



INFLUENCE OF THREAD TYPE ON THE MECHANICAL PROPERTIES OF SEAMS IN FOOTWEAR

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ABSTRACT: The modern mass-produced footwear is made of textile, leather, plastic, and rubber parts all glued and sewn together. Textile materials are increasingly being used in the footwear industry. The mechanical properties of the seams used to join individual parts of the shoe upper affect the durability, flexibility and comfort of the footwear. This paper analyses the influence of polyester and polyamide threads of different fineness on the mechanical properties of the seams of the shoe upper made of laminated two-layer textile material. The results showed that the fineness and raw material composition of the thread, as well as the direction of cutting the upper parts, have a very important influence on the strength, elongation and flexibility of the seams, and thus of the shoe.

Keywords: footwear, thread, seams, mechanical properties.

UTICAJ VRSTE KONCA NA MEHANIČKA SVOJSTVA ŠAVOVA U OBUĆI

APSTRAKT: Moderna masovno proizvedena obuća izrađena je od tekstilnih, kožnih, plastičnih i gumenih dijelova, koji su svi lijepljeni i sašiveni zajedno. U industriji obuće se sve više koriste različiti tekstilni materijali. Mehanička svojstva šavova koji se koriste za spajanje pojedinih dijelova gornjišta obuće utiču na trajnost, fleksibilnost i udobnost obuće. U ovom radu je analiziran uticaj poliesterskih i poliamidnih konaca različite finoće na mehanička svojstva šavova gornjišta obuće izrađenog od laminiranog dvoslojnog tekstilnog materijala. Rezultati su pokazali da finoća i sirovinski sastav konca, kao i pravac iskrojavanja dijelova gornjišta imaju vema važan uticaj na trajnost i fleksibilnost šavova, a time i obuće.

Ključne reči: obuća, konac, šavovi, mehanička svojstva.



1. INTRODUCTION

The modern way of life and work cannot be imagined without textile materials. Conventional applications include the use of textile materials for clothing and home textiles (various products used in the household). Today, textiles are used in all spheres of life. In addition to their application in the textile industry, textiles play a significant role in the footwear production. Textile materials of various types are widely used in footwear industry and play very important role in perfect shoe making [1]. The use of textile materials in shoes has been on the rise in recent years due to their numerous benefits [2-5]. Textile materials are more economic and more efficient way of replacing some costly traditional materials used to make footwear. Textile materials are lightweight, flexible and durable, providing a better fit and greater comfort [6]. Textile materials provide breathability, which helps to prevent the buildup of heat and moisture inside the shoe. With an infinite variety of weaves, colors, patterns, and special features, textiles have a special place in footwear design [7]. Blended and composite materials are also commonly used in textile materials for footwear [8]. Textile material is used almost in all parts of the footwear because the developments of various types of nonwoven fabric and other innovative forms textile. You will find textiles inside and out on footwear and even on the bottoms.

Today, there are many different methods for joining footwear parts, such as gluing and welding, but by far the most widely used method is the method of joining cut parts by sewing. A very important factor that affects the strength and flexibility of seams is the type of sewing thread. In the past, cotton thread was primarily used, but today polyester (PES) and polyamide (PA) threads are most often used. Therefore, this paper examines the influence of polyester and polyamide threads of different fineness on the mechanical properties of seams in footwear.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in the experimental work for the production of seams are commercially available polyester (PES) and polyamide (PA) threads for sewing footwear and laminated textile material for the production of footwear uppers. The designations and basic characteristics of the thread samples are shown in Table 1. The textile material for the footwear upper has a two-layer structure. The reverse side of the material is spunbond nonwoven made of polyester, while the top layer, which represents the face of the material, is a plain weave polyamide woven fabric.

Table 1: Thread samples used for experimental work

Sample code	Thread structure	Composition (%)	Fineness (tex)
PES300	Three-strand filament thread	100% PES	300
PES150	Three-strand filament thread	100% PES	150
PES75	Three-strand filament thread	100% PES	75
PA75	Three-strand filament thread	100% PA	75



2.1. Methods

The EN ISO 1833-1 standard was used for testing the material composition [9]. The longitudinal mass (fineness) of the thread was tested according to the EN ISO 2060 standard [10], while the breaking force and breaking elongation of the thread were tested according to the EN ISO 2062 standard [11]. The breaking force and breaking elongation testing procedure of textile materials for footwear uppers was carried out in accordance with the EN ISO 13934-1 standard [12] in the warp and weft directions, while the mass per unit area was determined according to the ISO 3801 standard [13].

Sample preparation and testing of breaking strength and breaking elongation of seams were carried out according to the EN ISO 13935-1 standard [14]. The samples were sewn on a universal sewing machine JUKI LZH-1290, with lock stitch type 301, with a density of 4 stitches/cm and a sewing needle of fineness Nm 90. In all samples, the seam was formed at a distance of 10 mm from the edge of the material.

For testing the breaking force and breaking elongation of the seam, 15 test samples were prepared for each tested thread, i.e. 5 test samples for making seams in three variants, when parts of the footwear upper are joined in the direction: warp/warp, weft/weft and warp/weft.

A Shimadzu universal dynamometer, type AUTOGRAPH AGS-X, was used for all breaking force and breaking elongation tests.

3. RESULTS AND DISCUSSION

The results of testing the physical and mechanical properties of textile materials for making uppers are shown in the Table 2.

Table 2: Physical and mechanical properties of textile materials for uppers

Mass per unit area (g/m ²)	Warp			Weft		
	Density (cm ⁻¹)	Breaking force (N)	Breaking elongation (%)	Density (cm ⁻¹)	Breaking force (N)	Breaking elongation (%)
425	14	2157	33	10	1917	40

The material used to make the upper has a high mass per unit area and high breaking force in both directions (warp and weft) because, due to its intended purpose, it needs to withstand forces and loads during use and ensure the durability of the product. The breaking force in the warp direction is greater than the breaking force in the weft direction, which is also influenced by the plain weave and the density of the fabric on the face of the material. The breaking elongation in the weft direction is greater than in the warp direction, which is common.

Figure 1. shows breaking force of thread samples. It is obvious that the breaking force depends on the fineness of the thread and decreases with increasing fineness [15]. The

breaking force of polyester (PES75) and polyamide (PA75) threads is not significantly different because both threads are synthetic and have the same fineness.

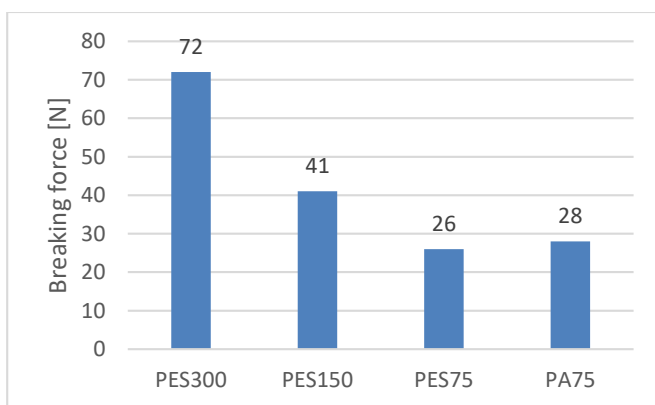


Figure 1: Breaking force depending on the type of thread

Figure 2. shows breaking elongation of thread samples. Unlike to the breaking force results, the polyester thread samples with higher fineness (PES150 and PES75) have higher breaking elongation compared to the PES300 thread sample, which has a significantly lower fineness. In addition, it is noticeable that the polyamide thread sample PA75 has the highest elongation at break (22.3%), significantly higher than all polyester thread samples.

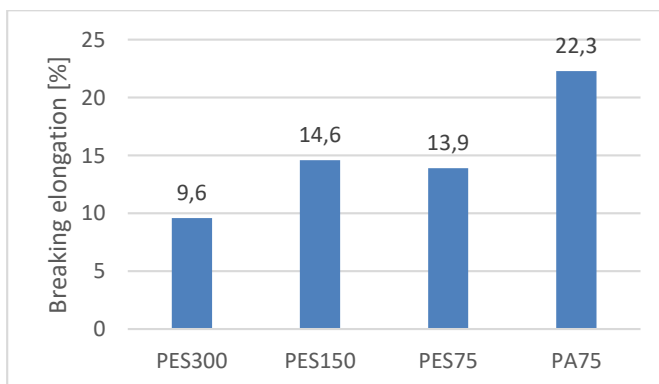


Figure 2: Breaking elongation depending on the type of thread

The dependence between seam breaking force and thread type for different cutting directions of footwear upper parts is shown in Figure 3.

The highest seam breaking force (1930 N) was obtained by sewing with PES300 thread and the cutting of the footwear upper parts in the warp/warp direction [15]. Sewing with



threads of lower breaking force (PES150 and PES75) results in lower seam breaking force (886 N and 621 N).

The influence of the cutting direction of the parts for the footwear upper on the seam breaking force is also significant. The highest seam breaking force is in the warp/warp direction, then warp/weft, and the lowest in the weft/weft direction for all thread sample. Also, the breaking strength of a seam with polyamide thread PA75 is greater than a seam with polyester thread PES75.

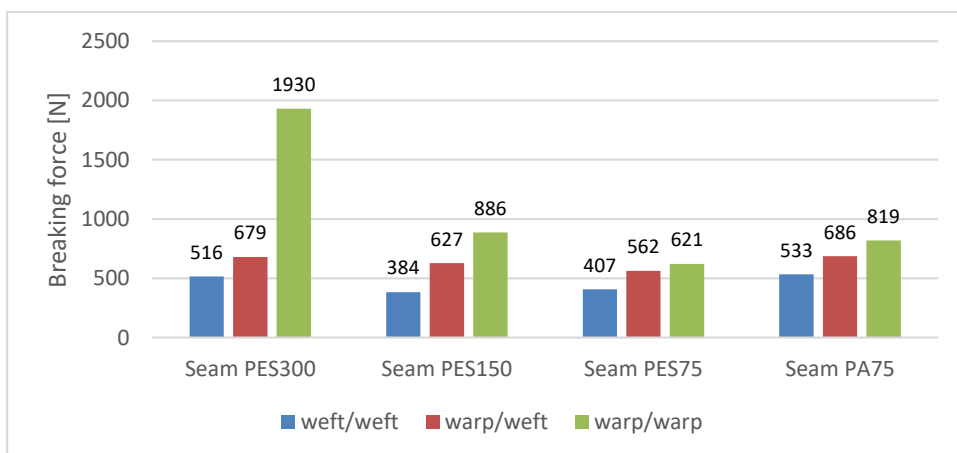


Figure 3: Comparison of seam breaking force on thread type for different cutting directions of footwear upper parts

The dependence between seam breaking elongation and thread type for different cutting directions of footwear upper parts is shown in Figure 4.

The highest seam breaking elongation (33,1 %) was obtained by sewing with PES300 thread and the cutting of the footwear upper parts in the warp/warp direction. However, the PES300 thread sample has the lowest elongation at break (Figure 2.). It is obvious that the material for the shoe upper and the direction of its cutting have a great influence on the breaking strength and breaking elongation. Similarly, sewing with threads of higher breaking elongation (PES150 and PES75) results in a lower breaking elongation of the seam. Also, the breaking elongation of a seam with polyamide thread PA75 is greater than that of a seam with polyester thread PES75.

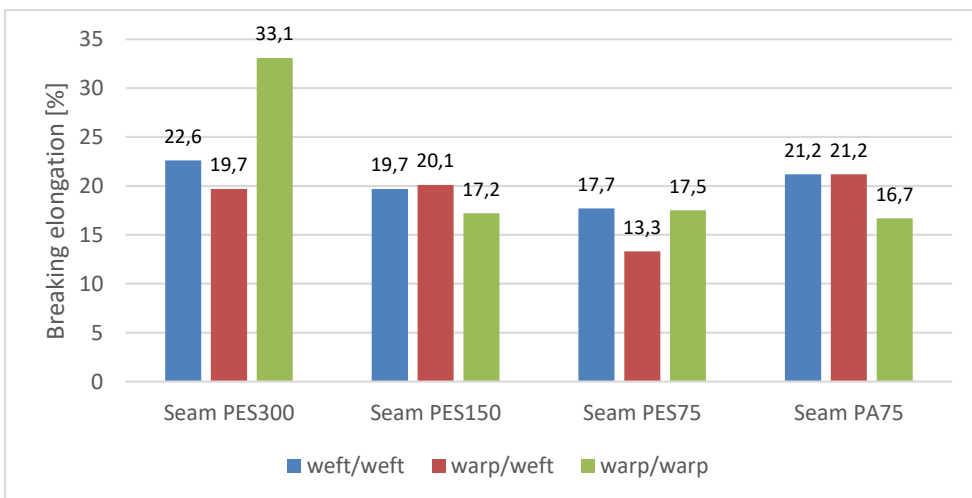


Figure 4: Comparison of seam breaking elongation on thread type for different cutting directions of footwear upper parts

4. CONCLUSION

Different types of textile materials are increasingly used in the footwear production. Textile parts are most often joined together by sewing, and the mechanical properties of the seam significantly affect the durability, flexibility and comfort of the footwear.

Based on the results obtained in this work, it can be concluded that the material composition, fineness and strength of sewing thread directly affect the breaking force and elongation of the seam. The strength of the seam decreases with increasing fineness of the thread used for sewing, meaning that threads with higher breaking force also produce a seam with higher breaking force. Also, using polyamide thread resulted in a seam (SeamPA75) with greater breaking force and elongation compared to a seam (SeamPES75) obtained by sewing with polyester thread of the same fineness.

The highest breaking force (1930 N) and breaking elongation (33.1%) of the seam (SeamPES300) were obtained using PES300 thread sample, which had the highest breaking force and the lowest elongation.

It is obvious that in addition to the thread, the material for the footwear upper and the direction of its cutting have a great influence on the breaking force of the seam and the breaking elongation of the seam.

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REFERENCES

- [1] Roy, R., Udhayakumar, G., Bhardwaj, P. (2023). The Role of Textile Materials in Sports Footwear: A Comprehensive Review, *Adv Res Text Eng.*, 8(1), 1081.
- [2] Canavan, K. (2015). Applications of Textile Products, *Textiles and Fashion*, 531-545.
- [3] Coyle, S., Wu, Y., Lau, K.T., De Rossi, D., Wallace, G., et al. (2007). Smart nanotextiles: a review of materials and applications, *MRS bulletin*, 32, 434-442.
- [4] Power, E.J. (2018). Advanced knitting technologies for high-performance apparel. *In High-performance apparel*. Woodhead Publishing, 113-127.
- [5] Bullon, J., González Arrieta, M.A., Hernández Encinas, A., Queiruga Dios, M.A. (2017). Manufacturing processes in the textile industry, *Expert Systems for fabrics production*, 6, 15.
- [6] Robbins, S., Waked, E., Gouw, G.J., McClaran, J. (1994). Athletic footwear affects balance in men, *British journal of sports medicine*, 28, 117-122.
- [7] Nigg, B.M., Nurse, M.A., Stefanyshyn, D.J. (1999). Shoe inserts and orthotics for sport and physical activities, *Medicine and science in sports and exercise*, 31, S421-S428.
- [8] Basit, A., Latif, W., Baig, S.A., Rehman, A., Hashim, M., et al. (2018). The mechanical and comfort properties of viscose with cotton and regenerated fibers blended woven fabrics, *Materials Science*, 24, 230-235.
- [9] EN ISO 1833-1:2020, Textiles – Quantitative chemical analysis – Part 1: General principles of testing.
- [10] EN ISO 2060:1995, Textiles – Yarn from packages – Determination of linear density (mass per unit length) by the skein method.
- [11] EN ISO 2062:2009, Textiles – Yarns from packages – Determination of single-end breaking force and elongation at break using constant rate of extension (CRE) tester.
- [12] EN ISO 13934-1:2013, Textiles – Tensile properties of fabric – Part 1: Determination of maximum force and elongation at maximum force using the strip method.
- [13] ISO 3801:1977, Textiles – Woven fabrics – Determination of mass per unit length and mass per unit area.
- [14] EN ISO 13935-1:2014, Textiles – Seam tensile properties of fabrics and made-up textile articles – Part 1: Determination of maximum force to seam rupture using the strip method.
- [15] Rastek, I. (2022). Kvaliteta i izgled šava u industriji obuće, *Koža&Obuća*, 71(3-4), 8-10.