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ABOUT THE PECULIARITIES OF MAKING ACCESSORIES OF THE ARCTIC MILITARY SERVICE COSTUME IN THE FORMATION OF COMFORTABLE CONDITIONS

Abstract: *The paper presents the results of studies on the reasonable choice of packages of materials for adjustments to the knee and elbow in order to ensure the comfort of servicemen in the Arctic during the entire time of his stay in climatic zones with low temperatures. Testing of the software product confirmed its high efficiency.*

Key words: *software product, software mathematical editor MAPLE, package of materials, heat and mass transfer, comfort, climatic zones with low temperatures, military personnel, Arctic.*

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Introduction

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Cold is one of the harmful environmental factors affecting humans. Reactions to the effects of cold can be both functional and pathological in nature: disease, defeat, death.

At low temperatures, a person can experience cold stress. Cold stress can be caused by cooling of the body as a whole or part of it, most often of the face and respiratory organs, hands, feet. At the same time, different types of cold stress are formed due to a combination of climatic factors, physical activity, clothing, etc. The main types of cold stress are:

- cooling the whole body;
- cooling of the limbs;
- skin cooling (convective);
- skin cooling (conductive);
- respiratory cooling.

The combinations of climatic factors are as follows:

- air temperature, average radiation temperature, air mobility, physical activity, relative humidity of air, clothing;
- air temperature, air mobility;
- the surface temperature of the clothing;
- air temperature, physical activity.

The effect of cold stress on humans is due to the intensity of cold stress (tissue cooling).

Hypothermia is a result of extreme cold stress intensity.

The results of the intensity of cold stress of the 1st degree will be:

- local cold damage - frostbite, numbness;
- cold damage without freezing;
- pain;
- functional damage;
- acute cardiorespiratory effect;
- deterioration in performance;
- the discomfort;
- heat balance.

Main part

Discomfort can cause a decrease in activity, especially in relation to solving problems associated with neuro-emotional stress, with the need to concentrate, and also increase the risk of occupational accidents and injuries. Moreover, cooling of tissues can lead to decreased physical activity, which contributes to the risk of accidents.

Cooling of a person, both general and local (especially of the hands), contributes to a change in his motor activity, disrupts coordination and the ability to perform precise operations, causes the development of inhibitory processes in the cerebral cortex, which can cause injury. With local cooling of the hands, the accuracy of the combat mission decreases; activity decreases by 1.5% for each degree of decrease in the temperature of the fingers.

A drop in body temperature, muscle temperature and skin temperature leads to a decrease in the ability to perform physical work due to a decrease in the level of metabolism.

These changes reduce coordination and can lead to an increase in accidents, especially when performing a combat mission in the cold. The sensitivity of the receptors also changes with a decrease in skin temperature. So, at a skin temperature of 20 ° C, it is 1/7 of normal.

The above means that a set of thermal protective clothing intended for work in open areas, in particular in climatic regions IA and IB ("special" and IV climatic zones), must include protective equipment for the face and respiratory system.

The hands and feet play an important role in thermoregulation, being specific heat exchangers between the body and the environment. The state of thermal comfort is provided at a foot skin temperature of 29-31 ° C and a heat flow of 52-87 W / m2. The thermal resistance of the tissues remains within the range of up to 0.3 clo.

Studies by a number of authors have shown that with an increase in the thermal insulation of shoes, the weighted average temperature of human skin increases (from 32.0 ± 0.30 to 33.5 ± 0.32 ° C) and the weighted average heat flux decreases (from 90.3 ± 4.0 to 57.0 ± 0.32 W / m2 (≈ 40%)). A decrease in total heat loss as a result of an increase in the thermal insulation of shoes can be 17.1 ° C.

Heat loss by convection and radiation from the surface of various areas the human body when it is cooled:

a) Head 19.0W (12%)
b) Hands 44.4 W (31%)
c) Torso 36.0 W (25%)
d) Feet 49.0W (32%)
e) Whole person 148.4W (100%)

The amount of thermal insulation in a shoe can have a significant impact on a person's overall heat loss and body surface temperature. This means that when developing thermal protective clothing, the requirements for thermal insulation of all areas of the body must be met. With an increase in the thickness of the package of materials for insulating clothing, almost only the skin temperature of those areas of the body that are protected (trunk, shoulder, thigh) rises... ABOUTthere is only a slight increase in skin temperature in the area of the hands. A change in temperature, depending on the degree of warming of the surface of the body, is practically not observed.There is a definite relationship between the general thermal state of the body and the degree of cooling of a particular area of the body, in particular, feet and hands. At the same time, the thermal insulation of the latter has a significant effect on the general heat exchange of a person.

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.

Requirements for materials and constructionthermal protective clothing in the Arctic:

- the heat-shielding ability of clothing for protection from cooling is determined by the thermophysical indicators of the package of materials from which it is made, by its design, type (jacket, jacket and trousers, overalls, etc.);

- a package of materials for heat-protective clothing is formed from a base material, an insulating pad and a lining. If necessary, to reduce the air permeability of the package of clothing materials, a windproof pad can be used, which should be placed between the base material and the insulation pad;

- the main material (cover, outer layer) determines the appearance of the clothing and performs protective functions. It must have protective properties that correspond to the operating conditions, be resistant to mechanical stress, precipitation, light, various types of pollutants, and be easy to clean from contamination. It must be able to conduct moisture from the clothing space into the environment and have adequate air permeability to the wind speed.

The work examines the process of cooling the surface tissues of the knee and elbow of a person when exposed to low temperatures (table 1).

Table 1 - Characteristics of the package of materials for the protection of elbow and knee joints

Model	Package materials	Thickness, mm	Thermal conductivity coefficient λ, W / m ºC
1	2	3	5
Model 1	cotton linen	0.9	0.044
	Wool sweater or pants	2.4	0.027
	Nylon lining	1.6	0.042
	Thinsulate insulation (1 layer)	6.0	0.044
	Arctic-tech - outer layer (85% PE + 15% cotton)	1.8	0.041
	Arctic-tech (knee pad or elbow pad)	1.8	0.041
Continuation of table 1 Model 2	Thermal underwear	1.76	0.039
	Wool sweater ooze pants	2.4	0.027
	Nylon lining	1.6	0.042
	Thinsulate insulation (21 layers)	12	0.036
	Arctic-tech - outer layer	1.8	0.041
	Porous rubber - damper	2.2	0.027
	Arctic-tech (patch pocket)	1.8	0.041

For the description, a mathematical model is built in the form of a boundary value problem:

$$\frac{\partial T_i}{\partial t} = a_i\left(\frac{\partial^2 T_i}{\partial r_i^2} + \frac{2}{r_i}\frac{\partial T_i}{\partial r_i}\right) + \frac{q_{iv}}{c_i\rho_i},\ i = 1,2,\dots n,$$

$$T_1(0,t) \neq \infty;$$

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

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

$$\lambda_{i-1}\frac{\partial T_{i-1}}{\partial r_{i-1}}(R_{i-1},t) = \lambda_i \frac{\partial T_i}{\partial r_i}(R_{i-1},t),\ \ i = 2,\dots n.$$

Initial conditions, where $T_i(r_i,0) = f_i(r_i)$ $t -$ time; - temperature of the i-th layer; $T_i\, i = 1,\dots n$; - ambient temperature; - coefficient of heat capacity of the i-th layer; - coefficient of thermal diffusivity of the i-th layer; - the density of the i-th layer; - coefficient of thermal conductivity of the i-th layer; volumetric heat flow density of the i-th layer; coefficient of heat transfer from the surface of the skin or protective layer (hair, hat); $T_C c_i a_i \rho_i \lambda_i\ q_{iv} - \alpha - f_i(r_i) -$ initial temperature of the i-th layer.

The solution to the problem is in the following form

$$T_i(r_i,t) = \sum_{k=1}^{\infty} D_k(t) X_{k,i}(r_i),$$

Where

$$X_{k,i}(r_i) = \frac{1}{r_i}\left(A_i \sin\left(\frac{\mu_k r_i}{\sqrt{a_i}}\right) + B_i \cos\left(\frac{\mu_k r_i}{\sqrt{a_i}}\right)\right) -$$

eigenfunctions of the corresponding boundary value problem:

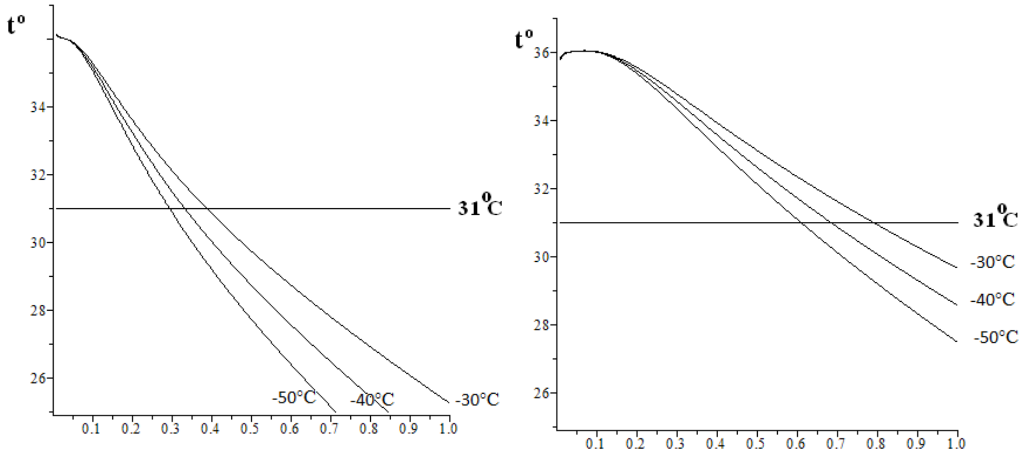
$$\frac{\partial^2 X_i}{\partial r_i^2} + \frac{2}{r_i}\frac{\partial X_i}{\partial r_i} + \frac{\mu^2}{a_i} X_i = 0,$$

$$X_1(0,t) \neq \infty;$$

$$\lambda_n \frac{\partial X_n}{\partial r_n}(R_n) + \alpha X_n(R_n) = 0;$$

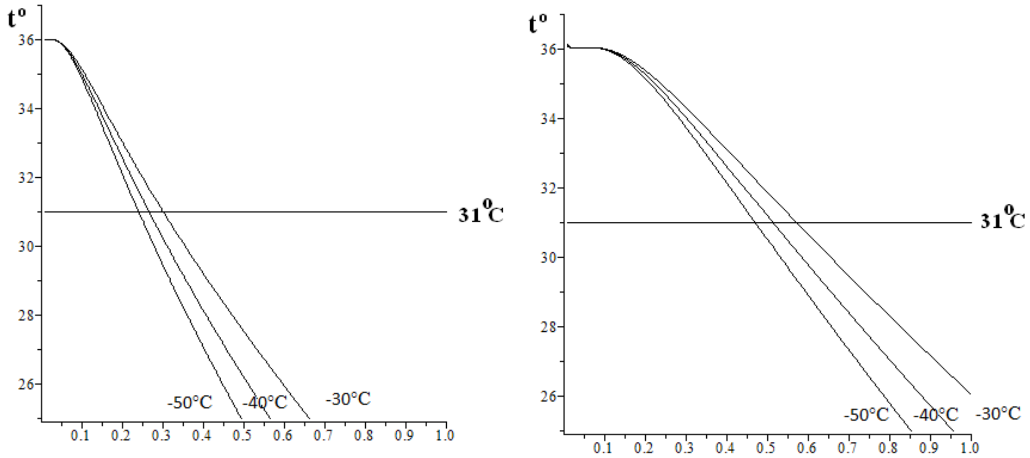
$$X_{i-1}(R_{i-1}) = X_i(R_{i-1});$$

$$\lambda_{i-1}\frac{\partial X_{i-1}}{\partial r_{i-1}}(R_{i-1}) = \lambda_i \frac{\partial X_i}{\partial r_i}(R_{i-1}).$$



a) **b)**

Figure 1 - knee:
a) model 1; b) model 2



a) **b)**

Figure 2 - Elbow:
a) model 1; b) model 2

Currently, one of the directions for developing clothing for the Arctic conditions is the field of professional clothing, in particular, clothing, including mittens and gloves for the needs of federal authorities. Survival in the polar regions directly depends on body temperature, or rather, its preservation. And this is possible only with the help of clothing.

The urgency of the problem of creating a suit for protection from the cold is confirmed by numerous studies in this area, conducted by domestic and foreign scientists. The first requirement for a suit in the Arctic is layering. The top layer should be moisture resistant, the middle layer should contain woolen fibers (preferably) or synthetic, the inner layer of the suit with good breathability. The second requirement is that the suit must be comfortable. This is ensured by sufficient air circulation and does not provoke overheating of the soldier's body.

The range of materials used for the production of thermal protective clothing is very diverse in terms of raw material origin, production methods, purpose and can be combined into the following groups:

- basic - fabrics of various fibrous composition for the top and lining, duplicated fabrics, films, fabrics with film, windproof and rubber coatings, etc.;
- insulation materials - batting, cotton wool, foam rubber, artificial and natural furs, non-woven insulation, etc.
- materials for joining parts - sewing threads, adhesive and thermoplastic materials, welds, etc.;
- accessories - buttons, hooks, loops, buckles, buttons, zippers, Velcro, etc.

A software was developed that allows you to select a package of materials for an assortment of clothes. As an example of the study, a heat-protective jacket and mittens for an ordinary soldier in the extreme conditions of the Arctic were chosen. The design and manufacturing technology of products meets the requirements of GOST 12.4.236-236-2011 SSBT. Special clothing for protection from low temperatures. And it is made in accordance with the basics of unit-by-unit processing of uniforms.

When choosing packages of materials for the study, the physicomechanical, thermophysical characteristics of materials, information about the specifics of the operation of this clothing, which were obtained from open literature sources, were taken into account.

With an increase in the thickness of the package of materials for insulating clothing, almost only the temperature of the skin of those areas of the body that are protected (trunk, shoulder, thigh) rises. Only a slight increase in skin temperature in the area of the hands is noted. A change in temperature, depending on the degree of warming of the surface of the body, is practically not observed.

The main role in protecting a person from the cold belongs to behavioral thermoregulation, which consists in the active, targeted regulation of the thermal load on the body .. Due to the need to be in an open area during the cold season or in an unheated room, personal protective equipment is of great importance, and namely, a set of items that provide adequate protection from cooling all parts of the surface of the human body in accordance with the specific conditions of his activity. The cold protection kit includes heat-protective clothing (for example, jacket and bib, jacket and trousers, overalls), headgear, gloves and shoes.

The creation of heat-protective gloves and gloves is a complex scientific and practical task, since gloves and gloves must meet a set of requirements, which are often incompatible with each other. So, for example, clothes should combine light weight and high heat-shielding properties; smallair permeability and sufficient moisture permeability necessary to ensure human moisture exchange with the environment. Clothing should protect the person from cooling at rest and not cause overheating during intense physical activity.

Reasons that can make design difficultheat protective gloves and gloves in accordance with the required thermal insulation:

- an increase in the thermal insulation of the kit is accompanied by an increase in its mass, which causes an additional load on the body and leads to an increase in energy consumption, a decrease in activity and the risk of an increase in injuries;

- the peculiarities of heat exchange in various parts of the human body, limiting the possibility of proper protection of some of them (hand, foot) due to the need to comply with ergonomic requirements;

- the traditional method of increasing thermal insulation by increasing the thickness of the package of materials, including insulation, is effective only within certain limits;

- human heat exchange is influenced by a complex of meteorological factors: air temperature, speed of movement, humidity, insolation, protection from which requires a different approach to the selection of technical indicators of materials and the development of clothing design.

An important role in the creation of clothing for military personnel in the Arctic is the protection of hands and feet. In this regard, the calculations of the thermal protection of the hands were made.

Table 2 shows a set of a package of materials for gloves and gloves.

Table 2 - a set of a package of materials for mittens for military personnel

Package materials	Thickness, mm	Total thermal resistance Rsum, m2 · ˚C / W
air	1	0.026
fur	5	0.04
gasket	0,4	0.04
leather	2	0.06

To calculate the temperature distribution, we used the Maple mathematical packages. Input data of the program

- the thickness of the layers of the package of materials;

-coefficients of thermal conductivity and thermal diffusivity of these materials;

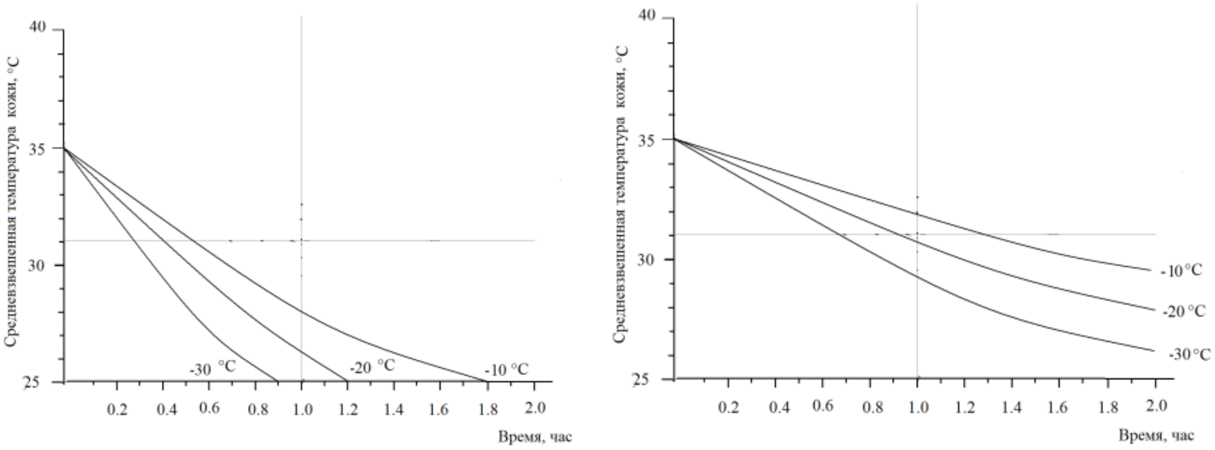
- the density of the heat flux coming from the body to the inner surface of the package;

- ambient temperature;

- the initial temperature of the package of materials that forms the suit;

- the coefficient of heat transfer from the outer surface of the package to the environment.

The calculation results are shown in Figure 3.



a) for thumb packs **b) for hand material packages**

Figure 2 - The result of the calculation of the dependence of the weighted average temperature of the skin of the human hand on the time spent at low temperatures (-10 °; -20 ° C; -30 ° C)

The solution to the problem is reduced to finding such a combination of the packet thickness in separate sections of the model, which implements a minimum heat flux from its surface with a restriction on the volume of the packet mass. In the classical approach, such a normalization equation for the weight of the insulation takes into account the thickness of the insulation for the entire geometric image of the package.

Thus, it can be concluded that using the proposed mathematical model, it is possible to optimize the choice of materials for the manufacture of heat-protective clothing.

The developed program allows in the process of calculations to change the parameters of the model: to introduce new layers of materials into the package of the corresponding sections.

The performed calculation showed that it is possible to use the software product to select the optimal package of materials for insulated gloves and gloves for military personnel. The introduction of the software product will allow designing a clothing package taking into account the climatic zones of the regions and the specific requirements of consumers, including for the conditions of the Arctic.

Conclusion

The development by the authors when using the MAPLE product allows for a separate selection of a package of materials for applying to the knee and elbow in order to provide comfortable conditions for the Arctic Servicemen during the entire time spent in low temperature zones. Justified use of a software product will confirm its high efficiency.

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