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U FINANSIRANJU ČASOPISA UČESTVOVALO MINISTARSTVO PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA REPUBLIKE SRBIJE

MATERIAL OPTIMIZATION IN THE PROCESS OF CUTTING THE MODULAR MODEL OF VEST FOR SPECIAL PURPOSE

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Abstract: *In this paper, a new model of protective clothing for special purposes was made. The model is advanced and modular, and consists of 27 construction parts that are carefully designed and built to respond to the basic need, which is a high degree of protection. The material that was used to create the new model is PA 6.6 with a waterproof layer used as a cover external material. Material savings are of great importance in the construction of protective clothing/vest models, as these materials have a high price on the market. For this paper, 5 cutting layouts were made for the basic material PA6.6. Each cutting layout shows a different degree of material utilization. Factors affecting the degree of utilization are also shown.*

Key words: textile materials, cutting layouts, outer material.

OPTIMIZACIJA MATERIJALA U PROCESU KROJENJA MODULARNOG MODELA PRSLUKA ZA SPECIJALNE NAMENE

Apstrakt: *U ovom radu napravljen je novi model zaštitne odeće za posebne namene. Model je savremen i modularan, a sastavljen je iz 27 krojnih delova pažljivo dizajniranih i izgrađenih da bi odgovorili na osnovnu potrebu a to je visok stepen zaštita. Materijal koji je korišćen za izradu novog modela, je PA 6.6 sa vodonepropusnim slojem koji se koristi kao pokrivni spoljni materijal. Ušteda materijala su od velikog značaja u izgradnji modela zaštitne odeće/prsluk, jer ovi materijali imaju visoku cenu na tržištu. Za ovaj rad izrađeno je 5 krojnih slika za osnovni materijal PA6.6. Svaka krojna slika pokazuje različit stepen iskoristenosti materijala. Prikazani su i faktori koji utiču na stepen iskorišćenja.*

Ključne reči: tekstilni materijali, krojna slika, spoljašnji materjial

1. INTRODUCTION

People use protective clothes to achieve safety and protection of their bodies in professional and other dangerous surroundings. Nowadays people are exposed at greater risk and danger of physical, chemical and biological attacks. With the advancement of technology, today there is a simple and effective protection for most of these risks. Textile materials are integral part and very important part of the protective equipment [1, 2]. With carefully selected materials and advanced design, a high degree of protection for carriers can be achieved. One of the most important thing for good design is to be modular (it means to improve the mobility of soldiers that will give positive impact to the comfort). The modular design of protective vest can save many human lives and facilitate the evacuation of the soldiers from the danger zone. The process of construction of modular protective vest is very complicated by the fact that many limiting factors must be taken into account. The vest includes many mobile parts that can be quickly removed from the injured user's body, so they further complicate the process of construction. Good design means also a good ratio price/performance [3, 4]. Price of protective normally depends of the price of used materials, but lower production costs can be achieved with use of different techniques for material utilization. In the past years continuous increasing of the price of textile materials, especially those that are used in industry for special purpose is noticed [5, 6]. The price of industrial materials is normally higher than the other materials (used for everyday clothing) because these materials are manufactured with precise characteristics to satisfy the specific requirements for given application. That means that every single higher percentage of utilization can mean a lot for the industry, because it directly affects positively to the overall production costs [7, 8].

Today with the use of contemporary CAD/CAM software packages can be achieved efficient level for making patterns and cutting layouts. Fully featured CAD tools enabling designers to create or modify patterns to their unique requirements. With use of this software, cutting layouts and construction parts can be made with high accuracy and with the maximum utilization of the material [9].

In this paper are presented the possibilities for improving the utilization of the basic material that is used for sewing a new advanced and modular vest for special purpose. Through the correct arrangement of the construction parts in the cutting layout, a higher percent of material utilization can be obtained. The utilization of the material has direct impact on the price of the final product, which means that maximal usage of material gives lower price of the final product.

2. EXPERIMENTAL

The modular model of protective vest with contemporary design was constructed following the requirements of the standard NIJ0101.06. The modular design means that new model is constructed of 27 parts that must be assembled together with one purpose – quickly to be released from the carrier's body and save his life when he is exposed to danger. Material that was used for sewing the model, was Polyamide 6.6 with water-repellent coating.

The model of protective vest (with front and rear part), for which cutting layouts are made, is shown on figure 1. The protective vest is composed of following construction parts: front and rear parts, mobile accessories for connecting and removing the vest from the wearer's body, collar and half – sleeves. The model also includes other parts which are not made from the basic material (Polyamide 6.6).

In order to achieve various levels of textile material utilization, three different types of cutting layouts were made as: One-sized, two-sized and multi-sized. The patterns for the new model of protective vest were made in OPTITEX PDS (Pattern design software), and cutting layouts were created using the OPTITEX CutPlan software program. This software program can automatically generate efficient plans for product grouping and distribution, but because we want to achieve higher lever of material utilization we used semi-manual method of fitting the construction parts. This method extend the proccesing time but gave higger level od utilization.

The biggest influence of material utilization have the following parameters:

- Type of the cutting layouts.
- Length and width of textile material.
- The number of cutting layers.

Figure 1. Front and rear part of the model of protective vest

In order to find the impact of the type of the cutting layout and cut layers on the utilization of the textile material used for presented model, 5 different cutting layouts where made. They differ in terms of the used sizes, the number of layers of material and the length.

3. RESULTS AND DISSCUSION

Construction parts for analyzed model of protective vest were made using the software program OPTITEX PDS. The 5 types of cutting layouts that where created and refer to the basic material (PA6.6) are shown in the figures bellow (Fig.2 - Pic. 6). Results obtained from all cutting layouts are given on the diagram in Figure 7.

From the results shown on Figure 7 it can be concluded that the lowest percentage of utilization (81.22%) of the material occurs in cutting layout 1 (Fig. 2), where is fitted only one size (L) with 1 layer. The size L is selected as an average value from five analyzed sizes (S, M, L, XL, and XXL). Also, a small degree of utilization (82.33%), is noticed in the second cutting layout (Fig. 3) where is used the same size (L) but the number of layers is increased to 10. Is been noticed that one-size cutting layouts don't give a high percentage of material utilization in this case. The cutting layout 5 shown on Figure 6, where was used a large length and combination of two cutting layouts in one didn't result with positively on increasing the percentage of material utilization (the percent of utilization in this case was 82.06%).

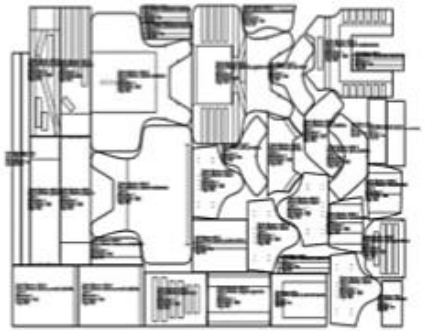

Figure 2. Appearance of cutting layout 1

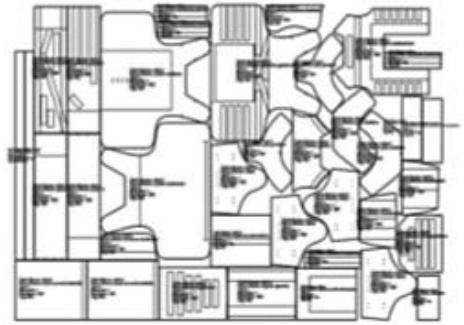

Figure 3. Appearance of cutting layout 2

Figure 4. Appearance of cutting layout 3

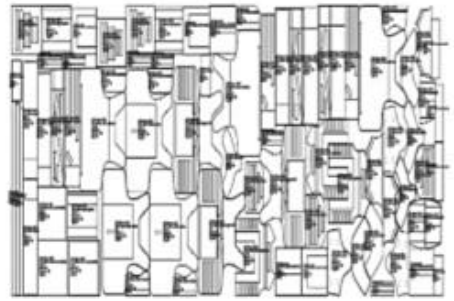

Figure 5. Appearance of cutting layout 4

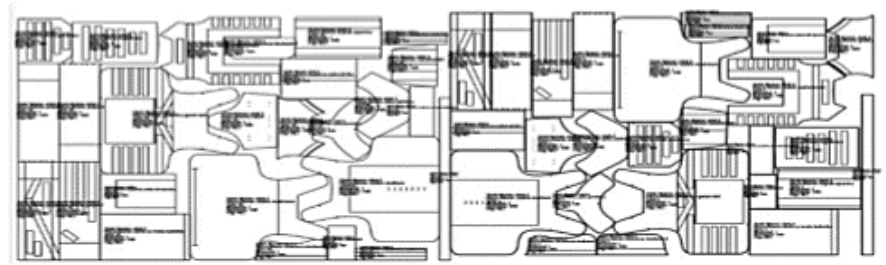

Figure 6. Appearance of cutting layout 5

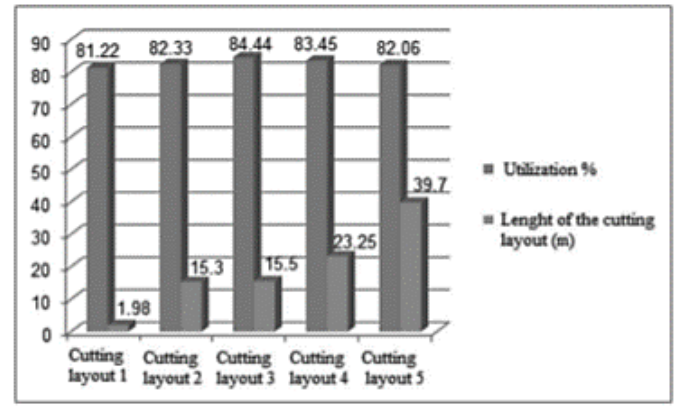

Figure 7. The utilization degree of the material during cutting in relation to the length of the cutting layout

The application of a large number of layers is unsuitable for use, especially for thick and expensive materials (like in this case). The waterproof coating of the material further complicates the cutting process. If the cutting is performed with a vertical knife, the generated heat could melt the coating as a result of the friction between the knife and material. This generally occurs in materials that contain Polyamide and Polyester, as in this case. For this model the best option for the cutting process are scissors instead of a vertical knife, because they eliminate the possibility for adhesion of spreading layers. In the case of layers adhesion the only way to separate the layers is by mechanical separation which can cause permanent damage to the material. The disadvantage of the cutting process for this type of material is the limitation of the height of the cutting layers, which extended the cutting process time. Vertical knife can be used if there is a need for time saving, but with a special paper placed on every single layer, or with use of cooling spray (for the knife). The speed of the knife is also an important factor that should be considered. For this case is recommended low speed of the vertical knife.

The higher percentage of material utilization can be noticed on Figure 4 (84.44%, cutting layout 3) where fitted two sizes, the smallest and the largest one. The cutting layout 4 (Fig. 5), where was made an effort to fit three sizes (M, L and XL), the higher percent of utilization hasn't been achieved. Compared with the cutting layout 3, the percent of utilization in the cutting layout 4 was lower for 0.99%. Also a limitation factor was the cutting direction, which was limited on rotation to 180⁰ that means that rotation of construction parts in 360⁰ wasn't acceptable, which has negative value on obtaining higher percent of material utilization.

4. CONCLUSION

From the obtained results it can be concluded that the best solution is the cutting layout 3 where fitted two sizes, the smallest and the largest (S and XXL) with utilization percent of 84.44% and optimal number of 5 layers. For this material is not recommended the use of higher number of layers because of the waterproof coating of the material, and the thickness of the main material. The use of vertical knife in the cutting process is also not recommended because of the possibility of melting the surface coating that cause string of negative effects in the next phases of production process. In this case is recommended special paper to be applied between the layers, or cooling spray can also be practical for use.

Because of the price of this material (it is very high) on the market, it was very important to achieve higher percent of material utilization. The optimization of material means that every higher percentage of material utilization is of a great importance for the model production, and directly effect to his final cost. That means that with the right position of construction parts in the cutting layouts with semi- manual type of arrangement of the construction parts good results can be achieved, which positively affects to the final price of the product and lead to higher material savings.

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