ACADEMICIA: An International Multidisciplinary Research Journal
ISSN: 2249-7137 Vol. 12, Issue 05, May 2022 SJIF 2022 = 8.252
A peer reviewed journal

DEVELOPMENT OF A FUNCTIONAL AND ERGONOMIC NATIONAL BASIC DESIGN OF SPECIAL-PURPOSE CLOTHING

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DOI: 10.5958/2249-7137.2022.00388.3

ABSTRACT

This article will talk about the development of a functional-ergonomic national basic design of specially targeted clothing. The author relied on tenological data, analyzed the problem on the basis of available scientific literature, and studied the existing peculiarities in the development of functional-ergonomic national basic design of specially targeted clothing.

KEYWORDS: *Ergonomic Clothing, Man-Clothing-Environment System, Ergonomic Design, 3D Scanning.*

INTRODUCTION

Clothing covers more than 80% of the surface of a person and forms together with a person a "Person-clothing-environment" system in which clothing is in constant contact and interaction with the surface of the figure, therefore, such indicators of the quality of clothing as "comfort" and "convenience" are important. Human and industrial product contacts are considered in ergonomics at the biological and psychological levels **[4].** During operation, a person has psychological feelings of comfort or discomfort, heat and cold, comfort, pressure on certain parts of the body, which affects fatigue and human performance. Consequently, the creation of ergonomic clothing requires a more complete alignment of the form of clothing with the anthropometric characteristics of the human body in accordance with ergonomic requirements.

Main part:

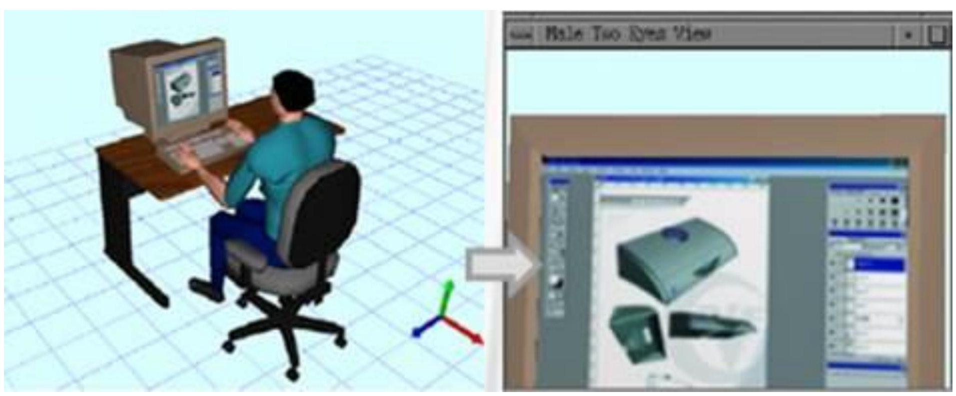
Several approaches have been identified for conducting research and studying the "Man-clothes-Environment" system. One of the main directions is to study the influence of the surrounding space on the operation of clothing. Thus, researchers in Croatia **[25]** have developed a kinematic method for studying the ergonomics of the worker using three-dimensional video recording, which allows to obtain a cyclogram of movement, and the assessment of physical risk factors is carried out by analyzing the posture and movements realized by the operator during the work.

When studying the ergonomics of the workflow, German researchers developed the technology "CUELA" (Ellesast) (Pic. 1).

Pic. 1. Study of workplace ergonomics using "CUELA" technology (Ellesast)

The essence of this technology lies in the methods of obtaining and analyzing data based on the use of a computer and a "suit" of wireless sensors, which provides an analysis of the movements of an employee during a full working day **[19].**

Chinese researchers **[29]** have developed a virtual mannequin to study the workplace in the office and the interaction of clothes with the figure (Pic. 2), consisting of physiological and anthropometric models repeating the poses, reactions and movements of a person, and an algorithm for analyzing the "Man-clothes-environment" system has been proposed.

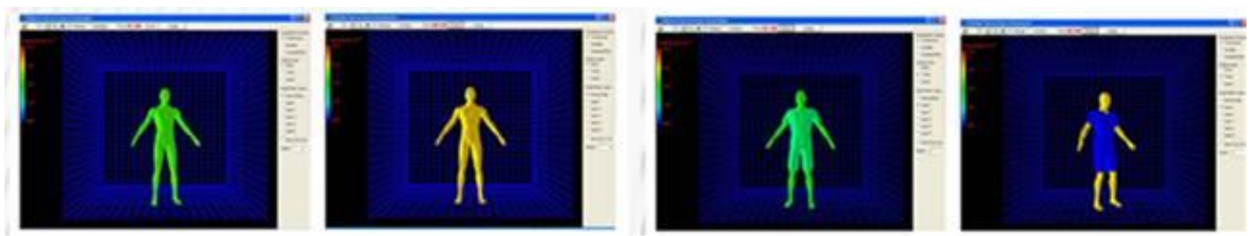


Pic. 2. The result of the workplace simulation and the analysis of the visual observation zone

The interaction of the "Person-clothing-environment" system is described in detail by the authors **[23, 26]** who noted that "psychological comfort" is provided by the comfortable microclimate conditions of the potezny space, and "physical comfort" characterizes the degree of adaptability of clothing to a person, i.e. static and dynamic correspondence.

Many foreign authors in order to study the interaction of the "Man-clothing-environment" system have developed mathematical models for the subsequent application of research results in the development of functional clothing to determine increases in freedom of movement, including German researchers (X. Xu, J. Werner, 1997) **[37**], scientists of the Faculty of Mechanical

Engineering of the University of Maribor in Slovenia (J. Gersak, M. Marcic, 2007) **[27],** American and Chinese scientists conducting joint research (L. Yi, U. Aihua, et. al., 2006) **[38]** at the Hong Kong Polytechnic University (Pic. 3, a), Chinese scientists (F. Li, Y. Wang, 2013) **[30]** (Pic. 3, b) from Nanjing University of Aeronautics and Astronautics in China. Such systems allow you to simulate and study the thermal and operational characteristics of products. The advantage of the developed systems is the ability to predict the thermal state of a person, which is an important aspect of comfortable clothing, as well as the possibility of multiple modeling of heat exchange in the "Man-clothing-environment" system in order to improve the design of clothing.



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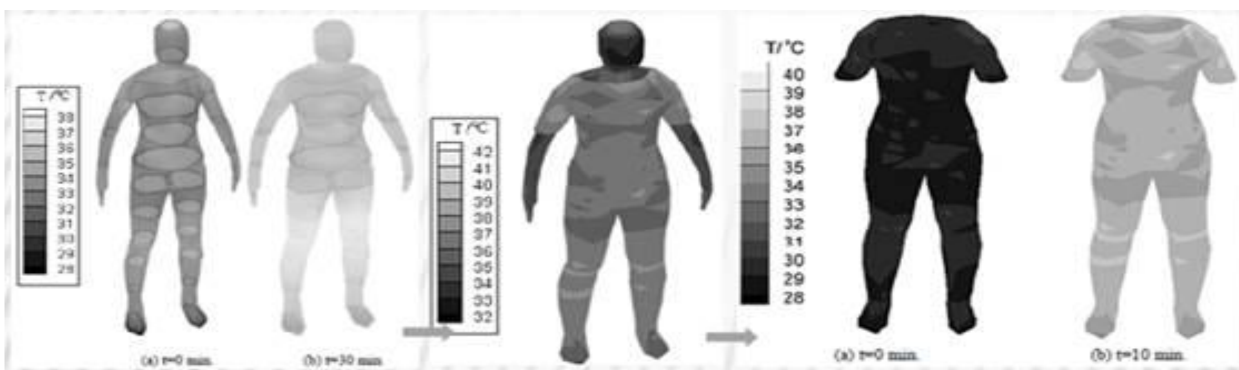

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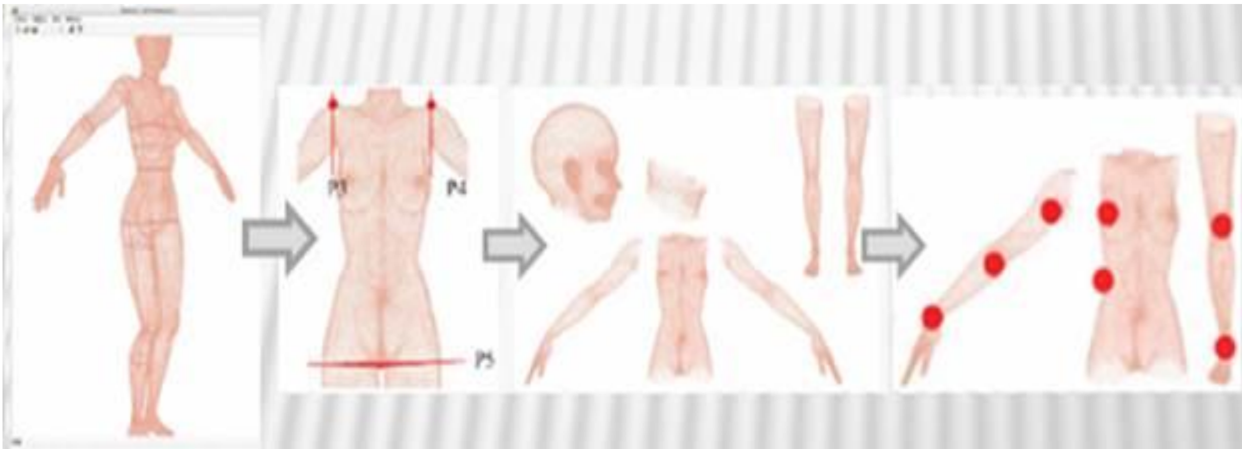
Pic. 3. Virtual environment for studying the interaction of the "Man-clothes-environment" system: a-**[38]** (L. Yi, U. Aihua, et. Al); b-**[30]** (F. Li, Y. Wang)

To study the interactions of the elements of the "Man-clothing-environment" system in statics and dynamics, anthropometric **[4]** and anthropodynamic studies are carried out, respectively, using various contact and non-contact methods. American scientists of the Department of Clothing, Textiles and Interior Design of Kansas State University **[28]** and Russian researchers **[14**] recommended finding dynamic effects when performing characteristic types of movements based on studying the operating conditions of the designed clothing.

Currently, contactless measuring systems of three-dimensional scanning have been developed to obtain reliable information about the dimensional characteristics of the human body, both in statics and dynamics. Thus, the development of non-contact measurements during movements is devoted to the research of foreign specialists (Liu Chi, R. Kennon, 2005) of the Textile University in Manchester **[31],** Chinese scientists (L. Bing et al., 2010) **[21],** scientists (Y. Cui et al., 2013) of the British University [**24],** scientific work of a German scientist (C. Mattman, 2008) of the Zurich Higher School **[33**] (Pic. 4, d). The 3D scanning system developed at

MGUDT **[11]** makes it possible to simulate in a virtual environment the movements characteristic for the operation of clothing during active human activity (Pic. 4, d).



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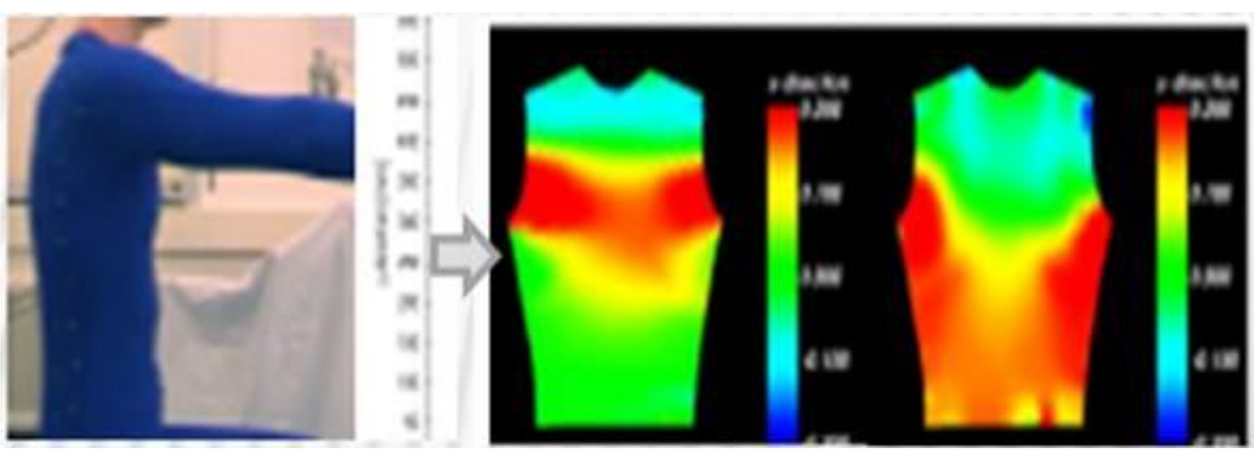

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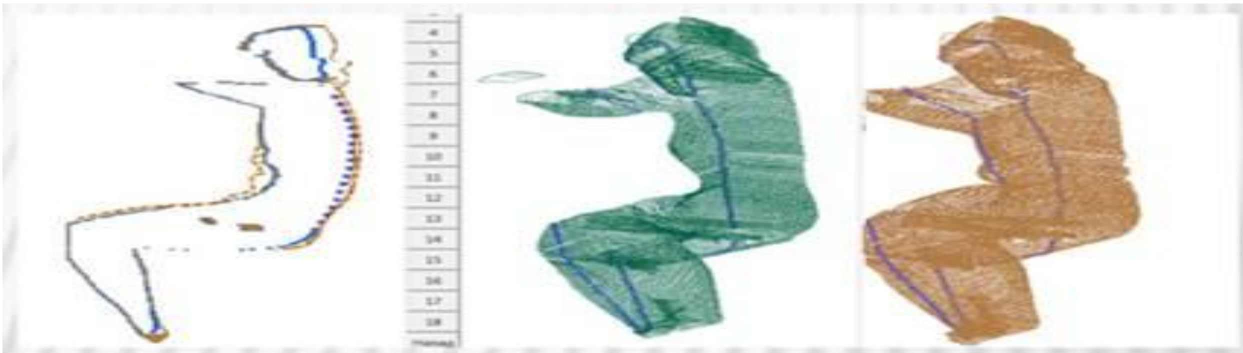

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Pic. 4. The use of modern systems in the study of figures in dynamics: a-**[21]** (L. Bing et al.); b-**[31]** (Liu Chi, R. Kennon); c-**[24]** (Y. Cui et al.); d- **[34]** (C. Mattman); d- **[11]** (I. A. Petrosova)

When studying scientific papers, the following methods of designing ergonomic clothing were identified: taking into account the biomechanical characteristics of movements and calculating the optimal values of design parameters; optimization of design parameters according to ergonomic indicators; application of original design and technological solutions of parts.

The works of E.Ya. Surzhenko are devoted to the problems of increasing the level of ergonomic compliance of special-purpose products. The author **[14]** proposed a new approach to the design of ergonomic clothing based on the bio-kinematic analysis of the interaction of elements of the "man-clothing" system. This approach provides a rational design with a given level of dynamic compliance, but a satisfactory level of static compliance of clothing **[2, 14].** Therefore, the proposed method cannot be applied in the design of household clothing.

RESULTS AND DISCUSSIONS:

A separate direction can be distinguished by the ergonomic design of special, sports and children's clothing, the use of structural and technological means to ensure the dynamic compliance of the product with the conditions of their functioning **[9, 18]:** the use of various sleeve cuts, the use of elastic inserts in stressed areas of clothing, non-sutured sections, folds, gussets, adjustable parts. However, it should be noted that the original design and technological solutions of the parts are used as additional means to increase the dynamic conformity of the product.

Ensuring the ergonomics of structures by optimizing design parameters according to ergonomic indicators were studied in the works of E. B. Kobyakova, V. V. Razmakhnina, N. H. Naurzbayeva **[4,13,17].** The essence of this method of obtaining ergonomic clothing is that it is necessary to find such a combination of design parameters at which the level of dynamic conformity of clothing would be maximum. Optimization of design parameters according to ergonomic indicators of dynamic compliance allows you to design clothes with a given level of dynamic compliance, which helps to increase the convenience of the product in operation and reduce material consumption. However, the cost of procedures is comparatively high. Since such an approach to solving the problem of ergonomics of clothing entails large material and labor costs for the production of layouts and for conducting studies of their dynamic compliance with a given set of movements.

In general, an analysis of existing methods of designing ergonomic clothing has shown that the methods determining the amount of the minimum necessary increase in the design of clothing have a common disadvantage - the amount of the minimum necessary increase is unevenly distributed over the surface of the figure and are based only on the linear dimensions of the human figure and do not take into account the shape of the surface being dressed.

It should be noted that a new direction is currently developing - the design of virtual systems "figure-clothing", where body scanners are used to digitize the surface of the figure and clothing. Thus, in the works **[5, 6, 7, 15],** the researchers established the relationship between the design parameters and the values of air gaps at the main anthropometric levels and obtained equations for calculating air gaps depending on the design parameters. However, the correctness of finding the values of constructive additions is questionable, since their values are determined for static and do not take into account ergonomic requirements that affect the comfort of clothing in motion.

An important stage in the design of ergonomic clothing is the assessment of its comfort, both in statics and dynamics. In scientific papers [**8, 14, 16, 17**, etc.] devoted to solving the problems of improving the ergonomics of the design of household and special clothing, various methods for assessing the static and dynamic compliance of the "man-clothes" system are proposed.

There is a known method for assessing the quality of landing with the help of various adaptations to the dummy and special screens determining the positions of the side, sleeve, side seams, etc. [**17].** When assessing the convenience of clothing in dynamics, devices were proposed by E. B. Koblyakova and V. V. Razmakhnin. However, it should be noted that these devices have disadvantages, since the data obtained during the evaluation process are subjective and are measured by devices located at a distance from the object, which leads to a high measurement error.

CONCLUSION:

The rapid development of computer technology and visualization options creates alternatives to traditional methods of landing analysis. Modern sewing CAD systems are equipped with virtual mannequins to visualize the shape of the designed clothing models in order to identify defects in the fit of products **[10, 36].** The ability to evaluate both static and dynamic landing defects is implemented in CAD "OptiTex", "Lectra". In addition to the folds and creases on the product, which are reflected directly when the mannequin is "dressed", the developers of these CAD systems provide a special viewing mode that allows you to assess the pressure of clothing on the human body and the tension in the fabric in various areas. Places on the product where mechanical forces (pressure, tension) act are marked with color spots, the saturation of which depends on the magnitude of the force.

At the second stage, the design features of the designed clothing are determined by selecting the values of the shaping parameters, an ergonomic design of clothing for a given target group is developed.

At the final stage, the quality of clothing is assessed using 3D scanning technology, by combining scanned three-dimensional models of figures in and without clothing **[12].**

Thus, the proposed technology provides the possibility of virtual modeling of the behavior of the "man-clothes" system in statics and dynamics. **[39, 40]** Provides an accurate determination of the dimensional characteristics and the external shape of the surface of the figure and the surface of clothing in order to evaluate the projected product to the external shape of the consumer's figure, which in turn will lead to rational product designs, and, consequently, an increase in the level of ergonomics of clothing.

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