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FEATURES DESIGNING SPECIAL CLOTHING FOR THE HOT CLIMATE OF UZBEKISTAN

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Abstract: *This paper considers the issues of establishing the relationship between the properties of fabric, clothing design and the comfort of clothing; communication of the size of the human body, allowance for free fitting, modern design when developing the design of clothing; connection of the allowance for free fitting with a suitable air gap. A diagram is given that characterizes the dependence of the comfort of clothing on its design and properties of fabrics. A mathematical model of the processes of air exchange in the underwear space is considered, which will allow obtaining more complete information and establishing more stringent dependences of the allowance on various factors affecting its value. The numerical value of the allowances for some parameters of the environment, which characterizes the hot climate, is obtained. An analytical method for calculating the allowance for free fitting is considered. The fact is stated that for the air exchange process a mathematical model has been obtained that allows one to determine the concentration of H_2O or CO_2 in the space under the space during diffusion air exchange, and that the mathematical model of complex convective-diffusion air exchange is based on the equation of the material balance of the transferred component for the space available; and that the curves were used to determine the influence of product design, fabric properties and environmental parameters on the free-fit allowance. The issue of verifying the correctness of the allowance for free fit, obtained by calculation, according to the formula was considered in detail. Physiological and hygienic assessment of special clothing intended for hot climates was carried out experimentally in a microclimatic room, testing samples of special clothing with different values of allowances for free fit compared to the calculated size.*

Keywords*: special clothing, microclimate, underwear parameter, temperature, humidity, carbon dioxide concentration, design, ventilation openings, radiation***.**

INTRODUCTION. Protective clothing is one of the most widely used personal protective equipment for workers. It must meet the following basic requirements: ensure the preservation of the normal functional state of a person and his performance during the entire period of using it; protect from external factors; do not have a general toxic and skin-irritating effect; be durable and aesthetically pleasing [1].

When the skin temperature rises to 35°C, the work of the sweat glands begins, and the secretion of the sebaceous glands simultaneously increases. In persons adapted to high temperatures, sweating, as well as the secretion of the sebaceous glands, are increased. Cooling by evaporation, the released sweat also serves to protect the body from solar radiation. Sweat partially reflects and blocks infrared and even ultraviolet rays. [2].

In the hot climate of Uzbekistan in the summer period temperature 40-45 °C during the day, tb = 26-28 °C at night, the mechanisms of thermoregulation of workers are under excessive stress. In many subjects, there is a decrease in systolic pressure, a weakening of the functional state of the cardiovascular system, a negative water balance, a characteristic swelling of the limbs, a sharp decrease in working capacity, constant thirst. The constant tension of the thermoregulation mechanism for a long time leads ultimately to the depletion of the body's defenses. [3].

To improve the thermal state of a person under conditions of elevated air temperature and intense solar radiation, it is necessary first to reduce the influx of the latter to the body surface. This can be achieved by using materials of low thermal conductivity, as well as materials that would reflect the maximum amount of sunlight [4]. As already mentioned, the evaporation of moisture from the surface of the body and upper respiratory tract in a warm environment may be the only way to maintain heat balance. In this regard, in the manufacture of clothing, all possibilities should be taken into account to increase the efficiency of perspiration:

-clothing should not be attached directly to the skin to ensure that there is an air layer around the body. The air layer promotes the evaporation of moisture from the skin, which increases the body's heat transfer. The resulting layer of water vapor between the skin and clothing reduces the effects of solar radiation;

-underwear space should be ventilated. This is achieved both due to the appropriate breathability of the clothing materials and due to its design;

-clothing materials must be hygroscopic, capable of absorbing moisture and releasing it into the environment. This helps to reduce air humidity in the underwear space.

Recently, there has been a certain tendency in clothing to prefer convenience and comfort in use [8]. The assessment of the quality of comfort in the operation of special clothing is determined by the degree of its compliance with the conditions of activity. Accordingly, the working conditions also determine the choice of materials for special clothing, the properties of which must meet protective, operational, hygienic and aesthetic requirements.

Rational design, the integrity of the compositional and color solutions of the model are mandatory indicators that characterize the quality of all types of overalls. However, the microclimate under clothing, which determines the thermal state of a person, in our opinion, is one of the most important. In turn, the normal thermal state of a person contributes to the preservation of good health and high performance [4].

The microclimate in the underwear space is determined by humidity, temperature and carbon dioxide concentration. Measurements of the microclimate in the underwear space are

carried out on materials and on garments, using standard tests in laboratories [7]. These studies are carried out in microclimatic chambers, the design of which allows simulating meteorological and special environmental indicators, i.e. humidity, air mobility, temperature, pressure change, content of harmful substances, etc. [6]. Such a camera is widely used abroad; it is not practiced in our country. Creating such a camera requires a lot of effort and expense. Therefore, it was decided to develop an accessible method and device for determining the parameters of the under-clothing microclimate.

MATERIAL AND METHODS. Objects and methods of research. In order to assess the comfort of the underwear space, in this paper, a method and device for determining the parameters of the underwear microclimate parameters of special clothing under working conditions have been created. This method and device make it possible to determine the temperature, humidity and concentration of carbon dioxide in the underwear space in a complex, and transmit information via Bluetooth directly to the mobile phone application.

The code for the software of this device was developed in the program "Arduino-1.8". This device consists of the following sets of items: ESP-32 Wi-Fi + Bluetooth is a modern microcontroller with which you can create remotely controlled Internet devices. CJMCU-811 The CCS811 is an ultra-low power digital gas sensor that integrates the CCS801 sensor and an 8-bit analog-to-digital converter (ADC) MCU to detect air quality, including carbon dioxide (CO2) and a wide range of volatile organic compounds (VOCs).). This is an ultra-low power device, which is used in battery-powered equipment, has high sensitivity, fast heating.

This device has a number of advantages: the ability to create a device with low costs; possibility of use in real field conditions; due to low cost, the possibility of using several devices at the same time, while only one test can be carried out in microclimatic chambers; since the device is based on modern sensors and information technologies, it becomes possible to obtain high-precision information on indicators in a short time using mobile applications. This device will fit into a linen T-shirt used in special clothing with a patch pocket in the back area, since in hot environmental conditions the temperature of the underwear space is usually determined at the level of the chest and back.

RESULTS AND DISCUSSION. Experiments were carried out in three samples of clothing in working conditions. Temperature, humidity and concentration of carbon dioxide in the underwear space is determined by the average statistical value of the period taken. Within 64 minutes, indicators of changes in temperature, humidity and carbon dioxide concentration in the underwear space are determined (Figure 1-6). The generalized results of the experiment are given in Table 1.

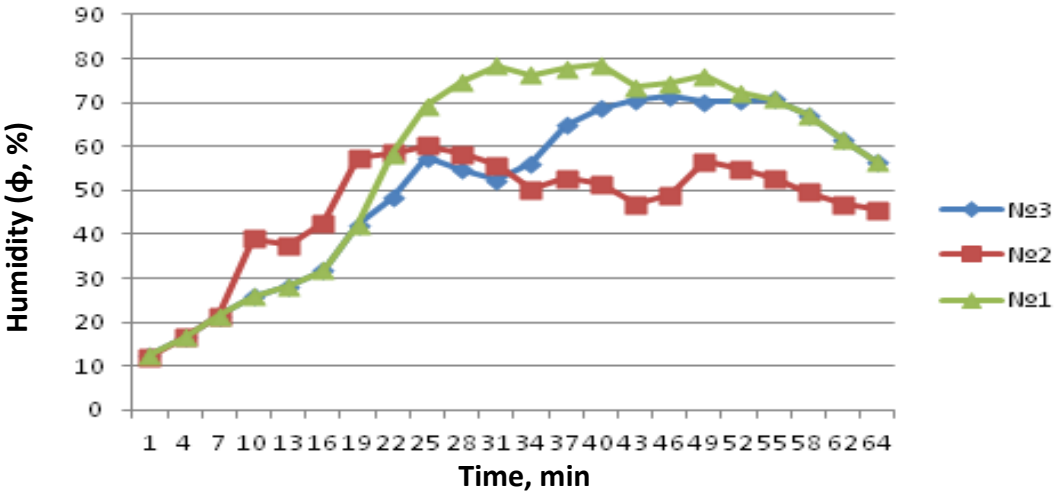

Fig. 1. Dynamics of changes in humidity in the underwear space of a field jacket, at T = 38°C; φ = 16% of the external environment.

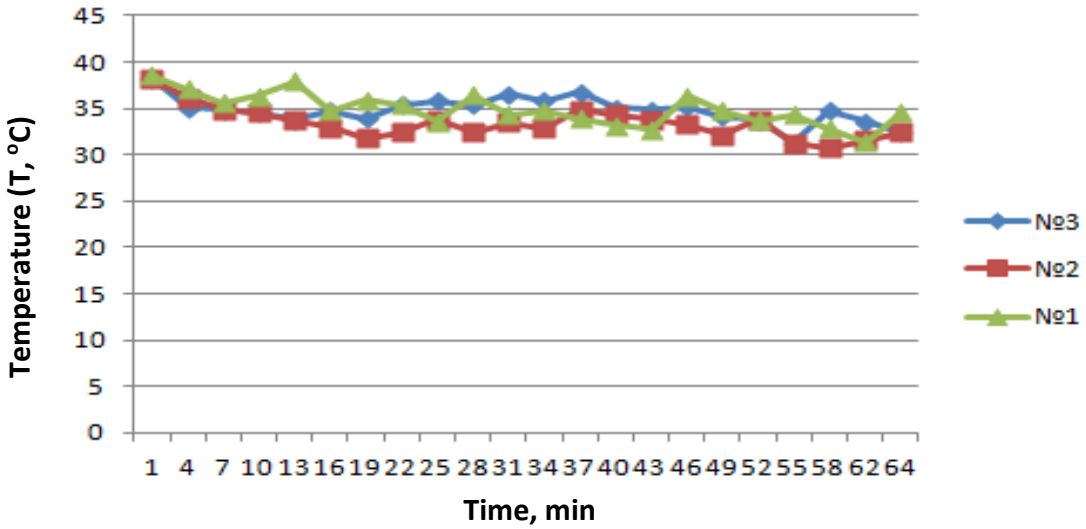

Fig. 2. Dynamics of temperature change in the underwear space of a field jacket, at T = 38°C; φ =16% of the environment

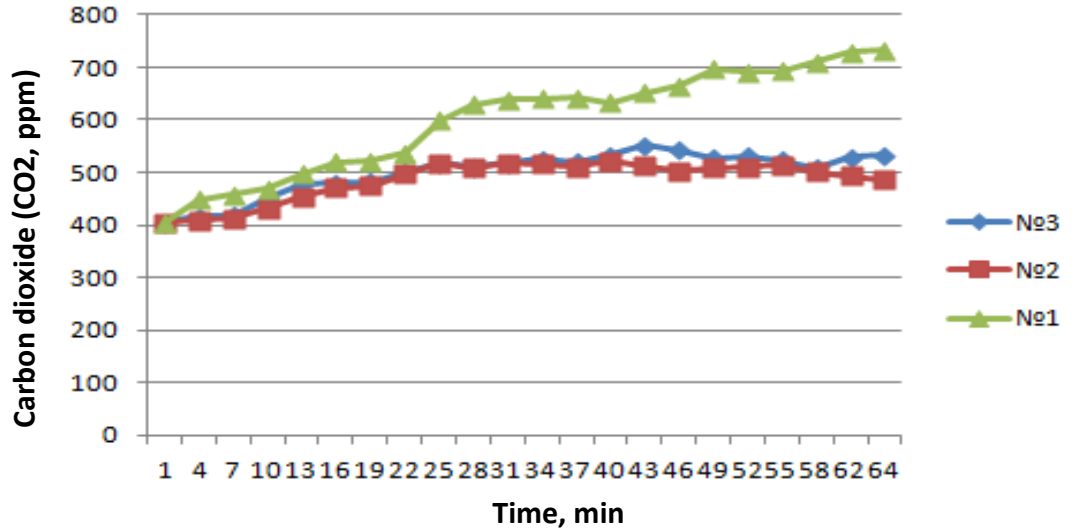

Fig. 3. Dynamics of changes in carbon dioxide in the underwear space of a field jacket, at T = 38^0C; φ =16% of the environment

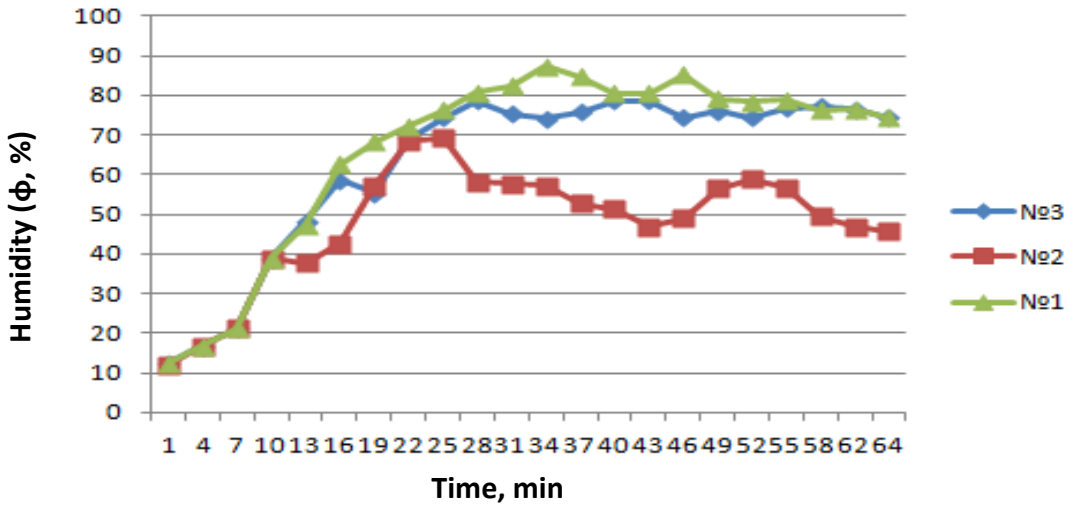

Fig. 4. Dynamics of changes in humidity in the underwear space of a field jacket, at T = 40°C; φ =12% of the environment

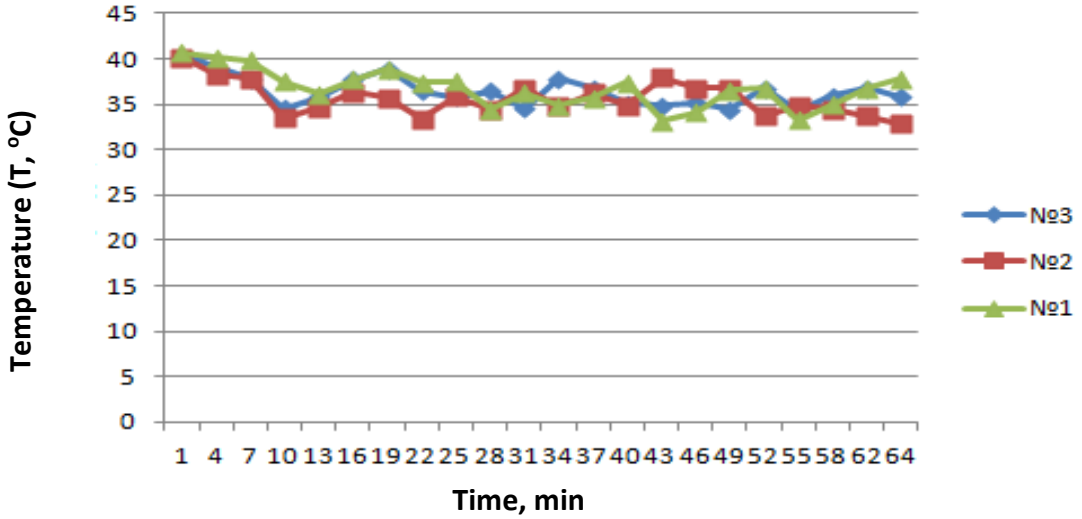

Fig. 5. Dynamics of temperature change in the underwear space of a field jacket, at T = 40°C; φ =12% of the environment

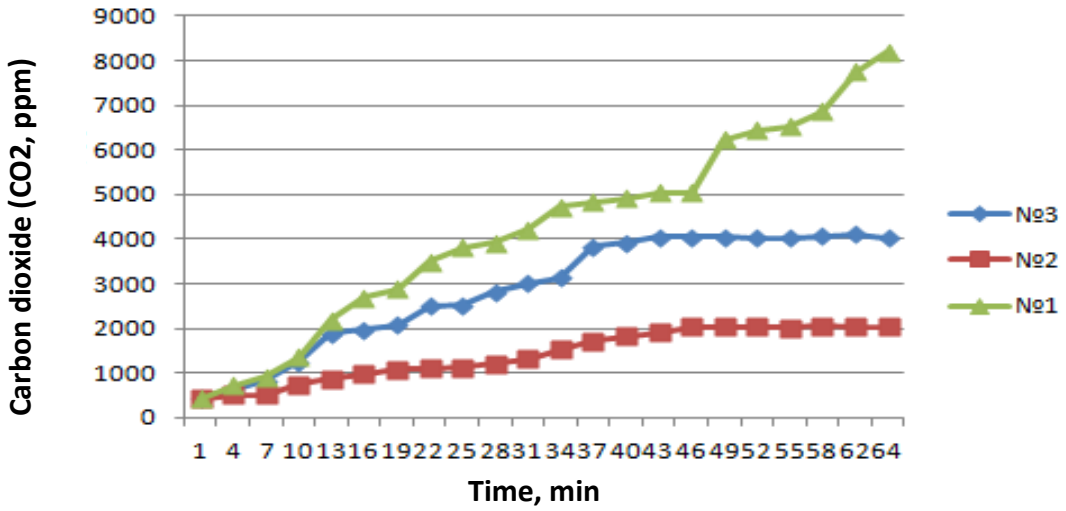

Fig. 6. Dynamics of changes in carbon dioxide in the underwear space of a field jacket, at T = 40^{0}C; φ =12% of the environment

Table 1

The results of the experiment of the parameters of the underwear space

Temperature (T, °C), Humidity (f, %), Carbon dioxide (CO2, ppm)	Sample №1			Sample №2			Sample №3		
	(T, °C)	(f, %)	(CO_2, ppm)	(T, °C)	(φ, %)	(CO_2, ppm)	(T, °C)	(f, %)	(CO_2, ppm)
T=30 °C, f=25%	30,6	26,4	554	26,4	35,7	413	29,6	27,1	465
T=38 °C, f=16%	34,9	56,5	600	33,4	46,1	485	34,8	50,8	500
T=40 °C, f=12%	36,7	66,4	4234	35,6	47,7	1413	36,4	62,9	2870

To determine the level of comfort of special clothing, it is conditionally proposed to use a comprehensive assessment, which consists of physical and psychological (Kf and Kp) comfort, expressed by the coefficient K

$$К=Кf+Кp \quad (1)$$

It is known from sources that for a person to feel normal, the humidity in the underwear space should be 20-40%, temperature 29-32 ^{0}C. The results of the humidity values of the underwear space make it possible to assess the level of psychological comfort of field clothing. For a comfortable microclimate in the underwear space, humidity is required no higher than 40%, which means:

$$Кp = φ/40 \quad (2)$$

where, Кp is the relative coefficient of psychological comfort; φ - humidity in the underwear space, %. Thus, the values of the relative coefficient Кp - psychological comfort (table 2) are characterized by the following:

-intervals (0.5-1.0) - underwear microclimate of a comfortable state;

-intervals (0.25-0.49; 1.01-1.25) - under-clothes microclimate of a sub comfortable state;

-intervals less than 0.25; more than 1.25 - underwear microclimate of an uncomfortable state.

Table 2

Indicators for assessing the level of psychological comfort of field clothing

Relative coefficient psychological comfort Кp	Clothing comfort level, score
0,5-1,0	3
0,25-0,49; 1,01-1,25	2
less than 0.25; more than 1.25	1

Physical comfort, as has been stated, is an acceptable dynamic fit characteristic, i.e. ergonomic design. If we take conditionally for the relative coefficient of physical comfort

$$Кf = P, (0<P<1) \quad (3)$$

where, Кf is the relative coefficient of physical comfort; P is an indicator of the range of movements of the hands of a dressed person, conditionally corresponding to the method for determining the dynamic conformity of the structure to the human body (Table 3).

Table 3

Assessment of the level of physical comfort of clothing

Relative coefficient physical comfort Кf	Clothing comfort level, score
0,75-0,98	3
0,55-0,74	2
0-0,55	1

A complex indicator of comfort is obtained from the calculated values of the relative coefficients of physical and psychological comfort, its value of 5-6 points reflects the comfortable level of clothing, 4 points sub comfort, less than 4 discomfort.

Table 4

Evaluation of the comfort of field clothing for military personnel

Special clothe	Kp		Kf		K	
	coefficient	score	coefficient	score	score	level
Sample №1	1,66	1	0,584	2	3	discomfort
Sample №2	1,19	2	0,976	3	5	comfort
	1,57	1	0,976	3	4	subcomfort

CONCLUSION. Thus, as a result of the analysis of special clothing, the following factors have been identified that affect the comfort of the product:

-composition and hygienic properties of tissues;

-constructive and decorative openings of clothes;

-silhouette of special clothes.

The results of the experiment showed that the 2-sample of special clothing at an average air temperature of 40 ° C and a humidity of 12% shows a high result in the air exchange of the underwear space, since it has constructive and decorative holes, and it is offered as comfortable special clothing for use in hot climate conditions. Therefore, this technique makes it possible to determine the degree of rationality of comfortable field clothing and overalls in general.

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