The influence of mechanical properties of sewing threads on seam pucker

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Abstract

Purpose – The paper aims to evaluate the influence of mechanical properties of sewing threads on the seam pucker.

Design/methodology/approach – The mechanical properties of sewing thread were obtained performing tensile testing research. The seam pucker of lightweight fabric was evaluated after sewing, then after 24 h, after 48 h as well as after washing and drying. To determine dimension changes of fabric, the relaxation shrinkage was calculated. The results of thread properties and seam pucker were compared.

Findings – In respect of seam pucker the best results were established sewing with polyester threads, the reversible strain of which were the least. After washing and drying, the highest pucker was typical of the specimens sewn with cotton sewing threads. It was noticed that increasing the amount of layers in sewing the influence of threads on seam pucker decreases. Washing and drying made considerably greater influence on the occurrence of pucker then time.

Practical implications – This study has practical implications in the clothing and other nearly related industries. In the paper recommendations involved with application of sewing thread and evaluation of seam pucker are presented.

Originality/value – In most cases the changes of sewn thread mechanical properties after sewing is analysed. This study is aimed to determine the influence of thread properties on seam pucker. Recommendations in the area of sewing thread and garment quality are based on the research.

Keywords Clothing, Thread, Textiles, Textile testing

Paper type Research paper

Introduction

Quality of sewing garments is determined by many factors including puckering in the place of a seam. This defect is relevant to garments sewn of light textile materials, especially of lightweight fabrics. Seam pucker is influenced by different factors, as properties of sewing threads and fabrics, processes of needle penetration, stitch formation, sewing thread tension and fabric feeding, seam construction and various technological parameters, and other. Particular great attention is paid to fabric properties and factors of a sewing machine as well as to their compatibility in the process of sewing (Stylios and Lloyd, 1990; Stylios and Pan, 1991; Kawabata et al., 1991; Kawabata and Niwa, 1998; Mori et al., 1997; Park and Kang, 1997). The shrinkage of threads after sewing may have not inconsiderable influence on occurrence of this defect. However, studying properties of threads, the changes of mechanical properties after sewing is analysed in most cases (Mori and Niwa, 1994; Sundaresan et al., 1997, 1998; Ziliene and Baltrušaitis, 2000; Rudolf and Geršak, 2001; Ajiki and Postle, 2003).
The limited amount of researches analysing the influence of sewing thread properties on seam pucker have been reported (Schwartz, 1984; Behera and Chand, 1997; Fan and Leeuwner, 1998; Park and Kang, 1999).

Seam pucker often is evaluated immediately after the sewing process or shortly after it. Thus, there is no possibility to evaluate relaxation processes of sewing garment fabrics manifesting themselves only after longer time passes from the sewing process. Particularly, it is relevant to sewing threads as in the process of sewing they undergo different loads, are stretched, flexed and otherwise deformed. Reversible deformations of threads may assert themselves only after some time, and this fact would also have influence on quality of a sewing garment as due to this deformation threads may crease seams, especially in the sewing garments of light fabrics. One of the factors relevant to seam puckering is the impact of humidity that is often left unconsidered. After sewing, seam quality may be acceptable, but under the impact of humidity seams may crease significantly as macromolecules of fibres in sewing garment fabrics become more mobile and return to their normal status.

Thus, in order to asses the reasons of seam puckering in a complex manner it is necessary to consider the compatibility of sewing garment fabrics both in the process of sewing and when some time passes after sewing as well as in the course of operation.

The aim of this paper is to evaluate the influence of mechanical properties of sewing threads on the seam pucker.

**Materials and methods**
Commercial polyester and cotton sewing threads having different structural, physical and mechanical properties were selected for the present study. The details of these threads are given in Table I. Defect of seam pucker is especially topical for lightweight fabrics of sewing garments. Therefore, in the research fabrics designed for light garments were used, marked as A1 (100 per cent cotton), A2 (PES/cotton), A3 (100 per cent CV).

Mechanical hysteresis of sewing threads was obtained using universal testing machine “ZWICK/Z005”. In the course of the analysis, load of 2 N was suddenly applied to tests specimens and eliminated immediately, returning the lower clamp to the initial position. Distance between clamps was 500 mm, their movement speed was 300 mm/min, with 1 load cycle performed.

From the obtained curves of mechanical hysteresis, parameters of sewing threads, i.e. total strain $\varepsilon_t$, per cent, elastic strain $\varepsilon_e$, per cent and remaining strain $\varepsilon_r$, per cent were determined. Remaining strain $\varepsilon_r$ was determined by measuring on the axis of abscissas the distance from the origin point of coordinates to the end point of a return part of a hysteresis loop, whereas $\varepsilon_e$ was determined by measuring on the same axis the distance from the end point of a return part of a hysteresis loop to the node of the axis of abscissas and a perpendicular drawn from the top of a hysteresis loop (Figure 1).

<table>
<thead>
<tr>
<th>Thread code</th>
<th>Composition</th>
<th>Linear density, tex</th>
<th>Elongation at break, per cent</th>
<th>Breaking tenacity, cN/tex</th>
</tr>
</thead>
<tbody>
<tr>
<td>A402</td>
<td>100 per cent PES</td>
<td>$14.8 \times 2$</td>
<td>18.9</td>
<td>36.3</td>
</tr>
<tr>
<td>C452</td>
<td>100 per cent PES</td>
<td>$13.1 \times 2$</td>
<td>19.3</td>
<td>502</td>
</tr>
<tr>
<td>M402</td>
<td>100 per cent cotton</td>
<td>$14.8 \times 2$</td>
<td>6.0</td>
<td>42.9</td>
</tr>
</tbody>
</table>
Single-cycle tensile testing of sewing threads were also performed using "ZWICK/Z005" testing machine. When determining single-cycle tensile characteristics of sewing threads, length of a working part was 500 mm and speed was 300 mm/min. To test specimens, permanent load of 2 N was applied, whereas load and relax time was 5 minutes. From the obtained curves, total strain $E_t$, per cent, reversible strain $E_{rv}$, per cent and remaining strain $E_r$, per cent were calculated.

Seam pucker was evaluated by measuring length of test specimens sewn with the sewing threads chosen for research and calculating pucker coefficient $W$ (per cent) (Kwong et al., 1997):

$$W = \frac{L_s - L_0}{L_0} \times 100,$$

where $L_0$ is initial length of specimen, $L_s$ is length of specimen, stretched until puckers disappears.

Length of specimens was measured immediately after sewing, then after 24 h, after 48 h as well as after washing and drying. To prepare the specimens for this investigation, the fabrics’ strips of 200 $\times$ 30 mm dimensions were cut in the warp direction. Two such strips were sewn together across the centre line in longitudinal direction. The seam type was 1.01.01. Another part of test specimens was prepared grouping strips by three. “Juki” DLU 490 one-needle lockstitch sewing machine and “Schmetz” needle No. 90 were used, with stitch length of 2.5 mm. For each group of different sewing thread, optimum tension was selected, respectively. Other sewing conditions were chosen insomuch as to avoid the rest part of reasons determining pucker.

After washing and drying, the specimens may shrink due to the shrinkage of sewing threads as well as the fabric. To determine dimension changes of fabrics,
the investigation according FAST-4 testing technique was carried out. From A1, A2, A3 fabrics' the specimens of 250 × 250 mm dimensions were prepared. In these specimens initial sections with length $L = 200$ mm were marked in the direction of warp and weft. In order to determine changes of dimensions, the specimen was dried up to humidity of 0 per cent ($T = 105^\circ$C) and lengths ($L_1$) of its sections were measured. Then the specimen was soaked into water, left until saturation and removed. After that, its lengths ($L_2$) were measured at humidity level of 100 per cent. After measurements, the specimen was dried again and its lengths ($L_3$) were established at repeated humidity level of 0 per cent. Relaxation shrinkage $RS$ was calculated such way:

$$RS = 100 \frac{L_1 - L_3}{L_1} \text{ (\%)}.$$  \hspace{1cm} (2)

**Results and discussion**

Inherent and tension seam pucker is those who associated with the sewing thread. Inherent pucker is a result of fabric yarns displacement, when a needle penetrates the fabric and the upper and the lower threads loop insert within fabric. The fabric yarns are bent, stressed, and attempting to return to their original positions, but are prevented by the sewing threads. The fabric structural jamming is the most influenced by the sewing thread diameter alongside with other factors such as fabric properties, seam type, stitch density. The sewing threads chosen for this investigation are fine, furthermore, the used fabrics according to their structure are not sensitive for such kind of defect. On the basis on the above it can be concluded that sewing thread diameter not impact the seam quality.

Tension pucker occurs when the over-stretched sewing thread shrinks to its original length and herewith gather up the fabric along the line of the seam. This defect due to sewing thread tension, uneven thread repartition and incorrect stitch length. In the study these factors were evaluated seeking to form well-balanced stitch, so it can be supposed the seam pucker was caused by sewing thread properties.

Research results of mechanical hysteresis of the sewing threads are shown in Figure 2. It was noticed that hysteresis curves of the polyester sewing threads A402 and C452 chosen for research are similar by their nature. Nature of the hysteresis curve of cotton sewing threads M402 is a little bit different, but essential differences unobserved when comparing curves start-up zone of all investigated thread. Character of the beginning of a hysteresis curve depends very much on the thread structure, surface and crimp, which may be natural (wool threads) or artificial (textured threads). In this instance, when investigating threads that are folded and made up of two branches, beginning of the curve is similar in all cases. Further parts of hysteresis curves for polyester and cotton threads are different: a hysteresis curve of cotton threads is more upright and this means that extensibility and total strain of cotton threads is lower compared to the respective performances of polyester sewing threads.

From the obtained curves of mechanical hysteresis (Figure 3) it was established that the lowest elastic strain is typical of cotton sewing threads M402, whereas elastic strain of polyester threads A402 and C452 are close. The highest remaining strain is characteristic to sewing threads C452, whereas this characteristic of other threads are close. The extent of remaining strain depends very much on intermolecular interaction of fibres. The stronger intermolecular interaction in fibres is the lower remaining deformation is observed.
After determining single-cycle tensile characteristics of the investigated sewing threads, it was obtained that the highest total strain is typical of polyester sewing threads C452 ($e_t = 50.01$ per cent) and polyester sewing threads A402 ($e_t = 46.3$ per cent) (Figure 4). It was obtained that reversible and remaining strain of threads A402 and C452 are

**Figure 2.**
The curves of mechanical hysteresis of investigated sewing threads

**Figure 3.**
The results of elastic $e_e$ and remaining strain $e_r$ of sewing threads
similar. Cotton sewing threads M402 feature the lowest total strain and rather high remaining strain, which in this case exceeds reversible strain almost by one third.

Hence, according to the presented results it can be seen that sewing threads A402 and C452 attributed similar deformation properties both against a hysteresis curve and single-cycle tensile characteristics. In both cases, C452 feature the highest total strain and the highest reversible strain. Cotton sewing threads M402 feature the lowest extensibility and reversible strain values of these threads are moderate.

The results of pucker coefficients $W$ (per cent) of the different fabric specimens prepared by sewing two strips are shown in Figure 5. It was obtained, when the sewing conditions are the same the influence of sewing threads with different composition and mechanical properties on seam pucker is uneven after passing the time as well as washing and drying. Analysing the obtained results it was determined that when sewing by the threads chosen, seam pucker coefficient $W$ is minor, does not exceed 2 per cent in most cases, and only specimens sewn of fabric A3 feature higher pucker ($W$ amounted 4 per cent). It was obtained that after 24 and 48 h from the sewing, the value of seam pucker changes negligibly compared to the results of the measurements carried out immediately after sewing. The processes of washing and drying of specimens was impacted the change of seam pucker considerably greater compared to the influence made by the time factor. Analysis of the results has been shown that greater pucker is typical to the specimen sewn with corespun threads C452. As research of mechanical hysteresis of threads showed, these threads attributed the highest reversible strain among the investigated threads. In the process of sewing threads are stretched, flexed and otherwise deformed, and after sewing due to the relaxation processes in progress threads shrink and a seam creases.

It is known, as in the process of manufacture sewing garment fabrics receive mechanical impacts, they become deformed. After manufacture processes, slowly vanishing elastic deformations are observed in fabrics and some stresses remains. Elastic deformation occurs, which due to the new intermolecular interaction may not vanish even over a long time. Under certain conditions (normal wear conditions), material is balanced. After affecting with humidity and warmth, kinetic energy of thermal movement in macromolecular segments increases. Materials having

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Figure 4. The results of single-cycle tensile characteristics of investigated sewing threads

![Graph showing single-cycle tensile characteristics of A402, C452, and M402 sewing threads.](image-url)
experienced the impact of humidity and warmth during manufacture processes and in the course of wear return to their previous status. Hence, the greater is the deformation of fibres, threads or the material itself, the greater is the shrinkage observed later. Besides, under the impact of humidity and after penetration of water molecules into fibre macromolecules, interaction between macromolecules becomes weaker. Therefore, macromolecules in fibres become more mobile and return to their normal status. It is known that under the impact of warmth, macromolecules and their links assume kinetic energy and become more mobile (mobility of macromolecules increases). Thus, humidity together with warmth stimulates the process of shrinkage. This fact might explain why in all cases the greatest influence on seam creasing is made by the process of washing and drying.

The results of seam pucker coefficients $W$ (per cent) of the specimens prepared by sewing three fabric layers are shown in Figure 6. It was noticed that sewing three strips, the seam pucker defect assert itself weaker than sewing two strips: some 1 per cent in specimens of fabrics A1 and A2, and some 2 per cent in specimens of fabric A3. Decrease of the pucker coefficient could be influenced by the increase of thickness and rigidity of a
sitting: it is known that thicker and more rigid fabrics crease less. In most cases the
tendency that threads with highest reversible strain determine greater pucker remain.
However, depending on fabric properties the results of investigations can be close. This
confirms the influence of fabric properties on seam pucker. Increase of pucker after
washing and drying had greater influence in the specimens prepared sewing together
three strips of fabric compared to the specimens with two ones. Seam pucker tendencies,
however, remain similar as sewing together two layers; a little bit higher pucker coefficient
is typical of sewing threads M402, but this value may be considered nonessential.

Notwithstanding the value of seam pucker coefficient is moderate, but practically
observed puckering is enough to determine downgrade a look of a final product sewing
from lightweight fabric (Figure 7). Analysis of seam pucker results in all the investigated
cases demonstrates that the lowest seam pucker coefficient is characteristic to the
specimens sewn with universal sewing threads A402. It can be explain that elastic strain
of these threads is negligible, whereas remaining strain is the lowest among all the
threads investigated. Reversible elongation of cotton sewing threads is also negligible,
however, according to the provided results it can be seen that particularly after washing
and drying seam pucker is high, in some cases the highest among all the investigated

Figure 6.
The results of seam
pucker coefficient $W$ (per cent) of specimens
prepared by sewing three
straps

Key
- immediately after sewing, ■—after 24 h, □—after 48 h, □ — after washing and drying
threads. Fibres of cotton threads absorb humidity and swell, therefore, their diameter increases. At the same time, thread diameter increases as well. Length of fibres, however, remains the same. As cotton sewing thread has twist, due to increase of cross-section outer windings are tensioned. However, they do not become longer, therefore thread becomes shorter. The higher is the twist, the greater is the shrinkage of thread. This fact may be used to explain why threads featuring low reversible deformation puckering seams rather strongly after washing and drying.

In order to know whether considerable shortening of specimens after washing and drying is observed due to the shrinkage of sewing threads and not of fabrics, testing for determining the shrinkage of the latter was carried out. Results of relaxation shrinkage of warp and weft are shown in Figure 8.

It was established that lengths of the investigated fabrics change neither in the direction of warp nor in the direction of weft while reducing humidity level to 0 per cent, whereas after soaking fabric into water and measuring its lengths \( L_2 \) at humidity level of 100 per cent, fabric lengths in the direction of warp become slightly longer, and fabric lengths in the direction of weft remain the same. When fabric is dried to humidity level of 0 per cent again, shrinkage increases and is the highest one.

Changes of specimen dimension take place due to relaxation, when fabric threads are deformed by tensioning or compression. Relaxation takes place due to the impacts of humidity, pressing or water. Problems may arise, when shrinkage exceeds 3 per cent. Relaxation shrinkage of the investigated fabrics both in the direction of warp \( RS = 0.35 \) – 1 per cent) and in the direction of weft \( RS = 0.20 \) – 0.50 per cent) is
negligible, therefore, it may be stated that after washing and drying sewing specimens become shorter not due to the shrinkage of fabric, but due to the shrinkage of sewing threads.

Thus, as results of the performed investigations demonstrated evaluation of seam pucker is greatly influenced by mechanical properties of threads. The latter determine the behaviour of a sewing garment in the places of thready joins both in the process of sewing and when some time passes after sewing as well as during exploitation.

Conclusions

• The results of the investigation showed that sewing threads used for this research due to theirs structural and mechanical properties caused seam pucker, which pucker coefficient was some 2 per cent in most cases. Principle the value of this coefficient is not high, but for all practical purposes observed puckering determine downgrade a look of a final product sewing from lightweight fabric.

• During the research inherent seam pucker was not stated, so the sewing thread diameter has not impact on structural jamming of fabric and a seam quality degradation from the point of view of seam puckering was conditioned by thread's properties to return to their original position after deformation.

• It was obtained, the best properties are characteristic of universal sewing threads, having the lowest reversible strain. After sewing specimens by these threads, the seam pucker defect is the least noticeable. These threads are recommended for sewing light fabrics.

• It was established, that when some time passes after sewing the greatest crease to seams is made by corespun polyester sewing threads, the reversible strain whereof is the highest. In all investigated cases the highest seam pucker was observed after washing and drying, the time factor made considerably less influence on the occurrence of creases. After washing and drying, the highest pucker was typical of the specimens sewn with cotton sewing threads, due to yarn swelling.

References


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