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Strength of stitched joints of the coating upholstery fabrics

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Abstract: *Strength of stitched joints of the coating upholstery fabrics*. The aim of this work is to explore the impact of selected factors on change of the strength and stiffness characteristics of sewn joints of upholstery fabrics. For experimental detection of said characteristic the methodology was used EN ISO 13935-1. Changes in seam joints was evaluated on the basis the impact of input parameters joints. Results of experimental measurements is possible observed the greatest impact stitch length. It is also possible to note from the results of the experiments the significant influence of the sewing thread construction on the strength of the stitched joint.

Key words: strength of stitched joints, upholstery stitched joints, sewing thread

INTRODUCTION

Textile materials, fabric or knitted fabric used in the production of upholstered furniture such coating upholstery materials are classified as flat material, that need to be cut and subsequently bonded according to cutting plans (Liao et al. 2014). Fabric construction involves the conversion of yarns, and sometimes fibres, into a fabric having characteristics determined by the materials and methods employed. Most fabrics are presently produced by some method of interlacing, such as weaving or knitting. Weaving, currently the major method of fabric production, includes the basic weaves, plain or tabby, twill, and satin, and the fancy weaves, including pile, Jacquard, dobby, and gauze. Knitted fabrics are rapidly increasing in importance and include weft types and the warp types, raschel and tricot. Weaving is a widely used constructional method because it is cheap, basically simple, and adaptable. Woven fabrics have valuable characteristics resulting partly from the geometrical conformation of their components and partly from the fact that the components are held in position not by rigid bonding but by friction set up at the areas where they make contact. Woven fabrics are used in household, apparel, and industrial textiles.

In the manufacture of upholstered furniture, the process of sewing is one of the critical processes in assessing the quality of the finished product (Thanaa, 2011, Sülar, 2015). The strength of seam is expressed as the load needed to break the stitched joint. Each seam has two components, a bonded upholstery coating material and a fastener, i.e. thread.

Threads are the most important part of the stitched joint. Enhancing thread knowledge, analysing thread parameters, the right selection procedure and use of thread plays a major role in achieving good sewing performance and the desired seam quality. Sewing threads are special kinds of yarns that are engineered and designed to pass through a sewing machine rapidly. They form efficient stitches without breaking or becoming distorted during the useful life of the product. The basic function of a thread is to deliver aesthetics and performance in stitches and seams. Smooth surface and absence of faults ensures less friction between the needle and the material during high-speed sewing. The thread must be well lubricated to increase its sewability and resistance to abrasion.

Previous scientific studies (Choudhury 2000) have shown that the appearance and strength of a seam depends on the interrelationship of fabrics, threads, stitch selection and sewing conditions, including needle size, stitch density, appropriate sewing machine maintenance, etc. The basic elements of flat and length fabrics are textile fiber, whose properties greatly influence the strength and deformation characteristics of fabrics

(Ezazshahabi et al. 2015, Akgun 2015). The scientific work is mainly focused on sewn joints of clothing fabrics. Kordoghli et al. 2011 investigated the strength of stitched clothing joints in terms of the density of the bonded material. The result of his work is that textiles with higher surface density cause greater heating of the sewing needle in the sewing process, and this temperature subsequently damages the fabric containing thermoplastic fibers. Thanaa (2011) investigated stitched joints of micropolyester clothing fabrics where the fastener was polyester thread PES 74/2 dTex. Based on the research he concluded, that for specific type of fabric is preferable shorter length of stitch, and as the most suitable type of stitch length is 7 stitches per 1 cm length of the joint. Vilhanová, 2018, in his research dealt with the issues of strength and durability of sewn joints upholstery fabrics Nanotex. The aim of this work is to investigate the strength of stitched joints of selected types of upholstery coating fabrics in the warp and weft direction.

MATERIALS AND METODS

For experiments woven cloth fabric with a fancy sewing thread chenille in the weft were selected. Upholstery fabrics are divided according to their surface densities. Fabric 1 with a surface density of 390 g/m^2, fabric 2 with a surface density of 550 g/m^2 and fabric 3 with a surface density of 600 g/m^2. The test specimens were made by bonding the fabrics in the warp direction as well as the weft direction by the back seam type. Polyester (PES) threads of two types of construction were used as joining material: thread of infinitely long fibers and thread of staple fibers. The fineness of both types of thread was 30 TPI. Stitched joints were created by knitted stitch and 4 mm, 6 mm and 8 mm stitch lengths were selected. The MUVA 100 sewing needle with round tip was used, and as a machine for the production of test specimens was used the JUKI 1181N industrial sewing machine.

The test pieces were conditioned under standard atmospheric conditions for 24 hours (temperature t = 20 ± 2 ° C, relative humidity φ = 65 ± 2%). For each type of joint were made 8 pieces of samples. The significance of the influence of the selected coupling factors, the construction of the sewing thread and the stitch length was evaluated by means of the determined characteristics, which were joint strength and joint efficiency. A shape and dimension of test sample for determining the maximum tensile force by the STRIP method, is shown in Figure 1.

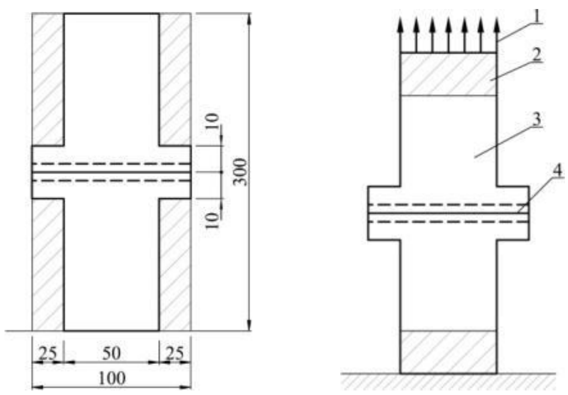

Figure 1: Test sample and tensile loading scheme (STN EN ISO 13935-1, 2001)
1- tensile loading, 2- clamping in test machine, 3- testing sample, 4- seam.

The load force is perpendicular to the seam. The seam position is in the middle of the sample length. The test sample is loaded perpendicular to the seam at a constant speed (100 mm/min with an accuracy of ± 10%), until to the seam breaking. The maximum force required to divulsion the seam shall be recorded. The initial distance between the jaws is 200 mm ± 1 mm. This distance defines the clamping length of the sample.

RESULTS

The experimental part of the work was focused on the influence of thread construction and stitch length on the strength of stitched joint on the selected types of coating upholstery materials. The test material was coating upholstery fabrics. Their common property is the type of construction and the different property is the surface density. The change of joint strength depending on the thread type and stitch length for selected types of coating upholstery fabrics bonded in the warp direction is shown in Figure 2.

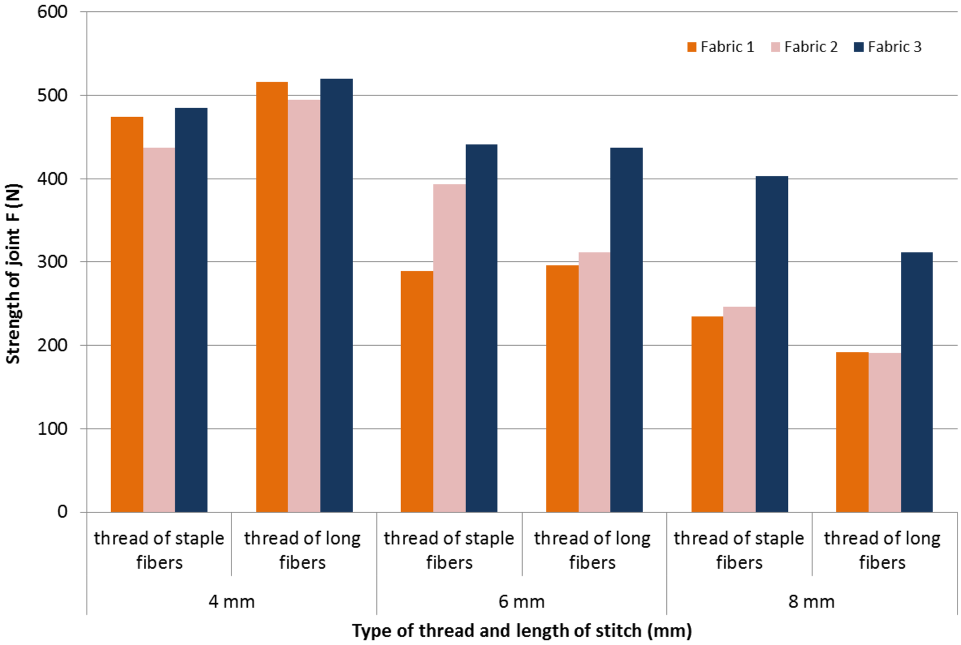

Figure 2. The change strength of joint depending on the thread type and stitch length for selected types of coating upholstery fabrics bonded in the warp direction.

When stitch length is increasing, the strength of stitched joints decreased, as experiments have shown. This decrease is most significant in stitched joints in fabric 1, with a surface density of 390 g/m^2. For this fabric, is used a staple thread as the connecting element. Stitched joint with a stitch length 6 mm had a lower strength compared to the linkage of the stitch length 4 mm by 39%. When testing the stitched joints of selected types of upholstery fabrics in the warp direction, the smallest decrease of joint strength, with increasing stitch length, was observed for fabric 3 with a space density of 600 g/m^2. The change of the strength of the sewn joints, stitched in the weft direction, for selected upholstery coating materials, is shown in Figure 3.

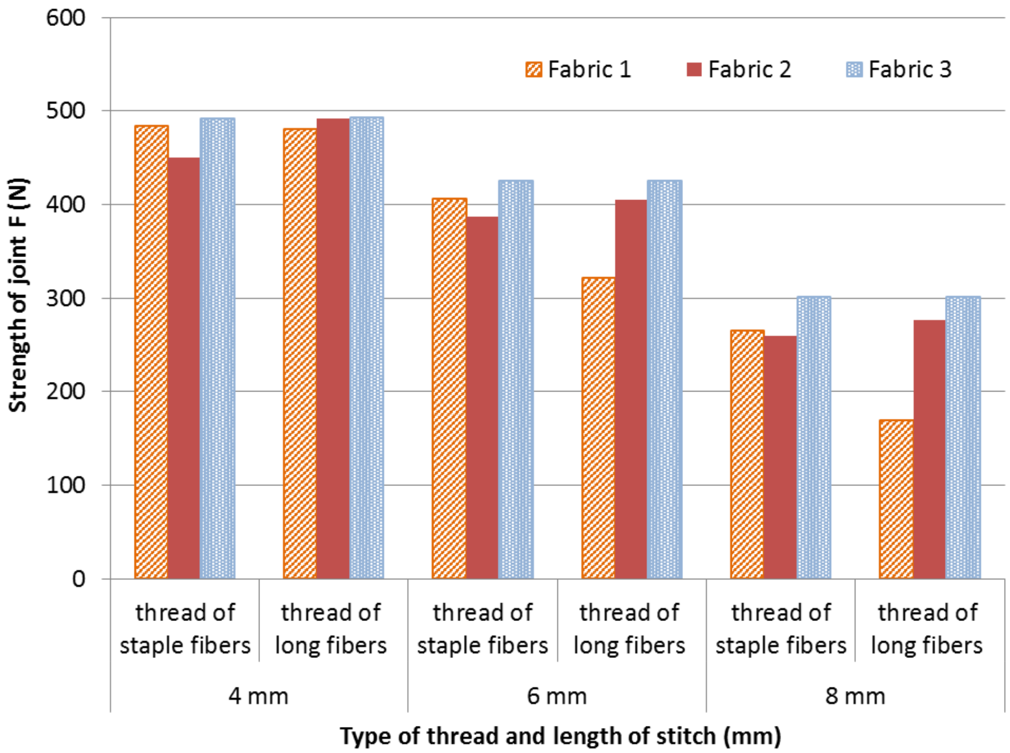

Figure 3. The change of the strength of stitched joints, stitched in the weft direction.

The results of the experiments show a significant effect of the stitch length on the strength characteristics of stitched joints. With the length of the stitch being extended, the bond strength decreased. However, the decrease in strength was more uniform compared to the joints where the fabric was bonded in the warp direction. Compared with joints with threads of an infinitely long fiber, joints created by staple thread has achieved higher strength values at all stitch lengths. The smallest differences in strength of joints were achieved with 4 mm stitch length, for both thread types. The highest decrease in the strength of stitched joints of a woven upholstery fabric bonded in the weft direction, was recorded at fabric 1. The strength of the stitched joint with a stitch length of 8 mm compared to stitch length of 6 mm is less than 47%.

For the strength of the stitched joint in the **warp direction**, all the investigation factors are significant for the significance level of 0.05 i.e. thread type, stitch length and upholstery fabric type. Also, their interactions are statistically significance (Table 1). Changing any of the monitored factors will change the strength of the stitched joint F_{max}.

Table 1: Univariate Tests of Significance for Strength of joints F_{max} (N) in the warp direction.

	Univariate Tests of Significance for Strength of joints F_{max} (N Sigma-restricted parameterization Effective hypothesis decomposition				
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	19789745	1	19789745	13743826	0,00
Type of fabric	281468	2	140734	97739	0,00
Stitch length (mm)	1217988	2	608994	422942	0,00
Type of thread	7773	1	7773	5399	0,00
Type of fabric*Stitch length (mm)	116400	4	29100	20210	0,00
Type of fabric*Type of thread	5253	2	2626	1824	0,00
Stitch length (mm)*Type of thread	72604	2	36302	25211	0,00
Type of fabric*Stitch length (mm)*Type of thread	19281	4	4820	3348	0,00
Error	181	126	1		

The effect of the thread type on the strength of the stitched joints at connecting the fabric in the wrap direction is shown in Figure 4.

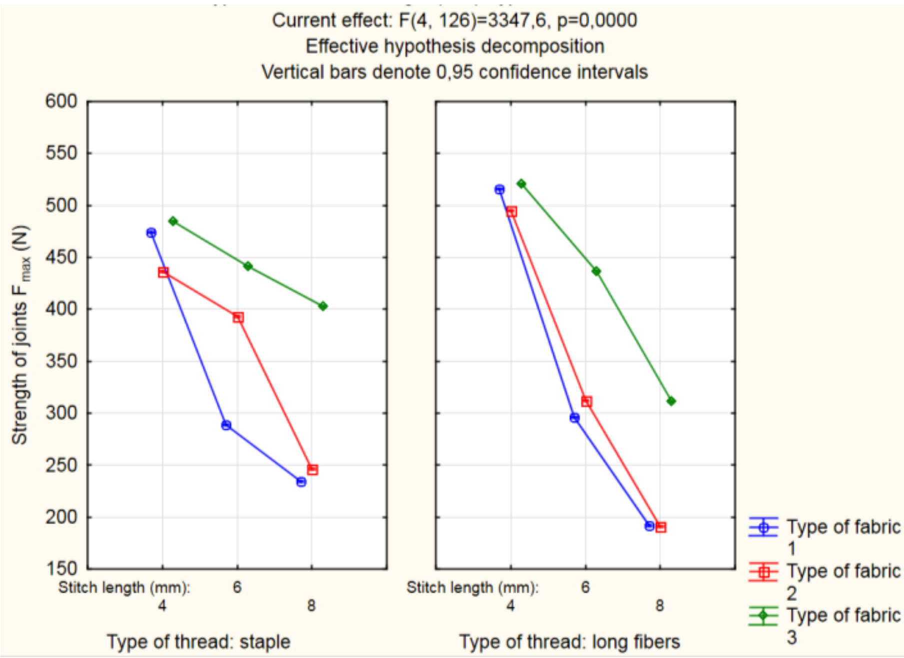

Figure 4. The effect of the thread type on the strength of the stitched joints at connecting the fabric in the wrap direction.

Based on the evaluation of the experiments, it can be stated that for joints with a stitch length of 4 mm higher strengths of joints were achieved with thread of infinitely long fibers for all three types of tested fabrics. Lower strengths of stitched joints created by threads from infinitely long fibers, were found at 6 mm and 8 mm of stitch lengths, compared to staple threads. It can be assumed, that the decline of strength is caused by sharper surface of thread, which appears to be a saw blade.

For the strength of the stitched joint in the **weft direction**, all the investigation factors are significant for the significance level of 0.05 i.e. thread type, stitch length and upholstery fabric type. Also, their interactions are statistically significance (Table 2).

Table 2: Univariate Tests of Significance for Strength of joints F_{max} (N) in the weft direction.

	Univariate Tests of Significance for Strength of joints F_{max} (N Sigma-restricted parameterization Effective hypothesis decomposition				
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	20767009	1	20767009	1137047	0,00
Type of fabric	64205	2	32103	1758	0,00
Stitch length (mm)	1175139	2	587569	32171	0,00
Type of thread	5210	1	5210	285	0,00
Type of fabric*Stitch length (mm)	27101	4	6775	371	0,00
Type of fabric*Type of thread	47646	2	23823	1304	0,00
Stitch length (mm)*Type of thread	11118	2	5559	304	0,00
Type of fabric*Stitch length (mm)*Type of thread	10748	4	2687	147	0,00
Error	2301	126	18		

The effect of the thread type on the strength of the stitched joint at connecting the fabric in the weft direction is shown in Figure 5.

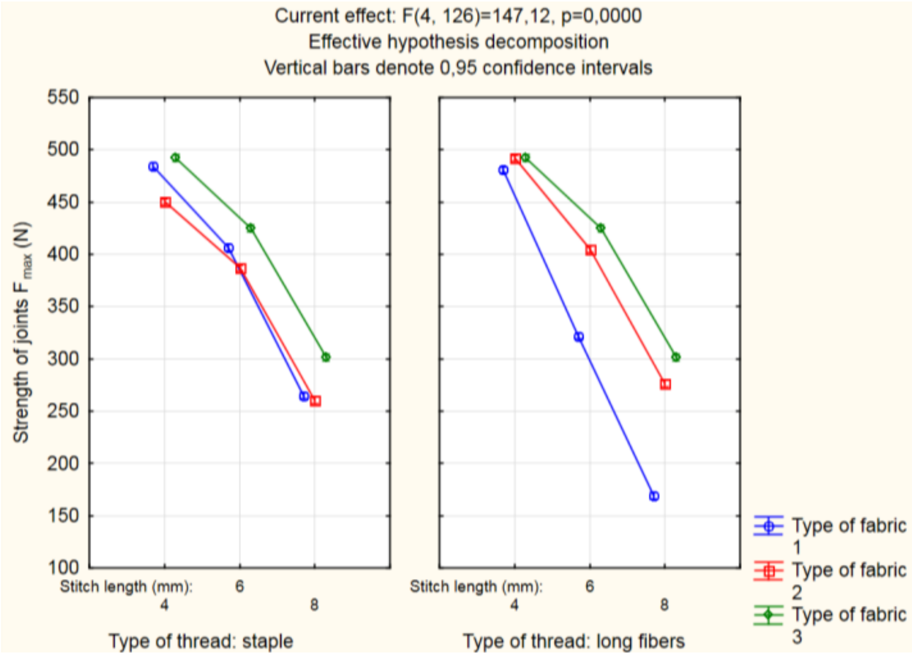

Figure 5: The effect of the thread type on the strength of the stitched joint at connecting the fabric in the weft direction.

The results show that the influence of the type of thread construction, at joining of upholstery fabric in the weft direction, decreases with the length of the stitch. The strength of the stitched joint is almost identical for both types of thread, for 6 mm and 8 mm stitch lengths. The difference was found only for joints with a stitch length of 4 mm. Long fiber threaded joints have a lower strength than shear-threaded joints.

CONCLUSION:

The aim of this research was to investigate the strength of sewn joints for selected upholstery fabrics. Input parameters, such as length of stitch and type of sewing thread construction type directly effect on the strength of the stitched joints. The stitched joints were formed in the weft direction of upholstery fabric.

The selected factors had a significant impact on the tested characteristic of stitched joint, this was confirmed by experiments. The stitch length has a negative effect on the joint strength. As the stitch length increases, the strength of the joint decreases. The most significant decrease of joint strength was recorded in fabric 1 with a surface density of 390 g/m^2; a fabric was joined in the warp direction. Connecting element of joint was a staple thread. In connection with the lengthening of the stitch length, in the joining of the fabric in the warp direction, the smallest decrease in strength was recorded for fabric 3, the density of which is 600 g/m^2.

In assessing the impact of the type of bonding construction on the observed joint characteristics, has been shown that with a stitch length of 6 mm and 8 mm, the joint strength with long fiber thread was lower than that of staple threads. This fact is confirmed by research (Vilhanová, 2018), which has examined the joint strength of Nanotex upholstery fabrics.

These technical knowledges are of benefit to experts dealing with the design and testing of textiles and sewn joints of upholstered furniture.

The mechanical stress of the stitched joints of the upholstery coating fabrics depends on the material and quality a supporting frame of upholstered furniture. With the current trend of decreasing the weight of furniture construction, some types of light-weight materials are often used, resp. new materials are being developed. However, the mechanical properties of these new light-weight materials need to be determined. The mechanical properties of the supporting material significantly affect the stiffness of the construction. The stiffness of the construction and the load from the user significantly affect the mechanical stress of the stitched joints; affects the choice of the construction of thread and upholstery coating fabric type.

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Streszczenie: *Wytrzymałość połączeń zszywanych tkanin tapicerskich*. Celem pracy było zbadanie wpływu wybranych czynników na zmianę wytrzymałości i sztywności połączeń zszywanych tkanin obiciowych. Badania przeprowadzono w oparciu o normę EN ISO 13935-1. Zmiany w szwach oceniono na podstawie wpływu parametrów wejściowych połączeń. Wyniki pomiarów eksperymentalnych wskazują, że najwiekszy wpływ na wytrzymałość miała długość ściegu. Na podstawie badań stwierdzono również znaczący wpływ konstrukcji nici do szycia na wytrzymałość złącza.

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