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# RESEARCHING OF THERMOPHYSICAL PROPERTIES OF THE NEWEST MATERIALS USED AS A HEAT-INSULATING LAYER FOR THE DESIGN OF WATER-RESISTANT CLOTHES

# ИССЛЕДОВАНИЕ ТЕПЛОФИЗИЧЕСКИХ СВОЙСТВ НОВЕЙШИХ МАТЕРИАЛОВ ИСПОЛЬЗУЕМЫХ В КАЧЕСТВЕ ТЕПЛОИЗОЛЯЦИОННОГО СЛОЯ ПРИ ПРОЕКТИРОВАНИИ ВОДОТЕРМОСТОЙКОЙ ОДЕЖДЫ

***Alshanski V., professor, PhD,***
***Penkrat D., postgraduate student, a junior research fellow,***
***Okunev R., assistant professor***
***Vitebsk State Technological University, Vitebsk, Republic of Belarus***



*Key words:* *heat-insulating materials, the newest materials, thermophysical properties of materials, a stationary heat exchange, the gaseous medium.*

*Ключевые слова:* *теплоизоляционные материалы, новейшие материалы, теплофизические свойства материалов, стационарный теплообмен, газообразная среда.*

*Abstract. Certain types of newest thermal insulation materials have been investigated. The values of the coefficient of thermal conductivity of the samples are obtained.*

*Аннотация. Проведены исследования некоторых видов новейших теплоизоляционных материалов. Получены значения коэффициента теплопроводности исследуемых образцов материалов.*

The assortment of materials used for designing clothes is rapidly expanding. Designing special water-resistant clothing is a difficult task, because special protective clothing represents a complete or partial barrier between a person and the environment. In the process of operation, clothing of special purpose must be hygienic, comfortable, durable, and not restrict movement, capable of removing perspiration in the form of a vapor-gas and wet phase.

The greatest inconvenience of operation in special protective clothing is caused by the thickness of package of materials. The greatest specific weight of thickness of a package of materials belongs to heat-insulating materials that is caused by their structure. In order to optimize the thickness of the material package, the thermophysical properties of the newest materials were studied.

Data on materials and their physical and mechanical properties are shown in Table 1.

Table 1 – Physical and mechanical properties of samples of materials

| Indicator name | The sample number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Material name | Slimtex | Slimtex | Slimtex | Hoopon | Hoopon | Hoopon | Isosoft | Isosoft |
| Surface density, g / $m^2$ | 100 | 150 | 250 | 100 | 150 | 200 | 200 | 250 |
| Thickness, m | 0.004 | 0.004 | 0.004 | 0.010 | 0.020 | 0.030 | 0.015 | 0.035 |

Experimental equipment and heat exchange conditions. The sample of the material under study was given the shape of a relatively thin square plate 5, with dimensions of 100x100 mm. The temperature difference was created due to the thermal electric heating element (TET) 3, placed in a heat-insulated chamber 2, to provide a one-dimensional constant heat flow. The power of heat flow Q (W) is equal to the value of the power expended for heating the heater, and is measured directly with the wattmeter. The value of the heat flux Q is set by the autotransformer 1, and equal to 180 W. The temperature values of the surfaces of the test material are determined with the help of thermocouples 6, the hot junctions of which are sewn up both from the side of the influencing heat flux (acting on the lower layer) and from the side not exposed to thermal flux (the upper layer). The scheme of the special equipment is shown in Fig. 1.

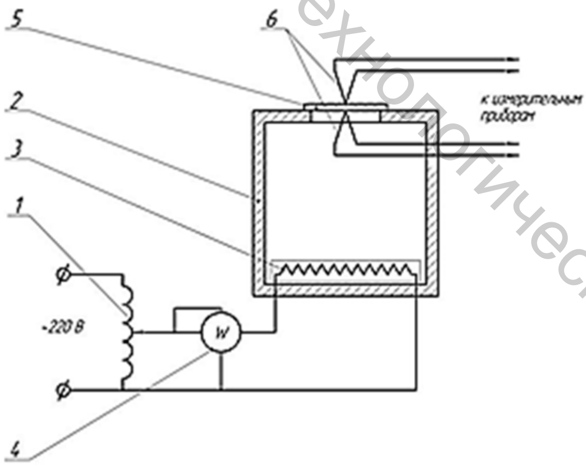


Figure 1 – The model of special equipment for the study thermophysical characteristics:
1 – autotransformer; 2 – the heat insulated chamber; 3 – thermal electric heating element; 4 – the wattmeter; 5 – test sample; 6 – thermocouples

The values of the change in temperature from the surface of the material were fixed from the moment the sample was placed in the experimental setup and until the onset of the stationary regime.

To ensure a constant heat flow after turn on special equipment to the network, it must be heated for 45-60 minutes. The temperature values on the upper surface were fixed at regular intervals, in the interval from 10 to 160 seconds. Temperature of the radiation source $t_{изл}$ = 170 ºC the air in the chamber was heated to $t_c$ = 130 ºC at the surface temperature of the material $t_п \approx 115$ ºC.

As a result, the typical temperature dependences of the surface of the material on the heating time of the internal surface are received and shown in Fig. 2.

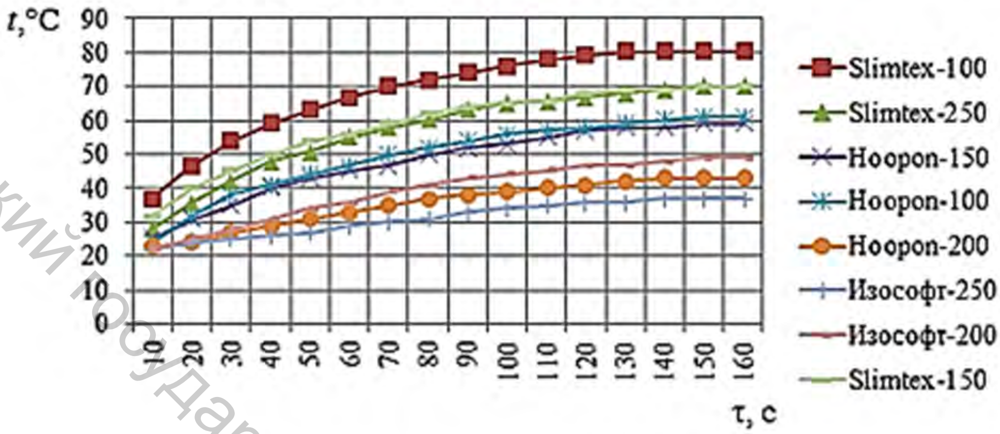


Figure 2 – Graphs of temperature change to time for the upper material layer with a heat flux of 180 W

Method for calculating the coefficient of thermal conductivity. Most of the experimental methods are based on observing the temperature field excited by the heat flux in the body under investigation. With reference to stationary conditions, the Fourier law is used:

$$Q = -\lambda \frac{\partial t}{\partial n} F \quad (1)$$

and the differential heat equation in the form:

$$\frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} = 0 \quad (2)$$

which is valid for bodies whose physical properties are independent of temperature.

The solution of the above differential equation applied to one-dimensional temperature fields for bodies of simple geometric shapes and allows us to find the thermal conductivity coefficient from:

$$\lambda = \frac{Q}{t_{ниж} - t_{верх}} \cdot \delta, \quad (3)$$

where Q is the heat flux, W, δ is the thickness of the flat layer, m.

The general principle of measuring the coefficient of thermal conductivity is to determine the heat flux Q passing through a prototype of a given size, and the temperature difference $t_{down}$-$t_{above}$ on both of its isothermal surfaces or in a careful measurement of the temperatures and location of junctions of thermocouples at any other two points in the direction of motion of the thermal flow. Expression (3) was derived on the assumption that λ is a constant independent of temperature [1].

The results of calculating coefficient of thermal conductivity of materials are presented in Table 2.

Table 2 – Results of calculation of coefficient of thermal conductivity of materials

| Indicator name | The sample number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Material name | Slimtex-100 | Slimtex-150 | Slimtex-250 | Hooopon-100 | Hooopon-150 | Hooopon-200 | Isosoft-200 | Isosoft-250 |
| A coefficient of thermal conductivity of materials, W / m · ºC | 0.019 | 0.025 | 0.017 | 0.027 | 0.050 | 0.066 | 0.038 | 0.062 |

The carried out experimental researches allowed to define values of factors of heat conductivity of new kinds of heat-insulating materials. Values are obtained and graphs of temperature variation in time for the upper material layer are constructed at a heat flux of 180 W. The results of the work will allow selecting the materials with the best thermophysical and physicomechanical parameters that will be used in the formation of packages of materials to improve the ergonomic, hygienic and operational performance of special protective clothing.

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# COLLECTION OF JACQUARD CARPETS

# КОЛЛЕКЦИЯ ЖАККАРДОВЫХ КОВРОВ

***Prishep A., Samutsina N., samusiya@mail.ru***

***Vitebsk State Technological University, Vitebsk, Republic of Belarus***

***Прищеп А.В., Самутина Н.Н.***

***Витебский государственный технологический университет, г. Витебск, Республика Беларусь***

*Key words:* *collection of carpets, carpet design, artistic design.*

*Ключевые слова:* *коллекция ковров, дизайн ковра, художественное проектирование.*

*Abstract. With the use of modern information technologies and package of applied graphical programs Adobe Photoshop pictures of a collection of jacquard carpets were designed, which are supposed to perform two-canvas method from*