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DEVELOPMENT AND STUDY OF THE SKI PACKAGE OF CLOTHES WITH IMPROVED OPERATION PROPERTIES

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The article is devoted to methods of determination of physical - mechanical properties of membrane materials, nonwoven insulators and clothing package in general. The standard known methods and methods of research are described, as well as the influence of operational and production factors on the structure and properties of membrane tissues that form packs of clothing materials. The physical and mechanical properties of membrane tissues to abrasion in the plane have been investigated, tensile to fracture, elongation, indestructibility, vapour permeability, water resistance, thermal conductivity, breathability. The article presents a reasonable selection and characterization of research objects, materials that form packs of heat-resistant clothing: top tissues - membrane fabrics, insulation - nonwoven volumetric insulation, lining and auxiliary materials and developed packages of heat-proof clothing.

Keywords: ski clothing package, membrane fabric, insulating layer, lining materials, ergonomic indicators, waterproof.

ТАУДА ШАНҒЫ ТЕБУШІЛЕРДІҢ КИІМ ЖАБДЫҚТАРЫН ҚОЛДАНУДЫҢ ОЗЫҚ ҚАСИЕТТЕРІН ЗЕРТТЕУ ЖӘНЕ ЖАСАП ШЫҒАРУ

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Мақала мембраналық материалдардың, тоқыма емес жылытқыштардың және жалпы киім пакеттерінің физика-механикалық қасиеттерін анықтау әдістеріне арналған. Зерттеудің стандартты белгілі әдістері мен әдістемесі, сондай-ақ киім материалдарының пакеттерін құрайтын мембраналық маталардың құрылымы мен қасиеттеріне пайдаланушылық және өндірістік факторлардың әсері сипатталған.Мембраналық маталардың жазықтық бойынша қажалуға физика-механикалық қасиеттері, үзілгенге дейін созылуы, ұзаруы, қыртыстанбауы, бу өткізгіштігі, суға төзімділігі, жылу өткізгіштігі, ауа өткізгіштігі зерттелген. Мақалада зерттеу объектілерінің, жылу қорғайтын киім пакеттерін қалыптастыратын материалдардың: жоғарғы маталардың – мембраналық маталардың, жылытқыштардың - тоқыма емес көлемді жылытқыштардың, астарлы және қосалқы материалдардың және жылу қорғайтын киімнің әзірленген пакеттерінің негізделген таңдауы мен сипаттамасы берілген.

Негізгі сөздер: шаңғы кнімінің пакеті, мембраналық мата, оқшаулағыш қабат, төсеніш материалдары, эргономикалық көрсеткіштер, су өтпейтін.

РАЗРАБОТКА И ИССЛЕДОВАНИЕ ГОРНОЛЫЖНОГО ПАКЕТА ОДЕЖДЫ С УЛУЧШЕННЫМИ ЭКСПЛУАТАЦИОННЫМИ СВОЙСТВАМИ

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Статья посвящена методам определения физико-механических свойств мембранных материалов, нетканых утеплителей и пакета одежды в целом. Описаны стандартные известные методы и методики исследования, а также влияния эксплуатационных и производственных факторов на структуру и свойства мембранных тканей, формирующих пакеты материалов одежды. Исследованы физико - механические свойства мембранных тканей к истиранию по плоскости, растяжение до разрыва, удлинение, несминаемость, паропроницаемость, водоупорность, теплопроводность, воздухопроницаемость. В статье представлен обоснованный выбор и характеристика объектов исследования, материалов, формирующих пакеты теплозащитной одежды: тканей верха - мембранных тканей, утеплителей - нетканых объемных утеплителей, подкладочных и вспомогательных материалов и разработанных пакетов теплозащитной одежды.

Ключевые слова: пакет горнолыжной одежды, мембранная ткань, утепляющий слой, подкладочные материалы, эргономические показатели, водонепроницаемый.

Introduction

Research was carried out by analyzing the scientific works on the direction of increase and improvement in the development of the product package of prototypes.

The aim of the study is development and study of the ski package of clothes with advanced technology of insulation in a ski suit.

The research task was to improve the insulation in the ski suit, thereby conducting a comparative study of non-woven insulations and membrane materials.

Outdoor sportswear has been designed and manufactured for different activities that will be carried out in different environmental conditions. This sportswear forms a "clothing system", which usually includes two layers of clothing: membrane and woven insulation. The middle layer is designed to keep a person warm by holding and retaining heated air. The outer layer provides protection to all other layers and the body. For complete protection against rain or water, you can wear clothing with a completely waterproof outer layer; however, the use of a simple waterproof outer layer is not effective because the moisture from perspiration generated during sports activities will accumulate in the clothing system, but this not only leads to loss of insulation, but also leads to excessive evaporation and cooling. Humidity control is another important factor in protecting against the cold. This means that it is necessary to avoid getting the layers wet (from the inside by perspiration or from the outside by rain or snow). If this is not possible, then the effects of moisture accumulation must be controlled [1]. Also the system should be waterproof but permeable to water vapour [2]. as shown in Figure 1. In order to achieve an optimal result, it is necessary to test the physical and mechanical properties of membrane fabrics and a package for ski clothing of domestic production.

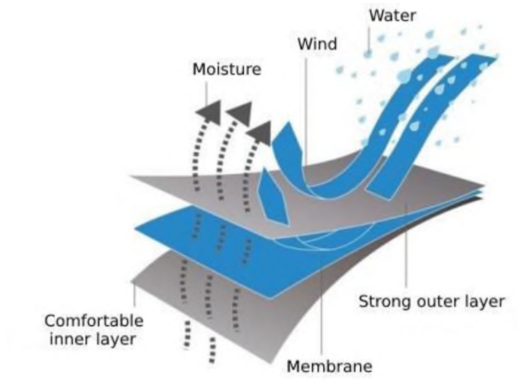


Figure 1. Influence of water and moisture on ski suit

Materials and Research Methods

In the course of work on this study, the methods of scientific analysis, synthesis, comparative and collation analysis, and theoretical method were fundamental, which is due to the specifics of the object under study. The tests were carried out according to known and standard methods. Physical-and-mechanical and operational properties were determined according to standards.

Results and their Discussion

Waterproof fabrics with improved performance are used in the production of protective clothing. With the development of membrane technologies, representatives of the textile industry have received a universal material for sewing sports and tourist equipment, and outerwear for children and adults. Membrane fabric has unique properties - it does not allow moisture to pass through from the outside, but at the same time it removes vapours exuded by the human body during intense movement. This eliminates the development of the greenhouse effect, which is characteristic of clothing with a rubber coating.

Microporous structures for a waterproof transpirable layer can be obtained both by coating with a porous PTFE membrane paste, for example - A 30 JOC-09- PL, and a film coating laminated with a polyurethane membrane fabric, for example - A32 MK 110516 and A 35 HK-CG 030, as well as a three-layer fabric glued together: outer layer, PTFE membrane, fleece insulation sample 02&A 1-1. The fibrous composition of the front side of the MF (membrane fabric) is nylon. It is often used because of its strength.

These types of membranes and coatings are hydrophobic in nature. Microporous coatings can be produced using wet coagulation, thermocoagulation or foam coating methods or mechanical fibrillation. Micro-holes found in the structure are smaller than raindrops. but much more than water vapour molecules (Fig. 2) [3].

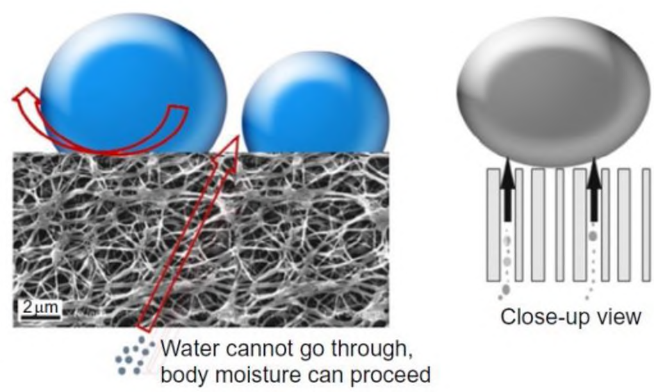


Figure 2. The functions of 'waterproof' and 'breathable' character in clothing fabrics and a schematic close-up view. [3]

Study of the physical and mechanical properties of domestically produced membrane fabrics for skiing clothing.

Waterproof testing

To determine the waterproofness of waterproof transpirable fabrics, appropriate waterproofness testing is required.

Testing methods can be roughly divided into two types: (1) tests that provide information about the resistance of a fabric to surface wetting or penetration into but not through the fabric, and (2) tests that provide information about the resistance of a fabric to rain penetration. Testing that provides information on surface wetting resistance include a rain simulation tester such as the Bundesmann tester, the WIRA shower tester , the Credit seam tester or the AATCC rain tester [4].

Water resistance, or waterproofness, characterizes the resistance of products to the initial penetration of water through them. The pressure of water on the sample, which it can withstand before getting wet, is often taken as the characteristic of water resistance. Sometimes water resistance is characterized by the time during which the sample withstands certain water pressure. The determination of the water resistance of fabrics on the penetrometer device is carried out in accordance with GOST 3816-81 (ISO 811-81) [5].

As a result, membrane fabrics A32 MK 110516, A 35 HK - CG 030, 02 & A 1-1 had the highest pressure resistance of more than 1,000 mm of water column / 10,000 Pa, while A 30 JOC -09-PL polyurethane materials have the lowest - 182 mm w.c. (1st table)

Table 1. Physical and mechanical properties of membrane fabrics for ski clothing of national manufacture.

№	Cloth articulation	Breaking lengths mm. warp/ weft	Wrinkle-free, ° warp/ weft	Wrinkle-free,° warp/ weft after 5 –min. rest	Breaking load, Pp, kgs, warp/ weft	breathability dm³/ m²s.	Flat abrasion, cycles	Water resistance, mm. aqua bar /Pascal	Changes in size after wet treatment%	Vapor transmission (water vapor), g/m² 24h	Fabric weight g/m²
1	Membrane fabric A30 JOC-09-PL	35/24	108/127	123/137	78/83	<6,9	2500	180/ 1800 Pa	+/- 1,65	2800	125
2	Membrane fabric A32 MK110516	34/34	105/122	113/132	106/100	<6,9	2800	1000/ 10000Pa	+/- 1,19	2000	283
3	Membrane fabric A35 HK-CG030	36/35	115/131	121/137	95/90	<6,9	3500	1000/ 10000Pa	+/- 0,97	2000	193
4	Membrane fabric with fleece	70/103	155/140	160/147	47/33	<6,9	11000	1000/ 10000Pa	+/- 0,80	3000	280

To identify people's requirements for winter sports clothing, a survey was conducted, during which it was revealed that many athletes are not fully satisfied with the modern range of winter sports clothing available in stores. The requirements are imposed, to a greater extent, on ergonomic and operational properties [6]. Thus, today the actual task of creating high-quality clothing is to ensure high performance and ergonomic performance of sportswear. The basis for the study is improvement of the ergonomic and operational properties.

Abrasion resistance of fabrics

The study of the mechanical properties of fabrics with a membrane coating made it possible to establish (table 1) that all samples of membrane fabrics meet the regulatory requirements of GOST 28486-90. Testing was carried out on the IT-3M-1 device in accordance with GOST 8976-73 [7]. The choice of this device was due to the fact that ski clothing is subjected to more intense interaction with various surfaces. The ski clothing should be resistant to friction in the area of the sleeves, collar , belt, as well as in the area of the elbow and knee. The destruction of the material is formed due to friction on hands, accessories, fittings and snow when falling. The obtained analysis of the results showed that the samples of membrane fabrics of the article A 30 JOC-09-PL, A32 MK 110516 have the highest average resistance to abrasion along the plane for 2500-2800 cycles, and the sample A 35 HK - CG 030 has an average resistance to abrasion along the plane for 3500 cycles, and sample 02&A 1 has the highest resistance to abrasion in the plane for 11,000 cycles, so in order to avoid the above defects, it is necessary to increase the level of strength at the destruction sites by introducing abrasion resistant fabrics into the package of the entire suit.

Determination of the crease resistance of membrane fabrics

Creasing is the ability of a fabric to form creases and bends under various deformations. A big disadvantage of heavily wrinkled fabrics is that clothes made of them wear out much faster, since the strongest abrasion occurs in the creases and wrinkles that form during deformation. The indicator was measured in laboratory conditions using a special device that meets GOST 19204-73 [8]. According to Table 1, it can be seen that 4 samples of membrane fabrics have a sufficient degree of crease resistance, due to the fact that under the action of a bending force, weakly twisted fibers tend to move relative to each other in order to return to their original position. The correlation coefficient between the reversible deformation of the fabric and its crease resistance after 5 minutes of rest is 10-15°, so membrane fabrics are characterized by high crease resistance. Due to the elastic polyester fibers, the surface of the fabric quickly returns to its original state, and all creases are smoothed out spontaneously.

Determination of the tearing load of fabrics

A very important role in the design of ski sportswear is played by anthropometric correspondence to the size and shape of the human body, not only in statics, but also in dynamics. Clothing should be comfortable, light, not restrict movement. 4 samples of fabrics are characterized by high strength at uniaxial tension to break more than 78-106 kgf for warp and more than 83-100 kgf for weft. Sample elongation of more than 20% characterizes membrane fabrics as those having medium extensibility. Fabrics are highly resistant to tearing, which is very important for sports ski clothing. The relative breaking load and elongation of the fibers were measured by GOST 6611.2-73 [9].

Determination of transpirability of membrane fabrics

Transpirability - the ability of the material to pass air through itself under the influence of its pressure drop. When describing the properties of clothing, a synonym for this term is often used - “blowingness”, i.e. to which extent the material is "windproof".

So, pore-free membranes demonstrate absolute "non-blowingness" - 0 CFM. Testing methods are most often defined by ASTM standards D 737 or ISO 9237, which, however, give identical results.

Manufacturers have begun, recently, to “remember” much more often about transpirability. The fact is that along with the air flow, much more moisture evaporates from the surface of our skin, which reduces the risk of overheating and accumulation of condensate under clothing [10].

The transparability of fabrics was determined according to GOST 12088-77 [11]. Experimental samples of membrane fabrics showed the same characteristics of 6.9 dm3/m2s.

Determination of vapour permeability of membrane fabrics

The permeability of membranes should be determined by the structure of the membrane - porous or non-porous. The vapor-permeable properties of the porous membrane should be determined by the fact that the size of the membrane pores (with a radius of less than 10-7 m) is ~700 times larger than the size of a water vapour molecule, therefore, vapours penetrate through the membrane and are removed to the outside. The movement of vapour occurs due to the pressure difference on both sides of the membrane. The capillary pressure that is created in the pores against the water column pressing from above can be calculated if we take the pores in the form of a regular round shape in the cross section of a capillary with walls that are absolutely not wetted by water. Water forms a spherical convex meniscus in such a capillary. In this approximation, the capillary pressure can be estimated using the Laplace equation: the surface tension of water, and r is the radius of curvature of the meniscus [12, 13]. This made it possible to establish that the membrane fabrics art. A30 JOC-09-PL, A32 MK110516, A35 HK-CG030 и 02&A1-1 are characterized by an average vapour permeability of 2,000-2,600 g/m2. (Table 1)

Insulation layer

The function of the insulation layer is to retain body heat in order to prevent a person from be cold. Insulating clothing should do an excellent job of transporting moisture, that is, be vapour-permeable. The second stage of a single system will work only in this way - moisture from the base layer enters the insulating layer and then, through the pores of the next layer, it comes out. Fig. 3

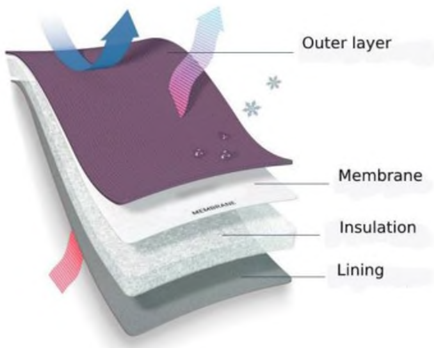


Figure 3 The ski package of clothes

To improve the performance properties of the ski clothing, there is a need to improve the clothing package in the ski suit by introducing an insulating layer made of the following insulation materials: thinsulate, sintepon, down, camel wool, sheep wool (down), fleece.

Table 2 Insulation rates

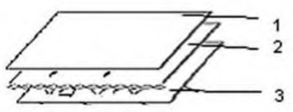
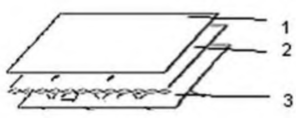
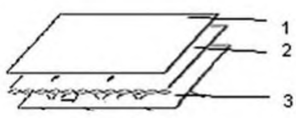
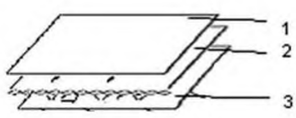
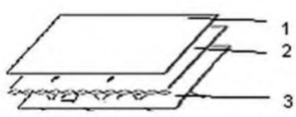
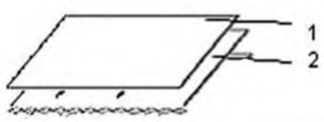
№	Specimen name	Surface density, g/m2	Fibers %	Measurements of fibre tonin. in microns
1	Tinsulate	150	65% polyolefin fibre, 35% polyester fibre	2 -10
2	Sintepon	200	polyester	10-40
3	Down	150	-	5-10
4	Wool (camel)	150	-	20-40
5	Wool (fur)	150	-	15-25
6	Fleece	280	polyester	-

The insulation layer is usually light, relatively thin and windproof. It is designed to maintain a comfortable skin temperature while transferring heat. Since hypothermia slows down the work of the muscles and worsens the coordination of movement, therefore, it is necessary to evaluate the effectiveness of the heat-shielding properties of the materials used and the structure as a whole under conditions of exposure to low temperatures [14]. The microclimate in the underwear space should be equal to about 28ºC. The relative humidity of the air under clothing should be at least 30% (to avoid dry skin) and not higher than 60% (to prevent stuffiness). The content of carbon dioxide is an indirect indicator of the effectiveness of ventilation of the underwear space. The content of carbon dioxide under multi-layer clothing, which has a generally lower transpirability than the transpirability of its individual layers, is higher than under a single layer. So, during overheating in ski clothing, it is necessary to design holes with a zipper for ventilation. The vent is designed to help skiers stay cool when activity levels rise [15]. For the manufacture of prototypes of the developed package, the same top and lining fabrics were used, and a non-woven material of different thicknesses and types was chosen for the manufacture of a complex insulating lining.

A special role in clothing for extreme conditions is played by a heat-insulating lining. The range of densities for heat insulation made of such materials is 40–400 g/m2 [16]. Microfiber insulations are supplied in the range of densities 40...250 g/m2 and are recommended for all types of winter clothing. A microfiber insulation under the Tinsulate trademark is the best known in the domestic market. The insulation should reliably retain heat, allowing excess moisture to freely evaporate and not lose thermal properties after washing. The sintepon does not "breathe" well, and after the first wash it loses up to 28% of its thermal properties. Thinsulate loses no more than 10% after 15 washes [17].

There is still debate about the benefits of synthetic wool and down over natural wool. It has been suggested that synthetics are good for warm, wet conditions, and down and wool - for dry, cold temperatures, and a combination of down and waterproof traspirable shell - for protection from cold and damp. [18].

Table 3 Material Package Structure and Properties

№	Packages	Composition of the material package layers	Surface density Ms, g/m²	Thickness δ, mm	Heat conductivity λ, W/(m *K)
1		1- Membrane fabric art. A30 JOC-09-PL A32 MK110516, A35HK-CG030 2- Tinsulate 3- Polaris lining	1- 125 283 193 2-150 3-76	13.5	0,029
2		1- Membrane fabric art. A30 JOC-09-PL A32 MK110516 A35 HK-CG030 2- Sintepon 3- Polaris lining	1- 125 283 193 2-200 3-76	17.4	0,039
3		1- Membrane fabric art.jy - A30 JOC-09-PL A32 MK110516 A35 HK-CG030 2- Down 3- Polaris lining	1- 125 283 193 2-150 3-76	16.2	0,0286
4		1- Membrane fabric art. A30 JOC-09-PLA 32 MK110516 A35 HK-CG030 2- Camel wool 3- Polaris lining	1- 125 283 193 2-150 3-76	15	0,052
5		1- Membrane fabric art. A30 JOC-09-PL A32 MK110516 A35 HK-CG030 2- Sheep down wool 3- Polaris lining	1- 125 283 193 2-150 3-76	14.5	0,035
6		1 Membrane fabric with fleece art. - 02&A1-1	1-280	2.5	0,027

Determination of total thermal resistance

The installation is designed to measure the thermal permeability of material samples and consists of a measurement unit and an electronic control unit. The installation is connected to the USB port of computer 1, which controls the temperature and temperature-controlled preset elements of the installation [19]. The determination of the total thermal resistance was carried out according to GOST 20489-75. When measuring a package of materials with non-woven insulation such as: Thinsulate, Wool Down, Down, Fleece is an effective insulation, that is, it has a thermal conductivity coefficient of 0.027 - 0.035 W/m*K. This indicator was experimentally calculated, when studying samples "Tinsulate , Wool down, Down , Fleece 150 g/m2".

When studying the samples "Sintepon" and "Camel wool": thermal conductivity indicators were 0.039 - 0.05 W/m*K, which meets the requirements for heat-shielding materials, but lower than the indicators for samples "Thinsulate, Wool down, Down and Fleece", therefore, it is necessary to additionally compare them in terms of comfort. (Table 3)

Conclusions

So, taking into account the requirements and recommendations of the standards, methods for determining the physical and mechanical properties of textile materials were chosen, and well-known methods for studying the structures and properties of membrane fabrics, insulation and clothing packages were described.

It has been established that the studied membrane fabrics made by applying polytetrafluoroethylene or polyurethane to the surface meet the regulatory requirements of GOST 28486-90, and are characterized by high tensile strength of 100/106 kgf, abrasion resistance along the plane of 2500-3500 cycles, crease resistance of more than 80/79%. All fabric samples are characterized by medium vapour permeability and water resistance, the thermal conductivity indicators meet the requirements for heat-shielding materials, which ensures their high competitiveness in the market. The use of membrane fabrics, domestic wool insulation, as well as improved top and lining fabrics in the structure of the new packages under study makes it possible to improve the performance properties of the entire ski suit as a whole.

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