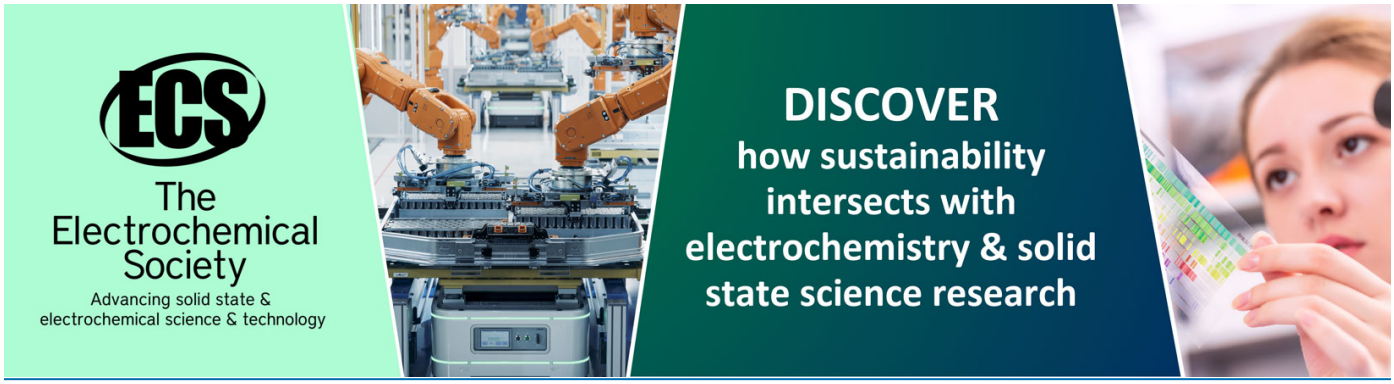
Research and algorithmization of the process for completing clothes by materials with electric propertie



Research and algorithmization of the process for completing clothes by materials with electric propertie

I Cherunova[1,2], G Kutilina[1], E Milyutin[1]

[1] Department of Design and technology Don State Technical University, Shevchenko street 147, Shakhty 346500, Russia Federation
[2] University of Rostock, Albert-Einstein-Straße, 2, Rostock, Germany

Abstract. In the article research results are presented, which aim to provide of automation algorithm of the process for completing clothes by materials with electric properties. The problem of electrostatic safety is included into the field of particular relevance. Analysis of the list of quality indexes of the special protective clothing allowed to form for automation of design works a group of protective properties of clothing to be used for positioning of the rational suit designated for the employees in the northern regions. Developed Structure of protective properties of clothing for automation of design works; Required properties of special anti-electrostatic clothing for the protection from reduced temperatures; additional quality parameters of materials and physical and mechanical properties. Designed and applied a support algorithm of the process for completing clothing by materials with electric properties. Installed normalizing parameters of materials for their automated forming into packages of details for protective clothing with up-to-date electric properties. The research was made in Don State Technical University within the framework of State Assignment of the Ministry of education and science of Russia under the project 11.9194.2017/BCh.

1. Introduction

Static electricity acquires high pace of spreading both in domestic field and in production. This is related to expanding application of electronic equipment, synthetic materials and substitution of natural materials by synthetic ones due to their inexpensiveness. This in combination with low ambient temperatures, low humidity and particularly when explosive gas mixtures are in the air can lead to occurrence of emergency situation [1].

At the present moment the main methods of protection from static electricity are the following [2]:

1) application of collective protection equipment, including earthing devices, neutralizers, damping devices, anti-electrostatic substances, shielding devices;

2) application of personal protective equipment, such as special anti-electrostatic clothing, special anti-electrostatic shoes, safety anti-electrostatic devices (rings and bracelets), anti-electrostatic equipment for the protection of hands;

3) ionization of premises.

The problem of electrostatic safety is included into the field of particular relevance. Therefore, it is important not only to select the materials correctly, but also to suggest technology for improving anti-electrostatic properties of materials for clothing that will enhance level of human safety at production.

2. Another Topicality, scientific relevancy

Analysis of the list of quality indexes of the special protective clothing allowed to form for automation of design works a group of protective properties of clothing to be used for positioning of the rational suit designated for the employees in the northern regions [3] (Figure 1).

Special anti-electrostatic clothing for protection against reduced temperatures must assure protection from electrostatic charges and fields, low temperatures as well as from general and specific production pollutions attritions [4,5,6].

Analysis of regulatory-technical and methodical literature showed that in the established system for providing human with personal protective equipment considering the rules of their mandatory certification there is no single regulatory document for the fabrication of anti-electrostatic suit for the protection from reduced temperatures [7,8,9]. In this case only averaged recommendations to the materials of similar suits that require detalization and additional research of the issues related to optimizing packages of materials and design parameters of similar protective clothing [10,11].

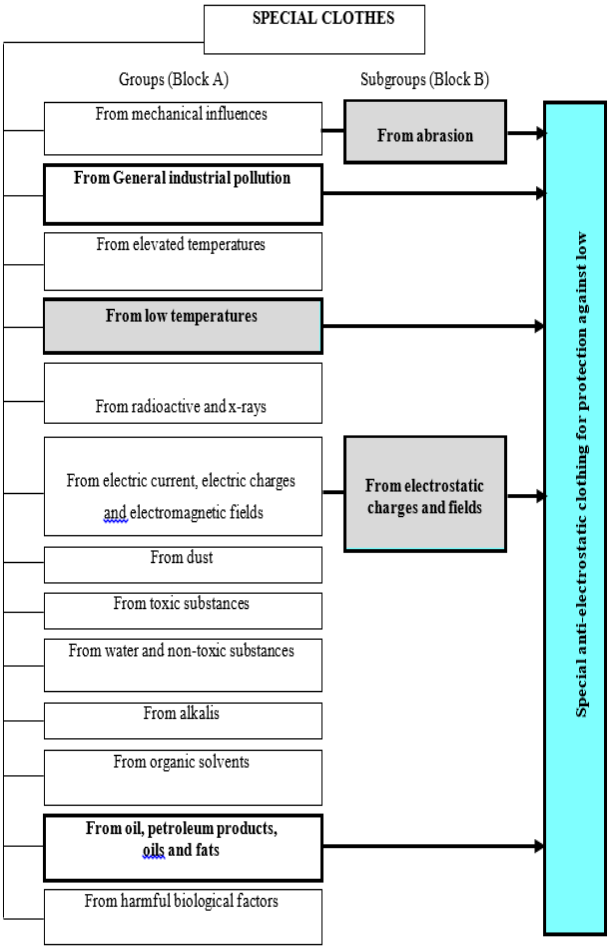


Figure 1. Structure of protective properties of clothing for automation of design works.

Special clothing must comply with complicated set of requirements of protective, hygienic, operational and aesthetic nature. Technical requirements to articles shape the main values of the article properties, and then requirements to the materials for this article. The most rigid requirements are imposed to special protective clothing designated for usage in unfavorable conditions. Clothing must protect the human from hazardous factors which have continuous impact in the course of production or which may arise in case of contingency. Clothing must not hinder movements and must allow to perform certain functional operations [12].

Design options for sets of materials for warm clothing with electrical properties is represented in Figure 2.

Requirements to special clothing for the protection from reduced temperatures are regulated by BS EN 342:2004 [5].

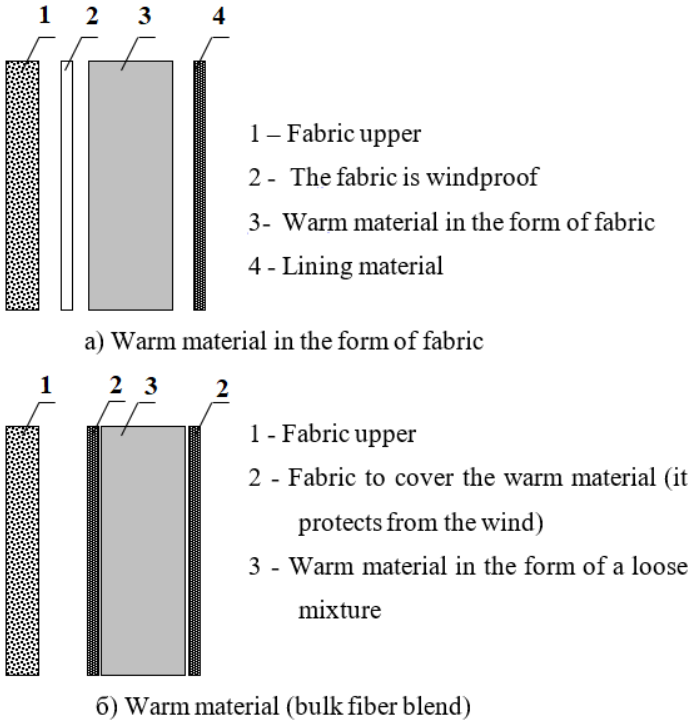


Figure 2. Construction of a set of materials for warm clothes with electrical properties

The overall thermal resistance of the set of heat-protective clothing must comply with the level of energy consumption, meteorological conditions (temperature, air moisture, wind speed) and the time of uninterrupted staying in the cold [13-15].

The range of thermal resistance of clothing as a whole which is used under conditions of the Far North must be within the limits 0,73 – 1,02 m2·K/W [5,6]. GOST 12.4.124-83 [16] stipulates general technical requirements to the protective equipment of workers against hazardous and harmful impact of static electricity. GOST 12.1.002-84 [17] introduces limitations and the extreme value of electric field intensity in the vicinity of operational area.

The processes of automated search and making of decisions represent important blocks of works [18]. The quality of received decisions depends on the completeness of the defined information and regulatory base as well as on algorithms used during analysis of data and decision-making. Therefore, a certain interrelation appears which becomes the ground for statement of task about the necessity to develop computer methods for reveal priority options in the up-to-date range textile materials of electrostatic protection.

3. Theoretical part

In order to automate the process of defining materials for the set of clothing with special anti-electrostatic properties the primary question is to consider complex protection of human by special anti-electrostatic heat-protective clothing . A group of the main properties of materials represented in Table 1. that form a package can be defined for the forecast conditions of operation.

Table 1. Required properties of special anti-electrostatic clothing for the protection from reduced temperatures.

Required properties of special anti-electrostatic clothing for the protection from reduced temperatures	
Protective properties	Characteristics of the suit (Block C)
From attritions	1.Materials with increased density 2.Reinforcing pads in the points of increased deterioration
From general production pollutions	3.Design of article with maximum coverage of the surface of human body by a layer of clothing 4.Properties of materials with water-repelling effect
From reduced temperatures	5.The package of suit materials must assure thermal resistance in accordance with the requirements of GOST [6] as well as considering actual conditions of operation 6.Materials used in the clothing package must assure protection against wind load to preserve its stable thermal resistance
From electrostatic charges and fields	7. Materials with surface specific resistance of not more than 107 Ohm must be applied for the fabrication of anti-electrostatic special clothing 8. Electric resistance between current-conducting element of anti-electrostatic special clothing and earth must be from 106 to 108 Ohm 9. Whereas the time for charge drainage from items of anti-electrostatic clothing that reduces voltage 10 times must not exceed 2 s
From oil, oil products and fats	10. Grease-, oil-repelling treatments for the materials of the top 11. Oil-resistant pads for the areas of direct clothing contact with oily fractions

Apart from properties listed in Table 1, special anti-electrostatic clothing for the protection from reduced temperatures must be comfortable for a person to perform production activity, i.e. to have minimal weight, not to hinder movements, to have reasonable cost and to possess good operation properties within the entire service life. Therefore to create comfortable conditions of work and to enhance human working efficiency technical requirements are introduced related to values of hygienic, operational and technological properties as well as economic values of the finished article. Physical and mechanical properties that determine the above-mentioned additional requirements are represented in Table 2. They define the next stage of arranging algorithm [19] for defining a set of materials for clothing with the

4. Practical relevance

During selection of textile materials for working clothing considering their diversity one should be guide by comprehensive assessment of all properties and their designation.

A support algorithm of the process for completing clothing by materials with electric properties is represented in Figure 3.

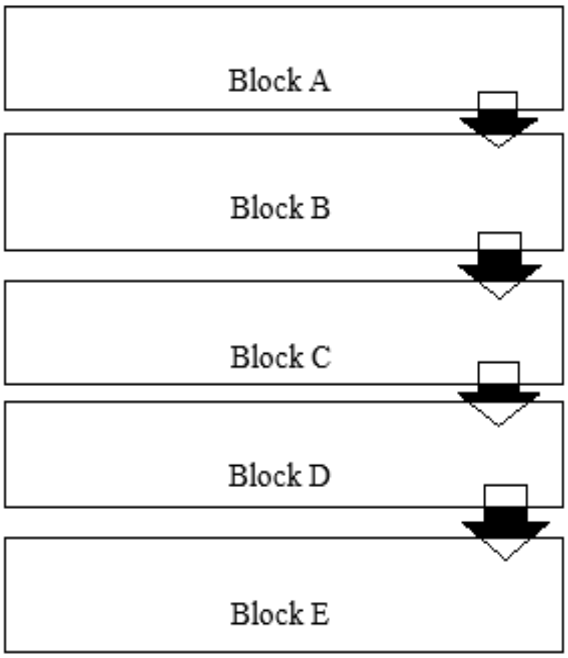


Figure 3. Algorithm of the process for completing clothing by materials with electric properties.

Considering the issue of increasing protection degree for special cold-protective clothing of workers at oil and gas industry a complex analysis was done of regulatory documents introducing limitations for the main criteria of assessing quality and safety of the special protective clothing. The results of the proposed algorithm for CAD are presented in Table 3.

Table 2. Normalizing parameters of materials for their automated forming into packages of details for protective clothing with up-to-date electric properties

Layer of clothing package	Parameters of materials		
	Characteristics	Value	Value of index
Lower (natural fibers)	Weight	Density	200 – 400 g/m3
	Moisture exchange	Hygroscopicity	Not less than 6 %
	Antistaticity	Specific surface electric resistance	not exceeding 1014 Ohm
	Anti-toxicity	Content of free formaldehyde	not exceeding 75 μ/g
	Heat exchange	Thermal conductivity	0,038 – 0,049 W/(m·0C)
Average (thermal insulating)	Weight	Density	300 – 800 g/m3
	Thermal insulation	Thermal resistance	0,50 - 1,02 m2K/W
	Heat exchange	Thermal Conductivity	0,04 – 0,06 W/(m·0C)
	Moisture exchange	Hygroscopicity	Not less than 5 %
	Antistaticity	Specific surface electric resistance	not exceeding 109 - 1012 Ohm
	Air exchange	Air permeability	not less than
Upper (protective)	Weight	Density	145 – 460 g/m3

Layer of clothing package	Parameters of materials		
	Characteristics	Value	Value of index
	Heat exchange	Heat conductivity	0,04 – 0,06 W/(m·0C)
	Moisture exchange	Hygroscopicity	Not less than 5 %
	Antistaticity	Specific surface electric resistance	not exceeding 107 Ohm
	Resistance to oil impact	Is not soaked during	3 - 6, h
	Fire resistance, no residual smouldering	Time of staying in the flame	Not less than 15 s, not less than 20 - 30 s
	Antitoxicity	Content of formaldehyde	not exceeding

Based on the data of table 3, a suit with thermal and electrostatic protection was developed (Figure 4).

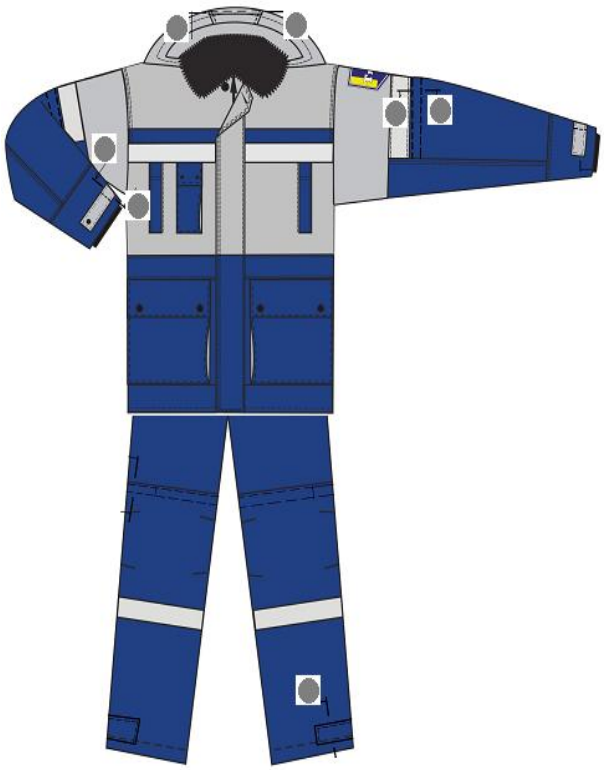


Figure 4. Suit with thermal and electrostatic protection.

The assembly of data received and the developed algorithm of the process for completing clothing by materials with electric properties is an important component of system base to solve the tasks of designing special anti-electrostatic clothing for the protection from reduced temperatures.

Application of such algorithm in general CAD-system at an enterprise of consumer industry will allow to significantly reduce the influence of personal variations of experience and time expenditure for search-analytical and experts procedures by design engineers of up-to-date special clothing.

References

[1] I.Cherunova, S.Tashpulatov, and A. Merkulova, ”Development of automation algorithm for step of designing technology of static electricity protection clothing,”International Russian Automation Conference. «RusAutoCon-2018». 2018, DOI: 10.1109/RUSAUTOCON.2018.85018218501821.
[2] A.Merkulova, I.Cherunova, and I.Danilenko, “Investigation of electrostatic fields by modeling methods, “MATEC Web of Conferences, 2017, Vol.132, Article number 04022, DOI: 10.1051/matecconf/201713204022.
[3] I.V.Cherunova, A.V.Merkulova, and Shenikova E.A., “Electrostatic safety. Ways to improve protective clothing. Monograph, “Publishing, “LAP Lambert Academic Publishing, 2011, 128p. ISBN 978-3-8454-1174-3.
[4] G.N. Mathur, H.Raj, N.Kasturiya, “Protective clothing for extreme cold region, “ Indian J. Fibre Textile. Res. 1997, Vol. 88, pp.292-96.
[5] BS EN 342:2004 “Protective clothing - Ensembles and garments for protection against cold, “London: BSI Group Headquarters-2008.
[6] GOST R 12.4.236-2011 “System of occupational safety standards. Special clothing for protection against low temperatures. Technical requirements, “Moscow: Publishing STANDARTINFORM, 2011.
[7] M.Jachowicz, Electrostatic Properties of Selected Personal Protective Equipment Regarding Explosion Hazard / Journal of Sustainable Mining, 2013, Vol.12 (1), pp. 27-33.
[8] K.A.Shoush, M.K.Mohamed, Zaini, H., and Ali, W.Y., “Measurement of static electricity generated from contact and separation of clothes and car seat covers, “Int. Journal of Scientific & Engineering Research, 2013, Vol. (10), pp. 33-38.
[9] E.R.Post, and K.Waal, “Electrostatic Power Harvesting in Textiles, “Proc. Electrostatic Power Harvesting in Textiles, Annual Meeting on Electrostatics, ESA, 2010, URL:http://web.media.mit.edu/~rehmi/pdf/ElectrostaticPowerHarvesting.pdf
[10] I.Cherunova , S.Samarbakhsh, and N.Kornev, “CFD Simulation of thermo-aerodynamic interaction in a system human-cloth-environment under very low temperature and wind conditions , “ECCOMAS Congress 2016 - Proceedings of the 7th European Congress on Computational Methods in Applied Sciences and Engineering, 2016, 4, pp. 7703-7710. doi: 10.7712/100016.2366.10854.
[11] L.Zhang, H.Zhang, and Y.Li, ”The New Development of CAD in Clothing, ”Computer and Information Science, 2008, Vol.1, No.8, pp.104-106.
[12] D.Gupta, “Design and engineering of functional clothing, “Indian Journal of Fibre and Textile Research, 2011. Vol.36. pp.327-335.
[13] K.C.Parsons, G.Havenith, I.Holmér, H.Nilsson and Malchaire J., ”The effect of wind and human movement on the heat and vapour transfer properties of clothing, ”Annals of Occupational Hygiene, 1999, 43(5). pp.347-352.
[14] B.W.Mangum, and J.E. Hill Thermal, “Analysis--human Comfort-indoor Environments, “Proceedings of a Symposium Held at the National Bureau of Standards, Gaithersburg, Maryland, 1977, Vol.13. 191 p.
[15] I.Cherunova, N.Kornev, and I.Brink, “Mathematical model of the ice protection of a human body at high temperatures of surrounding medium, “Forschung im Ingenieurwesen, Springer, 2012, Vol.76, Issue 3-4. pp 97-103.
[16] GOST 12.4.124-83, ”Occupational safety standards System. Means of protection against static electricity. General technical requirements, “M.: Publishing house of standards, 2003.
[17] GOST 12.1.002-84, ”System safety standards. Electric fields of industrial frequency. Permissible levels of field strength and requirements for control at workplaces, “Moscow: Publishing STANDARTINFORM, 2009.
[18] I.Dabolina, and A.Vilumsone, ”The Role of the Latest Clothing CAD/CAM System Applications in the vol educational Process, ”Material Science. Textile and Clothing Technology, 2012,

№7, pp.63-67.
[19] M. Aihua, L.Yi, L.Xiaonanb, W.Ruomei, and W.Shuxiaoa, ”A CAD system for multi-style thermal functional design of clothing / Computer-Aided Design, 2008. No. 40. pp.916–930.
[20] K.Parsons, ”Human thermal environments: The effects of hot, moderate and cold environments on human health, comfort and performance, , ”2nd ed. London : Taylor & Francis, 2003.