. A Bruker AXS D8 Advance diffractometer (Bruker, Germany) was also used to identify crystalline phases. Shooting Conditions-Cu-Kα cathode, step-0.05, shooting speed 2 deg/min. The Match! program was used to interpret radiographs. program package (Crystal Impact GbR, Bonn, Germany) [GOST 17177-94].

2.3 Semi-quantitative spectral analysis

Based on the results of research work and the results of the analysis of samples of basalt minerals "Aydarkul", they underwent a semi-quantitative spectral analysis. The purpose of this study is to identify near-Clarke and above-Clarke indicators of chemical elements in basalts. It turned out that the basalts of Uzbekistan do not contain valuable components, so we called them poor basalt rocks. They are valued due to the presence of more than one percent metal-containing oxides [GOST 17177-94].

3 Results and discussion

Investigation of the process of thermal action on basalts, where the transformation of basalt rock occurs, the derivatograms presented in Figures and Tables 1 and 2 are removed. In this study, the RLabsysEvo-1A Setaram device was used, where the heating temperature reaches from 50^0C to 1200 ^{0}C. At the same time, the heating rate is 5 ^{0}C/ min.

The samples were subjected to heat treatment at temperatures up to 100 ° C. The manifestations of the endothermic effect of the thermolysis process, which appear at a temperature of 80÷240 ^{0}C, have been studied. They show the decomposition of clay impurities or the removal of hygroscopic water contained in rocks. In the future, at a temperature of 520 ^{0}C, there is a weakening of the effects and an increase by an insignificant amount of mass, which corresponds to the mutual transformation of the component part of basalts (Fig.2., Table.1.) [12, 23-25,28].

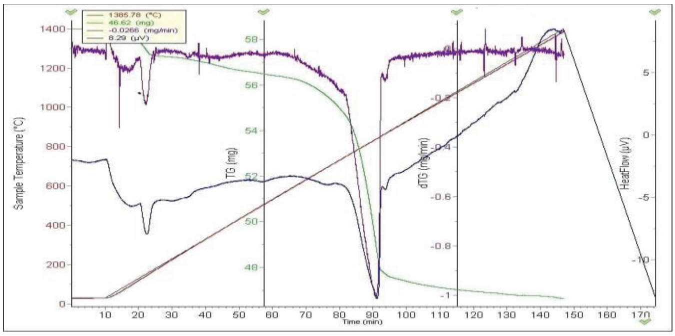

Fig. 2. Derivatogram of the results of heat treatment of Aydarkul basalt samples.

Table 1. Experimental data of the derivatogram results.

№	**Temperature, °C**	**Lost weight, mg**	**Lost weight, %**	**mg/min**	**Amount of energy consumed (µV*s/mg)**
1	50	0.09	0.167	0.009	0
2	100	0.52	0.89	0.083	6.91
3	200	1.19	2.02	0.214	3.89
4	300	1.36	2.31	0.223	3.99
5	400	1.73	2.93	0.262	4.13
6	500	1.97	3.35	0.282	4.97
7	600	2.21	3.75	0.284	6.70
8	700	3.04	5.15	0.309	4.32
9	800	6.13	10.34	1.317	5.32
10	820	7.76	13.17	1.359	5.36
11	850	10.5	17.86	1.408	3.35
12	900	10.9	18.59	1.917	4.36
13	1000	11.3	19.16	0.915	3.98
14	1050	11.4	19.35	0.915	5.36
15	1100	11.5	19.49	0.835	4.36
16	1200	15.3	22.3	0.635	3.35
17	1300	18.3	23.8	0.536	4.35

The study of the process of thermal action on basalts, where the transformation of basalt rock occurs, is expressed through derivatograms.

Analysis of the DTGA curve shows that the curve consists mainly of two sigmoids that occur in two stages. The first stage occurs in the temperature range from 150 ^{O}C to 700 °C, while the mass loss is 11.46%, the second stage occurs in the temperature range from 750 ^{O}C to 1200 °C, while the mass loss is 23.7%. When heated to 600-900 ° C in an oxidizing medium, the iron monoxide contained in olivine is oxidized to iron oxide, and olivine passes into forsterite ($2MgOSiO_2$) and clinoenstatite ($2MgOSiO_2$). At temperatures above 1200 °C, iron oxide interacts with forsterite and forms magnesium metasilicate. Magnesium metasilicate has four modifications, so their presence in refractories is impractical.

The study and analysis of the TGP curve shows that the decomposition rate of carbon-containing material in the temperature range of 600-1080 °C proceeds maximally and is 2.88 mg/min, and the amount of energy consumed, respectively, is 8.430 mv*c/mg. When the temperature rises, the process of crystallization of amorphous products of the initial raw materials occurs. At the same time, as a result of the destruction of the crystal structure of natural basalt, due to the heat treatment process, a second exothermic effect is manifested in the temperature range of 820-840 ° C. This phenomenon can be explained by the detection of three endothermic effects appearing in raw materials (at temperatures of 120-160 ^{O}C, 335-

375 ºC, 580-590 ºC, respectively) and two exothermic effects (at temperatures of 300-450 ºC and 700-720 ºC). It is established that the shape of thermal curves is associated with the thermal insulation of raw materials and with the characteristics of the basalts of the Aydarkul deposits [25-27].

The results of X-ray studies of basalt showed that the mineralogical composition of the crystalline phase is represented (in wt.%) by calcite minerals $CaCO_3$-29.8; albite $NaAlSi_3O_8$ - 27.7; silicon oxide SiO_2-35.9; alkaline basalt (Mg, Fe, Al, Ti), (Ca, Na, Mgm Fe) $(SiAl)_2O_6$-6.6 (Fig. 3).

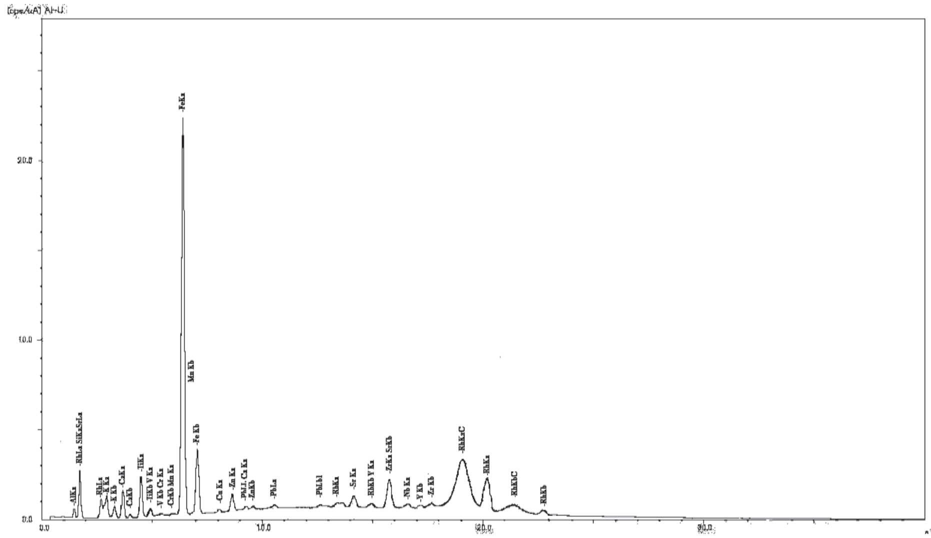

Fig. 3. X-ray diffraction pattern of basalt from the Aydarkul deposit.

On the radiograph of the basalt rock, the diffraction maxima of quartz are pronounced (d= 0.474; 0.367; 0.182 Nm). Along with them, studies revealed the presence of aluminosilicate compounds (b = 0.323; 0.296 T) and pyroxenes (b= 0.253; 0.205 T) (Fig.3., Table.2.).

The results of the conducted research show that the basalts of the Aydarkul deposit are quite suitable in the production of modern refractory thermal insulation materials of a new generation.

Table 2. Results of the X-ray analysis of the basalt sample of the Aydarkul deposit.

Elements	Content, %
Si	41.944
Al	8.627
Fe	5.593
K	3.818
Ca	1.906
Ti	1.557
S	0.255
Mn	0.180
Sr	0.045
Rb	0.028
Cu	0.023
Zn	0.022

4 Conclusion

According to TSh-64-15562057-03:2002, the studied basalts are environmentally friendly, have positive physico-mechanical ratings, are resistant to acidic and alkaline environments, and also have low thermal conductivity coefficients. In addition, they have a wide range of applications compared to other similar materials.

These properties of the basalts of the Aydarkul deposits have determined the urgency of the problem of further development and creation of highly effective thermal insulation materials and products for various industries.

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