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Study Of Structural Properties And Flame Of Vollastanite, Dolomite, Vermiculite Minerals

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ABSTRACT

This research paper analyzes the structural properties of vermiculite, including its bulk density, grain size composition, porosity and intergranular voidness. In addition, the results of relevant scientific experiments are presented, proving a higher degree of thermal insulation of vermiculite in comparison with other thermal insulation materials.

KEYWORDS

Vermiculite, bulk density, grain structure, porosity, intergranular voidness, heat-insulating property, experiment.

INTRODUCTION

In order to describe the structural properties of vermiculite, it is necessary first of all to pay attention to its bulk density, grain size composition, porosity and intergranular voidness. Bulk density is the main technical characteristic of expanded aggregates and is mainly determined by the porosity of these materials. The value of the bulk density of expanded vermiculite obtained in industrial installations by firing raw vermiculite is shown in Fig. 1.

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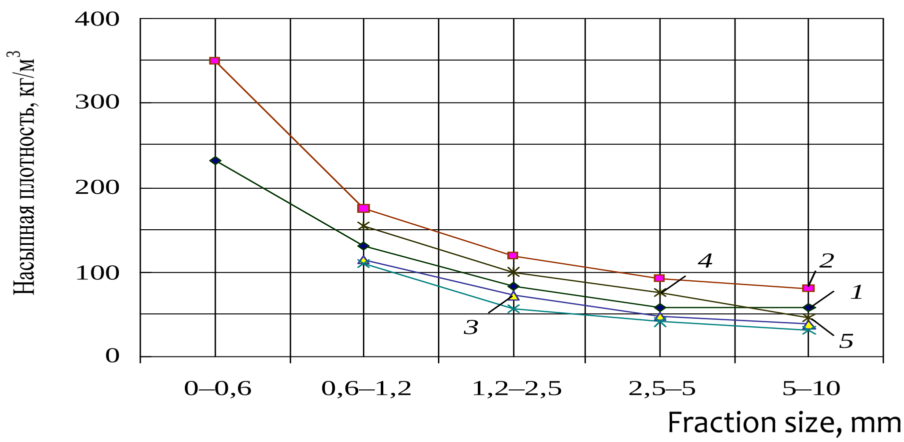

vertical - Bulk density- kg\m³

Figure: 1. Dependence of the bulk density of expanded vermiculite on the fractional composition:

1 - Kovdor hydrophlogopite, fired in a shaft furnace; 2 - inaglinsky vermiculite, fired in a shaft furnace; 3 - Kovdor hydrophlogopite, fired in a drying and kiln unit; 4 - inaglinsky vermiculite, fired in a drying-oven unit; 5 - Inaglinsky vermiculite, fired in a tube furnace.

The results confirm that the provisions according to which the bulk density of expanded vermiculite increases with decreasing grain size. This is especially noticeable for fractions less than 1.2 mm and is associated with the presence of waste rock. The grain size and shape also affects the bulk density of the expanded vermiculite. With decreasing size, it increases and for fractions less than 0.315, as a rule, it has o> 200 kg / m³ (Table 2.1). Grains of expanded vermiculite of plate form in loosely bulk form fit less densely than cubic ones, as a result of which the bulk densities of the latter are less. Some researchers believe that when vermiculite is used in backfill insulation, a lamellar grain material is often advantageous.

In concretes, it is preferable to use cubic vermiculite. It should be noted that GOST 12865 "Expanded vermiculite" does not take into account such an important indicator as the shape of the grains.

METHODS OF RESEARCH

The shape of the grains of expanded vermiculite, obtained by us from the Inaglinsky rock, is mainly cuboid, the color is light golden with a yellow tint, the surface is rough matt, regardless of which installation is fired.

In the Kovdor swollen hydrophlogopite, the grains generally have a smooth, shiny surface; their shape and color depend on the firing conditions. In the shaft furnace, a cuboid-shaped product of golden color was obtained. This is due to the fact that the shaft furnace has a larger swelling zone volume and a shorter pneumatic conveying path for the fired particles to the receiving hopper than tube furnaces, which contributes to minimal grain destruction. Since the shape of the grains significantly affects the properties of expanded vermiculite and materials based on it, the author recommends determining the shape of the grains using the following method. An average sample of expanded vermiculite weighing 100 g is sieved through sieves 5; 2.5; 1.25 and 0.6 mm. Samples equal to 3 g are taken from the residues on each sieve by quartering. Each particle conventionally has a diameter d equal to the diameter of the holes of the given sieve (for example, on a 5 sieve d

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= 5 mm). The height h of the "accordion" of each particle is determined based on the ratio h / d> 0.5 for a cube-shaped form and h / d <0.5 for a lamellar one.

The number of grains of a given form for each fraction and their content is determined as a percentage:

$$O_n = \frac{n \cdot 100}{N}.$$

where n - is the number of grains of this group; N - is the total number of grains in the test sample.

The content of grains of each group in the entire vermiculite sample is calculated as a weighted average from the results of determinations for all fractions:

$$O_n = \frac{Q_5 \cdot m_5 + Q_{2,5} \cdot m_{2,5} + Q_{1,25} \cdot m_{1,25} + Q_{0,6} \cdot m_{0,6}}{m_5 + m_{2,5} + m_{1,25} + m_{0,6}}$$

where Q5, Q2.5, Q1.25, Q0.6 is the content of grains of this group for the corresponding fractions,%; m5, m2.5, m1.25, m0.6 are the sample weights of the corresponding fractions, in g.

Expanded perlite grains have a shape close to spherical, as well as high porosity (like vermiculite). In addition, perlite has lower water absorption rates than vermiculite. At the same time, a large elastic deformation can be considered an advantage of vermiculite particles.

Expanded perlite and vermiculite, obtained by us by roasting in industrial conditions (Tables 1.1 and 1.2), belong to especially light, highly porous bulk materials. A characteristic feature of the grain size composition of perlite is the high stability of the bulk density by fractions in comparison with vermiculite.

The bulk density of fractions less than 0.315 mm in this material exceeds the regulatory requirements (ρn = 200 kg / m3), which is associated with the presence of a significant amount of waste rock. For the device of highly efficient backfill and heat-insulating materials based on it, it is recommended to screen out especially light fractions of expanded vermiculite.

Table 1.1

Dependence of the bulk density of expanded aggregates on their grain size composition

Aggregate	**Index**	**Bulk density, kg / m³**	**Fractions, mm**						
			5–10	**2,5–5**	**1,25–2,5**	**0,63–1,25**	**0,315–0,63**	**0,16–0,315**	**< 0,16**
	Private residues	–	–	1	26	18	35	15	5

Expanded Aragatsky perlite	on sieves,% by weight								
	bulk density, kg / m³	120	140	113	87	70	65	125	135
Swollen inaglinsky vermiculite	partial residues on sieves,% by mass	–	–	15	30	15	18	16	6
	bulk density, kg / m³	145	120	126	160	130	140	250	450

In fig. 2 shows integral and differential programs of expanded vermiculite and perlite obtained by the method of mercury porosimetry.

As follows from Fig. 2, expanded vermiculite has a large volume of large pores (more than 10 μm). Expanded pearlite is characterized by a more uniform pore diameter distribution.The test data indicate that both materials have a similar pore volume at sizes over 100,000 E, at 10,000 E for vermiculite the pore dispersion is 3.6–4.5 versus 0.5–0.6 cm3 / g for perlite at 1000, respectively 4.3–4.5 and 1.2–1.3 cm3 / g. Finally, at 100 these values are 4.1–4.4 and 2.0–2.15 cm3 / g.

Table 1.2

Dependence of the bulk density, porosity and voidness of expanded aggregates on their grain size composition

Aggregate	**Index**	**Fractions, mm**					
		2,5–5,0	**1,25–2,5**	**0,63–1,25**	**0,315–0,63**	**0,14–0,315**	**Less 0,14**
Expanded Aragatsky perlite	Bulk density, kg / m³	142	92	65	70	93	136
	Porosity,%	94,0	86,1	97,2	97,0	96,1	94,3
	Intergranular void,%	55,0	56,6	62,6	60,4	51,8	50,0
Expanded Kovdor	Bulk density, kg / m³	106	116	127	150	252	450
	Porosity,%	95,5	95,2	94,7	96,0	89,5	81,3

hydrophlo gopite	Intergranular void,%	82,4	76,2	63,1	69,6	72,4	75,0

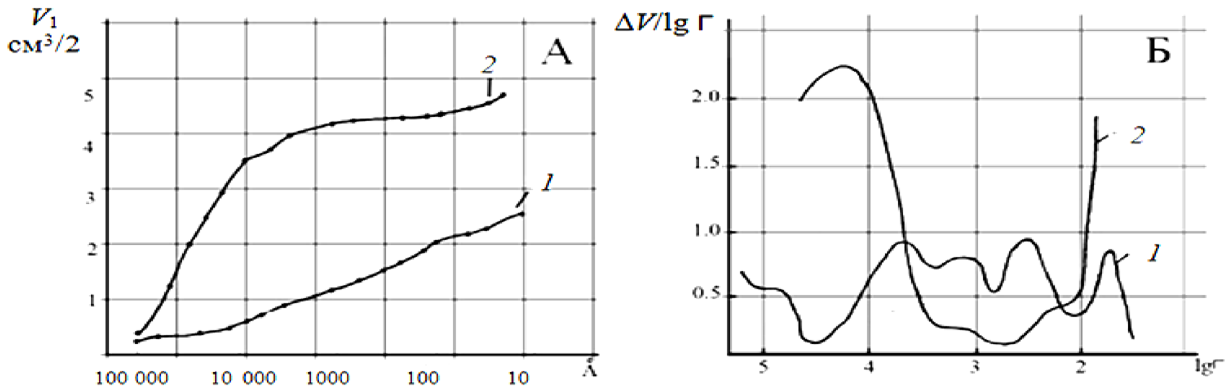

Figure: 2. Integral (A) and differential (B) pore size distribution curves:
1 – expanded inaglinsky vermiculite;
2 – expanded Aragatsky perlite

Thus, as the particle size increases, the volume of large pores grows, which is especially noticeable in vermiculite; moreover, expanded pearlite has a smaller spread of pores in diameter, which is associated with the peculiarities of its structure, isotropy, and grain shape. Expanded vermiculite has an anisotropic structure and a large open surface.

With an increase in the grain size of expanded vermiculite and a decrease in the bulk density, the thermal conductivity decreases, and the grain size composition has a greater effect on thermal conductivity than the bulk density. From the above it follows that for the purposes of thermal insulation at t <100 ° C it is rational to use vermiculite of medium and large fractions. It was experimentally established that the expanded vermiculite of the investigated deposits in terms of thermal conductivity meets the requirements of GOST.

Fractionated product (large and medium) corresponds to grade 100 (ρn <100 kg / m^3, 0 <0.065 W / mK. Vermiculite of fraction 0.6–10 mm corresponds to grade 150. Vermiculite of fine fractions (<0.06 mm) does not meet the regulatory requirements and was not used in the work. With decreasing particle size, the thermal conductivity of vermiculite increases more rapidly than that of pearlite.

Since thermal conductivity is one of the most important thermophysical characteristics of heat-fire retardant materials, the nature of the change in this indicator for expanded vermiculite and pearlite with increasing temperatures is of particular interest. In fig. 3 shows the dependence of thermal conductivity on the temperature of expanded vermiculite M-150 and pearlite M-100 (fraction 0.6–10 mm). For comparison, an ultra light thermal insulation material - foam asbestos M-25 was tested.

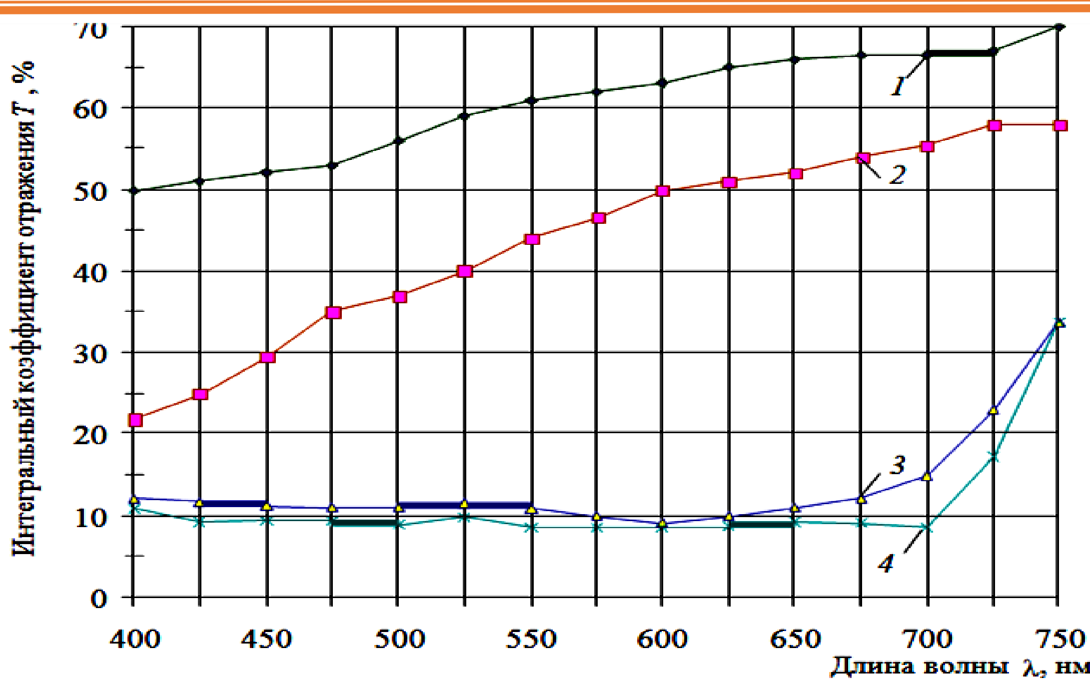

Fig. 3. Dependence of the reflection coefficient on the light wavelength of expanded vermiculite (perlite) fraction 0.14–0.315 mm:

Vertical - Integral reflection coefficient T,%

Horizontal – wavelength, nm

1 – expanded vermiculite; 2 – expanded perlite; 3 – expanded vermiculite "black"; 4 – expanded perlite "black"

The test results indicate that a significant increase in thermal conductivity as the temperature rises from 200 to 600 ° C was noted in foam asbestos (6 times!), A minimum - in expanded vermiculite (2 times) and expanded perlite by 2.6 times. Such an intensive increase in the thermal conductivity of asbestos foam is associated with the presence of a large number of large interconnected pores and significant air convection. This is typical for mineral fiber insulation materials. As a result, at elevated temperatures, foam asbestos works worse than perlite and vermiculite thermal insulation.

A slight change in the thermal conductivity of expanded vermiculite at elevated temperatures is explained by the fact that it has a golden or silver color and belongs to materials with a low emissivity C = 2.5 • 103J / (m² • K) (aluminum foil has C = 1.7 • 103 J / (m² • K)). At the same time, for theoretical research, it is generally accepted that an "absolutely black body" has C = 20.84 • 103 J / (m² • K).

Thus, vermiculite is a necessary heat-insulating material and, according to its refractory properties, can be used on a wider scale in the construction of buildings and structures, which will contribute to a tangible fire safety traverse, as a result of which the number of casualties in fires, both in residential and in the manufacturing sectors.

1-picture. Various forms of crushed fraction of vermiculite mineral

A series of experiments were conducted on the composition of mineral raw materials based on vollastanite, dolomite, vermiculite. Based on the experiments, the wood materials were treated with a new composition and thermally exposed in a special furnace for 50 minutes. While the newly obtained composition made it possible to increase the flammability of wood samples from the current temperature of 350-400 ° C to 880-900 ° C, and the steel composition samples when exposed to 90 minutes of thermal exposure from 1200-1600 ° C, the new composition effective flammable heat-resistant coating was achieved by increasing the value of the critical time (500 ° C) for the metals in use to 1200-1670 ° C.

2-picture. Primary appearance of the vollostanite mineral

Fire risk testing of building structures has shown that when the concrete structure is reinforced with wollastonite ceramic fiber and refractory perlibeton, the facility is more resistant to combined seismic and thermal effects to the maximum. It has been experimentally proven that wollastonite is the most effective flammable material proposed. In the course of the experiment, it was scientifically proven that the proposed new composition of flammable and heat-protective coatings is highly effective. The main scientific achievements of the study of the structural properties of wollastonite, dolomite, vermiculite minerals are the flammability of wollastonite mineral 1800 ° C, 0.1-0.3 μm

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crushed fraction of dolomite + kaolin powder mixture 1750-1810 ° C, expanding the scope of production found to be extremely important for.

CONCLUSION

In the second phase of the experiments, a convenient method of developing high-quality, hard-combustible wood chipboard based on local raw materials using vollastanite, dolomite, vermiculite, kaolin, liquid liquid glass and wood shavings based on flame retardant coatings and low viscosity carboxymethylcellulose was selected. detected. The physical and mechanical properties and flammability of the samples were examined. Preliminary positive results were obtained. These obtained scientific results are being processed.

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