THE INFLUENCE OF COTTON FABRIC STRUCTURE ON THE STRENGTH OF SEWING SEAMS

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ABSTRACT: *The goal of this work was to examine the influence of stitch density and different linear density of weft threads (20, 30 and 50 tex) on the seam strength of cotton fabrics. The following stitch densities were tested: 3, 4, 5, 6 and 7 stitches/cm. For seam strength testing, fabric samples were prepared according to the provisions of the ISO 13935-1 standard. The samples were sewn in the warp and weft directions with the selected seam type marked 1.01.01/301. The obtained results show that the seam strength values, for all samples, increase with increasing stitch density and linear density of the thread per weft. From the results, it can be concluded that denser stitches strengthen the seam structure itself. This makes the seams more resistant to external forces. The results obtained show that weft yarns, with a larger cross-section, more intensively resist the tearing forces acting on them in the seams. Also, the results of the research show that the warp yarn, which had a larger number of twists, more intensively resists the tearing forces acting on them in the seams. Defining these parameters represents a significant contribution for manufacturers of quality clothing. Knowing this data, it is possible to project in advance the intensity of the forces to which the seams may be exposed in clothing, without reducing their quality.*

Keywords: *density of stitched seams, strength of sewn seams, structure and fabric density.*

UTICAJ STRUKTURE PAMUČNIH TKANINA NA ČVRSTOĆU ŠAVOVA ZA ŠIVENJE

***APSTRAKT:** Cilj ovog rada bio je istražiti uticaj gustine šivaćih uboda i različitih podužnih masa potkinih niti (20, 30 i 50 tex) na čvrstoću šavova za šivenje kod pamučnih tkanina. Ispitivane su sledeće gustine uboda: 3, 4, 5, 6 i 7 uboda/cm. Za ispitivanje jačine šavova, uzorci tkanina su pripremljeni prema propisima standarda ISO 13935-1. Uzorci su šiveni u pravcu osnove i u pravcu potke odabranim tipom šivaćeg šava oznake 1.01.01/301. Dobijeni rezultati pokazuju da vrednosti jačine šavova, za sve uzorke, rastu sa povećanjem gustine šivaćih uboda i podužne mase niti po potki. Iz rezultata se može zaključiti da gušći šivaći ubodi jačaju samu strukturu šavova. Time se šavovi jače suprostavlja delovanju spoljašnjih sila. Dobijeni rezultati pokazuju da se pređe za potku, sa većim poprečnim presekom, intezivnije u šavovima suprostavljaju prekidnim silama koje deluju na njih. Takođe, rezultati istraživanja pokazuju da se pređe za osnovu, koja je imala veći broj uvoja, u šavovima intezivnije suprostavljaju prekidnim silama koje deluju na njih. Definisanje ovih parametara predstavlja značajan doprinos za proizvođače kvalitetne odeće. Poznavanjem ovih podataka mogu se unapred projektovati intenziteti sila kojima se šavovi mogu u odeći podvrgnuti a da se pri tome ne naruši njihov kvalitet.*

***Ključne reči:** gustina uboda šivenih šavova, jačina šivenih šavova, struktura i gustina tkanina.*

1. INTRODUCTION

The fashion market today requires the manufacturer of fabrics of very quick answers to the requests of clothing manufacturers. Namely, clothing manufacturers, often have requirements for fabrics of spares surface masses. Fabric producers, to some extent, can quickly respond to the change in the fine of the pope and density threads. It can be easily done on modern machines for making fabrics today. The available fabrics on the market are today different structural characteristics. Therefore, in this paper, samples of fabric testing aged three different fines per weft [1]. The fastest rating of fabric properties is to the tender. The feeler is a completely sensory experience in which the fabric touches with the fingers [2]. Every fabric, for making clothes, is complex material and its structure depends on a large extent and the properties of clothing. Therefore, many researchers deal with the analysis of structure of fabrics that is considered one of the basic parameters that contributes to the dominant physical and qualitative properties of woven material [3].
Woven textile materials are most often combined with seams in sewing technique. A large number of factors affects the quality of seams. Some of them are a type of material, types of sewing stitches, a density of sewing threads, a flexure threading point, sewing speed, and shape of the peak of needles as well as other elements of sewing machines participate.
According to research [4], damage that appear on the seams of clothing products, due to stretching in an interval of 68.3% on pants, where they are largest, blouses at 9.4%, jackets at 8.4%, skirts at 8.4% and up to 5.0% in the dresses. The largest deformations occur at the

seat seam of pants and skirts and moving at the interval of up to 59.1%. At the seam at the joint of the sleeves and the back of the shirt and a jacket up to 27.1%, on the side seams of pants, dresses and skirts go to value 9.0%. On the seam in the middle of the rear of the upper garments, 3.9% and on the other seams on the clothes move at the interval of up to 0.9%.

Seam is one of the most important parameters of clothing, because it combines pieces of fabric and gives a garment of the ultimate form. The proper selection of fabric, the sewing thread and the types of seams greatly affect the comfort of users and aesthetic and functional requirements of clothing. This area is largely explored by giving a new approach to predicting sean quality and strength [5].

Fabric producers are necessary to know how the structure of the fabric affects the quality of the seam or sliding or seam [6]. For this reason, a large number of tests of the influence of seam types, density of stitches and stitching the quality of seams in terms of stitches and suture glides. [7] today is mainly investigated: influence of density or seam structure on linen fabrics on the characteristics of seamless sutures and stitches [8]; Complex dynamic interactions between fabric performance, parameters of sewing and stitching processes [9]; Efficiency, strength and elongation of seams on cotton fabrics [10]; Influence of various sewing parameters, such as: type of sewing thread, suture type, stitches as well as stitch density on the seamless strength [11]; Influence of density of stitches and seam types on the properties of moisture management in seams [12]; Durability of clothing depending on the strength of seams, density of stitches, aesthetic appearance and sutures on the various fabric structures [13]; The impact of different stitch densities to achieve proper and adequate suture quality [14]; Influence of raw material composition fabrics, fineness of the sewing and sewing parameters for sewing on the characteristics of clothing seam; the reasons that lead to poor quality sutures in sewing; Resistance to sliding seams of unbalanced fabrics; The appearance of the seam depending on the types of cookies for sewing, fabric and sting [15].

From the available literature it can be seen that problems in sewing are not easy to solve. Therefore, a large number of parameters, such as: fibers, yarn, fabric structure, sewing thread, seams and sewing machines must be examined specifically in almost all sewing conditions that differ mostly [16].

2. MATERIALS AND METHODS

The study investigated the influence of stitch density and three different linear densities of weft yarns (20, 30, and 50 tex) on seam strength in cotton fabrics. For the purpose of the research, various cotton fabric samples were produced under industrial conditions on a "Vamatex" loom equipped with a rapier weft insertion system. The loom was also fitted with an electronic warp let-off system. The working width of the loom was 190 cm. All samples were produced on the same loom in order to eliminate the influence of different machines on the sample production.

The selected fabric for the research was made of 100% cotton, with a plain weave structure, using warp yarns with a linear density of 40 tex and a warp density of 24 threads/cm for all samples. The warp and weft yarn densities were measured according to the EN 14971 standard. The weft density was 25 cm^{-1}. Three different weft yarn linear densities were used for the test samples: 20 tex, 30 tex, and 50 tex. The linear densities of both warp and weft yarns were determined according to the SRPS ISO 7211-5 and SRPS F.S2.511 standards. The surface mass of the woven fabrics was determined according to the EN ISO 2286-2 standard for all fabric samples produced for testing.

For the seam strength testing, the fabric samples were prepared in accordance with the ISO 13935-1 standard. Laboratory test samples, measuring 350 x 700 mm, were cut in both the warp and weft directions for all fabrics. Each sample was then folded in half so that the longer side was parallel to the folded edge. The samples are shown in Figures 1 and 2. Figure 1 shows a laboratory sample sewn with a seam and marked cutting lines. Figure 2 shows a test sample with shaded areas indicating the parts to be cut out.

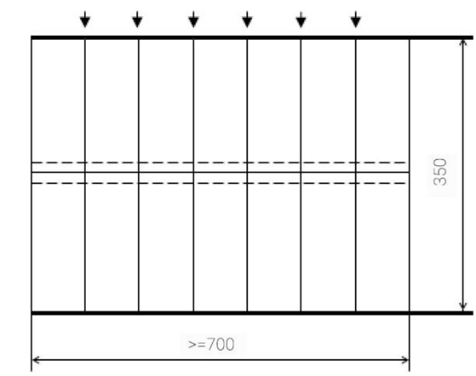

Figure 1: Laboratory sample sewn with a seam and marked cutting lines

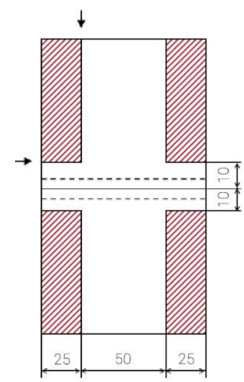

Figure 2: Test sample with shaded areas to be cut out

The samples were then sewn in the warp and weft directions using the selected seam type designated as 1.01.01/301 according to the international standard ISO 4916. The samples were sewn on a universal sewing machine manufactured by Juki, model DDL-5550, using stitch type 301. The following machine parameters were set: sewing speed – 3,000 stitches/min; needle size – Nm 90; presser foot pressure – 2.8 N; and thread tension – 0.50 N. The stitch density was adjusted on the machine in five increments. After measurement on the sewn seams, the stitch densities obtained were 3, 4, 5, 6, and 7 stitches/cm. The same type of thread was used for sewing all test samples, with a fineness of Tt 20.7 tex, a tensile strength of 23.37 N, and an breaking elongation of 15.17%. The thread was made of 100% polyester fibers. Seam strength testing was carried out using a Tenso Lab 3 dynamometer, series 2512A, manufactured by the Italian company Mesdan S.p.A. Figure 3 shows the dynamometer with a prepared sample placed in the grips for testing.

Figure 3: Prepared sample for testing

Table 1 presents the different samples of the tested fabrics sewn using seam type 1.01.01/301.

Table 1: Different fabric samples sewn in the warp and weft directions using seam type 1.01.01/301

Sample marking	**Weave structure**	**Linear density T_t (tex)**		**Yarn type**		**Density**		**Surface mass m ($g \cdot m^{-2}$)**
		for warp	for weft	for warp	for weft	warp d_{wa} (cm^{-1})	weft d_{we} (cm^{-1})	
A	Plain 1/1	40	50	100 Co	100 Co	24	25	232,52
B	Plain 1/1	40	30	100 Co	100 Co	24	25	190,32
C	Plain 1/1	40	20	100 Co	100 Co	24	25	153,40

3. RESULTS AND DISCUSSION

The tensile strength of the fabric samples was measured in both the warp and weft directions. The seams of the test samples were sewn parallel to the warp and weft directions. This was done to determine the influence of different weft yarn thicknesses on seam deformation. The seams were sewn with varying stitch densities in order to evaluate the effect of stitch density on seam strength. Based on the measurements and the investigation of the influence of different fabric densities on the mechanical properties of the seams, the obtained results are presented. Table 2 shows the results of seam tearing strength measurements on fabric samples in both the warp and weft directions.

Table 2: Results of seam tearing strength measurements on fabric samples in the warp and weft directions

Sample marking	Stitch density [cm^{-1}]	Seam breaking values in the warp direction		Seam breaking values in the weft direction	
		Force [N]	Elongation [%]	Force [N]	Elongation [%]
A	3	330	11.98	308	11.20
	4	362	11.75	332	10.78
	5	373	12.48	345	11.56
	6	395	11.28	359	10.25
	7	409	11.43	372	10.39
B	3	284	11.36	261	10.42
	4	315	10.83	286	9.85
	5	335	12.36	302	11.13
	6	340	11.14	312	10.22
	7	361	10.39	322	9.28
C	3	272	13.47	247	12.25
	4	288	11.27	257	10.06
	5	299	9.46	265	8.37
	6	313	9.97	275	8.75
	7	330	9.39	287	8.16

Figure 4 shows a comparison of the seam breaking forces for samples A, B, and C in the warp and weft directions.

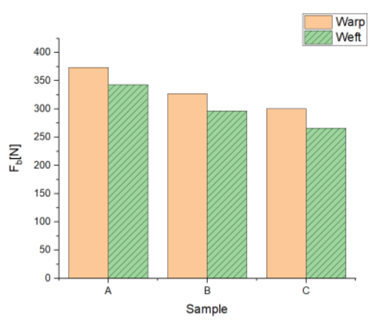

Figure 4: Comparison of seam breaking forces for samples A, B, and C in the warp and weft directions

The study examined three types of cotton fabric samples that differed only in the linear density of the weft yarn used. For sample A, the weft linear density was Tt 50 tex; for sample B, it was Tt 30 tex; and for sample C, it was Tt 20 tex. All samples were sewn with the following stitch densities: 3, 4, 5, 6, and 7 stitches/cm. During research, it was observed that the main difficulties in testing seam strength arose from different types of damage occurring during seam tearing. All observed damage types can be classified as: fabric rupture, fabric rupture near the clamp, fabric rupture near the seam, sewing thread breakage, thread pullout, or any combination of these. For the testing, only samples that failed at the seam itself were considered as relevant results. All other samples where failure occurred in other areas were excluded from analysis in this study.

The obtained results show that the stitch density significantly affects the seam breaking force. Specifically, observing the values presented in Table 2 for sample A in the warp direction, it can be seen that the seam breaking forces increase with increasing stitch density. This occurs because denser stitches strengthen the seam structure itself, enabling the seam to better resist the action of external forces. The seam breaking forces also increase for samples B and C as stitch density increases, for the same reason as in sample A. In other words, denser stitches reinforce the seam structure, and with increasing stitch density, the force resisting external deformation forces also increases. The same pattern is observed in the weft direction. For example, the values shown in Table 2 for sample A in the weft direction demonstrate that seam breaking forces increase with increasing stitch density due to the strengthening effect of denser stitches, which enable the seam to better resist external forces. The results also indicate that the linear density of the weft yarn influences the seam breaking force. Specifically, the weft yarn linear densities are Tt 50 tex for sample A, Tt 30 tex for sample B, and Tt 20 tex for sample C. Regarding the seam breaking force in the warp direction, the highest force values for all stitch densities are observed in sample A, which is made from the thickest weft yarns. These values decrease for sample B, which is made from thinner weft yarns compared to sample A. The seam breaking forces are lowest for sample C, which is made from the thinnest yarns in comparison to both samples B and A.

Expressed in percentages, the average seam breaking force for sample B decreases by 12.52% compared to the average seam breaking force of sample A. The average seam breaking force for sample C decreases by 19.64% compared to sample A. Furthermore, the average seam breaking force for sample C decreases by 8.14% compared to sample B.

Regarding the seam breaking force in the weft direction, the highest force values for all stitch densities are observed in sample A, followed by a decrease in sample B, with the lowest values in sample C. Expressed in percentages, the average seam breaking force for sample B decreases by 13.58% compared to the average seam breaking force of sample A. The average seam breaking force for sample C decreases by 22.44% compared to sample A. Additionally, the average seam breaking force for sample C decreases by 10.25% compared to sample B.

The results show that weft yarns with a larger cross-sectional area more effectively resist the breaking forces acting upon them.

When comparing the seam breaking forces for the same samples in the warp and weft directions, it can be seen that the seam breaking forces in the weft direction are lower. For sample A, the seam breaking forces in the weft direction are 8.19% lower compared to those in the warp direction. For sample B, the seam breaking forces in the weft direction are 9.30% lower compared to the warp direction. For sample C, the seam breaking forces in the weft direction are 11.38% lower compared to the warp direction.

The results also indicate that warp yarns, which have a higher number of twists, more effectively resist the breaking forces acting upon them.

4. CONCLUSION

The obtained results show that the stitch density for sewing has a significant impact on the seam breaking force. Specifically, when observing the seam breaking force values for all samples in the warp direction, it is evident that these values increase with the increase in stitch density. This occurs because denser stitches strengthen the seam structure itself, allowing the seams to better resist external forces. The same effect is observed in the weft direction.
The results also show that the linear density of the weft yarn affects the seam breaking force. In the warp direction, the highest force values for all stitch densities are observed in sample A, followed by a decrease in sample B, with the lowest values in sample C. The same pattern is visible in the weft direction, where the highest breaking forces are recorded for sample A, followed by lower values for sample B, and the lowest for sample C. These results indicate that weft yarns with a larger cross-sectional area more effectively resist the breaking forces acting on them.
When comparing the seam breaking forces of the same samples in the warp and weft directions, it can be seen that the seam breaking forces are lower in the weft direction. The results also show that warp yarns, which have a higher number of twists, more effectively resist the breaking forces acting on them.
Overall, the results demonstrate that the seam strength values for all samples increase with the increase in both the stitch density and the linear density of the weft yarn. Defining these parameters represents a significant contribution for manufacturers of quality clothing. This data enables them to proactively design the necessary production parameters. By understanding these factors, manufacturers can anticipate the intensity of forces to which seams may be subjected in garments without compromising their quality.

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