Development of Thermal Simulator of Human to Thermophysical Research of Medical Supplies and Thermal Surgical Equipment

Igor Khudetskyy, Anna Telpiakova

Abstract – **This paper provides the reasoning and technical solutions for development of thermal simulator of human - the device for measuring the thermo physical characteristics of materials and thermosurgical equipment.**

Keywords – T**hermal simulator of human, Thermal surgical equipment (TSE), Medical Products (MP), Thermo physical properties (TFP).**

I. INTRODUCTION

Today in Ukraine development of medical devices conducted some tests hygienic characteristics like hygroscopicity, capillarity, air permeability, etc., in accordance with the relevant regulations. Other hygienic testing program tests are not provided. This also applies to developments of special clothes (SC) and TSE. However, the thermo physical characteristics of the MP, SC, TSE and body heat environment in terms of their application is one of the main components that determine the suitability of their target.

The corresponding situation is caused by lack of data on the functional relationship between the hygienic parameters to be determined by known methods, and measure professional performance in specific microclimatic conditions, and rates of heat exchange between the product and the human body.

Existing methods and apparatus for determining the most indicators involve testing laboratories, and in the case of TSE focus their research by conducting tests on experimental animals.

The current system has several shortcomings:

- Hardware method for determination of the TFP today do not fully correlate with the heat exchange system in man-environment influence at MP, SC, TSE;
- Quite a long time study;
- Significant financial costs.

Given the above, solving problems of studying TFP by manufacturing thermal simulator of human is important.

II. INVESTIGATION OF THERMAL PRODUCT FEATURES

Thermal properties of many woven and nonwoven fabrics are among the important parameters for their effective use of the target, and their study is becoming more practical significance.

Anna Telpiakova –NTUU «KPI», 37 Prospect Peremogy, Kiev 03056, Ukraine, e-mail: a.telphyakova@ukr.net

High thermal properties of tissue depend on the thermal conductivity of fibers and their forms, as well as the nature and quantity of filling their volume of tissue.

Fabric that has more porosity, less conductive because it filled a larger volume of air is a poor conductor of heat.

Thermal conductivity of textile fabrics associated with the transfer of energy of thermal motion of microparticles from the more heated parts of the body to a less heated, leading to temperature equalization.

Factors affecting the thermal resistance of the material include: unit weight, thickness, humidity, type of fibrous material, breathable, and others.

In order to determine the optimum material for the production of a particular medical product it is necessary to study their TFP.

The urgency of the work is necessary in previous studies of heat transfer in the system "man - environment" and thermal characteristics of the MP, SC and TSE. This will determine the necessary characteristics for its material, which corresponds to the product intended purpose and scope of its efficient use.

One of the stages of the production is conducting preclinical tests. No one single method and apparatus for determining the thermal properties of materials and TFP does not allow them to evaluate this important parameter.

By solving this problem and optimize the design and operating parameters of equipment for remote control of tissue temperature is conducting research on thermal simulator of human.

Purpose - development of thermal simulator of human for studying basic thermo physical properties of the MP, SC and TSE.

The basis of the TFP assessment methodology of products by thermal simulator of human is reconstruction of main stages of semi natural laboratory research for layout samples. The choice of this technique as a prototype connected with its relatively high accuracy (compared to other similar methods), the presence of a large number of experimental data on samples with different layout TFP and the ability to use these data to predict performance in specific microclimatic conditions. [1]

Data analysis of literature on the thermal physics of the body temperature parameters "core body" and the membrane at restand under different microclimatic conditions, carried out research allowed to form their own medical and technical requirements for thermal simulator of human and continue to find constructive solutions to their implementation.

Also, it was established the dependence of material properties that are investigated by the microclimate in the environment. [2] In this context of the research and test rig included micro-camera, in fact thermal simulator, a set of measuring devices and regulating devices (Fig. 1). Appearance of thermal simulator of human presented in Fig. 2.

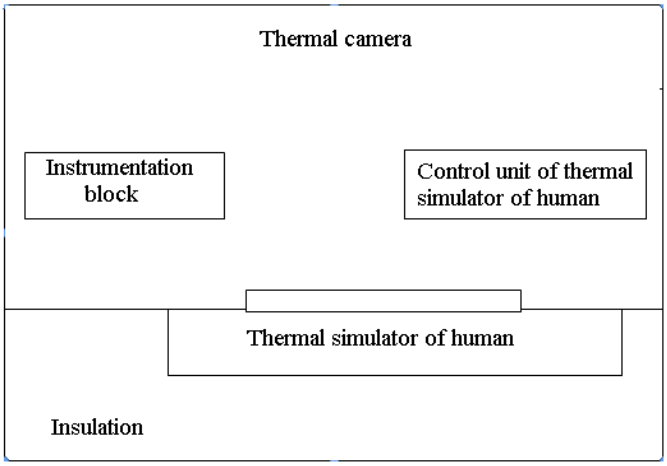

Fig. 1 Flowchart of thermal simulator of human

Thermal simulator of human is a calorimetric chamber with built-in heating element that allows simulating the specific heat of man at rest and maintaining a thermal balance with the environment. The design allows to maintain the temperature of thermal simulator's core "body" at 37 ° C and the temperature of the shell "body" in the range of 33-36,5 ° C, depending on the ambient temperature. It meets the conditions of thermal balance of man at rest.

Microclimatic camera provides automatic maintenance of air temperature and relative humidity and the possibility of regulating the speed of air movement and intensity of thermal radiation. Its overall dimensions: height - 1000 mm, width - 1000 mm, depth - 500 mm.

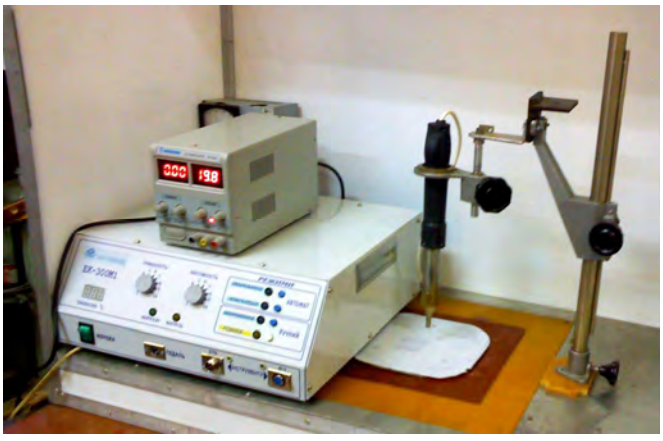

Fig. 2 Screenshot of thermal simulator of human

The temperature is maintained using the developed automatic fan control that allows you to create and maintain it to within 0.2°C. Humidity in the chamber is created for humidification device and evaporator with automatic humidity control, and maintains a relative humidity of 20% to 80%.

Given that the actuators machine moisture control is provided by means of drying air, the zone regulation is limited to the minimum value of real humidity during the studies with temperature in the chamber close to room temperature.

Thus, the expected systematic error connected with the main difference between thermal characteristics of the standard man and thermal simulator of human is 3%. Whereas, for the real man in the range of fluctuations in body weight from 40 to 100 kg, height 150 to 190 cm surface area of the body varies from 1.32 to 2.46 м^2, and the ratio of body weight per unit area (1 м^2) is 30.3 to 40.6, this systematic error can be neglected, and thermal simulator of human recognize adequate for the thermal characteristics of the standard model of man.

The main advantages of thermal simulator are:

- Ability to study heat transfer rights to use the clothes with desired properties and environment using various materials (nonproduction models or prototypes and conduct full-scale experiments);
- Low cost research;
- Ability to use automated procedures, materials research climate change and simulate variable loads during the experiment;
- Using of biological tissues for thermal stabilized surface interactions in the process of modeling convection-radiation flow and living tissue;
- Modeling of surface sterilization procedures tissue convection-radiation flow.

III. Conclusion

Through the above research and testing set up terms of reference for the development and subsequent production of thermal simulator of human. This device allows to improve the choice of materials used in the manufacture of medical devices by extending the range of characteristics obtained after appropriate testing. In addition, the using of thermal simulator of human you can reduce the cost of testing in the process of entering a specific product on the market.

References

[1] V. S. Koshcheev, I. V. Lebedev, M. A. Razran, G. Ter-Akopian, «The method of studying heat transfer with the environment under conditions of natural convection», in Apparatus and methods of medical control, 1982, pp. 99—100.

[2] R. F. Afanasieva, L. A. Basargin, N. Bessonov, O. Zalogueva, «On the methods of identifying and assessing changes in body heat content», in Hygiene and Occupational Diseases, 1992, N 6, pp. 3-5.