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Professional paper

TEXTILE MATERIALS USED IN MILITARY PROTECTIVE CLOTHES DESIGN

Sanja Risteski[1], Silvana Zhezhova[1], Vineta Srebrenkoska[1]

[1]*Univerzitet "Goce Delčev", Štip, Tehnološki fakultet*
Miro Baraga bb., Probistip, R. Makedonija

[1]*University "Goce Delčev", Štip, Faculty of Technology,*
Miro Baraga bb., Probištip, R. Macedonia

e-mail: sanja.spasova@gmail.com

Abstract

In this paper the design of currently used protective vests in R. Macedonia with the main characteristics of the fabric covering material are presented. Protective clothing is used to achieve safety for people in professional and other surroundings. In the past people wore protective clothes with one purpose - to protect their body from attacks, but today the advanced soldier needs protective clothes with featuring design and higher level of protection. The process of designing advanced protective clothes is a lengthy process that is based on researching the currently existing models of the protective vests, and searching the needs of the soldiers for new model with contemporary design.
In this paper new generation of materials used in this protective vests and their selection is made. The right selection of vest design means better protection and higher satisfaction of both, the wearer and the technologist.

Keywords: *protective clothes, design, fabric, materials.*

Introduction

In the past, different civilizations and cultures around the world used the protective clothing that was made from natural raw materials. The oldest data indicate that the first type of protective clothing was made of leather, and was found in Europe and East Asia. The first known armor, worn by the Egyptians in 1,500 B.C.E., consisted of an unwieldy shirt-like garment to which overlapping bronze plates were sewn [1]. In the eighth century B.C.E., the Greeks made improvements on this garment by shaping metal plates to each body part. With the development of chain mail by the Celts in the third century B.C.E., a warrior's ability to function in battle was significantly improved. Mail was lighter than earlier armor and flexed with every body movement. Since it provided protection from arrows and knives and other weapons of the times, chain mail remained as the primary protective material used in battle for many centuries [2]. The first commercial protective vest was made of silk

fiber in the late 1800's. One of the first recorded descriptions of soft armor use was found in medieval Japan, and the armor was made of silk [3]. The development of technology and the creation of artificial fibers in late 1960's create a perfect base for production of protective clothing with a higher level of protection [4]. With the advent of synthetic fibers, better protective systems have been developed. In protective clothes design, no amour design is suitable for all the situations, and all levels of protection [5]. For soldiers good design means high level of protection and comfort, and for technologists, the level of required protection and energy absorption characteristics are more important. Designers should put all these needs in new advanced model of protective clothes [6, 7, and 8].

Design and materials demands on the market

The process of designing protective clothes includes right selection of material or combination of materials that will be resistant to impact, with required level of protection and comfort. Determining the number of layers for given level of protection is also important to note. The final weight is a very important factor in the process of designing protective clothes. Lower weight permits greater mobility and better capability for soldiers to perform their assignments with reduced threats from attackers [9]. The future goals in the field of protective military clothes are to design protective clothes that will give the required level of protection with the right selection of materials. Design should ensure comfort and unrestricted movement of the soldier. The weight of the protective clothes should be light and easy removable [10].

Analysis of the protective clothes in R. Macedonia, used fibers and materials

Advances in technology impose the need for the application and development of new contemporary design of protective military clothes. The new design should make the product more competitive in the market and comparable to many such products in Europe and beyond. The design of the currently existing body armor in R. Macedonia has quite simple design with classical shape and minimalistic design. Fibers used for design of protective clothes in R. Macedonia are:
Para–aramide fibers such as Kevlar® (Du Pont) Twaron® (AKZO) Technora® (Teijin) and High tenacity polyethylene fibers such as Dyneema® (DSM) Spectra® (Allied Signal).
Most widely used material for ballistic protection is Aramid, Ultra high molecular weight polyethylene and liquid crystal polymer based fibers. These fibers have provided body armor with extraordinarily improved ballistic protection levels at a significantly reduced weight [11, 12].

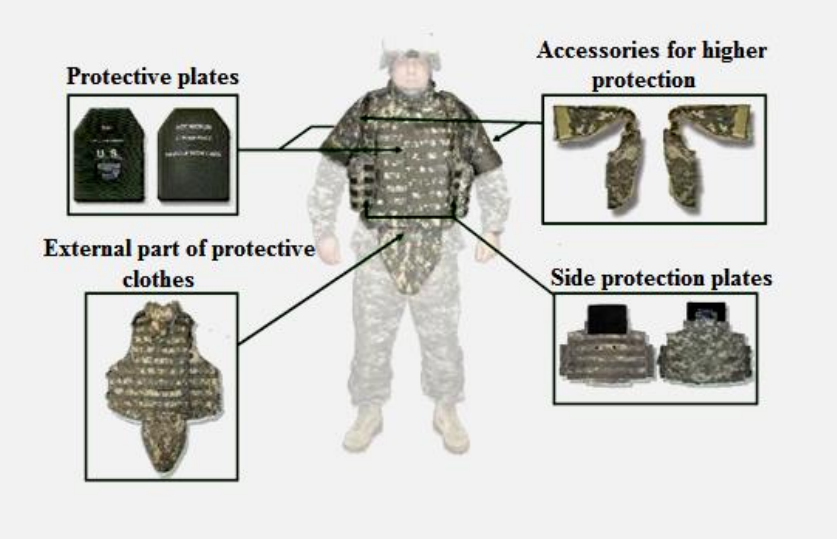

Figure 1. Primary design demands in protective clothes [11]

Figure 2. Appearance of protective clothing (vests) in R. Macedonia [12]

Fabrics that are used for protective clothes could be woven and non-woven. Woven textiles are the most commonly used for ballistic protection. The majority of ballistic fabrics are of plain-woven

types. Continuous multifilament yarns with the minimum of twist tend give the best results. The principal factor that dictates the design of body armors is the type(s) of threat(s) for which protection is required. Traditionally, soft body armors for ballistic protection were manufactured using layers of woven fabrics stitched together, but now they include laminates stacked with nonwoven, unidirectional (UD) layers and combinations of woven/nonwoven laminates [13].

Table 1. Fabric characteristics of mostly used fibers for military clothes design [13].

Fabric characteristic	*Nylon, cotton*	*Kevlar®, Nomex® P-140*	*Cotton, Kevlar®, Nylon P-140*
Flame resistance	*No*	*Yes*	*Yes*
Liquid chemical agent resistance	*Yes*	*No*	*Yes*
Electrostatic resistance	*No*	*Yes*	*Yes*
Day/night camouflage	*Yes*	*Yes*	*Yes*
Durability	*Yes*	*Yes*	*Yes*
Weight (g/m^2)	*237*	*186*	*220*
Cost ($/m)	*4,37*	*21,87*	*12,3 (estimated)*

New design, in line with functionality and future trends

In protective clothes design there are a many factors that should be considered. Factors that deserve attention are: Design of protective clothes with low weight materials, easy adaptable model to the soldier's body, comfort, permeability, maintenance, cost etc [14]. The protective clothes should be easily removable which is very important if the soldier is injured. With new modular and easy removable vest soldiers can be easily evacuated from the danger, and with that he can save his life and life's of other soldiers.

The experimental part

The experimental section provides design solution for the protective vest. For the protective clothes these main characteristics are very important: weight of the body vest, right selection of materials and the time that the soldier needs to remove the vest from his body. They are serious problems especially in situations when mobility is reduced, or the soldier is injured. The main construction parts of the design solution for the front and back, inner and external parts with mobile parts, cables and straps are presented on the figure 3. As can be seen, the model has layers of soft protective material and special designed pockets for cables – which ensured easily vest removal, as well as pockets in the front and back external parts for ballistic (inserts) plate.

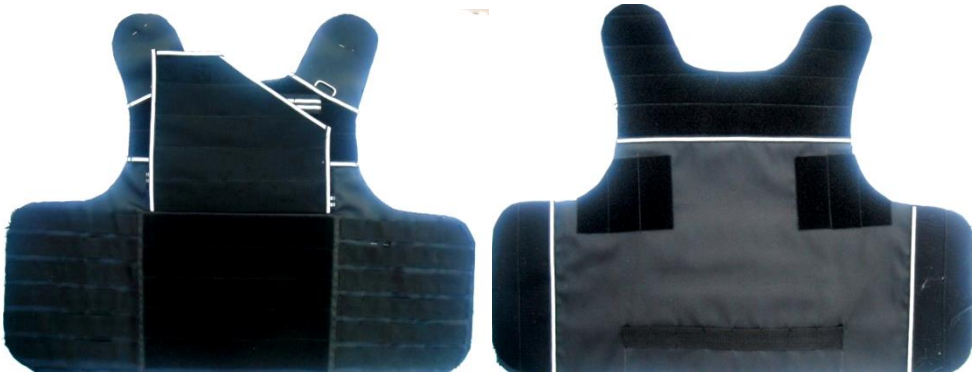

Figure 3. Front (external and internal) part of the new model of protective Military vest.

Figure 4. Rear (external and internal) part of the new model of protective Military vest.

Figure 5. Mobile parts of the protective vest

Figure 6. Mobile sleeves for higher level of protection (on the arms)

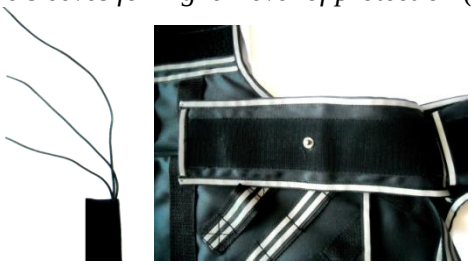

Figure 7. Cables for easy vest removable and overalls

Results and discussion

The featuring model of protective vest is water resistant, and used materials prevent from chilling and maintain comfort. The base layer is worn directly next to the body. It is primarily used to keep the skin dry and at a regular temperature. All of the layers are also designed to maintain freedom of movement. The material used for middale layer is added to increase insulation and maintain body heat. The outer layers are made from high performance fabrics, which also promote water vapour transfer out of the clothing system, and middle layer is made of polyester fabrics, which are light weight, breathable and resistant to compression.
Design solution presented in this paper has the following advantages of protective clothing:

- ✓ More layers of the covering light wear materials, which increase the degree of protection.
- ✓ The vest is comfortable, easy to carry, and it can be removed from the soldier's body in a few seconds.
- ✓ Modular parts sewed with Velcro tape.
- ✓ Mobile collar.
- ✓ Increased number of pockets for functional purposes.
- ✓ Cables for instantly removing from the body and hidden internal pockets for soft and hard ballistic protection.
- ✓ Made of advanced materials and futuristic look in line with functionality and high quality.

Conclusion

This paper presents the models of protective vests that are produced in R. Macedonia, used materials and fibers. The need of new advanced model with the right use of fabrics, for the required level of protection was also presented.
From the above it can be concluded that knowing the history of protective clothes, the new materials and featuring trends, is a step forward in the process of designing advanced model of protective military clothes which can fulfill all the requirements of the advanced soldiers.

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TEKSTILNI MATERIJALI ZA DIZAJN VOJNIČKE ZAŠTITNE ODJEĆE

Sanja Risteski[1], Silvana Zhezhova[1], and Vineta Srebrenkoska[1]

[1]*Univerzitet "Goce Delčev", Štip, Tehnološki fakultet*
Miro Baraga bb., Probistip, R. Makedonija

[1]*University "Goce Delčev", Štip, Faculty of Technology,*
Miro Baraga bb., Probištip, R. Macedonia

e-mail: sanja.spasova@gmail.com

Izvod

U ovom radu predstavljen je dizajn zaštitne odeće koji se trenutno koristi u R. Makedoniji sa glavnim karakteristikama nadvorešnih tkanina. Zaštitna odeća se koristi za postizanje sigurnosti za ljude u opasnim i drugim okruženjima. U prošlosti su ljudi nosili zaštitnu odeću sa jednim ciljem - da zaštite svoje telo od napada, ali danas savremeni vojnik treba zaštitnu odeću sa naprednim dizajnom i viši nivo zaštite. Proces izrade savremene zaštitne odeće je dugotrajan proces koji se zasniva na istraživanju trenutno postojećih modela zaštitne odeće, a potreba vojnika za novi model sa savremenom dizajnom je sve veća U ovom radu predstavjena je nova generacija materijala koji se koriste u dizajnu zaštitnih prsluka. Pravi izbor u odnosu na dizajn prsluka znači bolju zaštitu i veće zadovoljstvo i jednih i drugih, vojnika koj nosi taj prsluk i tehnologa koji ga dizajnira.

Ključne reči: *zaštitna odeća, dizajn, tkanine, materijali.*