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Investigation of the techniques decreasing the seam slippage in chenille fabrics (Part I)

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Abstract

Seam slippage, which occurs frequently in furniture upholstery fabrics on the parallel sewing line, even though it is undesirable, results in partial or full distortion of fabric appearance. The purpose of this study is to reduce the seam slippage in upholstery chenille fabrics, which are widely used in furniture production.

This is the preliminary study, in which the effects of sewing direction and the number of interlaced chenille yarns over warp yarns on seam slippage were investigated for the first time. Aside from the effects of fiber content, sewing stitch step, weft densities of fabrics, sewing direction according to the weft and warp and the number of interlaced chenille yarns over warp yarns on seam slippage were studied with the use of multifactor experiment. On the basis of these experiments, effects and impact factors of the aforementioned parameters on seam slippage were shown with the use of mathematical models.

Keywords

Chenille fabrics, seam slippage, regression-based mathematical model

Introduction

Sewing quality is the most important parameter which determines the quality of finished products. Sewing quality is closely related to the seam slippage. Seam slippage is defined as slipping of yarns in the parallel direction with the seam in sewing line, and it causes partial or full distortion of the fabric appearance. Seam slippage is caused by the effects of applied mechanical forces on the seam by slipping of weft yarns over warp, or warp yarns over weft and it leads not only to a distortion of the sewing surface, but also a reduction in product usage life. Seam slippage frequently occurs in furniture upholstery fabrics and in clothing. Therefore, it has attracted a great deal of interest by researchers.

Galuszynski has investigated the seam slippage mechanism in woven fabrics theoretically and showed that seam slippage or fabric resistance to seam slippage results from: the friction between fabric yarns and sewing yarns; the bending rigidity of fabric yarns; and the structure and density of the fabric and stitch.[1] Galyuzinski revealed a mathematical relationship between seam slippage and the factors given above. He showed that the resistance of the fabric to seam slippage increases with increasing values of the aforementioned factors.

Kalaoglu et al.[2] have obtained the same results and have shown experimentally that seam slippage is related to the fabric structure and the density of weft yarns. Prior to this, Shimazaki et al.[3] proposed the use of an empirical equation for calculating the seam slippage depending upon the sewing length, loading and the axis of loading. Behera et al. emphasized that seam slippage is related to the mechanical properties of fabric and seam yarns.[4]

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Gurarda observed that, the properties of the seam were related to seam type, seam stitch length, seam yarn tension and seam efficiency.[5] In another experiment, Gurarda et al. showed that the reduction of the weft density of fabric, results in an increase of seam slippage.[6]

In other studies,[7–9] it was shown that seam properties are related to the structure and density of the fabric, linear density of the sewing yarns, needle parameters and the sewing type. Lin added sewing conditions and human factor to the factors which effect seam slippage.[10] Garibaa et al.[11] emphasized that the direction of sewing, the mutual interaction between sewing width and sewing density should be considered as well. Meanwhile, Yucel[12] studied the dependence of seam slippage in linen fabrics on linear density of sewing yarns and fiber type used and revealed that using mercerized cotton yarns in sewing provides a reduced seam slippage. Other studies included those by Miguel et al.[13] who investigated the dependence of seam slippage in wool fabrics upon the structural properties of fabrics and claimed that it is possible to design wool fabrics with optimum seam slippage. It was determined by Pavlinic et al.,[14] that seam slippage is a seam deformation which occurs in the sewing area due to the fabric elongation. Domingues et al.[15] studied the changes in dependence of seam slippage upon the periodical washing, drying and ironing processes and claimed that there is a relationship between fatigue periods of sewing and seam slippage.

Yildirim[16] showed that stitch density, linear density of yarn, and number of weft yarns per unit length are important parameters, causing seam slippage. He also showed that fabric properties play a more important role than stitch density in seam slippage. According to Yildirim, the seam slippage is more significantly affected under dynamic loading conditions than the static loading conditions.

In spite of many studies relating to the seam slippage mentioned above, this problem has not been completely studied yet.

According to the sources, the factors causing seam slippage can be divided into three main groups:

- factors related to the properties of fabric yarns and fabric structures
- factors related to the properties of sewing yarns and stitch structure
- factors related to the sewing conditions.

In all of the studies, it has been shown that the increase of the fabric and stitch densities leads to the reduction of the seam slippage or the increase of the resistance against seam slippage. It has also been shown that the seam slippage increases with the increase of slippage and elasticity of the sewing yarns. In the related studies, the effects of fabric structure and sewing stitch types on seam slippage have been emphasized. Nevertheless, there has not been any generalization on this issue. Sewing direction has also been shown to be an important factor.

However, in related studies, only the sewing in weft and warp directions were taken into consideration. The seams directed at an angle to threads of a weft and warp were not researched. There is, currently, insufficient research on seam slippage mechanism.

In this study, we took it a step further by taking into consideration the sewing properties of fabrics with seams at oblique angles to the warp and weft. Taking into account the requests of the furniture sector, the general purpose of this research was to find ways to reduce seam slippage in products which are prepared from upholstery chenille fabrics. The study has been performed in two stages. In the first stage, the effect of various parameters, which affect seam slippage, has been exposed by the examination of seam slippage in chenille fabrics. For this purpose, the effects of fiber content, sewing stitch step, weft density of the fabric, sewing direction to weft and warp, number of interlaced chenille yarn over warp yarns on seam slippage are studied with multifactor researches. The last two factors were examined for the first time. According to these factors the mathematical models of seam slippage can be obtained with samples of chenille fabrics. Based on mathematical models, the contribution of different factors in seam slippage and the type of effect are obtained and have all been identified in Part I.

Materials and methods

Determination of the factors

The factors used in this study were selected from the studies mentioned in the introduction. Chenille upholstery fabrics, which have a complex structure, are produced in jacquard weaving looms.These fabrics have chenille yarns in addition to warp and weft yarns. The same or different fiber types can be used in weft and warp directions. The friction coefficients of these yarns change depending upon the yarn structure and fiber type which are important in seam slippage.[1] In this study, the warp yarns applied to the fabrics consist of polyester, while the weft yarn was either polyester or cotton.

One of the most important factors is the weaving type which determines the fabric structure. In order to show the effects of the weaving type on slippage, woven fabrics with the structure of two weft yarns and one chenille yarn, in which the warp interlaces are six, nine and 12 yarns, were used. Another important factor which determines the structure of fabrics is the fabric density. To investigate the effect of this factor on seam slippage, fabrics with various weft densities were woven. The warp density of the fabrics was kept constant.

The fabric and sewing properties will be different in weft and warp directions since chenille fabrics have an anisotropic structure. Therefore, sewing direction has to be taken into account depending on the weft or warp yarns.

In this study the effects of sewing yarn were not studied since they have already been established. The widely used 301 class (shuttle straight sewing) sewing stitch was utilized as a stitch type for sewing the upholstery chenille fabrics.

According to preliminary experiments, the stitch step was found to be effective during sewing conditions. Therefore, in seam slippage researches this factor was included as a controllable factor, along with that of stitch step with weft density of the fabric, number of interlaced chenille yarns over warp yarns, sewing direction depending on the warp and weft yarn, and fiber type of the weft yarn.

Measurement of the seam slippage

Seam slippage was measured according to the TS EN ISO 13936.[17] Samples were prepared on a single needle shuttle type JUKI DDL-8700 machine (Figure 1) according to the standard, and seam slippage tests were performed on the INSTRON 4411 tensile machine (Figure 2).

Experimental design

The experimental works were performed using $abcd = 1$ semi cue, which enables a diagnostic contrast of the four factor full experimental plan.[18] The stitch step of the sewing machine (*a*), warp density of the fabric (*b*), sewing direction according to the warp and weft yarn (*c*), and the number of interlaced chenille yarns over warp yarns (*d*) were taken as input factors.

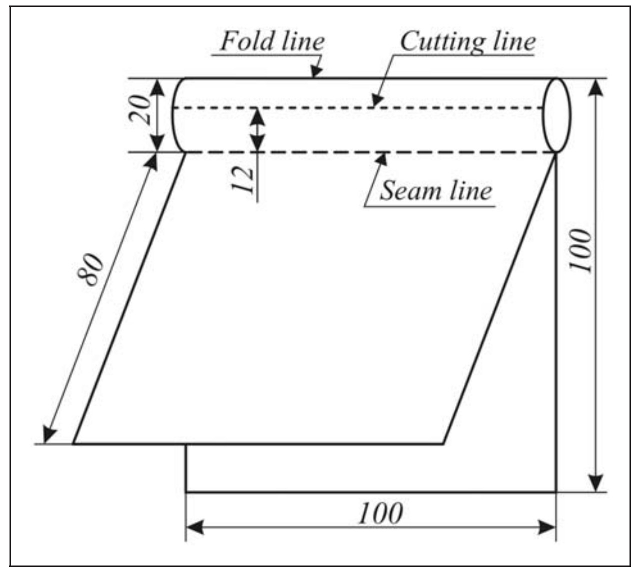


Figure 1. Schematic of the sample preparation. Sizes are in mm.

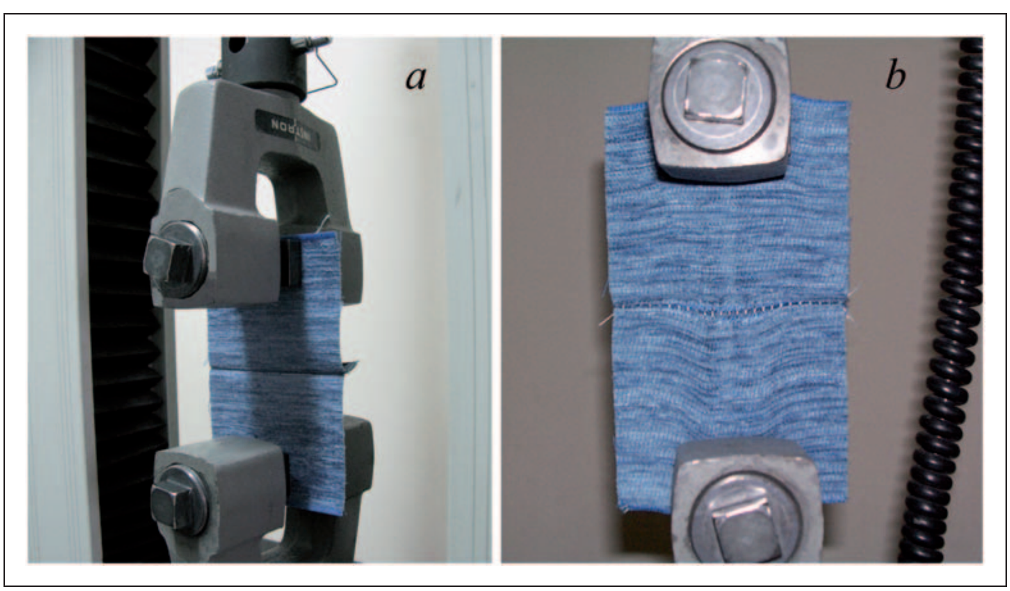


Figure 2. Views of the fabric samples before (a) and during (b) the test.

Seam slippage was measured as an output parameter. Factor levels are shown in Table 1.

The same plan was used for all fabric types. Experiments were designed using Design-Exper 8 software (Stat-Ease Inc.), repeated five times, and randomized.

Selection of the fabrics and sewing yarns

Upholstery chenille fabrics were produced according to the parameters given in Table 1. The technical parameters of the fabrics are shown in Table 2. The linear yarn density of the warp yarns used was 170 denier polyester yarns. In the weft direction, cotton (Ne 8) with acrylic (Nm 4) and polyester (300 denier) with chenille acrylic (Nm 4) yarn were used. In the sewing process, 80 tex polyester core spun sewing yarn was used (Epic, COATS)

Table 1. Factors and levels used for the experimental plan

Factors	−1	0	1
Stitch step in sewing, mm (*a*)	2	4	6
Weft density of the fabric, threads/cm (*b*)	15	17	19
Sewing direction according to the weft, degree (*c*)	0	45	90
Number of interlaced chenille yarns over the warp yarns, unit (*d*)	6	9	12

Results and discussion

Experimental results

The samples were tested according to the experimental plan. The results obtained are presented in Table 3.

The results were analyzed using Design-Expert software and the related evaluations were done by methods described by Montgomery.[19] ANOVA results are given for both fabrics containing cotton and polyester weft yarns in Tables 4 and 5, respectively.

The mathematical models were obtained from the coded values as given:

For cotton weft fabrics

$$S_{Co} = 3.49 + 0.45a - 0.64b - 0.36c + 0.17d - 0.25ab - 0.026ac + 0.15ad \tag{1}$$

For polyester weft fabrics

$$S_{pe} = 4.38 + 0.66a - 0.80b - 0.73c + 0.18d - 0.27ab + 0.12ac - 0.12ad \tag{2}$$

The models given in Tables 4 and 5 have been found to be significant and reflect the validity with sufficient

Table 2. Characteristics of threads fabrics used

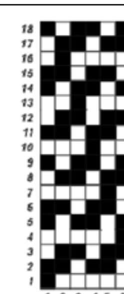
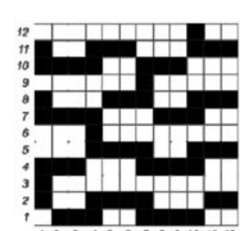
Fabric name	Weft density, ends/cm	Warp density, threads/cm	Number of interlace	Weft yarn	Type of weave
Upholstery chenille	15	66.6	6	Cotton	
Upholstery chenille	19	66.6	6	Cotton	
Upholstery chenille	15	66.6	6	Polyester	
Upholstery chenille	19	66.6	6	Polyester	
Upholstery chenille	15	66.6	12	Cotton	
Upholstery chenille	19	66.6	12	Cotton	
Upholstery chenille	15	66.6	12	Polyester	
Upholstery chenille	19	66.6	12	Polyester	

Table 3. Matrix plan of the experiments

	Factors				Seam slippage in cotton weft fabrics, mm					Seam slippage in polyester weft fabrics, mm				
	a	*b*	*c*	*d*	S_{C1}	S_{C2}	S_{C3}	S_{C4}	S_{C5}	S_{P1}	S_{P2}	S_{P3}	S_{P4}	S_{P5}
1	+	+	+	+	3.45	2.82	2.79	3.18	2.71	3.23	3.70	3.66	3.00	3.59
2	–	+	+	–	2.07	2.20	2.81	2.26	2.20	1.84	2.38	2.00	2.03	1.89
3	+	–	+	–	4.34	3.82	3.52	4.32	4.69	5.56	4.14	5.63	5.22	5.70
4	–	–	+	+	3.68	3.10	3.33	2.73	2.77	4.07	3.04	3.74	3.85	3.82
5	+	+	–	–	3.14	2.87	3.29	2.76	3.50	4.05	4.83	4.27	4.86	4.48
6	–	+	–	+	3.15	3.28	2.69	3.17	2.67	4.36	4.80	3.96	3.88	4.78
7	+	–	–	+	5.72	5.90	4.98	5.64	5.65	6.54	7.11	7.41	6.62	6.13
8	–	–	–	–	3.71	3.60	4.06	3.69	3.71	5.20	4.80	4.70	4.37	4.99

Table 4. Analysis of variance table for cotton weft fabrics (Partial sum of squares)

Source	Sum of squares	Contribution	DF	Mean square	F Value	Prob > F	
Model	34.3678	90.65	7	4.909685	44.34376	<0.0001	significant
a	8.127023	21.44	1	8.127023	73.4024	<0.0001	
b	16.60232	43.79	1	16.60232	149.9504	<0.0001	
c	5.048103	13.32	1	5.048103	45.59393	<0.0001	
d	1.112223	2.93	1	1.112223	10.04548	0.0034	
ab	2.505003	6.61	1	2.505003	22.62492	<0.0001	
ac	0.027563	0.07	1	0.027563	0.248942	0.6212	
ad	0.945562	2.49	1	0.945562	8.54022	0.0063	
Pure error	3.543	9.35	32	0.110719			
Corr. total	37.9108	100.00	39				

Table 5. Analysis of variance table for polyester weft fabrics (Partial sum of squares)

Source	Sum of squares	Contribution	DF	Mean square	F value	Prob > F	
Model	69.4997975	94.46	7	9.9285425	77.9305155	<0.0001	significant
a	17.2003225	23.38	1	17.2003225	135.007731	<0.0001	
b	25.6800625	34.90	1	25.6800625	201.566394	<0.0001	
c	21.0975625	28.67	1	21.0975625	165.597712	<0.0001	
d	1.3505625	1.84	1	1.3505625	10.6007535	0.0027	
ab	2.8783225	3.91	1	2.8783225	22.5923549	<0.0001	
ac	0.7049025	0.96	1	0.7049025	5.53287808	0.0250	
ad	0.5880625	0.80	1	0.5880625	4.61578462	0.0393	
Pure error	4.07688	5.54	32	0.1274025			
Corr. total	73.5766775	100.00	39				

probability. In the first model, the contribution of the mixture of the *ac* factors is not appreciable. A statistical analysis of the experimental results is given in Table 6. According to the table, the statistical values of the models are almost the same which shows that they are compatible.

Interpretation of the experimental results

As shown in Tables 4 and 5, the most influential factor on the seam slippage is the weft density of the chenille fabrics. In order to determine the effect of the weft

Table 6. Statistical analysis of the experimental results

	Std dev	Mean	CV	PRESS	R-squared	Adj R-squared	Pred R-squared	Adeq precision
Cotton weft fabrics	0.3327	3.4948	9.5213	5.5359	0.9065	0.8861	0.8540	21.7327
Polyester weft fabrics	0.3569	4.3808	8.1478	6.3701	0.9446	0.9325	0.9134	29.6568

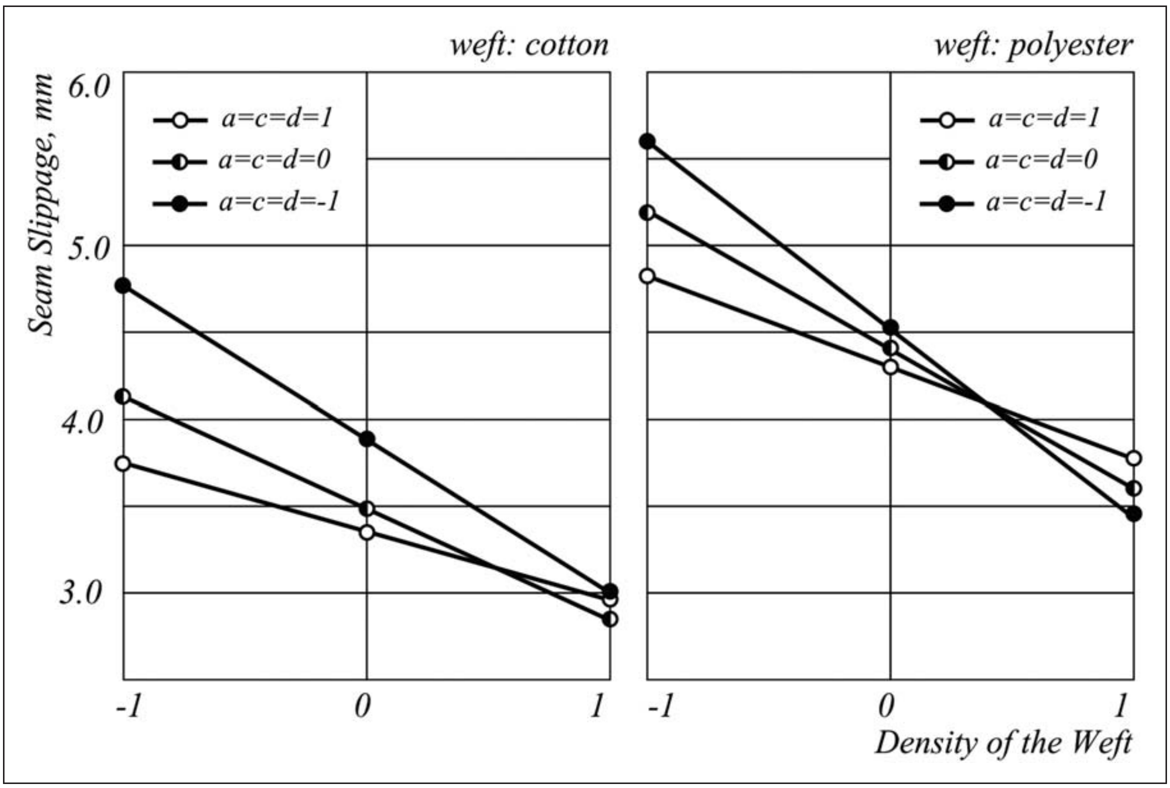


Figure 3. The effect of fabric weft density on the seam slippage. *a*, stitch step in sewing; *c*, sewing direction according to the weft; *d*, number of the interlaced chenille yarns over warp yarns.

density on the seam slippage, quazi single factor models were obtained by making the other factors constant at different levels. The graphs of the quasi single factor models are given in Figure 3. Seam slippage decreases with the increase of the weft density of the fabrics. This reduction is very attractive when the other parameters have low values. The volume filling degree of the fabric increases with the increase in weft density. Therefore, the free movement of the weft yarns decreases which leads to the increase in resistance against seam slippage, i.e, less seam slippage. In addition, the seam slippage of the fabrics with polyester weft yarns is higher than that with the cotton weft yarns. This is a result of the smooth structure of the polyester yarns. These results are in accordance with the other studies.

Stitch length is another important factor which influences the seam slippage, as seen in Tables 4 and 5. Figure 4 shows the relationship between the stitch length and the seam slippage.

Seam slippage increases with the increase in the stitch length at all levels for the other factors. Increased stitch length reduces the tension of the sewing yarn, which causes an increase in the deformation reserve of the sewing yarn when tension is applied on the seam in a straight direction. Consequently, the seam slippage increases. Because polyester yarns have a smoother structure than cotton yarns, seam slippage is higher in polyester weft yarn fabrics than in fabrics which have cotton weft yarns, as seen by the comparison of the groups in Figure 4.

One of the factors affecting the seam slippage is the sewing direction according to the weft yarn. Tables 5 and 6 show the effects of sewing direction on the seam slippage. As seen in Figure 5, the seam slippage

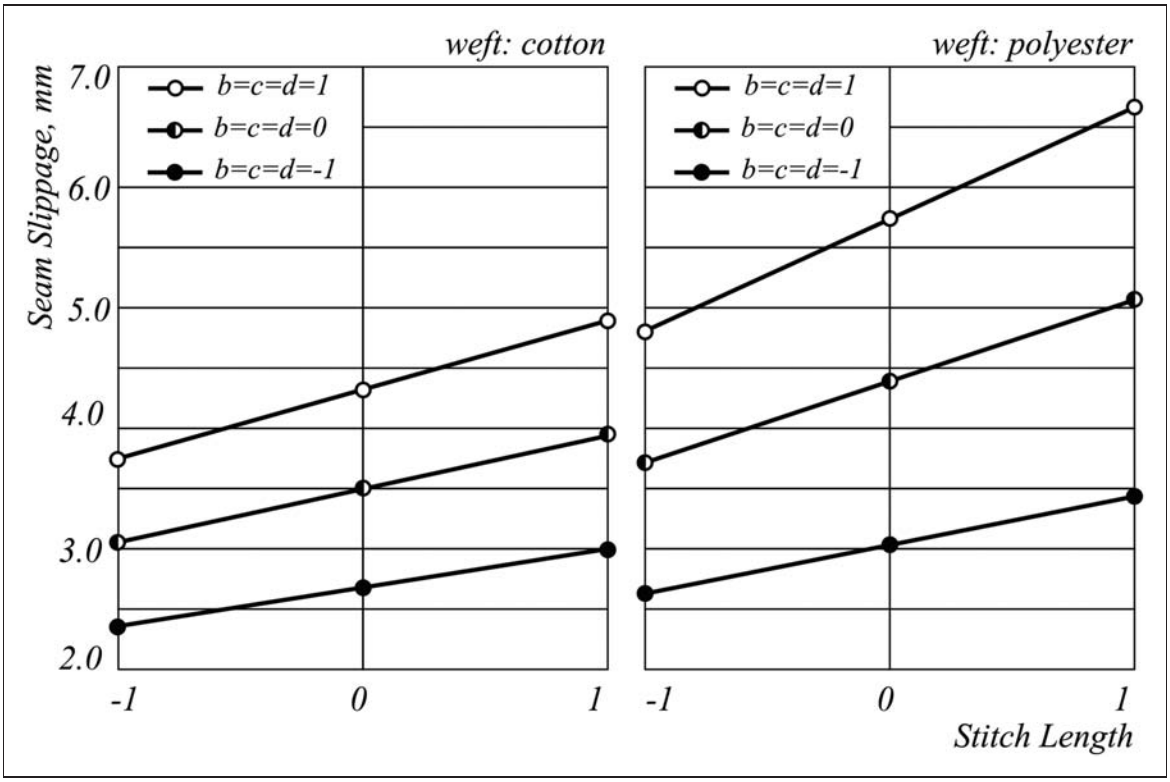


Figure 4. The effect of sewing stitch length on the seam slippage. *b*, weft density of the fabric; *c*, sewing direction according to the weft; *d*, number of interlaced chenille yarns over warp yarns.

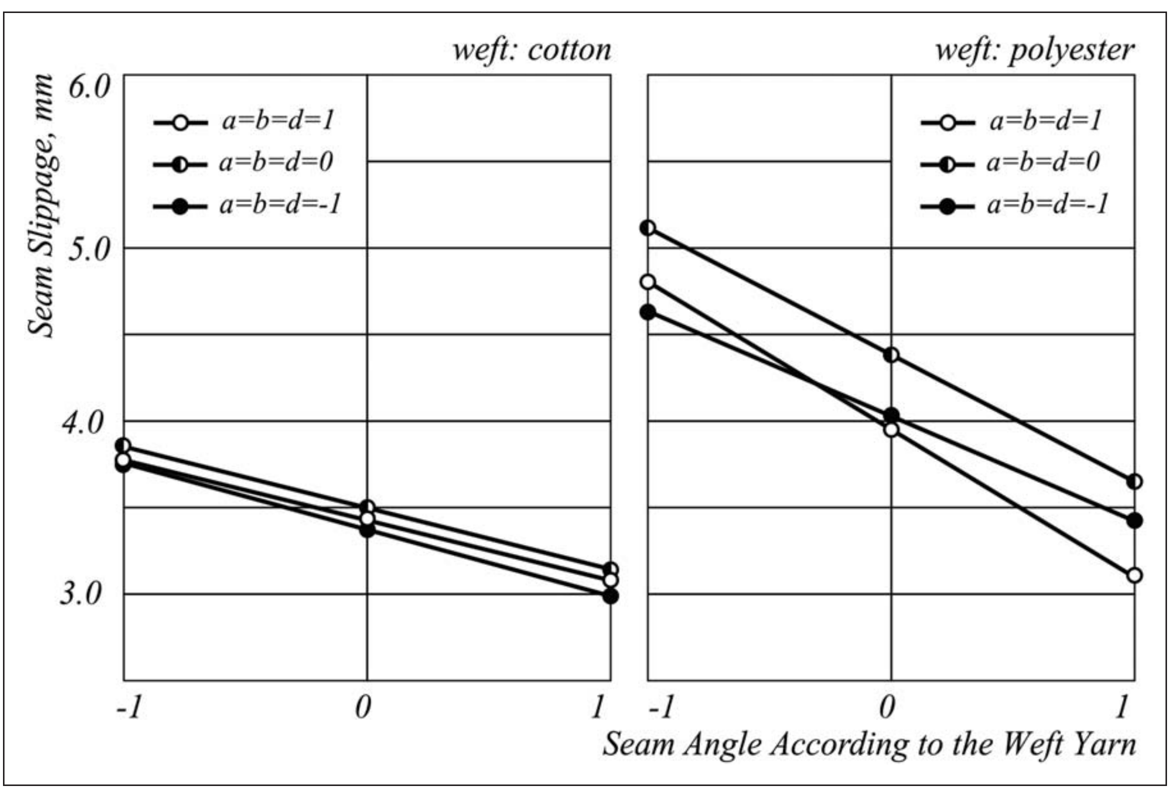


Figure 5. The effect of sewing direction according to the weft on the seam slippage. *a*, stitch step in sewing; *b*, weft density of the fabric, *d*, number of the interlaced chenille yarns over warp yarns.

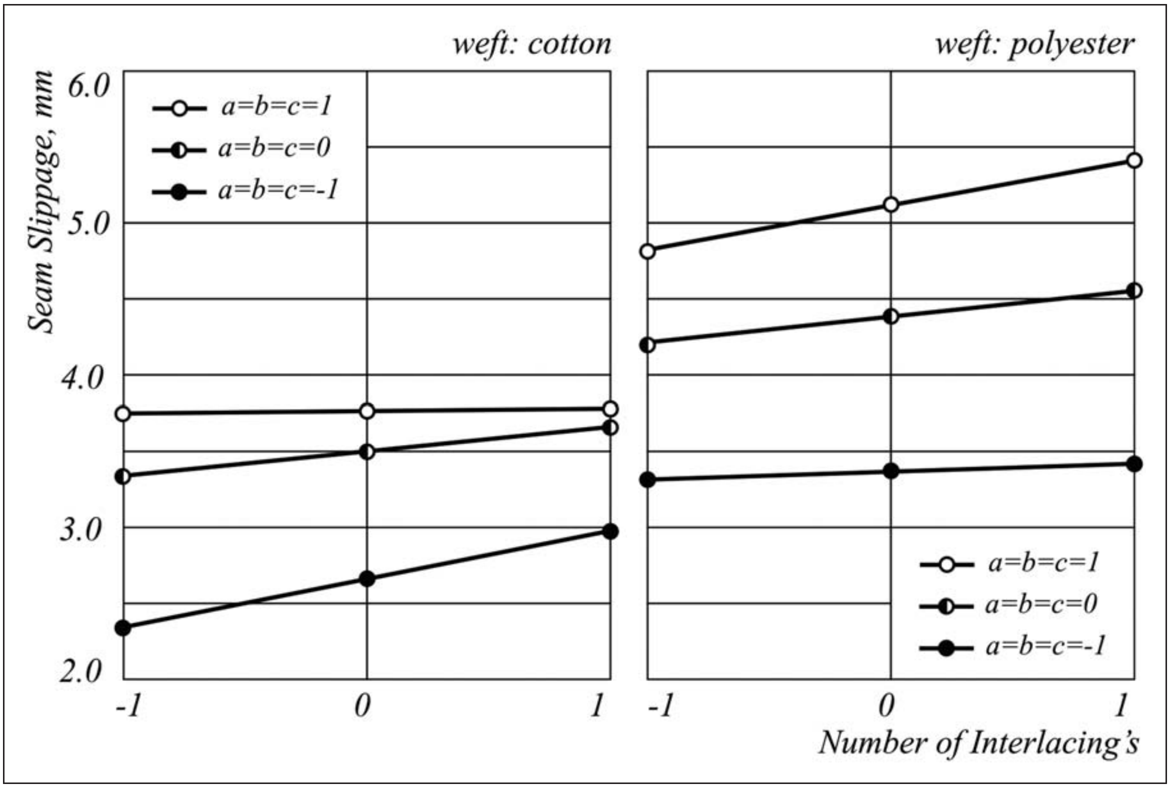


Figure 6. The effect of number of chenille fiber interlaces on seam slippage. *a*, stitch step in sewing; *b*, weft density of fabric; *c*, sewing direction according to weft.

decreases when the angle between the sewing and the weft direction increases. In other words, seam slippage in the weft direction is higher than the warp direction when mechanical forces are applied. When sewing is performed in the direction of weft yarns, seam slippage occurs by slipping the weft yarns and chenille yarns together over the warp yarns. If the sewing is in the same direction as the warp yarns, seam slippage occurs as the warp yarns slip over the weft and chenille yarns.

According to these results, it is obvious that using either polyester or cotton yarns as the weft yarns would have an enormous effect on the seam slippage. Seam slippage will be high due to the low tangential resistance when polyester yarns are used (Figure 5). Warp yarns slip, not only over the weft yarns, but also the chenille yarns when sewing is done in the direction of warp yarns. Therefore, resistance to the slippage increases due to the non-uniform surface structure of the chenille yarns. As a result, the seam slippage reduces.

The effects of the number of interlaced chenille yarns over the warp yarns on the seam slippage were calculated by using the mathematical models given in Tables 4 and 5 and depicted in Figure 6. The quasi single factor models were obtained by taking the other factors of the mathematical models as constants at different levels. As seen in Figure 6, the seam slippage becomes more pronounced with an increase in the number of interlaced chenille yarns over warp yarns. This results from the reduction of the interlacement points of the yarn sets.

Conclusions

It has been emphasized that, the factors causing the seam slippage can be divided into 3 groups. These are: structure of the fabrics and properties of the fabric yarns; structure of the sewing stitch, and the sewing yarn properties, and the applied sewing conditions.

The regression models relating to the seam slippage which took place in chenille fabric products have been obtained. According to the regression models, the contribution and type of effect of the different factors on seam slippage have been revealed.

The weft density of the fabric which is related to the fabric structure was determined to be of great importance in terms of slippage. According to the results, seam slippage decreases with the increase of the weft density of the fabric. The number of interlaced chenille yarns over warp yarns which is related to the fabric structure is also important in terms of seam slippage. An increase in the number of interlaced chenille yarns over warp yarns increases the seam slippage. The sewing stitch step or stitch length, which are related to the sewing conditions, were researched and it was found that increased stitch length led to a pronounced seam slippage.

Sewing direction according to the weft yarns also has a significant effect on the seam slippage. It was determined that the seam slippage was considerably higher in the weft direction than that in the warp direction under the mechanical forces applied when the sewing is done in the weft direction. Also an increase in the angle between the weft yarn and the sewing direction led to a reduction in the seam slippage.

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