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A.A. Blagorodov
Institute of Service Sector and Entrepreneurship (f) DSTU
Shakhty, Rostov region

D.O. Bordukh
Institute of Service Sector and Entrepreneurship (f) DSTU
Shakhty, Rostov region

V.T. Prokhorov
Institute of Service Sector and Entrepreneurship (f) DSTU
Shakhty, Rostov region

G.Yu. Volkova
FGBU «Federal Bureau of Medical and Social Expertise»
Moscow

ON THE CRITERIA FOR THE JUSTIFICATION OF THE USE OF MATERIALS FOR THE PRODUCTION OF THE SUIT FOR THE MILITARY SERVICES OF THE ARCTIC WITH THE HELP OF THE DEVELOPMENT OF INDUSTRIAL SUPPORT

Abstract: *Research has been carried out to create a jacket to protect a serviceman from the cold in the Arctic. The basis for the creation of thermal protective clothing for operation in the Arctic should be based on a scientific principle that takes into account the physiology of heat exchange between humans and the environment. When developing thermal protective clothing, the requirements for thermal insulation of all areas of the body should be met. The packages of materials were selected in accordance with the requirements for thermal protective clothing and the materials used for its manufacture. When compiling the packages, the purpose of each layer and the thermophysical characteristics of the materials were taken into account. The materials must meet the criteria that would provide the servicemen with their comfort. The possibilities of the software mathematical editor MAPLE for a reasonable choice of a package of materials for the production of a comfortable suit for Arctic military personnel, as well as the entire range of related products of accessories, to ensure their comfortable conditions when performing their tasks, are considered.*

Key words: *suit, serviceman, in the Arctic, heat-protective jacket, package of materials, nanotechnology, nanomaterials, physical-mechanical and thermophysical characteristics of materials, criteria for a reasonable choice of materials, accessories, suit, comfort, climatic zones, heat-mass transfer.*

Language: *English*

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Introduction

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Criteria for a reasonable choice of a package of materials for the production of a suit for servicemen in the Arctic were chosen as the object of the study. At the same time, preferences will be clarified that would guarantee them comfortable conditions in the performance of their official duties. "Ratnik" is a

Russian military equipment of a serviceman, also referred to as a "set of the soldier of the future." "Warrior" is part of a general project to improve the quality of an individual soldier on the battlefield by using the latest scientific advances in navigation, night vision systems, tracking the psychophysiological state of a soldier, using advanced materials in the manufacture of armor and clothing fabrics. The system is a complex of modern means of protection, communications, weapons and ammunition. Research and development work was carried out by dozens of Russian defense enterprises, such as FSUE TsNIITOCHMASH, NPO Spetstekhnika i svyaz, OAO TsNII Tsiklon, NPO Spetsmaterialov, Tchaikovsky Textile and others. The general designer of the Ratnik equipment is Vladimir Nikolaevich Lepin. As conceived by the creators, the new equipment will be able to compete on equal terms with similar models of equipment of the "soldiers of the future". The "Warrior" includes about 10 subsystems. According to the first deputy chairman of the Military-Industrial Commission established under the government of the Russian Federation - Russia, Yuri Borisov, this kit will have a modular layout and will be adapted to operate in a variety of conditions and at any time of the day.

The "Ratnik" includes several dozen items of weapons, including:

– aramid overalls made of Alyutex fiber of the Kamenskvolokno company, capable of withstanding the hit of fragments of grenades, mines or shells, and also has a certain fire resistance;

– the protection kit includes 6B43 body armor (with ceramic plates) of protection class 6A according to GOST R 50744-95 (adopted in 2002) or Br5 class according to the new GOST R 50744-95 (adopted in 2014, is the main one): in an extended configuration (weight up to 15 kg) or as standard (weight up to 9 kg) - without groin protection (armor plate and anti-splinter module), bulletproof side armor plates, shoulder pads (anti-splinter module). The kit also includes a multi-layer helmet that can withstand the hit of a pistol bullet (protection class 1) from a distance of 5-10 meters.

– the set is equipped with the "Strelets" control system, which includes means of communication, target designation, processing and display of information, identification, which allows transmitting information about the soldier's location to the command post;

– a communicator that determines the coordinates of a serviceman using GLONASS and GPS, to solve the problem of orientation on the ground and target designation and other applied calculations;

– power supply kits;

– safety goggles capable of withstanding 6 mm shrapnel flying at a speed of 350 m / s;

– shields for knee and elbow joints;

– water purification filters, autonomous heat sources;

– automatic, or machine gun, or sniper rifle, equipped with a night vision sight and thermal imaging aiming system;

– video module for shooting from cover. Consists of a thermal imaging sight and a helmet-mounted monitor with a control system, on which an image from the sight is displayed (developed at JSC TsNII "Cyclone", which is part of the holding "Ruselectronics");

– several types of thermal imaging sights - 1PN139 (large-caliber), 1PN140 (for normal observation) and an option for reconnaissance (no name). Developed at TsNII "Cyclone", which is part of the holding "Ruselectronics";

– thermal imaging sight "Shahin" - provides detection, recognition and aimed fire at targets at any time of the day in a simple and complex meteorological environment;

– day-night sighting system (DNPK) for small arms, including a collimator sight (KP) 1P87, night monocular (NM) - 1PN138, a telescope (ZT) - 1P90 and a laser designator (LC) - 1K241. DNPK allows you to significantly increase the effectiveness of hitting targets from small arms, when using a night monocular with a collimator sight or a laser designator - to conduct aimed fire at dusk and in low light conditions. The 3X scope can also be mounted on the weapon in addition to the scope.

– the life support system includes backpacks of various types (universal backpack with a volume of 50 liters, a raid knapsack of 10 liters; a 24 kg unloading vest with interchangeable quick-detachable elements), camouflage kits, a folding heat-insulating pad, a removable insulation for use in winter, a ventilated T-shirt, a vest with compartments for ammunition, a mat, a raincoat, a hat, a comforter, a mosquito net;

– tent, sleeping bag;

– frost-resistant rechargeable battery for powering electronic devices. Multiple batteries can be connected. The modular charger allows you to charge from virtually all AC and DC sources. One battery can withstand 12-14 hours of active work;

– active headphones that allow you to communicate during the battle;

– knife "Bumblebee".

Thus, the formation of the basic requirements for the heat-shielding properties of packages of materials for a suit will allow manufacturers to produce a rational assortment of camouflage clothing and footwear for servicemen in the Arctic.

Main part

When choosing packages of materials for research, we took into account the physical and mechanical, thermophysical characteristics of materials, information about the specifics of the operation of this clothing, which were obtained by us from open literature sources.

A feature of the reasonable choice of packages of materials for a suit for servicemen in the Arctic is the fact that they must provide him not only with a comfortable state due to a guaranteed temperature regime of the clothing space of at least 340C, but also meet all the requirements for the manufacture of heat-protective clothing.

For the study, packages of both imported polymeric materials for the production of jackets and packages of domestic polymeric materials were considered, which were evaluated for their satisfaction with the requirements for heat-protective clothing when military personnel are in climatic zones with temperatures of -200C, -30C and -400C. The results of previous studies using a software product developed by the authors for a reasonable choice of a package of materials in the manufacture of a suit for servicemen in the Arctic showed that at the initial weighted average surface temperature of a soldier of + 360C for all packages of materials using both domestic polymer materials and imported polymer materials, a sharp drop in body temperature is observed at an air temperature of -200C, -30C and -400C, provoking a feeling of discomfort within the first hour of their stay in these conditions, which implies the search for new materials that would guarantee them a comfortable state for at least two hours. Table 1 shows the characteristics of the package of imported polymer materials for the production of jackets, and Table 2 shows the characteristics of the package of domestic polymer materials. The packages of materials were selected in accordance with the requirements for thermal protective clothing and the materials used for its manufacture. When compiling the packages, the purpose of each layer and the thermophysical characteristics of the materials were taken into account.

Domestic hot-melt interlining materials (TKPM), the characteristics of which are given in Tables 1 and 2, will find the greatest application in the manufacture of a suit for servicemen in the Arctic.

Table 1 - Characteristics of a package of imported polymeric materials for the production of a jacket

Model	Package materials	Thickness, mm	Coefficient of thermal conductivity λ, W / m ºC
1	2	3	4
Model 1	Synthetic fabric (100% PE)	1.6	0.042
	Insulation Promaloft (main) Gasket materials: 1. TKPM "Picardy" 1242 \ 17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 4. TKPM AKR-622 \ AKR218	12.0 1,2 1,3 2.1 3.5	0.034 0.041 0.031 0.021 0.009
	Lining fabric	0.76	0.039
Model 2	Synthetic fabric (100% PE)	1.6	0.042
	Insulation "Hollofan" 2 layers basic Gasket materials: 1. TKPM "Picardy" 1242 \ 17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 3. TKPM AKR-622 \ AKR218	12.0 1,2 1,3 2.1 3.5	0.036 0.041 0.031 0.021 0.009
	Lining fabric	0.76	0.039
Model 3	Synthetic fabric (100% PE)	1.6	0.042
	Insulation "Kombisherst" "250 + 150" basic Gasket materials: 1. TKPM "Picardy" 1242 \ 17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 3. TKPM AKR-622 \ AKR218	12.0 1,2 1,3 2.1 3.5	0.33 0.041 0.031 0.021 0.009
	Lining fabric	0.76	0.039

Table 2 shows the characteristics of a package of domestic polymeric materials for the production of a jacket.

Table 2 - Characteristics of a package of domestic polymeric materials for the production of jackets.

Model	Package materials	Thickness, mm	Coefficient of thermal conductivity λ, W / m °C
1	2	3	4
Model 1	Membrane fabric	3.5	0.06
	Sintepon (100% PE) basic Gasket materials: 1. TKPM "Picardy" 1242 \ 17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 4. TKPM AKR-622 \ AKR218	15 1,2 1,3 2.1 3.5	0.035 0.041 0.031 0.021 0.009
	Fleece	1,2	0.039
Model 2	PE fabric (art. 06617-kv)	2.1	0.040
	Insulation Termofinn Micro basic Gasket materials: 1. TKPM "Picardy" 1242 \ 17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 4. TKPM AKR-622 \ AKR218	15 1,2 1,3 2.1 3.5	0.036 0.041 0.031 0.021 0.009
	Viscose-complex lining fabric	0.6	0.044
Model 3	Blended fabric (67% PE + 33% CL)	1.8	0.041
	Wool stitched fabric 2 layers (80% PE + 20% wool) main Gasket materials: 1. TKPM "Picardy" 1242 \ 17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 4. TKPM AKR-622 \ AKR218	 20 1,2 1,3 2.1 3.5	 0.038 0.041 0.031 0.021 0.009
	Lining fabric art. 32013	0.69	0.049

Each material from the compiled bags meets the requirements for the manufacture of thermal protective clothing.

The difficulty in compiling the package was the lack of information on a number of materials. Therefore, packages of materials for models No. 1- No. 3 are made up of the most famous imported materials, and packages No. 1 * - No. 3 * are made up of materials of domestic production.

The difficulty in choosing a package of materials also lies in the fact that when choosing the materials used for a specific product, it is necessary to take into account the region in which these products will be used, since specific products will be subjected to different operating conditions in relation to climatic zones. This is especially true for heat-protective clothing used in the Arctic.

Let us repeat and name the main criteria for the comfort of clothes: the temperature of the skin, which should not be lower than 33.3 ° C, and the temperature of the underwear space should be at least 34 ° C, that is, the microclimate of the underwear space is an indicator of its comfort, including when exposed to low temperatures. For a person, it is not indifferent which part of the body is cooled more while maintaining the total heat transfer, for example, strong cooling of the legs cannot be fully compensated by heating another part of the body without disturbing the person's sense of comfort. Therefore, it was so important to develop a mathematical model to justify the choice of a package of materials in order to create comfort for a serviceman, taking into account the duration of exposure to low temperatures.

The concept of the mathematical model is based on the representation of clothing as a set of multilayer packages of materials of various shapes and compositions.

To calculate the temperature distribution, the authors used the Maple mathematical packages.

The solution to the problem was reduced to finding such a combination of materials for the package, which would realize a minimum of heat flux from its surface while limiting the volume of the package. Thus, we can conclude that using the proposed mathematical model, it is possible to optimize the choice of materials for the manufacture of a heat-protective suit.

Consider the temperature distribution problem $T_i i$ - th layer in the details of the suit, which is a cylindrical multilayer surface. The ambient temperature is kept constant, equal to T_0 ... The heat flux of density comes from the body to the inner surface of the garment q ... On the outer surface of clothing, heat exchange with the environment occurs according to Newton's law with a heat transfer coefficient α.

Let us introduce the following notation for the basic criteria:

t - time; $T_i(r,t)$ - temperature i -th layer; λ_i - coefficient of thermal conductivity i -th layer; a_i - coefficient of thermal diffusivity i -th layer; R_{i-1}, R_i - inner and outer radii i -th layer; $i = 1,2...n.$

Now consider n - layered hollow cylinder and boundary value problem

$$\frac{\partial T_i}{\partial t} = a_i \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T_i}{\partial r}\right), \quad R_{i-1} < r < R_i \quad i = 1,2...n. \quad (1)$$

With boundary conditions:

$$\lambda_1 \frac{\partial T_1}{\partial r}(R_0,t) + q = 0;$$

$$\lambda_n \frac{\partial T_n}{\partial r}(R_n,t) + \alpha(T_n(R_n,t) - T_0) = 0 \quad ; (2)$$

Ideal contact is assumed between the layers:

$$T_{i-1}(R_{i-1},t) = T_i(R_{i-1},t);$$

$$\lambda_{i-1}\frac{\partial T_{i-1}}{\partial r}(R_{i-1},t) = \lambda_i \frac{\partial T_i}{\partial r}(R_{i-1},t), \quad i = 2,..,n. (3)$$

Initial conditions

$$T_i(r,0) = \phi_i(r), i = 1,..,n. \quad (4)$$

Solving the problem, it is possible to find the temperature distribution in the layers of the suit and, in particular, the change in the temperature of the underwear space depending on time.

The passage of heat through a multilayer spherical wall is described by a system of heat conduction equations:

$$\frac{\partial T_i(r_i,t)}{\partial t} = a_i \frac{1}{r_i}\frac{\partial^2 (r_i T_i(r_i,t))}{\partial r_i^2}, \quad (5)$$

$R_{i-1} \le r_i \le R_i$, Where R_{i-1}, R_i - inner and outer radii i - th layer,

t - time, a_i - thermal diffusivity i - th layer, $(i = 1,...,n)$.

The heat flux of density arrives on the inner surface of the ball segment from the foot q:

$$\lambda_1 \frac{\partial T_1}{\partial r_1}(R_0,t) + q = 0. \quad (6)$$

On the outer surface of the body, heat exchange with the environment occurs according to Newton's law with the heat transfer coefficient α:

$$\lambda_n \frac{\partial T_n}{\partial r_n}(R_n,t) + \alpha(T_n(R_n,t) - T_c) = 0. \quad (7)$$

We will assume that there is an ideal contact between the layers, which is expressed by the following relations:

$$T_{i-1}(R_{i-1},t) = T_i(R_{i-1},t),$$
$$\lambda_{i-1}\frac{\partial T_{i-1}}{\partial r_{i-1}}(R_{i-1},t) = \lambda_i \frac{\partial T_i}{\partial r_i}(R_{i-1},t), \quad (8)$$

$i = 2,...,n.$ At the initial moment of time, the temperature of the telp is set

$$T_i(r_i,0) = \phi_i(r_i), \quad (9)$$

$$i = 1,..,n...$$

Thus, the process of heat passage through the spherical segment from the body to the outer surface is described by the boundary value problem with the initial conditions given above.

When calculating, we took into account the following criteria:

- the thickness of the layers of materials in the package;
- coefficient of thermal conductivity and thermal diffusivity of package materials;
- the density of the heat flow coming from the body;
- ambient temperature;
- initial temperature of the package of materials;
- coefficient of heat transfer from the outer surface of the package to the environment;
- the presence of an additional layer in the form of thermal underwear and a woolen sweater.

When calculating, it was also taken into account that a person has guaranteed thermal protection of the legs, arms and head, that is, he is dressed in accordance with climatic conditions.

The calculation results are presented in Figure 1 for imported materials and in Figure 2 for domestically produced materials. These figures show the dependence of the weighted average temperature of the skin of the human body on the time spent at low temperatures (-20 ° C; -30 ° C; -40 ° C). It can be seen from the above figures that at the initial weighted average skin temperature of + 36 ° C for all packages of materials, a sharp drop in body temperature is observed at an air temperature of -20°C, -30°C, -40°C.

Analysis of the research results confirmed the justification of using TKPM as cushioning materials in the manufacture of a suit for servicemen of the Arctic, since with all TKPM, the comfort of a serviceman is provided for 2 hours of his stay in climatic zones with an ambient temperature of -20 ° C and -30 ° C, but comfortable conditions when it is in the climatic zone at -40 ° C is provided only with the use of TKPM AKR-622 / AKR218, the thermal conductivity coefficient of which is the lowest, namely λ = 0.009W / m · ° C.

If for shoes and clothes the software developed by the authors allows to formulate requirements for a package of materials and ensure a comfortable state of servicemen for the performance of their official duties, then for the face, hand, big toe, comfortable conditions are guaranteed without additional research on the selection of packages of materials. fails.

The characteristics of the materials for gloves, the use of which would be justified, is given in table 1.

The analysis of foreign experience has shown that the so-called mitts are used together with gloves.

Mittens - gloves without fingers held on hand with the help of jumpers between the fingers or due to the plastic properties of the material from which they are made. Mitts protect your hands from cold, but do not hinder the movement of the fingers.

Initially, mitts were used to protect against the cold when performing work that required finger mobility. But starting from XVIII century mitts began to be used as a fashionable female accessory, ladies wore mitts indoors, respectively, mitts performed more an aesthetic rather than a practical function. This fashion lasted even in 19th century... Both simple knitted mitts and lace were used, and they could reach in length both to the middle of the arm and to elbow...

In Russia mitts were used in 19th century and were considered women's gloves. At the moment, mitts are used as women and men, but still considered to be more feminine accessory clothes... Women's mitts can be decorated with various patterns...

In some models, the material may slightly cover the fingers, in other models, the material covers only the palm and back of the hand. Mitts can also cover not only the palm, but also part of the hand, rising more or less high.

There are different types of mitts: ordinary mitts without fingers; mitts with a clip-on mitten; "Pipes" without compartments for fingers and palms.

The peculiarities of the choice of materials for gloves for servicemen in the Arctic are provoked by the climatic conditions of this zone in order to guarantee him comfortable conditions during the entire period of use or his military duties. At the same time, special attention was paid to ensuring the comfort not only of the soldier's hand, but especially the index finger of the right, if he is right-handed, and of the left hand, of course, if he is left-handed. This need is dictated by the specifics of the performance by the military personnel of their duties, namely, to carry out shooting, in which a more intensive cooling of the index finger is provoked.

The use of mitts provides the soldier with additional protection for the hand, and what is especially important, for the index finger, while the main protection is provided by the glove, and here the authors test not only different wool, but also yarn, forming it from one or double thread.

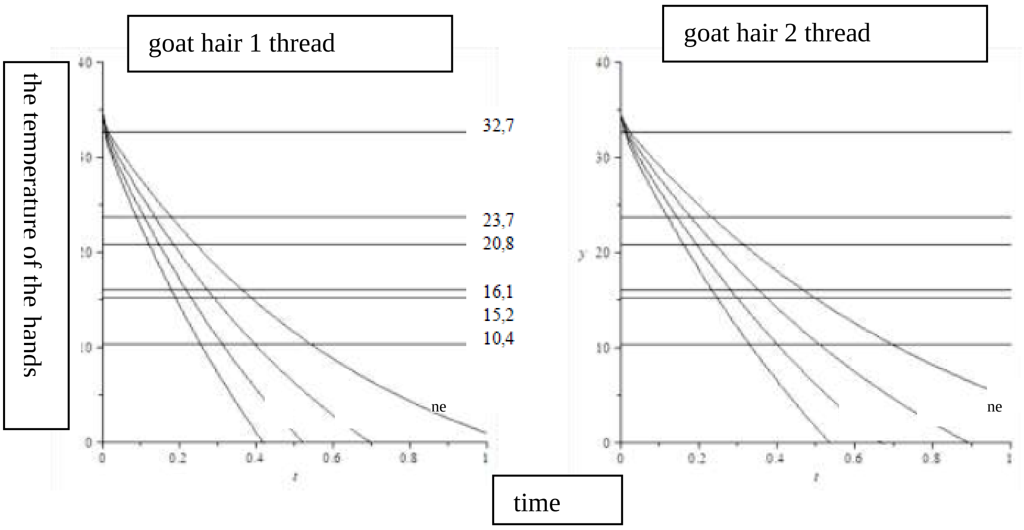
Possibilities of using nanomaterials capable of thermoregulation and providing the skin of the hand with a comfortable temperature, not less than 32 ° C. Such studies are possible using the same software that the authors developed and used for materials, the characteristics of which are given in Table 3.

Table 3 - Characteristics of materials for the manufacture of gloves for military personnel in the Arctic

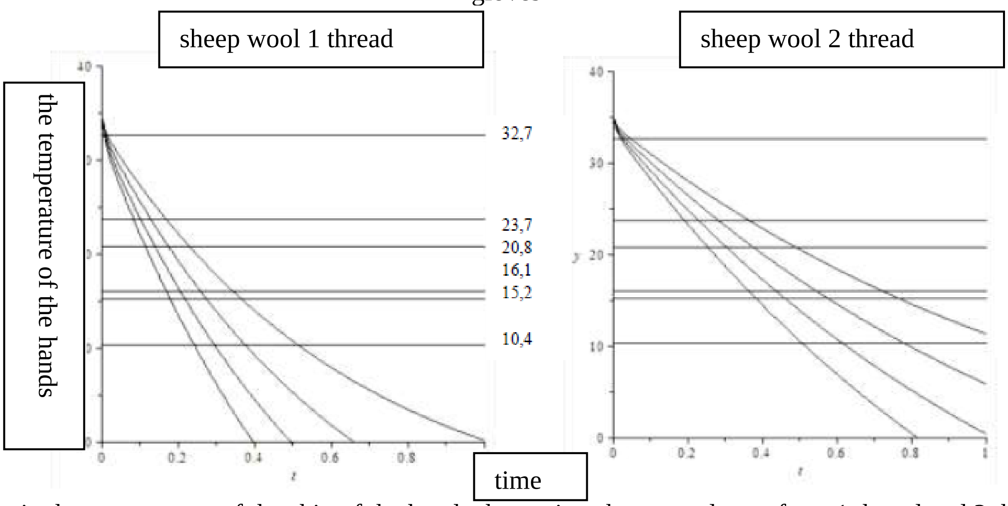
Materials used to make gloves	Thickness mm	Coefficient of thermal conductivity, λ, W / m ° C
1 Single strand yarn:		
1.1 From goat hair	0.7	0.015
1.2 Sheep wool	0.8	0.020
1.3 Camel	0.9	0.005
1.4 From dog hair	0.8	0.010
2. Two-strand yarn:		
2.1 From goat hair	1.4	0.015
2.2 From sheep wool	1.6	0.020
2.3 From camel	1.8	0.005
2.4 From dog hair	1.6	0.010
3. A package of materials for the index finger of the hand, suede + yarn from one strand		
3.1 when using goat hair	1.7	0.02 / 0.015

3.2 when using sheep's wool	1.8	0.02 / 0.020
3.3 when using camel hair	1.9	0.02 / 0.005
3.4 when using dog hair	1.8	0.02 / 0.010
4. A package of materials for the index finger of the hand, suede + yarn from two strands		
4.1 when using goat hair	2.4	0.02 / 0.015
4.2 when using sheep's wool	2.6	0.02 / 0.020
4.3 when using camel hair	2.8	0.02 / 0.005
4.4 when using dog hair	2.6	0.02 / 0.010
5 Material for the fingertip of the index finger of the soldier's hand - "natural suede leather" and for mitts	0.8	0.020

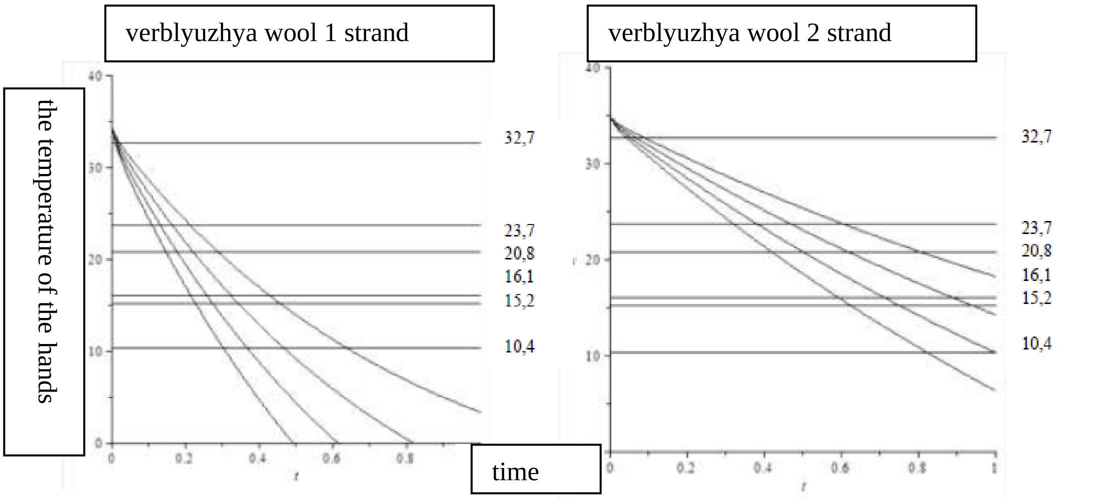
With the help of the software developed by the authors, graphs were constructed characterizing the condition of the skin of a soldier's hand for four ambient temperatures, namely: - 100C, -200C, -300C, -400C from the time he spent at the post, but not less than 1 hour. The figures show the temperature values of the skin of the hand, characterizing the various heat sensations of a serviceman, namely, comfort 32.7 ° C, slightly cool 23.7 ° C, cool 20.8 ° C, cold 16.1 ° C, very cold 15.2 ° C, pain 10.4 ° C (frostbite). At -10 ° C, a comfortable state is provided only by a suede-dog hair package (double thread), and for -20 ° C, -30 ° C, - 40 ° C, none of the materials under study and their packages together with natural fur "winter" do not guarantee comfortable conditions for servicemen.



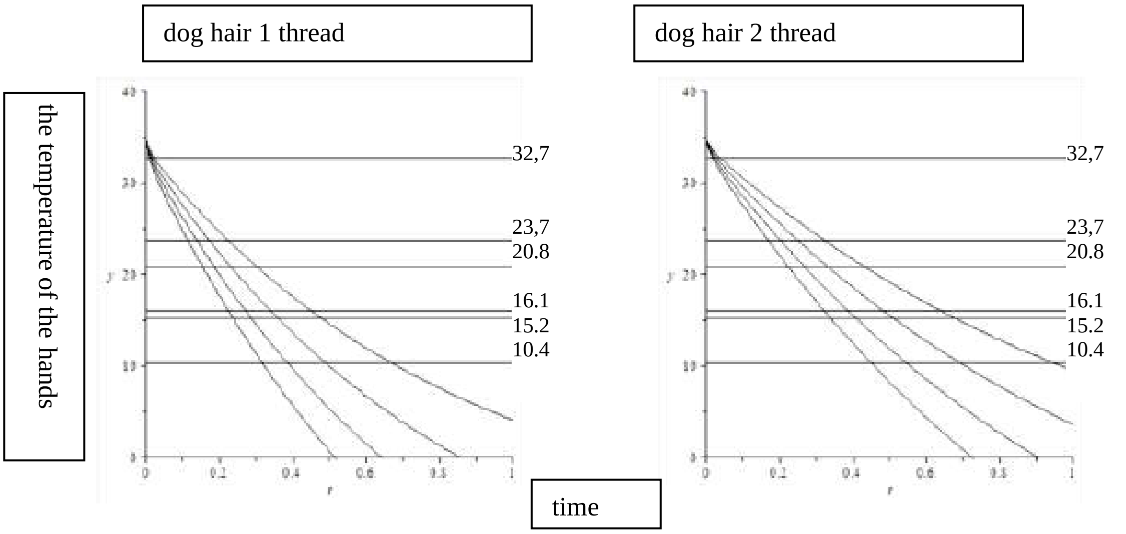
a) Change in the temperature of the skin of the hand when using goat hair yarn from 1 strand and 2 strands for gloves



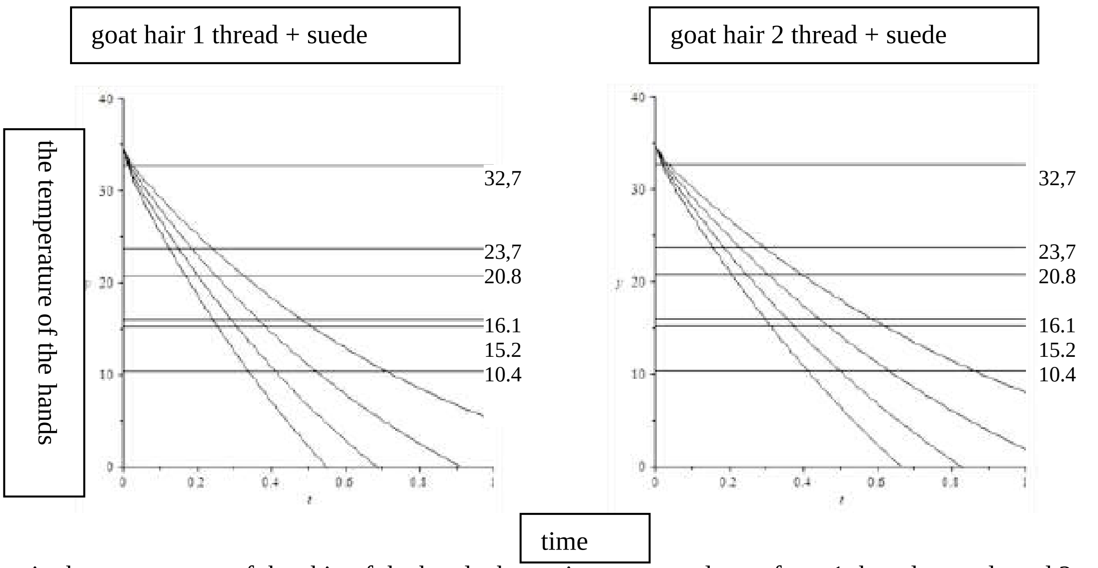
b) Change in the temperature of the skin of the hand when using sheep wool yarn from 1 thread and 2 threads for gloves



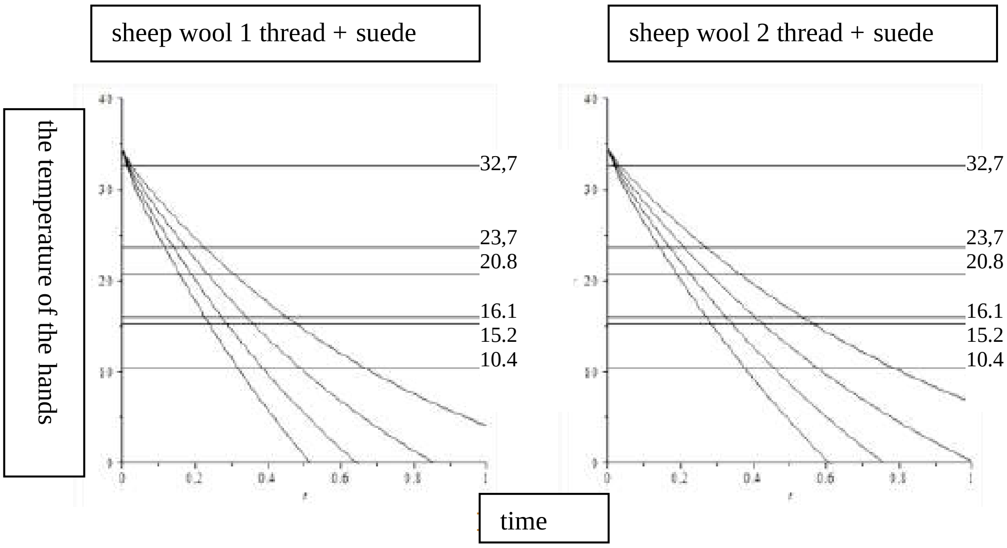
c) Change in the temperature of the skin of the hand when using camel wool yarn from 1 thread and 2 threads for gloves



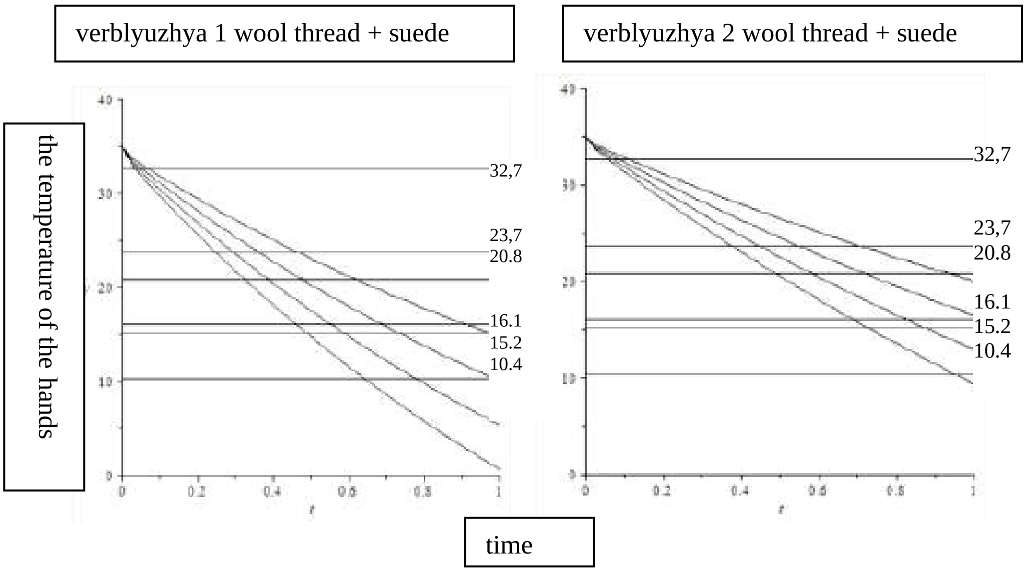
d) Change in the temperature of the skin of the hand when using dog wool yarn from 1 strand and 2 strands for gloves



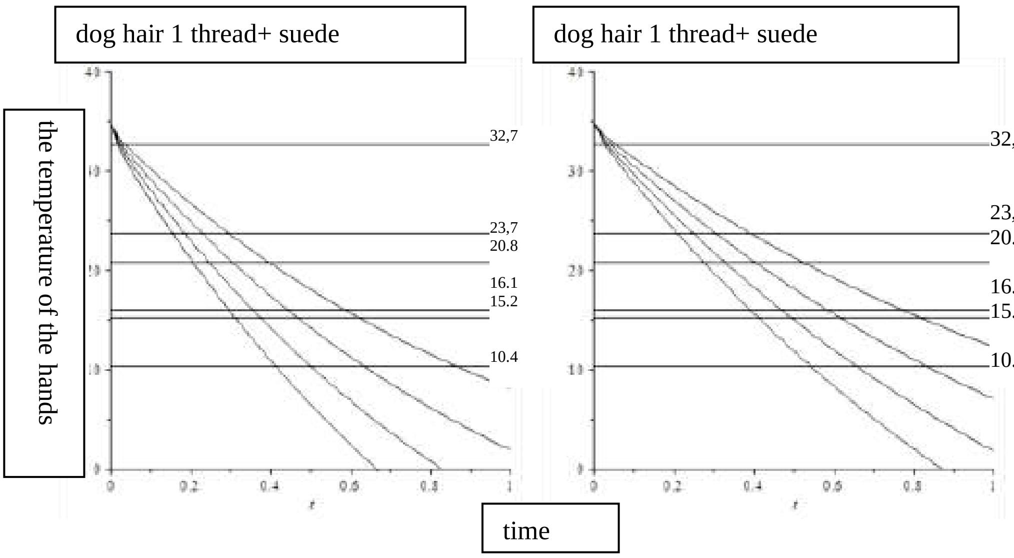
e) Change in the temperature of the skin of the hand when using goat wool yarn from 1 thread + suede and 2 threads + suede for gloves



f) Change in the temperature of the skin of the hand when using sheep wool yarn from 1 thread + suede and 2 threads + suede for gloves

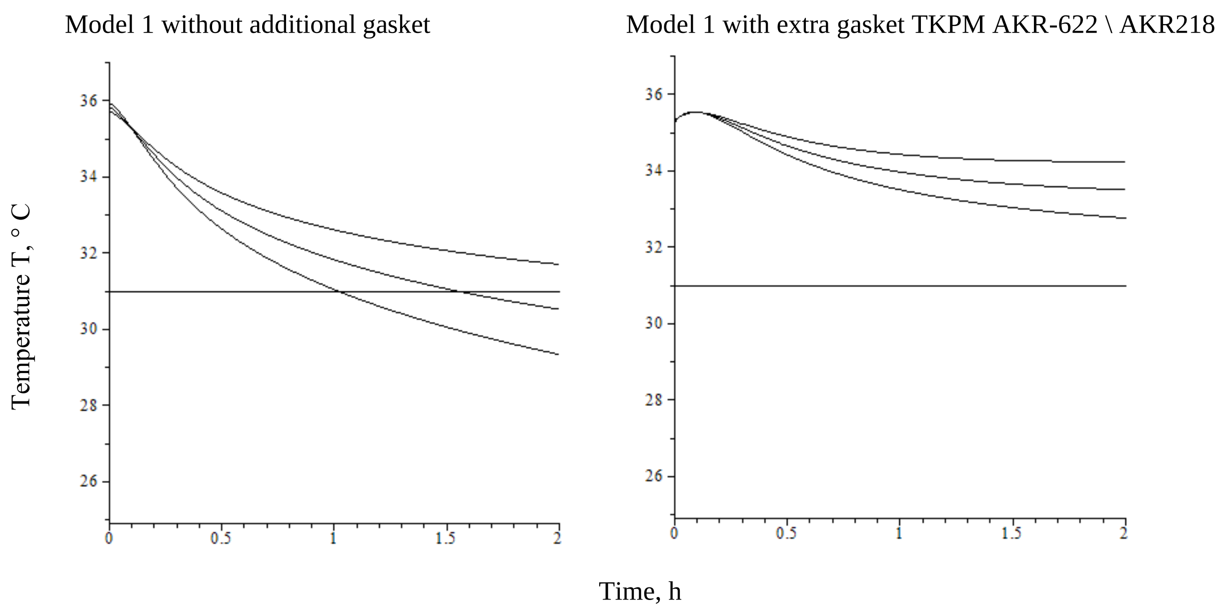


g) Change in the temperature of the skin of the hand when using camel wool yarn from 1 thread + suede and 2 threads + suede for gloves



e) Change in the temperature of the skin of the hand when using dog wool yarn from 1 thread + suede and 2 threads + suede for gloves

Figure 1 - Characteristics of the state of comfort of the hand (skin) of a serviceman when he is in various climatic conditions: curve 1 - at -10 ° C, curve 2 - at -20 ° C, curve 3 - at -30 ° C, curve 4 - at -40 ° C



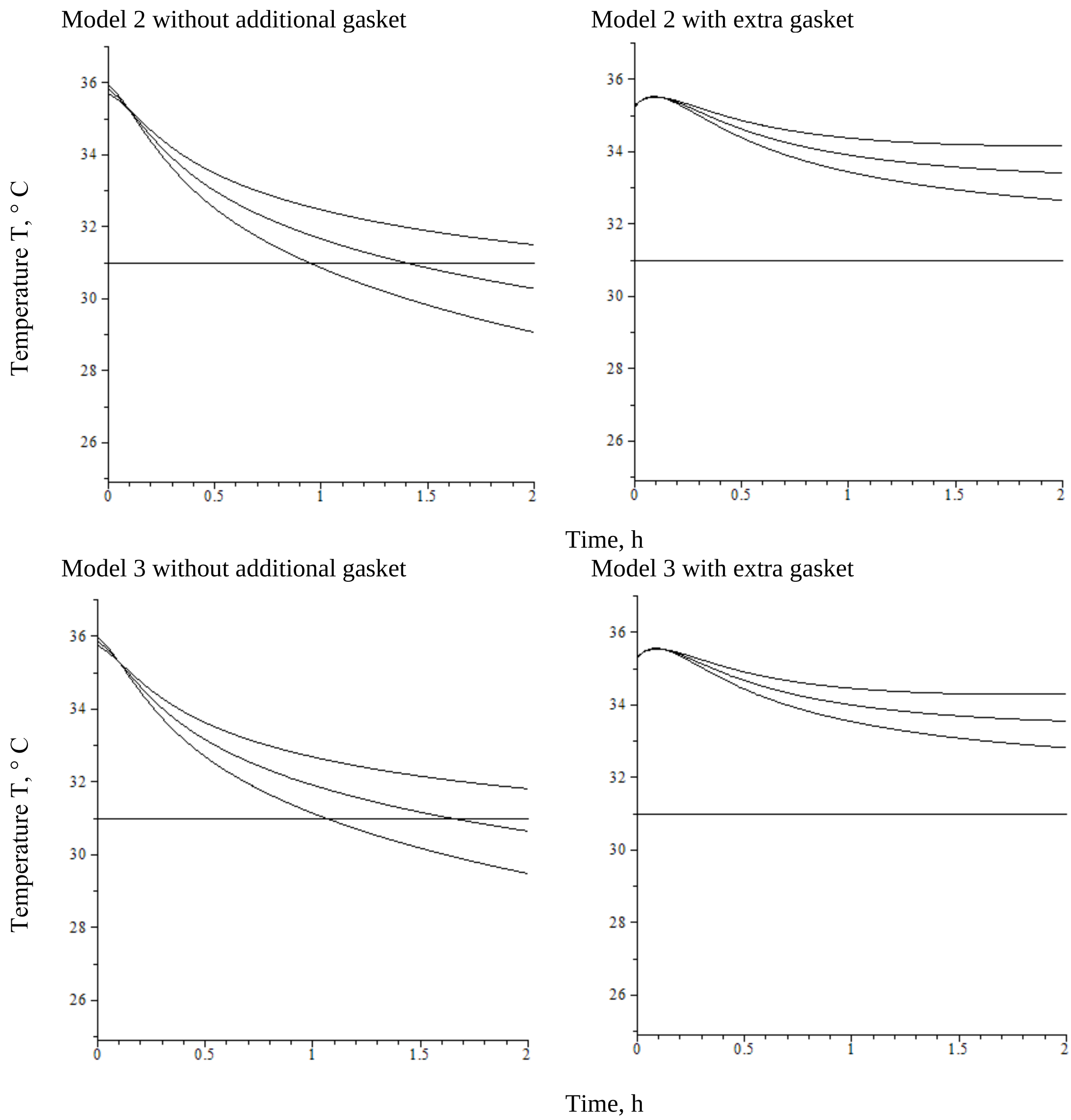
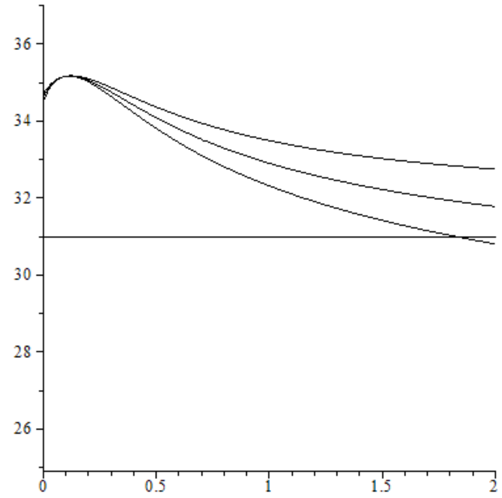
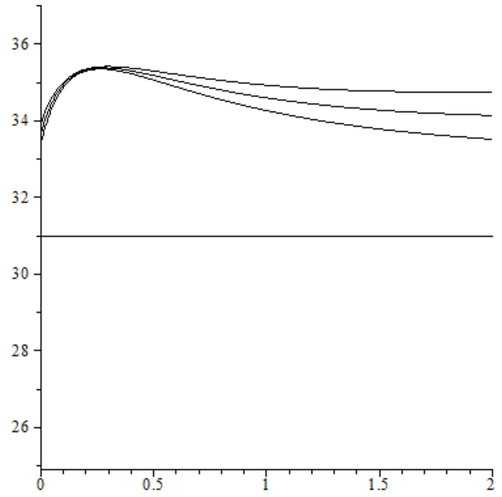


Figure 2 - The results of calculations of the weighted average temperature of the skin for bags consisting of imported materials at ambient temperatures: curve 1 -20 ° C, curve 2 - 30 ° C, curve 3 - 40 ° C.

Model 1 * without additional gasket

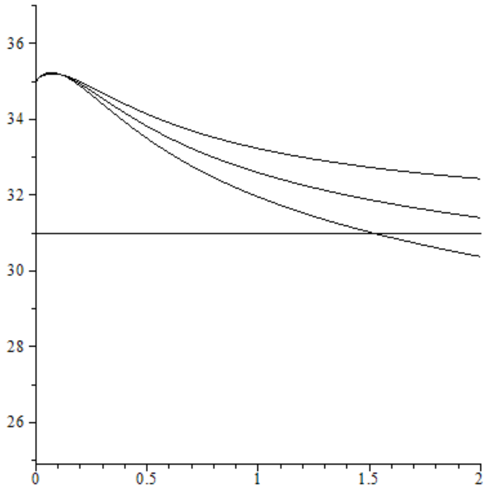


Model 1 with extra gasket

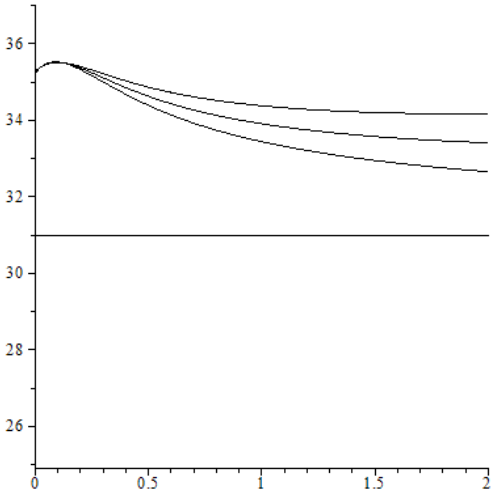


Time, h

Model 2 * without additional gasket

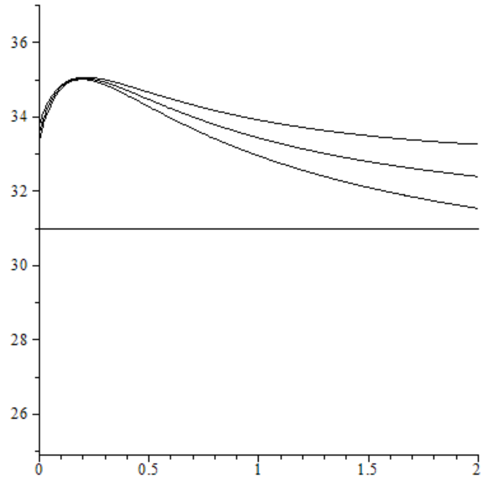


Model 2 with extra gasket

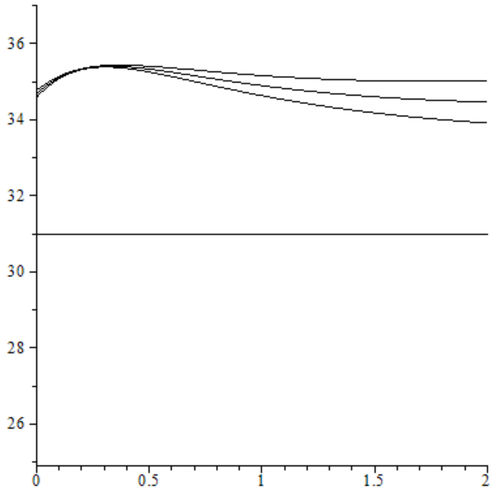


Time, h

Model 3 * without additional gasket



Model 3 with extra gasket



Time, h

Figure 3 - The results of calculating the weighted average skin temperature for bags consisting of domestically produced materials at ambient temperatures: curve 1 -20 ° C, curve 2 - 30 ° C, curve 3 - 40 ° C.

Conclusion

Has been proven that the main criterion for the comfort of a suit of servicemen in the Arctic when they are in different climatic zones is the coefficient of thermal conductivity;

The possibility of using the software product to substantiate the choice of material packages for the suit of the Arctic military personnel in various climatic zones was confirmed;

High coincidence of the calculated values of heat loss from the surface of the tested jackets with experimental data was achieved, which confirms the legitimacy of using the software product developed by the authors for a reasonable choice of material packages for a suit of Arctic military personnel located in different climatic zones;

It has been proven that the use of domestic nanomaterials and nanotechnology as linings for suits for servicemen in the Arctic during the period of the need for import substitution due to sanctions has confirmed their high quality and efficiency, which allows expanding research and their production with the presence of basic criteria that form a comfortable state in within two hours in any climatic zone.

Consequently, the results obtained substantiated the high efficiency of using the software for a reasonable selection of packages of materials for gloves and other sets of suits for Arctic servicemen and confirmed the need to continue research on the selection of such materials that would provide them with a comfortable state in a given temperature regime for at least one hour.

For the packages and materials shown in Table 3, curves are plotted characterizing the state of comfort of the soldier's hand for the following ambient temperatures, namely, curve 1 at -10 ° C, curve 2 at -20 ° C, curve 3 at -30 ° C, curve 4 - at -40 ° C (Figure 3).

The software developed by the authors allows the manufacturer to have a tool for making an informed decision on the choice of material packages for the suit of the Arctic military personnel, including in the production of gloves to protect the hand from the effects of low temperatures while performing their statutory duties.

Confirmation of these conclusions is the analysis of the properties of the most effective in terms of comfortable conditions of the skin of the hand, carried out by the authors, providing a constant temperature within 32.5 ° C.

Unfortunately, gloves made from wool yarns of various animals, made from either one or two threads, do not guarantee servicemen such a comfortable state even at a temperature of -10 ° C, not to mention that the air temperature may be lower. In this case, the skin surface of the hand is cooled below the critical value, i.e. below 10.4 ° C and can lead to frostbite and irreversible processes.

The use of mitts to protect the hand also does not guarantee the servicemen protection from the effects of low temperatures, suggesting the search for such materials and the formation of bags from them for the manufacture of gloves that would provide them with comfortable conditions, which is possible when using nanomaterials capable of thermal regulation within the limits, allowing servicemen to fulfill their statutory duties within the required time period.

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