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

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Abstract

The seam slippage in woven fabric products is an adverse event in sewn products. The purpose of this study is to examine the seam slippage in chenille fabric products which are widely used as upholstery fabrics and to research ways to decrease seam slippage. In this study, the theoretical analysis of the seam slippage mechanism has been performed by the literature analysis and the results of experimental studies which were obtained in Part I. In this analysis, seam slippage is examined as the sum of two factors: the deformation of sewing stitch and the slippage of the fabric yarns by sewing stitch chains. According to the theoretical analysis of the processes, it can be inferred that it is possible to decrease seam slippage by driving the energy of applied mechanical forces to other tasks. Based on the results, the ways to decrease seam slippage, which occur in sewn products, have been determined. Two of them are related to the selection of sewing yarn and sewing parameters based on previous researches. The dependence of the other two ways on the fabric structure supported with adhesive interlining and the selection of sewing type were examined. The results of the experimental studies supported the results of the theoretical analysis.

Keywords

Chenille fabrics, seam opening, seam slippage

Theoretical analysis

According to the literature analysis and experimental studies mentioned in Part I, the following evaluations can be made on the theoretical mechanism of seam slippage.

The seam slippage which occurs when mechanical forces are applied to the seam in steep direction can be thought of as the result of two processes:

- The occurance of blank space in the woven fabric and the decrease of seam length which occurs by the deformation of seam stitch.
- The slippage of fabric yarns which are parallel to the sewing by sewing stitch chain.

In the first step of applied mechanical forces, the seam slippage occurs due to the deformation of the sewing stitch because the energy of applied mechanical forces is only concentrated on the deformation of the seam stitch. The sewing yarns stretch and a little blank space occurs between stitched fabrics due to the seam stitch deformation (Figure 1). This open space can be defined as $\Delta s = s_1 - s_2$ (here $s_0 \to 0$) and it increases up to a certain level by increasing the applied forces. Above that level, the reserve of seam opening is expended by the stretching of the sewing yarns. A further increase in the seam opening occurs due to the elongation of the sewing yarns. If mechanical forces continue to increase elongation, it results in yarn breakage which means that the seam unravels. The seam stitch deformation causes slippage of yarns which remain in stitch of the fabric. This slippage occurs

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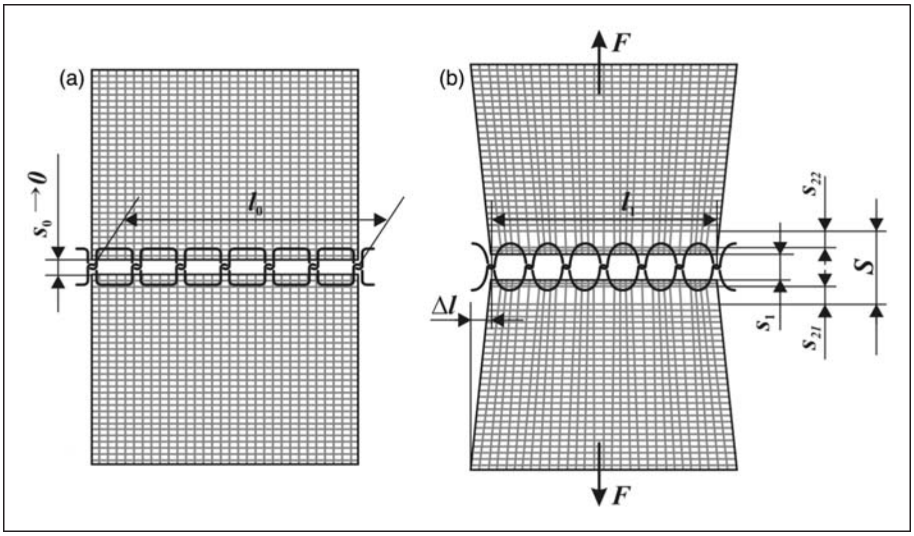

Figure 1. Schematic of the seam slippage. *a*, before tensile application; *b*, after tensile application.

due to the reduction of stitch width and therefore the seam size becomes smaller.

The seam stitch deformation is closely related to the seam density. Increasing the seam density (or decreasing stitch step) causes a decrease in the yarn flexibility. Therefore, seam slippage is reduced by stitch deformation. On the other hand, the decrease of the stitch step means that the seam yarns are closer to each other with the same length of sewn stitches and they also pass more closed through the fabric. Therefore seam yarn deformation and seam slippage will be more difficult because one part of the applied mechanical force is spent for deformation of the yarns while the other part is spent for rejection of the forces opposing this deformation. The more these forces give, the less seam slippage there is. Finally, we should consider at the expense of the decreased stitch step, the increased probability that the needle and seam yarns will pass through fabric yarns. This prevents both stitch and seam yarn deformation to some extent and decreases seam slippage.

However, seam slippage does not occur only because of the seam stitch deformation. A substantial amount of the energy of mechanical forces applied is spent on the slippage of fabric yarns which are parallel to the sewing line. Therefore the majority of the seam slippage occurs as a result of this case. According to Figure 1, seam slippage which occurs due to the slippage of fabric yarns parallel to the seam can be defined as $s_2 = s_{21} + s_{22}$ and full seam slippage is $S = \Delta s + s_2 \approx s_1 + s_2$.

There are many factors that affect the slippage of one yarn system relative to the other yarn system due to applied mechanical forces in the horizontal direction. The most important factors are friction of fabric yarn systems, which is caused by the characteristics of fabric yarns, fabric weave type, fabric weft and warp density and the deformation characteristics of the fabric yarns. The studies have shown that the friction between yarns and the density of fabrics are the most important factors.

It is obvious that increased friction between the fabric yarns should require a substantial amount of mechanical energy. Free movement of fabric yarn decreases due to the increase of fabric density. Wedging of part of the the yarn system after the seam, which is parallel to the sewing line by the seam chain, is getting more difficult. Therefore seam slippage gradually decreases. Development of seam slippage can occur due to the stretched yarns, and is perpendicular to a seam line as a result of applied mechanical forces.

With the subsequent increase of the mechanical forces, tension in the seam yarns will be higher than that of the fabric yarns which are perpendicular to the sewing line. Therefore, sewing yarn breakage occurs and fabric yarns unravel without deformation.

When the mechanical forces become fixed before the fabric yarn breaks, equilibrium occurs in the seam system and seam slippage also becomes constant at a certain level. This level is related to spending of the energy force during seam slippage.

If distribution of the energy of the mechanical forces (E) is set constant at a certain level with development, and is not caused by the dispersion of the seam, one can realize that this energy would be spent during the deformation of the fabric stitch (E_{i1}) and the slippage of fabric yarn (E_k).

$$E = E_i + E_k \quad (1)$$

Here E_i and E_k are the sum of energies which are spent for some processes in sequence. E_i energy is spent for deformation of the seam stitch (E_{i1}), stretching of the seam yarn (E_{i2}) and rejection of forces which are directed against realization of these cases (E_{i3}). E_k is spent on slippage of the yarn system of the fabric, perpendicular to a seam which remains in a sewing stitch by reduction of width of a stitch (E_{k1}), deformation of the fabric in perpendicular direction of yarns (E_{k2}) and the rejection of forces to these cases (E_{k3}).

$$E = E_{i1}+E_{i2}+E_{i3}, E = E_{k1}+E_{k2}+E_{k3} \quad (2)$$

Mechanical forces, which have the same value, lead to different seam slippage depending on the type and parameters of stitch and seam, seam and fabric yarn, and fabric parameters. It shows that increasing the energy consumption of mechanical forces, which is perpendicular to a sewing line, will lead to the reduction seam slippage. In other words, it is possible to reduce seam slippage by taking appropriate precautions which will promote more distribution of mechanical forces.

Precautions for decreasing the seam slippage can be divided into four main groups:

- precautions related to the selection of the seam parameters
- precautions related to the selection of the seam yarns
- precautions related to the strengthening of the fabric structure
- precautions related to the selection of the seam type.

Many researches have been carried out that are connected with seam slippage.[1–16] In these researches recommendations have been made about the reduction of seam slippage by the type of management of the affecting factors. It has been shown that depending on the mechanical properties and structure of the fabric it is possible to reduce the seam slippage with the right selection of the seam yarn, seam and needle parameters. The obtained results given in Part I are in accordance with the results determined by other researchers. In practice, however, it is a problem that the opportunity for selection is not possible or is very limited. Therefore, a different approach should be followed, in order to reduce the seam slippage. For example, by strengthening the fabric structure or changing the seam structure (seam type), it is possible to change the distribution of the energy which occurs during seam deformation and by doing so it is possible to decrease seam slippage. To verify the theoretical results, experimental researches were carried out.

Materials and methods

To reduce seam slippage, it is necessary to direct the energy of the mechanical forces causing it, and reject obstacles created which increase seam slippage development. In other words changing the mechanism of the distribution of energy of the process of seam slippage, it is possible to alter the slippage. The decrease of the seam stitch step or the increase of the fabric density is a possible example. However, these parameters are sometimes non-managable parameters. In order to decrease the seam slippage, extra precautions should be considered. These precautions can be related to the fabric structure or seam type.

In this study the possibility of decreasing seam slippage by strengthening the fabric structure and the selection of seam type were investigated.

Fabric density affects the seam slippage, to a large extent. Nevertheless, this parameter is not managable. Consideration of this fact was carried out by the application of a glutinous edge on opposite sides of sewing parts of fabrics. To this end, woven, knitted and non-woven types of adhesive interlinings, produced by Telatex Co. have been used (Table 1). The bands (8 cm) have been cut from these interlinings and glued onto the samples which were prepared according to the ISO 13936-2[17] (Figure 2a, b, and c).

The characteristics of fabrics used are given in Table 2. The adhesive process was performed on an STP 400 MT machine at 135°C temperature, 0.4 Mpa pressure for 15 seconds. For sample preparation, Polyester Corespun sewing yarns of Epic mark with linear density 80 tex (COATS), were used. On samples, connecting seams with Ssa code were formed using 3 mm stitch steps in 301 class. Five samples were prepared for each test. Seam slippage tests were carried out on an INSTRON 4411 universal tensile testing machine.

For the purpose of studying the change in seam slippage depending on the seam, three different seam types were investigated, including the Ssa code seam (according to ISO 4916, the code is 1.01[18]). In Figure 2a, a connecting Ssa seam is shown; in Figure 3a, connecting Lsq seam (according to ISO 4916, 2.02.03), and in Figure 3b, LSc-2 (according to ISO 4916, 2.04.05) code schemes are given. Sewing patterns have been prepared with these schemes. Samples were prepared with 3 mm length stitches and a 301 class shuttle sewing stitch which are given in Table 2. Sewing yarn is Polyester Corespun (COATS, mark Epic, 80 tex linear density). Five samples were prepared for each test. Seam slippage tests were carried out in an INSTRON 4411 universal tensile testing machine.

Table 1. Characteristics of the interlinings used in tests

Basic fabric	Code	Composition	Weight in grams (g/m^2)	Covering	Mesh/CP
Warp knitting fabric	8830 DR	100% PES	62	PA	40 CP, Double dot
Woven fabric	8475 DR	100% PES	42	PA	76 CP, Double dot
Non-woven surface	1254 DN	50% PA, 50% PES	32	Special dust	52 CP, Double dot

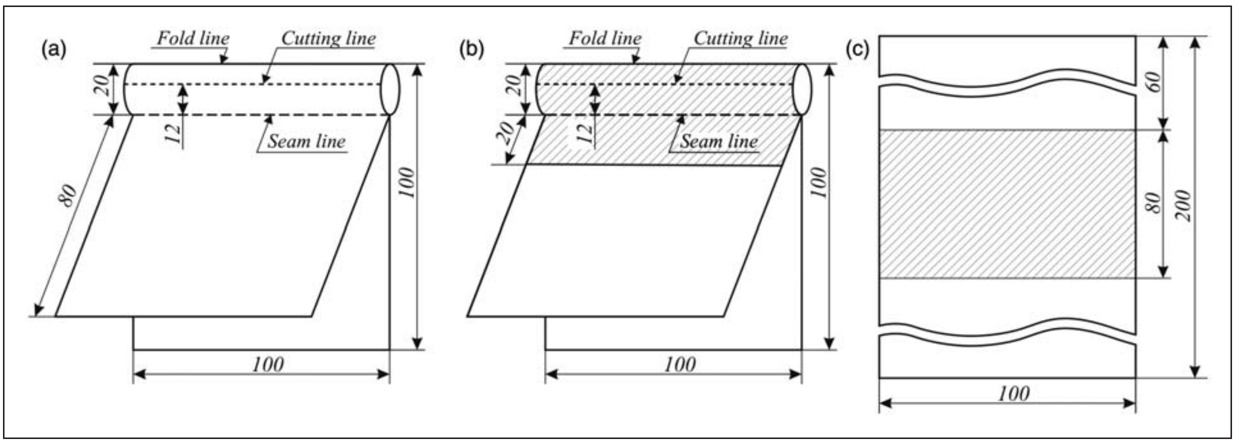

Figure 2. Preparation of the samples. *a*, Schematic of the sample preparation according to ISO 13936-2; *b*, Schematic of the sample of sewing part with adhesive interlining; *c*, Schematic of the adhesive interlining onto the sample (Dimensions are given in mm).

Table 2. Fabric properties used in tests

Fabric name	Weft density, threads/cm	Warp density, threads/cm	Interlace	Weft fiber
Chenille fabric	17	66,6	12	Cotton
Chenille fabric	17	66,6	12	Polyester

Results and discussion

Knitted and woven based interlinings were stuck onto the seam part of the fabric samples and these samples were then tested in the tensile testing machine. Under the same conditions, samples without interlining were prepared and tested for seam slippage. The results were compared. The diagram of the results is given in Figure 4. According to the diagram, the bonding of interlining onto the sewing area helps reduce the seam slippage and the seam slippage was determined to change depending on the interlining type used. The reduction results from the difficulty of fabric yarns to slip parallel to the seam, due to interlining. Slipping yarns parallel to a seam of fabric under the effect of mechanical forces perpendicular to a seam can occur either as a result of delamination of the interlining or its deformation. These processes need extra energy, however, the energy of the mechanical forces is already spent and thus seam slippage reduces.

After testing, there were some cases of interlining delamination from the fabric. This means that sticking of interlining to the sewing part of fabrics complicates the yarn slippage of a fabric parallel to a seam. Some part of the mechanical energy is spent on delamination of the interlining from the fabric and this is positive effect in terms of seam slippage reduction.

Different seam slippages were obtained depending on the interlining types, but in all cases it has been seen that seam slippage decreased. The results given by different interlining types occurred due to interlining structures and other characteristics. Better results probably would have been achieved by selecting the

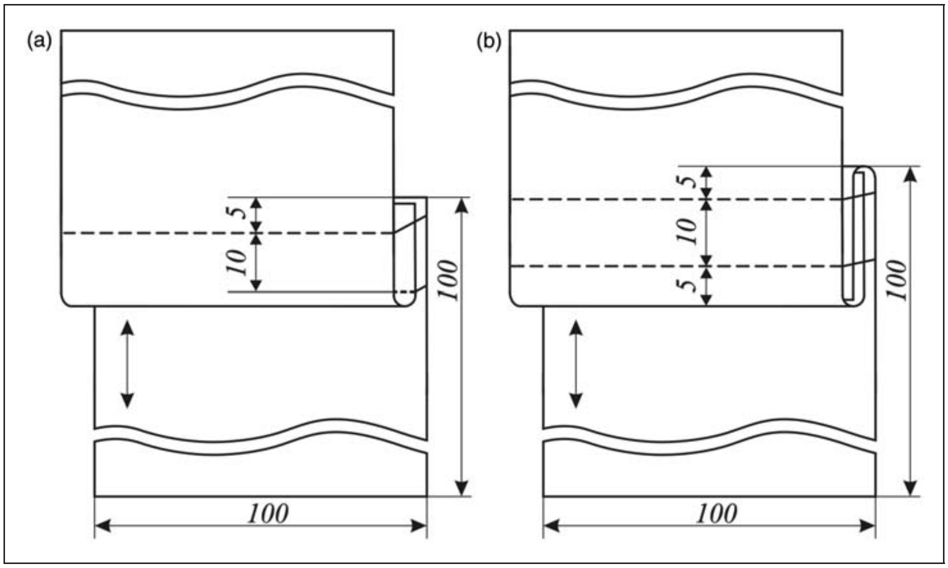

Figure 3. Sewing types used in experiments. *a*, Lsq code unified seam with folding; *b*, LSc-2 code unified seam lock (Dimensions are given in mm).

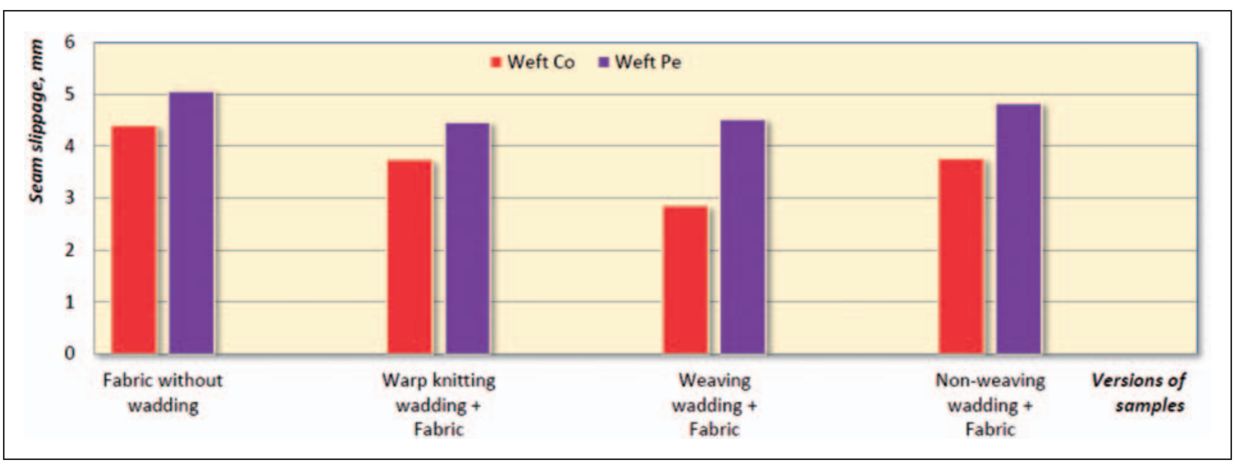

Figure 4. Test results on samples of sewing portion with adhesive interlining.

interlining base and basic fabric parameters, parameters relating to the glue application onto the interlining, and the correct direction of interlining warp.

In order to observe the effects of seam types on seam slippage, samples with different seam types were prepared and tested in the tensile machine. The results are given in Figure 5. It was observed that the choice of seam type is important for seam slippage.

As seen in Figure 5, the Ssa type connecting seam results in more pronounced seam slippage. This type of seam is economic in terms of fabric, time and labor costs. However, it is not effective in terms of seam slippage, because energy of mechanical forces during seam slippage is available to be used mostly in the slippage process.

The Lsq type seam, as a connecting seam with top stitching, is very useful for preventing the seam slippage. This seam type is different from the Ssa type seam because it has two seam lines and three fabric layers. One of the seam lines joins two fabric layers and the other line joins three fabric layers. Mechanical energy is dissipated between the fabric layers and this energy is used to overcome the friction force which occurs between the fabric layers. Therefore, seam slippage in the Lsq type seam is less than in the Ssa type seam by approximately 25–30%.

The LSc-2 code connecting seam locks have two seam lines and each seam line joins three fabric layers. Increasing the friction force between fabric layers causes a large dissipation of mechanical energy.

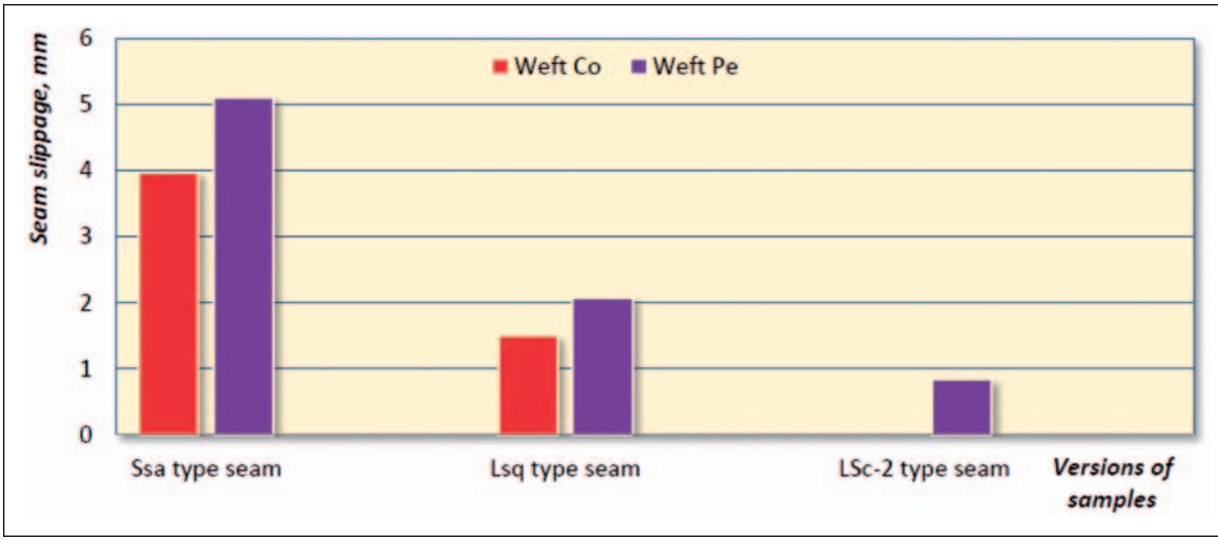

Figure 5. Test results of samples with different seam types.

Therefore seam slippage is minimal. Measurable seam slippage has not been examined in upholstery chenille fabrics with cotton weft which were sewn with LSc-2 code seams. However, in polyester weft fabrics, the amount of seam slippage was determined to be small.

In different seam types, seam slippage has different values. However, seam slippage decreases when the number of sewing lines and sewn layers of a fabric increase.

Conclusions

As a result of literature analysis and experimental studies which were shown in Part I, an explanation of the theoretically seam slippage occurring due to mechanical forces, which are applied to sewing yarn in a perpendicular direction, has been attempted.

It has been determined that seam slippage under the effect of mechanical forces which is perpendicular to a seam is a result of two processes: deformation of stitches and yarn slippage of a fabric parallel to a seam. The theoretical analysis of these processes was carried out and the distribution of energy has been expressed generally. As a result of theoretical analyses of the processes mentioned, it has been shown that by managing the energy of mechanical forces applied to a seam, it has been suggested that it is possible to reduce seam slippage.

Different conditions of the sewing, different parameters of stitches, seams and fabrics under the effect of the identical mechanical forces applied to a seam, result in different seam slippage. It confirms that the increase in energy consumptions of the mechanical forces applied to a seam should result in a reduction of the seam slippage. In other words, it is possible to take precautions that cause an energy consumption of mechanical forces and by this process the seam slippage can be reduced. These precautions were classified. To verify the theoretical results that were obtained, experimental researches were carried out.

Decreasing of seam slippage by selection of the correct sewing parameters and sewing yarn has been put forward in previous studies. Therefore in this study, consolidating of fabric structure and selection of seam type were investigated. To consolidate fabric structure, the samples with interlining stuck to the fabric were prepared and tested for seam slippage. As a result it can be inferred that seam slippage decreases by the consolidation of fabric structure. The reason for this decrease is that the wadding which sticks on fabric prevents slipping of parallel yarns. Experiments show that, it is possible to get good results from the correct selection of interlining base, basic fabric parameters, and parameters of material stuck over interlining and warp side of interlining.

To investigate the possibility of the decrease of seam slippage with alterations to the seam structure, samples were prepared with different sewing types and tested for seam slippage. The highest seam slippage occurred in the Ssa type seam and the lowest result belonged to LSc-2 seam type. Tests proved that the results were reasonable. When the sewing structure became complex, the energy of mechanical forces was used in different tasks and only a small amount of energy remained for seam slippage. Therefore the seam slippage decreased.

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