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SEAM PROPERTIES OF STRETCH FABRICS

DEMBOSKI Goran, JANKOSKA Maja

University "Ss. Cyril and Methodius" in Skopje, Faculty of Technology and Metallurgy, Department of Textile engineering, Rudjer Boskovic 16, Skopje, North Macedonia, goran@tmf.ukim.edu.mk

Corresponding author: Demboski Goran: goran@tmf.ukim.edu.mk

Abstract: *The paper investigates the longitudinal seam stretching properties on ISO 301 lockstitch seams on garments made of stretch fabric. The influence of factors such as manual manipulation during sewing, stitch density, ply number in the seam and sewing thread extension, was investigated on stretch fabric. The result of planed experiment shows that the ply number thread extension and stitch density are significant factors to seam stretching in seam direction. It was found that the most significant factor on seam stretching in longitudinal direction is ply number. By application of sewing thread of higher extension, the stretching of the lockstitch seams in longitudinal direction of over 100% can be obtained.*

Key words: *longitudinal seam stretching, stretch fabrics, ply number, thread extension, stitch density*

1. INTRODUCTION

Seam is a basic requirement in clothing production. The seam must have good visual appearance, appropriate functional properties and durability. The seams are considered one of the essential requirements in apparel construction and their properties must correlate to the quality of main fabric. Seam performance relies on several parameters such as: seam strength, elasticity, durability, puckering, appearance and yarn severance [1-4]. Also, seam quality depends on its type, stitch density, sewing thread tension and seam efficiency [5].

During the usage and wear, the seams may be loaded at any angle to the direction of sewing. The response of the seam to application of a load, and to its subsequent release, is the issue underlying many investigations. A response of the seam varies with the direction of loading and size of the load.

Appearance and performance of the seam are dependent upon the quality of sewing threads and their dynamic behavior. One essential requirement of any sewing thread is that it must be compatible with the needle size, various sewing machine settings (sewing speed, thread tension) and the fabric on which it is being used [6]. Although the effect of the sewing thread on seam performance is generally much less noticeable than the fabric one, many situations occur where the use of better sewing thread represents a practical solution to a seam performance problem [7].

Due to the tendency for stretch fabrics in the textile industry, garment manufacturers need to work more precisely on the sewing of elastic fabrics. Most stretch knit garments are seamed with overedge and/or cover stitch seam constructions because these stitches offer the best seam elasticity and coverage of the raw edge of the fabric. A quality problem that is common with stretch knits is excessive "broken stitches" or "stitch cracking" when the seam stretches excessively. It was found that the linear density of the weft in-laying threads and the preliminary tension of the ground yarn at pillar stitch affect stretch properties of elastic warp knitted fabric and deformation [8]. The detail analyses of the constructions of the medical preventive goods were carried out, and Melnyk and Kyzymchuk [9] considerate that an elastic warp knitted structure with pillar stitch is usually used for such purposes. The influence of inlaying variants of weft yarn on structure parameters of such stretch warp knitted fabric was found to have greater effect on fabric stretching [10]. Pillar stitch is not widely used interloping and the tensile strength of pillar stitch fabric is smallest among three common types of warp knit stitches (tricot, cord, and pillar) [11]. In recent years, stretch fabrics have been extensively used in garment production as face fabric and in combination of other face materials [12, 13]. Beside improvements in deformation and compression properties, there are still problems regarding seam extensions in longitudinal direction in stretch fabric garments, especially in application of lockstitch type stitch. The aim of the paper is to investigate the factors affecting longitudinal seam stretching and possibilities of improving longitudinal seam stretching in production of shirts made of stretch material.

2. EXPERIMENTAL

The investigation is undertaken to deal with real production problem in shirt manufacturing. The shirt was produced from stretchable knit fabric of fibre composition 76% polyamide and 24% elastane. Apart from other seams of the garment, the bottom hemming seam of the shirt was required to be produced on single needle lockstitch sewing machine employing stitch type 301. It was noticed that the extension of bottom hemming seam in longitudinal direction was not sufficient for the extension of the fabric. This was exhibited by thread breaking in the seam or seam cracking when stretching the seam in longitudinal direction. To investigate the possibility to increase seam extension, the manual stretching of the material while sewing was applied. The material was stretched as evenly as possible while sewing. Furthermore, the influence of various factors such as: stitch density, material ply number in the seam and sewing thread extension, on seam stretching properties was evaluated using planned experiment. Two types of sewing threads of various breaking strength and extension at break were used for production.

The following methods were employed for testing the fabric and seams:

- BS EN ISO 13934-2:1999Textiles. Tensile properties of fabrics. Determination of maximum force using the grab method
- DIN EN ISO 2026:1995-05Textiles – Yarns from packages – Determination of single-end breaking force and elongation at break using constant rate of extension (CRE)
- AATCC TS-015: 2004Seam stretchability of knitted garments. The width of the sample is 100mm and the distance between the clamps is 75mm.

3. RESULTS AND DISUSSION

The features of the fabric and sewing thread are depicted in Table 1 and 2.

Table 1: *The properties of the stretch fabric*

Fibre composition	Fabric weight, g/m^2	Breaking strength, N		Extension at break, %	
		Lengthways	Widthways	Lengthways	Widthways
76% PA 24% Elastane	154.7	225.3	226.9	287.9	364.8

Table 2: *The properties of the sewing threads*

Thread designation	Fibre composition	Thread count, Tex	Breaking strength, N	Extension till break, %
S1	100% PES	27	9.62	13.72
A1	100% PES	27	11.39	17.69

The fabric for shirt production has similar breaking strength in both testing direction. The extension of the fabric till break is over 100% and it is 70% higher widthways. Regarding applied sewing threads, the thread A1 has higher breaking strength and has 4% higher extension at break than thread S1.

When testing the seam in longitudinal direction, there is characteristic load extension curve consisting of several peaks (fig 1). When seam is being extended, the sewing thread breaks first. This can repeat several times, till the seam is still capable of carrying the stress. After that, the fabric carries the stress and test continues till fabric breaks. The moments when sewing thread breaks is displayed on graph by several peaks starting at the beginning of load extension curve.

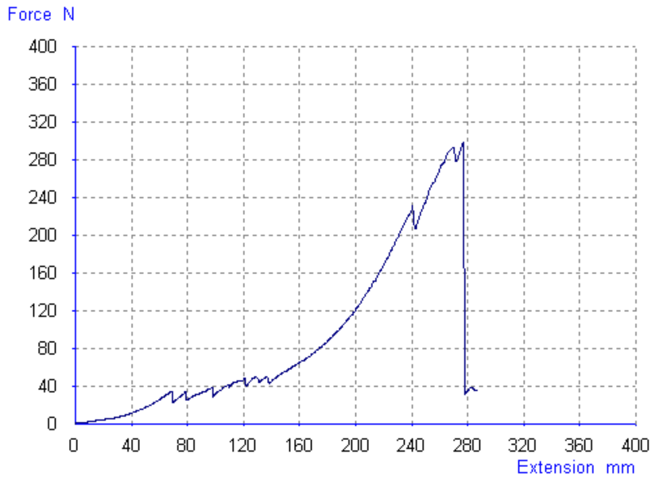

Fig. 1*: Stress extension curve for the seams in longitudinal direction*

The results of longitudinal seam strength and extension for 2 ply superimposed seams is shown in table 3. The strength and extension of the seams are recorded for the first 4 peaks of the load extension curve. In all cases the breaking strength and extension increase from the first to the following peaks. However, already at first peak, the tread in the seam breaks and the seam is regarded unacceptable. The seam made of thread S1 (which have higher strength and extension than A1) shows higher seam strength and stretching. There is not clear difference in seam breaking strength and extension between the stretched sewing seam and the regular one, at the first peak. At this peak, which is most important for the seam quality, there is no difference for stretched sewing and regular sewing seams of thread S1. The stretched seam from thread A1 shows just 2% higher percentage of extension than regular one. At following peaks, the difference in strength and extension of stretched and regular sewn seams is greater and generally stretched sewing seams show higher extension and breaking strength.

Table 3: *The seam strength and extension in longitudinal direction*

Designation	I peak		II Peak		III peak		IV Peak	
	Breaking strength (N)	Extension (%)	Breaking strength, (N)	Extension (%)	Breaking strength (N)	Extension (%)	Breaking strength (N)	Extension (%)
S1-stretched sewing	25.7	44.2	26.6	63.7	37.7	109.4	41.8	123.4
S1-regular sewing	26.2	44.5	24.7	53	35	105.6	34.5	114.3
A1-stretched sewing	18.6	33.1	18.9	43.3	24.4	73.5	29.8	97.1
A1-regular sewing	18.7	31.3	21.1	41	24.4	82.4	26	92

Planned 2^3 experiment was conducted to analyze the influence of three factors: A-seam stitch density, B-seam ply number and C-thread extension on seam extension properties in longitudinal direction. The seam extension was registered from the load extension curve just for the first peak of the thread breaking. For testing three ply seams, knife pleat 2.0 cm wide was made in the middle of the sample and pleat was seamed in the middle by single needle lockstitch machine. The factor levels are shown in table 4 and the results of the planned experiment in table 5.

Table 4: *High and low levels of the factors for planned experiment*

Factors / Levels	A	B	C
	Stitch density	Ply number	Thread extension
-1	4.5 cm^{-1}	1	13.9%
1	5.5 cm^{-1}	3	17.7%

Table 5: *The factors combination matrix and result of 2^3planned experiment*

Run	Replication	A-Stitch density	B-Ply number	C-Thread extension	Seam extension, %
1	1	1	-1	1	36.33
2	1	-1	1	1	89.2
3	1	-1	-1	-1	31.77
4	1	1	1	-1	74.13
5	2	1	-1	1	43.16
6	2	-1	1	1	92.4
7	2	-1	-1	-1	28.12
8	2	1	1	-1	72.26
9	3	1	-1	1	35.41
10	3	-1	1	1	93.73
11	3	-1	-1	-1	28.58
12	3	1	1	-1	74.13

The ANOVA results show that the all three factors have significant influence on seam extension in longitudinal direction (Fcalc.>Fcrit. for 95% confidence limit and $p<0.05$). The Pareto chart shows the effect of the three factors on seam extension in longitudinal direction (fig. 2). The ply number has greatest effect on seam extension, followed by sewing thread extension and stitch density.

Table 6: *ANOVA table of the influence of three factors on seam extension in longitudinal direction*

	SS	df	MS	F	p
(C) Stitch density	67.119	1	67.119	9.432	0.015322
(B) Ply number	7128.713	1	7128.713	1001.742	0.000000
(A) Thread extension	549.995	1	549.995	77.286	0.000022
Error	56.931	8	7.116		
Total SS	7802.757	11			

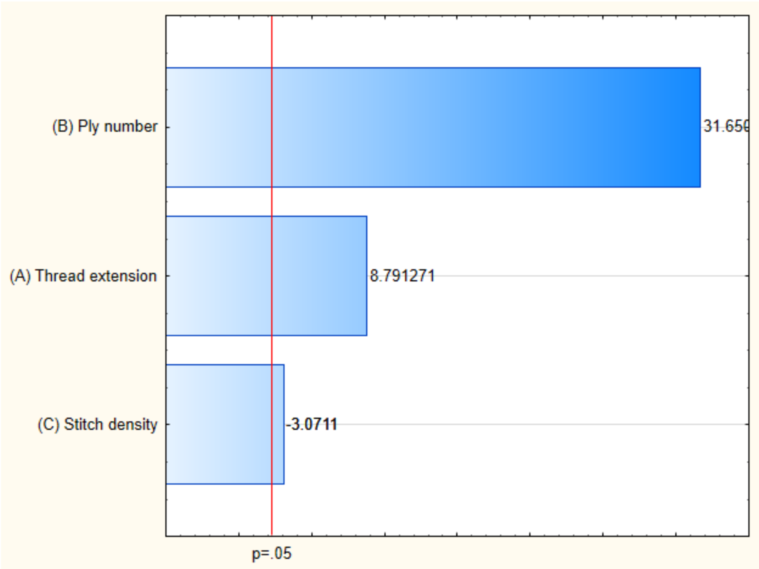

***Fig. 2**: Pareto chart of standardized effects of the three factors on two levels on seam extension*

Although the factor ply number has greatest effect on seam extension, the ply number cannot be changed during manufacturing since it is specified in technical pack. The same apply for stitch density. So, the only solution that can do in manufacturing is the application of the sewing thread of higher extension. The regression equation of seam extension in longitudinal direction is given in equation 1.

***Table 7:** Regression summary for dependent variable seam extension*

	b*	Std. Err. - of b*	b	Std. Err. - of b	t(8)	p-value
Intercept			-23.1262	10.16253	-2.27564	0.052427
Stitch density	-0.092747	0.030200	-4.7300	1.54016	-3.07110	0.015322
Ply number	0.955832	0.030200	24.3733	0.77008	31.65031	0.000000
Thread ext.	0.265494	0.030200	3.5632	0.40531	8.79127	0.000022

$$E_{seam/L} = -23.1 + 24.4 \times n + 3.6 \times E_{thread} - 4.7 \times s_d \quad \textbf{(1)}$$

Where:
$E_{seam/L}$ - seam extension in longitudinal direction
n- ply numbers in the seam
E_{thread} - thread extension
s_d- stitch density

There are several sewing thread manufacturersoffering sewing threads for stretchable fabrics of high extensibility up to 22% [14]. For the threads S1 and A1 the equation gives values of 77.6% and 91.7% seam extension respectively. For the thread extension of 22%, ply number of 3 and stitch density of 4.5 cm^{-1}, the equation returns the value of seam extension in longitudinal direction of 107%. So the application of the special sewing thread of high extension can considerably improve longitudinal stretching properties of the lockstitch seam.

4. CONCLUSION

The sewing thread extension, stitch density longitudinal seam stretching and ply number in the seam affects seam stretching in longitudinal direction.

The manual stretching of the ply while sewing does not show clear effect on longitudinal seam stretching.

The result of the planed experiment and analysis of variance shows that most significant factor on seam stretching is ply number in the seam, followed by sewing thread extension and seam stitch density.

The regression model of seam stretching suggests that the application of special sewing thread of high extension can increase the longitudinal seam stretching or lockstitch type seam to over 100%.

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