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The Influence of Technological Parameters on Quality of Fabric Assemble

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When garment details are assembled using thready joint method it is rather difficult to assure that aesthetical, exploitation and production requirements would be fulfilled. The aim of the research is to analyze the influence of technological parameters on puckering of fabric assemble. The same composition, warp/weft density and different weave fabrics were investigated. They were produced using computerized Jacquarg looms. The joints were prepared at different rotational frequency of a sewing machine main shaft, i. e. 200, 900, 1600 and 2300 min^{-1}; stitch density also varied, i. e. 3, 4, 6 cm^{-1}. The seam pucker magnitude has been determined by the method of the measurement of geometric characteristics of the wave generated in the specimen near the seam. It was obtained that in the case of ~80 % specimens the puckering coefficient was lower than 25 %, therefore the fabrics under investigation may be stated to have no significant puckering defect. Assembling of fabrics by a longer stitch determine a greater puckering effect. The analysis of the impact of fabric mechanical properties on the seam pucker has shown that the greatest influence was made by fabric elongation E, %, relating it in a complex manner to the technological parameters.

Keywords: fabric, seam, pucker.

INTRODUCTION

Three-dimensional garments are formed from confusing shape items having different curvature. Usually thready joint is used to assemble garment details, which must assure that aesthetical, exploitation and production requirements are fulfilled. Unambiguous characterisation of seam quality is a complicated task since quality assessment may be carried out at a range of aspects: from the aesthetical point of view, some seam quality indicators are important, whereas in terms of garments usage, other seam quality indicators are significant. It is rather difficult to achieve optimum between final product appearance, form stability as well as production time and costs whereas processed textile materials are prone to various defects. When highlighting aesthetical and exploitation characteristics of seams, aesthetical quality indicators of thready assembling are considered as encompassing such features as fabric puckering in the place of the seam, shrinkage along the seam and across the seam, shifting of fabric layers. During garments' manufacturing woven structure is affected by internal and external forces. As a result an undesirable crease surface may occur at the place of the stitching. This defect is known as seam pucker and it is common problem when thin, flexible fabrics are assembled. The studies dedicated to investigate seam pucker are focused on understanding reasons caused this fault and for assessment of it. Subjectively seam pucker is evaluated by ISO 7770, AATCC 88 B standard, however the biggest interest is shown to develop modern methods for objective evaluation. Various techniques such as finite element, image analysis, self-organizing map, fractal geometry, artificial intelligent, neural network are used to perform prediction and evaluation [1 – 6]. Simple methods are equally important considering commercial application and demand of quick answer in industry [7 – 10].

The analysis of studies aimed to determine the factors caused the pucker emergence shows that fabric and sewing thread properties, assemble technological modes as well as characteristics of sewing equipment have impact on this defect [11 – 20]. Considering different reasons of fault occurrence, there are various seam pucker types, such as inherent, feeding or tension pucker. Fabric structure and mechanical properties determine inherent seam pucker as fabric deformation during the processes of needle penetration, feeding, thread tightening depends on these properties. In most cases fabric properties can't be changed. Meanwhile it is possible to select proper technological parameters to get off or reduce tension and feed pucker. It is relevant to know controlled factors and their magnitudes, which allow to avoid the problem.

The aim of the research is to investigate the influence of technological parameters on puckering of fabric assemble.

METHODOLOGY

In order to analyze pucker defect, the same composition, warp/weft density and different weave fabrics F1, F2, F3 were selected. These fabrics were specially produced using computerized Jacquarg looms. Basic characteristics of the fabrics are shown in Table 1.

Fabric thickness was measured at pressure of 1 kPa according to the standard LST EN ISO 5084:2000. Fabric warp/weft density and mass per unit area was determined according to the standard LST EN 1049-2:1998 and standard LST ISO 3801:1998 (method No 5) respectively.

From previous studies [13 – 19] it is known that textile material mechanical properties have influence on seam pucker. FAST (Fabric Assurance by Simple Testing [20 – 21]) system was used to obtain bending rigidity B, formability F, extensibility E, shear rigidity G of selected fabrics (Table 2).

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Table 1. Characteristics of analysed fabrics

Characteristics		F1	F2	F3
Weave		plain	twill	combined twill
Composition	warp	70 % cotton, 30 % PES	70 % cotton, 30 % PES	70 % cotton, 30 % PES
	weft	100 % PES	100 % PES	100 % PES
Mass per unit area, g/m^2		155	153	155
Thickness, mm		0.43	0.47	0.54
Density, cm^{-1}	warp	28	28	28
	weft	20	20	20
Linear density, tex	warp	39.9	39.9	39.9
	weft	18.1	18.1	18.1

Table 2. Mechanical characteristics of analysed fabrics

Characteristics		F1	F2	F3
Bending rigidity	warp *B1*, μNm	22.90	19.20	20.40
	weft *B2*, μNm	15.10	7.70	4.90
Formability	warp *F1*, mm^2	0.59	0.53	0.65
	weft *F2*, mm^2	0.31	0.26	0.26
Extensibility	warp *E1*, %	1.00	0.84	0.95
	weft *E2*, %	0.64	0.92	1.15
Shear rigidity *G*, N/m		209.54	61.50	41.27

The specimens for seam pucker evaluation were prepared sewing two fabrics' strips together across the centre line in longitudinal direction. Strips were cut and sewn in the warp and weft directions (warp + warp, weft + + weft). The sewing conditions were as follows: rotational frequency of a sewing machine main shaft was different, i. e. 200, 900, 1600 and 2300 min^{-1}; stitch density also varied, i. e. 3, 4, 6 cm^{-1}; sewing needle No. 90. The lock-stitch one-needle sewing machine Gemsy 8900 was used. Before sewing this machine was checked to ensure that the sources of seam pucker occurrence depending on sewing equipment work is eliminated. For this purpose a specimen wrinkles were evaluated after sewing, not changing the initial machine feeding conditions. The 100 % polyester core spun sewing threads linear density 31.5 tex were selected for the preparation of the specimens. The upper and lower thread tension was chosen to ensure that interloop lies in the mid-fabric that means that well balanced lock-stitch is formed.

The seam pucker magnitude was determined by the method of the measurement of geometric characteristics of the wave generated in the specimen [7 – 8]. According to this method digital images of a specimen contours are obtained by photo-capturing using Olympus E620 (resolution 12.3 megapixels), each wave's length *l* and height *h* are measured and characteristics of the defect evaluation are calculated. The specimen was placed on a flat horizontal solid surface in rectangular not transparent box seeking to eliminate an influence of external light sources and photo-captured from both sides. The photos of the specimens were imported in CorelDraw11 software. This software was used to measure geometric characteristics of wave. Pucker sharpness *SH* was computed as height *h* and length *l* ratio. Sharpness was supplemented by the relative pucker coefficient *k*. This coefficient involves factors describing nature of waves distribution in a specimen, namely the quantity of waves within the section of a given length. Considering to this relative pucker coefficient *k* was calculated according:

$$k = \frac{SH \times n_v \times l_v}{l_d} \times 100 , \qquad (1)$$

where *SH* is the pucker sharpness, n_v is the average number of puckers in specimen, l_v is the average length of a creasy section in a specimen, mm, l_d is the length of the working section in a specimen, mm (in this case 200 mm).

EXPERIMENTAL RESULTS AND DISCUSSION

Analysis of the seam puckering results has demonstrated that puckering coefficient *k* exceeded 25 % just in one fifth (~18 %) of the specimens (Table 3). This coefficient in one third of the test samples varied from 15 % to 25 %. In the greatest portion of specimens, puckering coefficient *k* was less than 15 %. According to the aforesaid results, the fabrics under investigation may be stated to have no significant puckering defect, however, even minor puckering may impair the quality of the garment taking into account the garment appearance and surface properties of the fabric.

Table 3. The results of pucker coefficient *k* at different technological parameters

Fabric code	Direction	Rotational frequency of a sewing machine main shaft, min^{-1}											
		200			900			1600			2300		
		Stitch density, cm^{-1}			Stitch density, cm^{-1}			Stitch density, cm^{-1}			Stitch density, cm^{-1}		
		3	4	6	3	4	6	3	4	6	3	4	6
F1	warp	24.2	18.9	15.9	21.4	14.8	16.0	15.5	29.0	27.0	21.7	13.0	31.7
	weft	25.7	27.6	7.4	12.2	8.1	9.4	9.2	23.5	5.4	10.9	13.7	9.9
F2	warp	26.9	11.7	12.2	19.4	6.6	14.8	22.3	15.5	22.4	18.1	13.9	24.4
	weft	25.0	12.4	15.1	17.8	10.1	14.0	23.6	21.6	13.1	14.7	13.3	12.9
F3	warp	30.0	5.2	18.7	26.2	12.8	18.9	28.2	13.6	19.3	25.9	16.2	32.8
	weft	20.8	19.3	7.8	9.4	13.5	8.5	10.6	27.4	8.7	7.3	9.3	8.7

(light grey) – k < 15, (dark grey) – k > 25.

Analysis of dependence of seam puckering coefficient *k* on technological parameters has shown no strong correlation. Examination of results shall consider the fact that puckering coefficient *k* allows complex assessment of different puckering performances: sharpness of puckers *SH*, average length of a creasy section in a specimen l_v and number of the puckers formed *n*. Seam pucker sharpness *SH* has been observed to grow with increase in rotational frequency of the main shaft *v* and in fabric extensibility *E*, whereas number of puckers *n* has decreased from 4 – 5 to 2 puckers in most cases. Such a tendency with respect to decrease of number of puckers *n* has been especially strong making longer stitches. Similar variation tendencies have also been demonstrated by analysis the length of the puckered section l_v. Research works carried out by other authors showed in the same manner that stitch length has influence on quantity of puckers but has no influence on other characteristics [22]. According to recommendations of the authors, puckering shall be decreased by changing the tensioning value of a sewing thread rather than the stitch length. Considering the process of fabric's penetration by the needle, feeding and sewing thread tightening it should be noted that both technological parameters may influence an occurrence of crease surface.

The sewing thread is deformed when passes through the sewing machine's parts and inserts into the fabric when a needle penetrates textiles, interlace with a bottom thread as well as press the fabrics' layers together. The relaxation processes in threads begin when they lie between adjacent pricks after transportation of assembled fabrics. The distance of these pricks depends on stitch length. Due to increased stitch length, the formation thereof requires more thread, and this fact determines inevitably change in thread tensioning that distributes along greater length. Thus, different stitch length may lead to changes in the nature of puckers, e. g. puckers may be higher and longer, thereby resulting in different visual perception of assembling puckering. During transportation different friction and inertia forces effect fabric layers therefore upper assembling fabric stretch and lower fabric shrink in the stitch area.

Research works in this field [11 – 19] illustrate that in order to avoid undesirable seam puckering, a range of factors shall be assessed with respect to both performances of a sewing equipment and technological parameters of assembling's as well as to properties of the fabrics under assembling that make influence on occurrence of this defect.

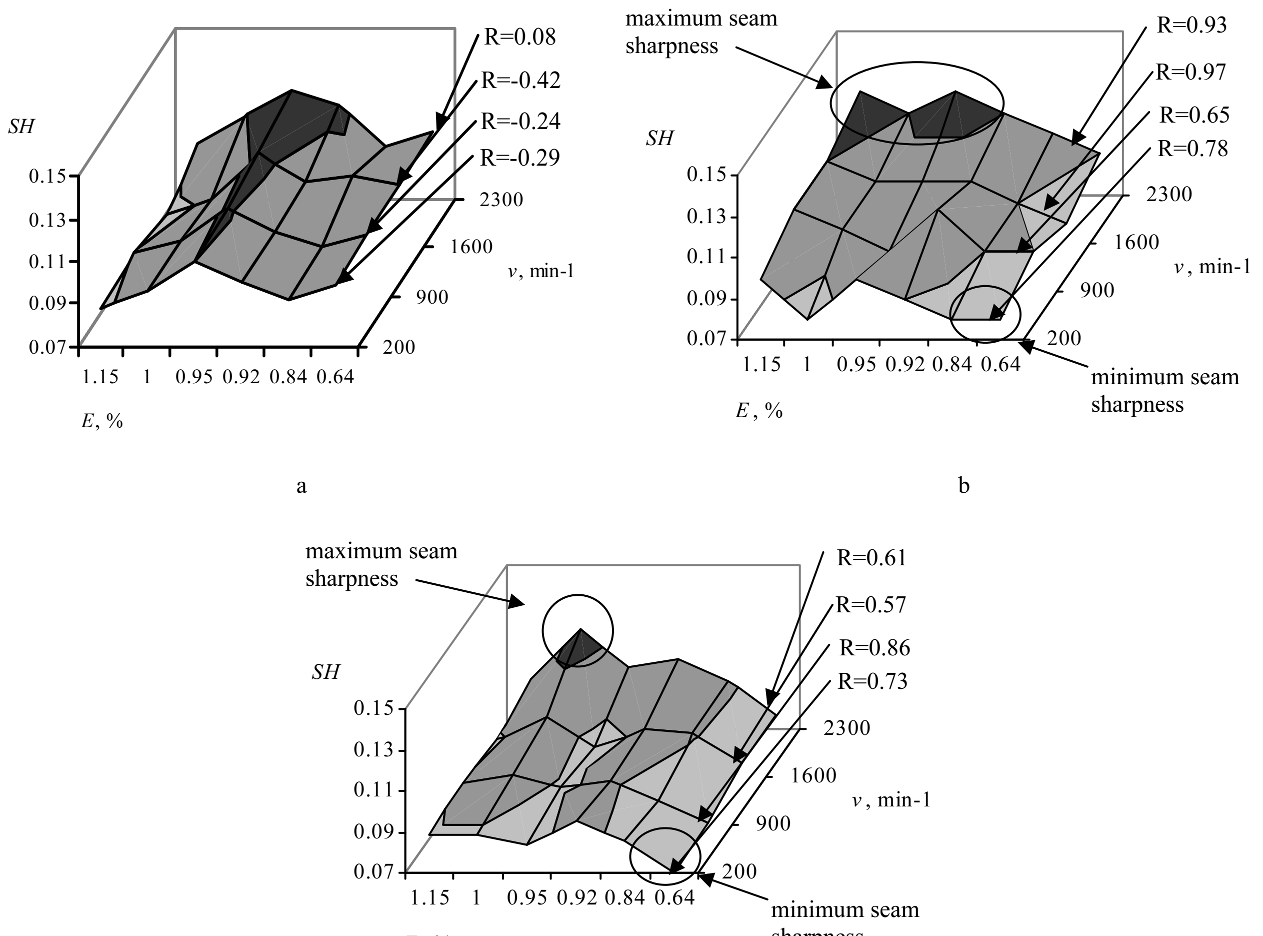

Fig. 1. The influence of fabric extensibility *E*, % and rotational frequency of a sewing machine main shaft *v*, min^{-1} on seam sharpness *SH*, when stitch density: a – 3 cm^{-1}, b – 4 cm^{-1}, c – 6 cm^{-1}

In the analysis of the results, assessment of the influence made by mechanical properties of the fabrics under investigation on seam puckering was carried out taking into account different stitch length and different rotational frequency of the main shaft. It was obtained that the greatest influence on the seam puckering defect was made by fabric elongation *E*, %, relating it in a complex manner to the technological parameters discussed. Analysis of compatibility of the aforementioned parameters has shown that fabric elongation *E* makes no influence on the seam sharpness when the longest seam stitch (Fig. 1, a) and different assembling speed are available, whereas correlation coefficient *R* dominates within the limits $-0.42 \div 0.08$. In this case, the tendency established by former investigations and revealing that increase in rotational frequency of the main shaft also leads to greater seam puckering is just observed [7, 11, 12].

Increase in stitch density up to 4 stitches per cm (Fig. 1, b) has demonstrated that the seam sharpness *SH* is influenced directly by fabric extensibility in this situation. The present example shows the tendency that more extensible fabrics form sharper, thereby more visually noticeable puckers, in the place of assembling with increase in rotational frequency of the main shaft. At rotational frequency of the main shaft of 200 min^{-1}, seam sharpness has grown from 0.08 to 0.10. Assembling at the maximum analysed rotational frequency of the main shaft ($v = 2300\ \text{min}^{-1}$) has illustrated that seam pucker sharpness *SH* in the most extensible fabric increases up to 0.12. However, assembling of fabrics with lower extensibility has demonstrated seam sharpness *SH* not exceeding $0.08 \div 0.09$ in all cases. Similar results have also been obtained at the greatest stitch density under investigation (Fig. 1, c). The present situation also shows the tendency that the sharpest puckers are observed at joint the most extensible fabrics at the maximum analysed rotational frequency of the main shaft. Assembling of fabrics by the shortest stitch decreases seam sharpness from 3 % to 23 % in most cases compared to the fabrics sewn by a longer stitch (4 stitches per cm).

During analysis of the seam sharpness *SH* dependence on stitch length, all cases have illustrated that the sharpest seam was observed by assembling fabrics by the longest stitch. In this situation, seam sharpness was up to 25 % greater compared to sewing by stitch length of 4 stitches per cm and up to 40 % greater compared to sewing by stitch length of 6 stitches per cm.

Examination of the quality of assembling in terms of seam puckering shall take into account the type of the pucker and distribution nature thereof. Puckered surface may be very different: relatively even waves in both pieces of the sewing garment, greater fabric rumples around the seam, convexity of the sewing garment at the seam with the tightened sewing thread seen in the upper or lower portion of the stitching; minor circular waves having formed at the stitching and evenly distributed on the left and right sides of the stitch; wavy middle portion of the stitching with the initial and end portions being straight; straight assembling seam and stitching with circular waves at the stitch; creases having formed on one side of the sewing garment, i. e. on right or left. In the process of investigation, puckers were analysed taking into account the fact how far they are distributed from the place of thready joint. The specimens presented in Figure 2, a, have demonstrated no significant puckering defect. Here, long puckers but with low seam sharpness predominate. Examination of the seam puckering shall also consider minor puckers observed at the seam (Fig. 2, b) that are low and are not distributed by the edge of the specimen. Visual inspection of the test samples have revealed that short puckers may impair the garment appearance. In specimen with the puckering defect (Fig. 2, c), coefficient *k* exceeds 25 %. In this situation, long puckers of both types distributed along and short not distributed puckers are usually observed. If the assembling contains long puckers with great sharpness, the short puckers formed have no significant influence on the quality of the assembling.

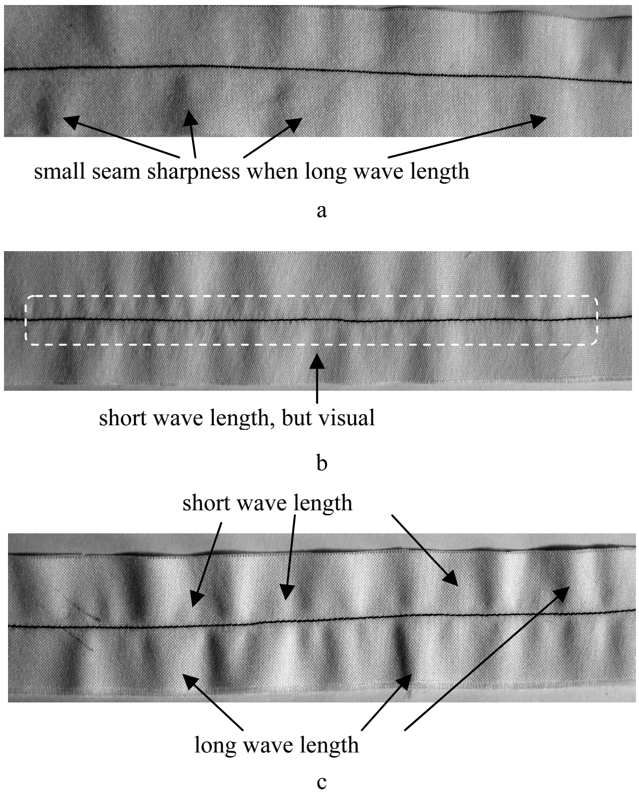

Fig. 2. The main types of seams puckers: a – small sharpness with long wave length, b – visual pucker determinate by short wave length, c – long and short wave length in one specimen

Thus, research has illustrated that the fabrics under investigation show no tendency to pucker significantly in the places of assembling, however, the puckering defect is observed in either case when certain technological parameters are available. Besides, fabric properties shall be considered in all cases as this fact determines the distribution nature of puckers, thereby the quality of assembling.

CONCLUSIONS

Examination of the influence made by technological parameters on seam puckering has demonstrated that assembling of fabrics by a longer stitch results in a greater puckering effect (from 25 % to 40 % greater seam pucker sharpness). Analysis of compatibility among rotational frequency of the main shaft and stitch length as well as fabric properties has shown that fabric extensibility makes direct influence on seam sharpness when greater stitch density is observed: more extensible fabrics have formed sharper puckers in the place of assembling with increase in rotational frequency of the main shaft. Assembling of fabrics with low extensibility has demonstrated the lowest values of seam puckering characteristics.

Investigating the same composition, warp/weft density and different weave fabrics it was observed that ~80 % specimens have shown the puckering coefficient lower than 25 %. Hence, the fabrics under investigation have no significant puckering defect. In order to assess influence of technological parameters on pucker coefficient *k*, variation tendencies of individual fabrics shall be analysed rather than making general evaluation with respect to dependence of the coefficient on the aforesaid parameters. Due to complex interaction among different factors that determine puckering, such individual puckering performances as pucker sharpness or number of puckers enable more accurate analysis of pucker formation compared to a complex puckering coefficient.

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