СТРОИТЕЛЬНЫЕ МАТЕРИАЛЫ

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TO THE QUESTION OF STUDYING THE CONVECTIVE PROPERTIES OF THERMAL INSULATING MATERIALS

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The popular heat-insulating materials presented on the market of the Republic of Belarus are considered and compared with the screen heat-insulating material presented in the form of aluminum foil.

Formulation of the problem. The increase in the energy efficiency of residential buildings, dictated by the energy crisis, required a significant increase in regulatory requirements for the resistance to heat transfer of the building envelopes and the development of a set of energy-saving measures.

At the moment, the issues related to the use of screen thermal insulation in modern enclosing structures have not been sufficiently studied. At the same time, the lack of a methodology for calculating such heat-shielding systems and technical solutions for the insulation of building envelopes hinders the use of the above materials in construction.

Analysis of preliminary studies. Given the wide variety of thermal insulation materials, an important issue is their systematization and the development of highly efficient materials. Thanks to the research carried out, a wealth of experimental experience has been accumulated and effective materials have been developed to ensure thermal insulation of buildings and structures. And carrying out a comparative analysis of materials will allow you to choose the path of developing new compositions for the manufacture of heat-insulating materials and their effective optimization. It is known that the main requirements for thermal insulation materials are low thermal conductivity and suitability for thermal insulation of building structures of residential, industrial and agricultural buildings, surfaces of production equipment and units (industrial furnaces, turbines, pipelines, refrigerator chambers, etc.). These materials should have a low average density - no more than 600 kg/m^3, which is achieved by increasing their porosity [3]. In civil and transport construction, thermal insulation allows you to reduce the thickness of the enclosing structures (walls, roofs), reduce the cost of basic building materials (brick, concrete, wood), lighten structures and reduce their cost, and reduce fuel costs during the operating period. In technological and power equipment, thermal insulation reduces heat losses, provides the required technological temperature regime, reduces the specific fuel consumption per unit of production, and improves working conditions. To obtain a sufficient effect from the use of thermal insulation, in engineering projects, appropriate thermal calculations are carried out, in which specific types of thermal insulation materials are taken and their thermophysical characteristics are taken into account [2]. In recent years, dozens of new heat-insulating materials have appeared on the Ukrainian construction market, thanks to which a significant breakthrough has taken place, primarily in the field of energy saving. With the development of new technologies, modern insulating materials have become more efficient, environmentally friendly, diverse and meet specific construction specifications: the possibility of building high-rise buildings, reducing the thickness of the enclosing structures, reducing the mass of buildings, the cost of building materials, as well as saving fuel and energy resources while ensuring normal indoor climate.

Organic heat-insulating materials are made from natural raw materials: woodworking and agricultural waste, peat, as well as various plastics, cement. This is a fairly large group of materials available on the market in an extensive range. Almost all organic heat insulators are characterized by low fire, water and biological resistance. As a rule, organic heat insulators are used in areas where the surface and ambient temperature does not rise above 150 degrees, as well as as a middle layer of multilayer structures - in plaster facades, wall cladding, in triple panels, etc. More resistant to action moisture, fire and bioagents, materials made of gas-filled plastics (expanded polystyrene, expanded polystyrene, expanded plastic, honeycomb, etc.). Cellular plastics now occupy a significant market share in thermal insulation materials. Heaters based on them enjoy well-deserved popularity due to their physical properties, low cost, ease of processing and durability.

The analysis of research materials and publications [1-7] indicated the problems of using modern heat-insulating materials. If we talk about expanded polystyrene, then its main negative properties are fragility, flammability and environmental hazard. As the experience of construction shows, the expanded polystyrene embedded in the walls is destroyed in 10-15 years. The same is the case with mineral wool products. Already after

7-9 years, they turn into a dusty state, which is environmentally unsafe. Consequently, the use of foam and mineral wool products in construction leads to the fact that after 7–10 years the enclosing structures will not provide the required thermal resistance. Despite the advantages of aerated concrete in comparison with other heat-insulating materials, they have significant disadvantages. High water absorption results in low moisture and frost resistance. Their increased hydrophobicity reduces adhesion to the surface and makes plastering difficult. Low strength in combination with high density and insufficient thermal insulation properties narrows the area of their application [5].

Today, as thermal insulation materials are often used: mineral wool, expanded polystyrene, penoplex. All of the listed heat-insulating materials are in great demand, but do not forget about their service life, emission of toxic substances and cost. At the moment, in the Republic of Belarus there are no heat-insulating materials or structural solutions for walls, at least on the market, that would be cheaper and more energy efficient. An alternative to this material can be screen heaters, which will be played by foil.

The use of such materials in construction is constrained by the lack of experimental data on the thermal resistance of closed shielded air layers, as well as a methodology for calculating building envelopes insulated with the use of shield thermal insulation.

Having studied this problem, we conducted laboratory studies in which we tried to improve the thermal insulation qualities of insulating materials.

Purpose of the study. Consider the popular heat-insulating materials on the market of the Republic of Belarus and compare them with the shield heat-insulating material presented in the form of aluminum foil.

Research results and discussion. Digital temperature sensors were used to monitor the temperature readings.

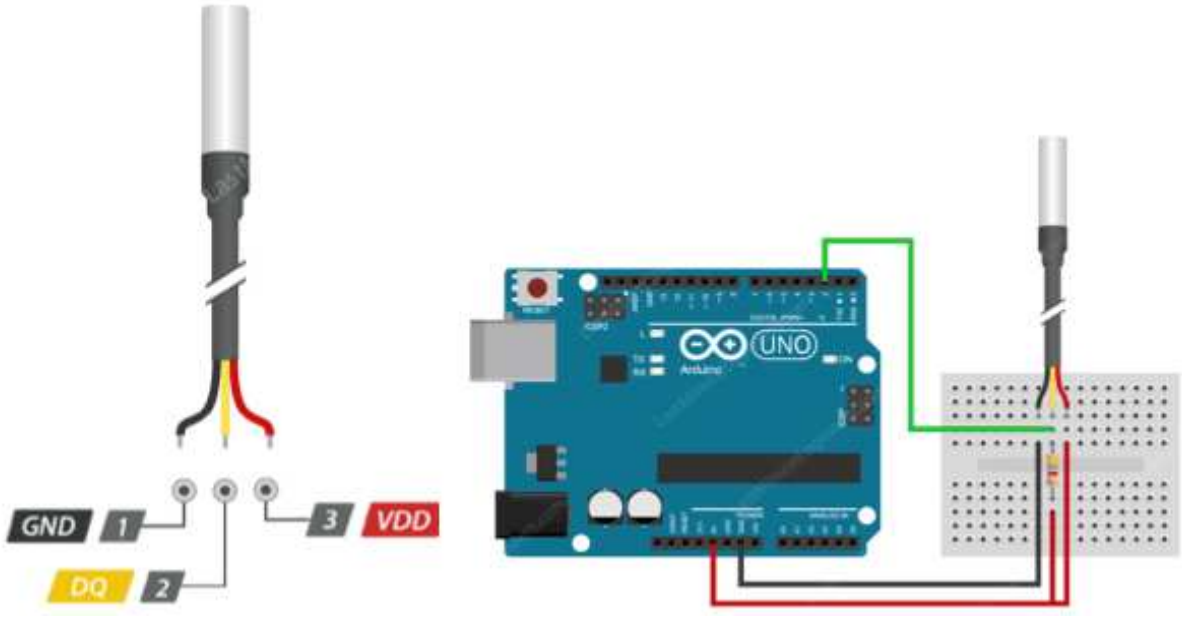
Main characteristics of digital temperature sensor ds18b20:

– range of measured temperature from -55 to +125 °C;
– measurement error in the range from -10 to + 85° C is 0.5 °C.

The connection diagram of the ds18b20 sensor to the microcontroller (for example, Arduino) is shown in Figure 1:

GND, VDD - power pins (3.3 to 5 V);

DQ - digital output for connection to a microcontroller.



A B

A - diagram of the terminals of the ds18b20 sensor;
B - wiring diagram of the ds18b20 sensor through a 4.7 kOm pull-up resistor to the Arduino uno microcontroller

Figure 1. − Connecting the ds18b20 sensor to the Arduino uno microcontroller

Based on the analysis of existing heat-insulating materials, we carried out laboratory studies in which, in addition to insulation (mineral wool, penoplex, expanded polystyrene), aluminum foil was used as a screen insulation. A cardboard box with different insulation inside was used as a model. The following materials were chosen as insulation materials: polystyrene, foil, mineral wool and wood concrete. A sample (with sensors inside) was placed on the setup, a lamp inside the sample was turned on and heated the space (Fig. 2.). The readings of temperatures were recorded by sensors and provided information to the specialized program Arduino uno. The automated processing of the obtained experimental data was carried out using the Microsoft Office Excel software package.

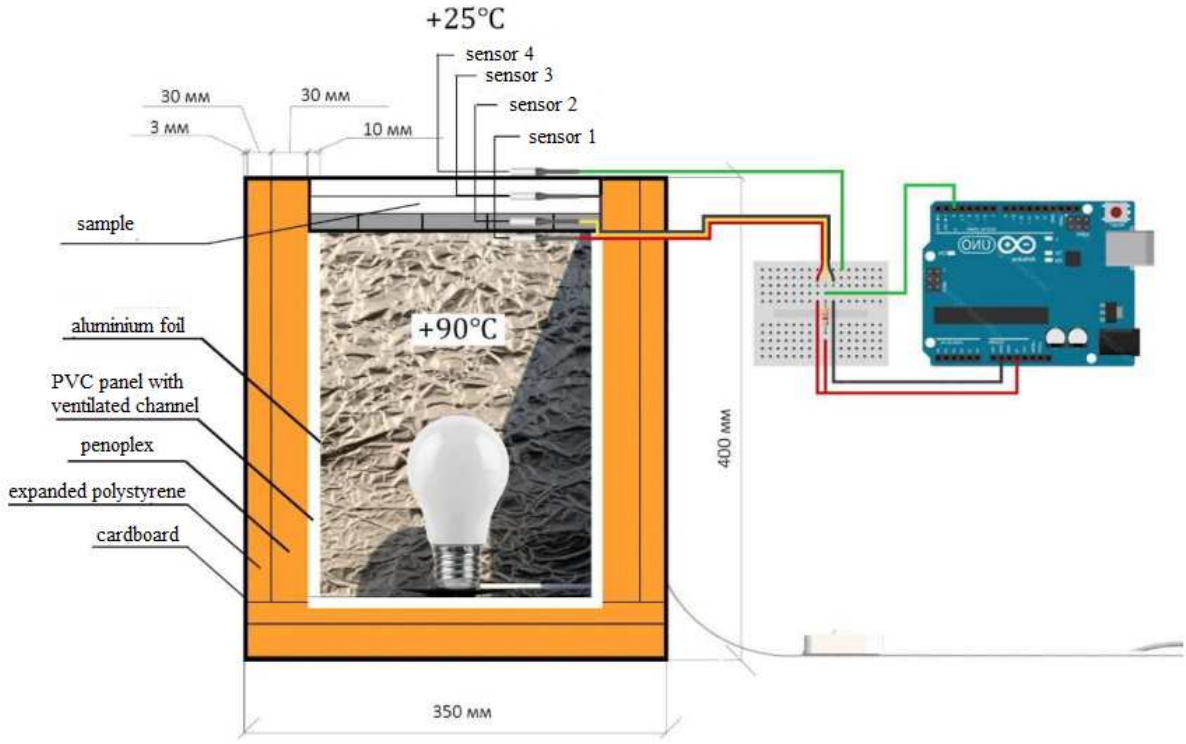


Figure 2. − Sectional view of the pilot plant

On top of the pilot plant was placed a prototype, which was a box with ribs (which formed an air gap) and an empty space into which various insulation materials 30 mm thick were laid. The pilot plant was heated to create a temperature difference of + 80-90 ℃ and 23-25 ℃, after heating, the incandescent lamp was turned off and the temperature readings were monitored and the rate at which the heat from the pilot plant went outside.

Conclusion. Today, in addition to convection and heat conduction, radiative heat transfer also takes place in the system under consideration, especially in the case of using heating devices with a significant share of heat transfer by radiation (the "Plan" system). Radiation heat exchange can significantly affect the nature of the distribution by the microclimate parameter. Due to the fact that air is a mixture consisting mainly of two atomic gases, it does not represent an obstacle to thermal radiation, that is, it is diathermic. It can also be assumed that bodies in a room form a closed system of gray surfaces that diffusely radiate and reflect. All surfaces can be considered gray surfaces if radiation of practically uniform spectral composition propagates in the system, i.e. when radiation from high-temperature sources (the sun) and bodies with ordinary room temperature is not simultaneously considered. Even surfaces with pronounced mirror properties can be considered diffusely reflecting in calculations, if chaotically oriented radiation falls on these surfaces (the air - foil system in several layers).

When reconstructing or overhauling buildings of architectural or historical value, it is not possible to insulate the walls from the outside. Therefore, in order to preserve the external historical appearance of the building, it is advisable to use an internal insulation system, in which the thermal insulation is located on the inside of the enclosing structure.

So far, we have carried out preliminary tests on a standard machine and have received first encouraging results. For example, the required resistance to heat transfer for the first sample using aluminum foil was 0.764 m^2·K/W, which is more than 0.623 m^2·K/W for the control sample using mineral wool.

After the completion of laboratory tests, we plan, according to the existing agreement with the plant KPD Stroytrest No. 17 and the Novopolotsk City Executive Committee, to carry out factory tests and, if these tests

give a positive result, to launch the new solution into the serial production of residential houses, first in our region, and then throughout the Republic of Belarus, which may allow, subject to the implementation of the remaining measures we plan, in terms of internal structures, the transition to an open typification system, etc., to reduce the cost of construction by about 3 times, having received the cost 1m2 of total area less than 350 denominated Belarusian rubles.

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