EXPERIENCE EXCHANGE

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DETERMINATION OF THE THERMAL CHARACTERISTICS OF THE MATERIAL OF THE INSULATING SHEATH FOR THE TREATMENT OF COLD INJURIES

In the treatment of cold injuries for maximum tissue recovery is very important temperature. The frostbitten area must be warmed up due to the natural heat exchange by the blood circulation, for this the condition of maximum thermal insulation of the affected area must be observed. The article describes the method and provides data on the laboratory determination of thermal conductivity and heat transfer resistance of the material from which the heat-insulating sheaths are made for treatment frostbitten limbs. The results were obtained by the method of stationary thermal conditions at the facility assembled in the department of heat and mass transfer processes of the IPTPN SB RAS. In this paper, a climate chamber, a precision "Tercon" signal converter and non-standard heat flux transducers of the PTP-1B type with integrated temperature sensors are used.

Keywords: climatic chamber, frostbite, low temperatures, heat insulation, thermal conductivity.

The Republic Sakha (Yakutia) is famous for its extremely low temperatures, it is here that the so-called "Pole of Cold" is located - Oymyakon village, where the air temperature in winter falls to -71.2°C. In severe climatic conditions, the problems associated with frostbite and hypothermia of people is of indisputable relevance. During the winter, about 200 people come to hospitals in the Republic of Sakha (Yakutia) with frostbite of the extremities and in a state of profound hypothermia. Proper, timely provision of medical care in the regions of the Far North is largely ensured by qualitative preliminary clinical and technical research [2].

The vast majority of cold injuries cause frostbite of the extremities. In case of severe frostbite of the extremities, for the maximum possible tissue repair, it is necessary to observe the condition of slow and gradual warming of frostbitten tissues due to natural heat exchange by the blood circulation. To this end, the injured limb is thermally insulated as much as possible and various means are used to accelerate blood circulation [1]. One of the original solutions is "Hotutent" developed and produced by the Yakut developer's multilayer insulating material.

The **purpose** of the work is to determine the thermal conductivity of a heat-insulating material "Hotutent", which is used as thermal insulation for extremities of people, who received frostbite under conditions of low climatic temperatures.

A rectangular sample of material "Hotutent" with dimensions of 29.5 cm by 26 cm was examined. The material is stitched through the seams and has a layered structure.

The structure of the material consists of 8 layers:

1. Outer layer: oxford fabric.
2. Bamboo heating insulation filler.
3. Insulation №1. Fuzz
4. Insulation number 2: Deer wool.
6. Bamboo heating insulation filler.
7. Oxford fabric.
8. Inner layer: heat reflective material (foil).

Thermal conductivity was determined by the stationary method at the facility assembled in the department of heat and mass transfer processes of the IPTPN SB RAS. To create a constant temperature difference across the sample thickness, the BINDER MK-53 climate chamber was used. The working temperature range of this chamber is from -40 to +180 °C. Thermostat accuracy in a chamber is ± 1 °C. One side of the plate is maintained at a negative temperature in the chamber of -30 °C, and the other side is at room temperature + 22 °C.

The temperature and heat flux were recorded using a multichannel, precision Tercon signal converter. Converter is coupled with IBM PC through a serial interface type RS -232 C , and allows you to record measurement data of heat fluxes and temperatures in the form of a table or graph.

PTP-1B converters, developed by the Institute of engineering thermophysics of the National academy of sciences of Ukraine (Kiev), were used to measure the heat flux. The PTP-1B sensor is a round thin plate made of a PCB with a diameter of 100 mm and a thickness of 2 mm with six leads. The PTP-1B sensor also contains a resistance thermometer, where the Pt 100 platinum thermometer with a nominal static characteristic W_{100} = 1.385 is used as sensitive element. The nominal value of the resistance thermometer at 0 °C is 100 Ω. The limit of permissible basic relative error of heat flux measurement is ± 4%, and the limit of permissible absolute error of temperature measurement is ± 0.5 K [3].

Such combined sensors are very convenient for use in the experimental determination of resistance to heat transfer and thermal conductivity of materials, since when placing them on both sides of the sample under study, we obtain a complete set of initial data for the calculation.

To place the sample in the boundary plane between the chamber and the room, an extruded polystyrene foam screen with a size of 550 × 550 × 100 mm was made with an opening in the center for the dimensions of the sample plate.

After reaching the specified negative temperature in the climate chamber, the value of which was chosen as - 30 °C,

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and the establishment of a stationary mode, data recording continues for another 5 minutes for calculations, we took the values of fluxes and temperatures averaged over this stationary period.

The value of thermal resistance to heat transfer is determined by the formula 1 [4]:

$$R_k = \frac{t_2 - t_1}{\bar{q}}, \qquad (1)$$

Where t_2, t_1, are temperatures on the warm and cold surfaces of the plate, °C; $\bar{q}$ - the average density of the heat flux W / m2, determined by the formula 2:

$$\bar{q} = \frac{u_2 K_2 + u_1 K_1}{2}, \qquad (2)$$

Where u_2, u_1 , – voltage signals from two heat meters, mV; K_2, K_1, – the corresponding values of the conversion coefficients, W / (m² · mV).

The value of thermal conductivity λ plate, W / (m·°C) is determined by the formula 3:

$$\lambda = \frac{h}{R_k}, \qquad (3)$$

Where - *h* is the plate thickness, m; R_K – calculated by the formula (1) thermal resistance to heat transfer, (m² ·°C) / W. The thickness h was taken as the average profile of about 3 centimeters.

In fig. 3 and fig. 4 shows the graphs of the development of the density of the heat flux and temperatures on the surfaces of the sample.

Thermal resistance to heat transfer of the heat-insulating material for isolation of frostbitten extremities is equal to 1.050 (m ² · K) / W. Thermal conductivity of the material corresponding to the given thickness is 0.028 W / (m · K).

These results confirm declared thermal insulation properties of the material. The obtained value of thermal conductivity is below the tabulated values of thermal conductivity of materials such as mineral wool and low density polystyrene insulation (0.045 W/(m*K)) [5].

Fig.1. Installation for measuring thermal conductivity

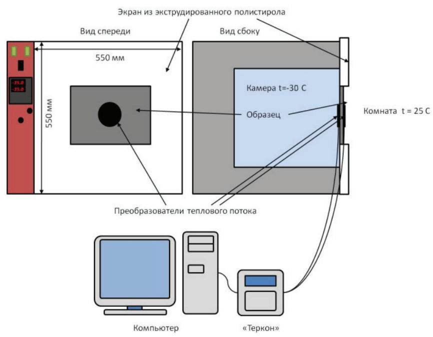

Fig.2. Diagram of the measurement setup

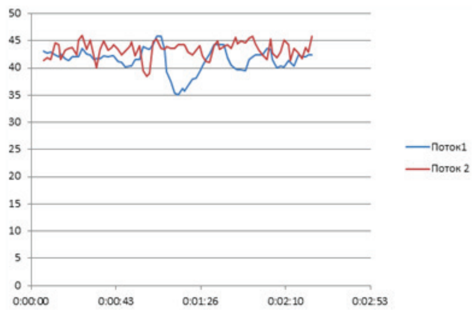

Fig. 3. Graphs of change in the density of the heat flux on the warm and cold sides of the sample on time

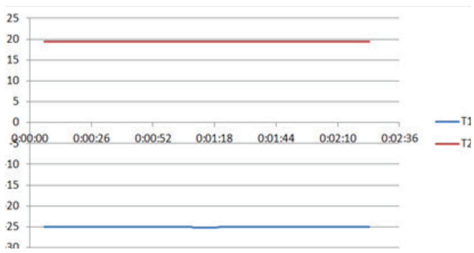

Fig. 4. The graphs change the temperature of the warm and cold sides of the sample over time

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