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DEVELOPMENT OF KNITTED GLOVES FOR PROTECTION AGAINST MECHANICAL DAMAGE AND THE EFFECT OF FLAME

Purpose. *Development of protective gloves for combat vehicle crews.*

Keywords: *tactical gloves, knitted protective gloves, equipment of a military serviceman, personal protective equipment.*

Introduction. Under conditions of a full-scale war, the first priority is to protect the territorial integrity of our state and ensure the combat capability of the Ukrainian army. Effective combat types of uniform and equipment of servicemen of the Armed Forces of Ukraine, in particular the crews of combat vehicles, are one of the most important factors in the success of military operations and ensuring the survival of soldiers. Combat injury statistics indicates that shrapnel wounds and burns are the most common. Therefore, providing protection against mechanical damage and the effect of flame is an important part of the security of a serviceman during combat missions. The elements of combat equipment include tactical gloves that protect hands from various types of hazards that can affect the combat ability of a fighter. The order of the Ministry of Defense of Ukraine approved a sample of winter and demi-season gloves made of one-colored knitted fabric of the "fleece" type protective, olive or blue color with linings made of natural suede [1]. On the inner part of the palm, along the line of the wrist, two rows of an elastic tape are arranged. The normative documents of the Ministry of Defense of Ukraine also approved several types of tactical gloves, in particular tactical type TS A01XJ.68845-142:2019 [2], TS A01XJ.68845-254:2020 [3], and leather gloves RTSH TU U 32.9-00034022-096:2015 [4]. For their production the cutting method is used, which involves the presence of stitches that increase the product thickness in the area between the fingers. The research-work [5] proposed knitted structures for the manufacture of gloves made of high molecular weight polyethylene (NVMPE, UHMW PE) to provide protection against mechanical damage. The authors of another work proposed a design of gloves for the protection against fire, consisting of several layers of materials and membranes with different properties [6]. The presence of a multi-layer package of materials

leads to thickening of the shape and complication of the manufacturing process. Therefore, such gloves will be inferior to seamless knitted ones made of fire-resistant yarn from the point of view of the efficiency pertaining to the use of materials and the complexity of a manufacturing process.

Methodology. In the course of the work, methods of analysis and synthesis of scientific, technical and patent literature corresponding to the field of research and an experimental research method were used.

Research results. Modern flat knitting equipment makes it possible to implement the technology of manufacturing tactical gloves as a seamless knitted article, produced directly in the knitting process. Due to the extensibility of the knitted material, the whole-knitted glove will ensure the repetition of the anatomical shape of the fingers, palm and wrist, and anatomical and tactile comfort in the area between the phalanges in the process of using the product. For the manufacture of such gloves, depending on their functional purpose, certain types of raw materials should be selected, that will provide protection against mechanical and fire damage. High-strength polyethylene and para-aramid threads are recommended as raw materials that will provide protection against mechanical damage. For flame protection, yarns made of meta-aramid fibers or meta-aramid fibers in combination with non-flammable viscose should be used. The construction of a functional tactical glove can be double-layered, that is, made as a package of materials. The outer layer should provide protection against mechanical damage, and the inner layer should provide protection against fire. This arrangement of functional layers will prevent the molten material from sticking to the human body. Another manufacturing option is also possible, that will ensure the formation of functional layers directly in the process of knitting a glove. For this variant of glove production, a perfect plated structure is proposed, in the formation of which a high-strength thread is used for the plaiting yarn and a fire-resistant thread is used for the base yarn.

PA-8 glove machine 8 gauge is used for knitting of test samples. The knitted fabrics from high-strength polyethylene (PE) and para-aramid (PA) threads with the linear density of $44 \text{ tex} \times 3$ and non-combustible yarn made of meta-aramid (MA) fibers with the linear density of $40 \text{ tex} \times 3$ were produced. 4 levels of knock over depth are used. The influence of knitting parameters on the knitting structure parameters (the loop length, thickness and surface density) was established. The influence of raw material on the loop formation, which determines the change in the through porosity of the knitted structure and its indicators of resistance to mechanical damage and fire was thoroughly considered by the authors.

Conclusion. The research revealed that the surface density of test knitted samples varies in the following range: PE – $328.4 \div 384.27 \text{ g/m}^2$; PA – $257.5 \div 347.2 \text{ g/m}^2$; MA - $264.0 \div 328.0 \text{ g/m}^2$. An increase the knock over depth in the given range leads to a decrease the surface density of test samples of a knit from PE threads - by 14.5%; from PA threads - by 25.8%; from MA threads - by 19.7% and reducing the thickness of test samples of knit by 13.06%, 17.42% and 12.37% respectively.

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