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The study of the insulating properties of a new material based on straw and isoprene rubber C-nitrous vulcanization

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Abstract. Research has been carried out on the thermal insulation properties of a new composite material based on straw and synthetic rubber of low-temperature vulcanization. The values of heat transfer resistance (R_{cp}) and thermal conductivity coefficient (λ) are determined depending on the humidity of the environment.

The problem of energy conservation has become one of the most pressing for our country. Therefore, the development of new efficient and affordable energy-saving materials is an urgent task. On the fields after harvesting, a significant amount of straw remains, which can become the basis for creating a number of new composite heat-insulating materials. The main mass of straw remaining after harvesting is burned [1]. As is known, a straw is a potential competitive heater, based on a renewable environmentally friendly resource base.

Straw is used as a thermal insulation material in house building, namely, in a clay earthen house on a lightweight foundation [2], for the manufacture of building materials, for thermal insulation of walls, ceilings, partitions, etc. [3]. It is used as organic materials for the manufacture environmentally friendly multi-layer lightweight fire-resistant wall panels [4].

Prospects for the use of straw due to its low specific density $\rho \approx 10{,}2$ kg / m3, fiber structure and good physical and mechanical properties. Due to the low weight of straw blocks, the building does not require a heavy foundation; no lifting mechanisms are required for construction.

The straw has a smooth stem, long (up to 50 cm) internodes, small changes in the stem thickness along the length. With relatively thin walls of the stem, rye straw is the most durable and coarse. After moistening, it acquires plasticity, and when dried, it keeps well the shape that was given to it.

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The combination of elastic-deformation properties of the material and the availability of raw materials, straw - unsaturated rubber can be widely used in the production of new heat-insulating materials in rural areas.

To create experimental samples of the material, we used rye straw, isoprene rubber SKI – 3 and one of the available C-nitrous vulcanization systems generating p-dinitrosobenzene [5].

The heat-insulating characteristics of plates made of straw material - rubber of different thickness 10 mm, 20 mm, 30 mm were studied for the first time according to the method [7, 6] using ITP-MG-4.03 X(Y) «Potok» with 3 density sensors of heat flows and 2 temperature sensors attached to the material through a layer of thermal paste KPT-8 (Figure 1.)

Figure 1. Straw material plate - rubber with heat flux density sensors and temperature sensor

A 1l air thermostat was used. A 40 W incandescent lamp was used as a heat source. The data from the sensors of the density of heat fluxes and temperature on the surface of the material with an error of 10% was recorded in the memory of the device every 20 minutes. within 24 hours (Figure 2).

Figure 2. Air thermostat with a device ITP-MG-4.03 X(Y) «Potok».

Heat transfer resistance is determined by the formula: $R_{av} = (T_{in} - T_{out})/ q_{av}$

The arithmetic average values of heat transfer resistance (R_{av}) of plates of different thickness were: $R_{10мм}$= 0,07 м²·°C/W; $R_{20мм}$= 0,29 m²·°C/Вт; $R_{30мм}$= 0,40 м²·°C/W.

Also, the thermal conductivity coefficient of the straw sample was found - SKI-3 rubber according to the GOST method [8] with dimensions of 150x150x9 mm. Using the ITS – 1 device. Value of thermal conductivity λ= 0,046 W/mK.

Figure 3 shows the installation for the study of the coefficient of thermal conductivity λ of a sample based on straw and rubber according to the method of GOST [6].

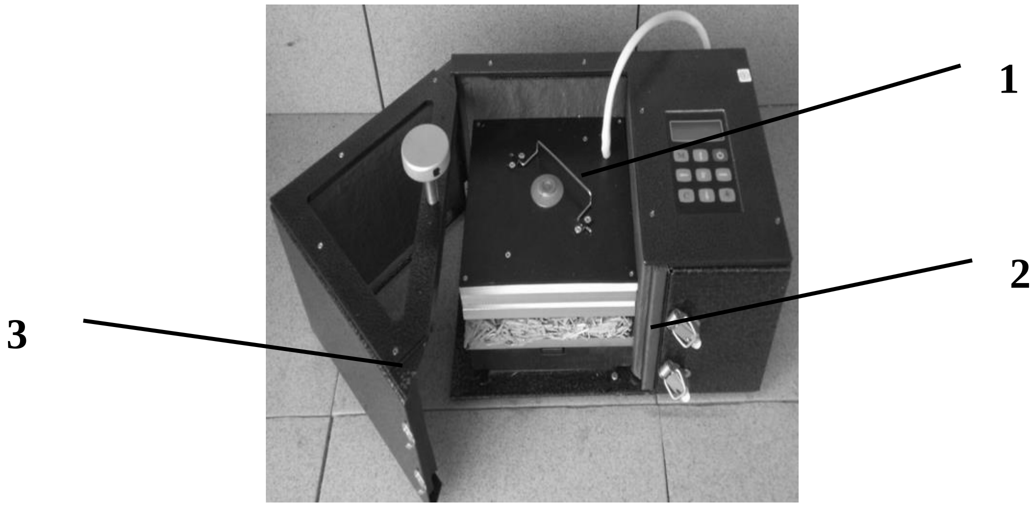

Figure 3. Study of the thermal conductivity coefficient λ of a composite based on straw and rubber using an ITS device - 1

Also, a sample of 150x150x9 mm was placed in a climate chamber CM-70/75-XXTBX with a set temperature of 22 ° C (Figure 4.). In this chamber, the sample was kept for 1 hour with a humidity of 20%. After that, we measured the thermal conductivity λ, which turned out to be equal to 0.054 W / m K.

Following this, a similar series of experiments were carried out by holding the sample for 6 hours with a change in the relative humidity of 40.60.80%, the results of which are presented in Table 1 (the dependence of the thermal conductivity λ on the sample moisture based on straw and rubber).

Figure4. Climate chamber CM-70/75-XXTBX

Table 1
The dependence of thermal conductivity λ on the moisture content of the sample based on straw and rubber.

№	T, °C	Humidity, %	λ, W/m K
1	22	20	0,053
2	22	40	0,057
3	22	60	0,059
4	22	80	0,065

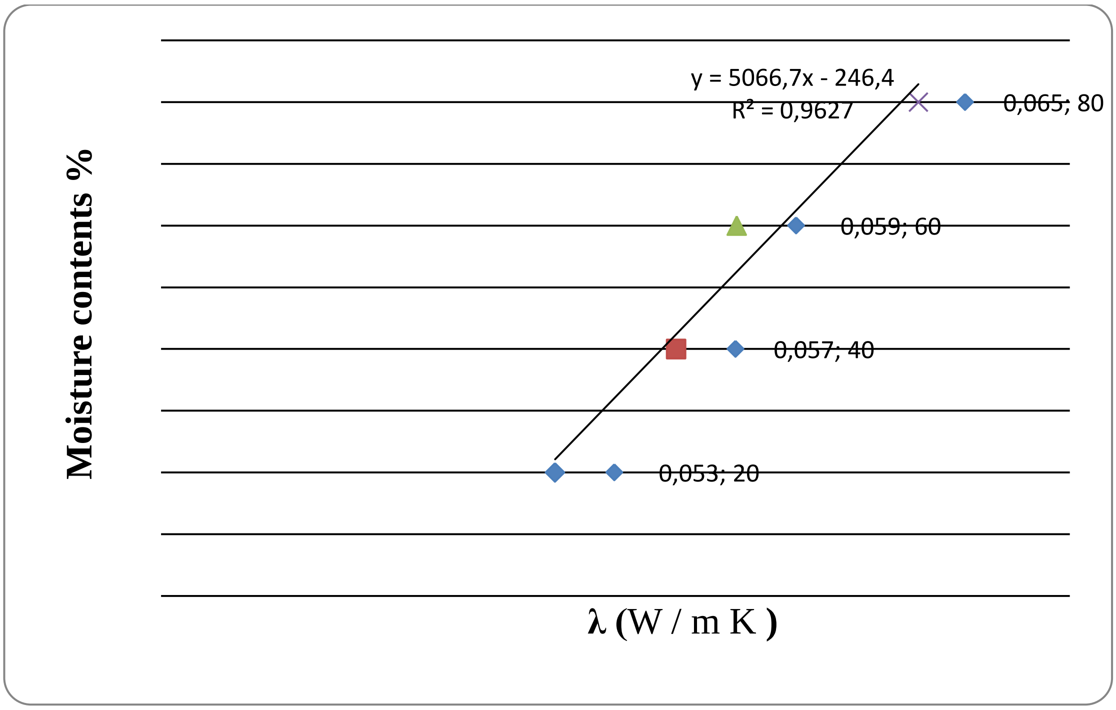

Figure 5. Graph of change of thermal conductivity λ as a function of moisture content in a sample 150x150x9 mm.

As can be seen from the table and graph with an increase in humidity, thermal conductivity coefficient λ does not significantly increase.

A sample based on straw and rubber 150x150x9 mm in size was examined for the influence of the external environment, while the sample was exposed for one year in the open air (Figure 6).

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Figure 6. Sample based on straw and SKI-3 C-nitrous vulcanization rubber after exposure to the external environment for one year.

Under the influence of the external environment, including solar radiation and precipitation, the prototype darkened, and the insulating properties did not significantly change λ = 0.056 W / m K.

The change in the surface layer of the composition is associated by us with the partial destruction of vulcanized SKI-3, which has in its composition double bonds that are not resistant to ultraviolet, oxygen or air ozone. Promising in this regard may be a material based on straw and rubber, SKEPT-ENB- (DCPD) with a C-nitrous vulcanization system, known for its high heat resistance [9, 10].

Conclusion

For the first time, the values of heat flux density and thermal conductivity of a sample based on straw and rubber λ = 0.04 (W / m K) were measured experimentally. After accelerated thermal aging, the sample retained its previous form, destruction was not observed, and the thermal conductivity remained at the same level . We see the prospect of research on heat insulating material based on straw and rubber type SKEPT-ENB- (DCPD).

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