Influence of Sewing Machine Parameters on Seam Pucker

Prof. **Vaida Dobilaitė**, Ph.D.
Prof. **Milda Jucienė**, Ph.D.
Kaunas University of Technology, Faculty of Design and Technologies
Department of Clothing and Polymer Products Technology
Kaunas, Lithuania
e-mail: vaida.dobilaite@ktu.lt

Received November 20, 2006
UDK 677.017.7:687.023
Original Scientific Paper

The effect of rotational frequency of a sewing machine main shaft and pressing force on seam pucker has been studied. Seam pucker of the specimen prepared from lightweight fabric was evaluated according to the method of the measurement of the geometric characteristics of a wave generated in a seam and propagated towards the reference edge line. The pucker height and length have been measured and sharpness calculated. It is found that the pucker height increases when rotational frequency of the main shaft increases and pressing force decreases. A strong correlation exists between characteristics of seam pucker and different sewing modes. The seam pucker is closely related to fabric friction and structural properties. Different puckering of the specimens cut in the directions of warp and weft is determined by anisotropy of textiles and this fact confirms the influence of fabric properties on the investigated seam defect.

Key words: *sewing garment, fabric, seam pucker, rotational frequency, pressing force*

1. Introduction

The high quality sewing items have to meet the requirements of manufacturing (parts join, formation and fixation), appearance, form stability, selling, etc. Seams in a garment from lightweight fabric are prone to pucker, when creasy surface emerge in the area of part joint. Such kind of defects downgrades the look and the price of a final production.

A series of studies have been dedicated to ascertain causes of a seam pucker and to quantitatively evaluate them in order to control or eliminate this defect. Various methods from simple to sophisticated based on forward technologies have been proposed to measure a seam pucker [1-8]. There have been several studies concerning to evaluate seam pucker in three-dimensional garment, not only on flat surface, when specimens are laying on a plane [9-11].

All the studies were aimed to determine the main reasons as well as the factors causing the occurrence of this defect. The properties of sewing fabrics and threads have influence on seam pucker. The decrease in diameter of a sewing thread reduces the possibility of a fabric jamming and subsequently that of puckering [12]. On studying an effect of physical and mechanical properties of sewing thread on the seam appearance, it has been observed that a better sewing thread is a thinner thread with a law irregularity, less extensibility under law load, lower surface friction, lower reversible strain [13, 14].

To go deep into the influence of fabric properties on seam pucker, it is supposed that the shear and flexibility are the main factors in respect to pucker, as they determine fabric deformation during sewing process. Besides, thickness, surface density, extensibility, formability are associated with this defect [15-19]. Also, devices and mechanism of sewing machine (upper thread tension regulator, take-up lever, shuttle and fabric feeding mechanism), characteristics of needle, garment construction and technology, sewing regimes are none the less important [20-25]. The changes in above mentioned factors can determine the reduction in crease; however, the recommendations mostly are based on practice.

When in the course of transportation of the sewing fabrics, a toothed plate moves in an elliptical trajectory, so upper and lower fabric layers are affected by forces of different size. Due to this reason, upper fabric in the place of a stitch may stretch, whereas lower fabric may shrink and in the place of a stitch puckering may be observed. Normal pressing force thus the extent of fabric compression, may be regulated, hereby ensuring high-quality feeding of fabrics by the length of a stitch. Inertial forces acting in the process of transportation depend upon the sewing speed; therefore the influence of speed on the occurrence of puckering is relevant as well.

The present study is aimed as investigating the effect of rotational frequency of a sewing machine main shaft and pressing force on seam pucker.

2. Materials and Methods

The lightweight fabrics having different structures and mechanical properties were chosen for seam pucker investigation. Basic characteristics of the used fabrics are given in Tab.1.

The fabric settings (P_{wa}, P_{we}) were determined in accordance with EN 1049-2, as well as surface density (W) in accordance with ISO 3801. The final result was calculated as arithmetic average of five specimen results and the confidence limit does not exceed 5%. Fabric thickness ($T2$) (at pressure of 196 Pa) was determined according to the FAST system [16]. In this case, confidence limit does not exceed 3%.

The coefficient of friction (μ) was computed on the basis of the $F=\mu N$, where F is frictional force and N, the normal force (Tab.2). For the friction force (F) measurement, a tensile tester equipped with a special device was used. The output was recorded on a personal computer through an amplifier and A/D converter. An experiment was performed when the sled contact surface was fabric/metal (variation of the result seek 3.3 %) and fabric/fabric (variation was 4.6 %).

To prepare the specimens for seam pucker study, the fabrics' strips of 300×30 mm dimensions were cut in the warp and weft directions and two strips were sewn together (Wa+Wa, We+We) across the centre line in longitudinal direction. The conditions of the specimens' sewing were as follows: stitch type, 301; stitch length, 2.5 mm; needle No. 90; sewing threads, Gütermann Nm 120; the upper and lower thread tension was set to ensure that interloop was in mid-fabric. Before sewing, lockstitch sewing machine Unicorn used for this investigation was assured in order to eliminate the sources of seam pucker occurrence, depending on sewing equipment work, (wrong feeding, stitch tightening and etc.). The specimens were sewn with rotational frequency of a sewing machine main shaft φ, namely 200, 900, 1 600 and 2 300 min^{-1}, at pressing force P of 25, 45, 65 and 85 N.

In order to determine magnitude of seam pucker, the method of the measurement of the geometric characteristics of a wave generated in a seam and propagated towards the reference edge line was used. According to this method, the surface contours of sewn specimens were photo-captured from both sides by digital camera, recording the view of the shape of generated wave cross-section. Seam pucker is evaluated by geometric characteristics of this shape [24]. During image capturing, the specimens were laid on a hard flat surface. Images were captured with a rule at one edge of specimen for image scaling. The source of light was over the specimen at a distance of ~ 3 m. The digital camera was stationary fixed on the support in the same level with specimen overlie at a steady distance 3 L, where L is the specimen length. Such distance was selected considering a quality of captures and minimum distortion of view.

The standard Microsoft Windows software was used for bitmap editing and measuring of generated wave cross-section geometric characteristics. These characteristics were measured using the *CorelDraw11* software. Geometric shape of the seam pucker was measured in the length of 20 cm from both sides of the specimen (at the distance of 5 cm from specimen edges pucker was not evaluated because of sewing inaccuracy).

The shape of the wave generated in a seam can be described by particular parameters, such as wave amount n, wavelength l, and wave height h at the edge line of the specimen. To measure a seam pucker characteristics the xyz system of axes was selected, where x axis was parallel to sewing line, z was perpendicular to x line and lay in plane of specimen, y was perpendicular to

Tab.1 Basics characteristics of the fabrics

Fabric code	Composition	Weave	Surface density (W), g/m^2	Thickness ($T2$), mm	Setting, cm^{-1}		Cover factors		
					warp (P_{wa})	weft (P_{we})	warp (e_{wa})	weft (e_{we})	fabric (e_f)
M1	100% PES	Combined	149	0.35	65	38	0.623	0.537	0.826
M2	100% PES	Plain	130	0.32	49	26	0.493	0.467	0.729
M3	45/55% PES/CV	Combined	111	0.46	56	26	0.534	0.380	0.711

Tab.2 Coefficient of friction μ

Coefficient of friction (μ)	M1	M2	M3
fabric – to –fabric	0.25	0.49	0.48
fabric – to –metal	0.15	0.18	0.20

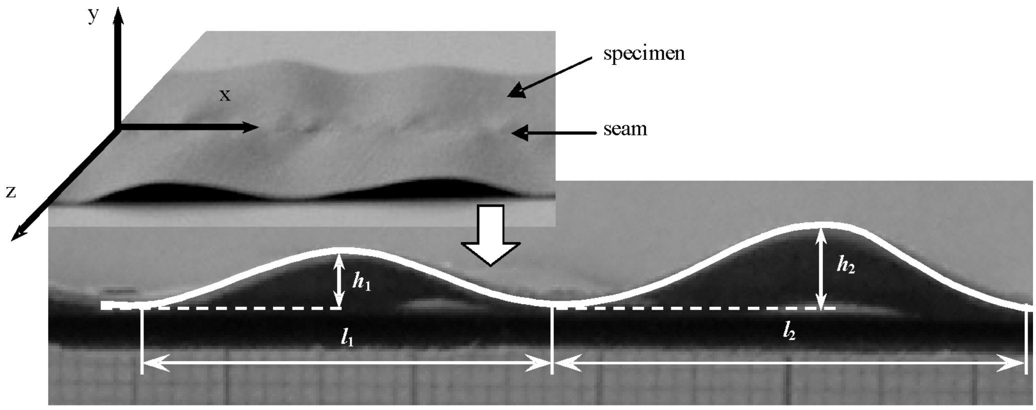

Fig.1 The scheme of wave height h and wavelength l measurements

x-z plane (Fig.1). The generated waves were analysed in y-x plane, shifting of the amount z=const and since stitching line (z=15 mm). The wave height h was measured as the distance between the highest wave's contour point to the lowest contour point of this wave; and the wavelength was measured as the distance between point at which the wave starts to rise up ($h \geq 0$) to its lowermost point (h=0).

The geometric characteristics of puckered seam shape of one specimen were calculated as average of all full waves (having clear points of the beginning and the end) height h and wavelengths l of that specimen:

$$h = \frac{\sum_{i=1}^{n} h_i}{n} \tag{1}$$

$$l = \frac{\sum_{i=1}^{n} l_i}{n} \tag{2}$$

where h_i is the height of i^{th} wave; l_i, the wavelength of i^{th} wave; and n, is the number of waves in work area of one specimen.

For each fabric the averages of all heights and wavelengths of all fabric'specimens cut in one direction were calculated. These results were taken as the final results of seam pucker geometric characteristics.

It is known that the visual perception of investigated seam defect is influenced by the sharpness of a pucker, i.e. when height of pucker is even, the surface with narrower puckers will look more creasy. Respecting that fact, above mentioned characteristics of seam pucker was supplemented by the ratio of wave height h and length l, which defined as the pucker sharpness (h/l).

3. Results and Discussion

In the course of sewing, textiles go through the complicated impact of outer forces. At the moment of stitch formation, fabric is needled and an upper sewing thread is inserted. After the needle thread loop is hooked by the shuttle nose and wrapped around the shuttle, its thread loop is retracted inside the sewing fabrics. The toothed plate, moving in an elliptical trajectory, presses fabric to the pressing foot bottom and shifts by stitch length. At the moment of stitch tightening, sewing threads press fabric layers due to tensioning and later due to deformation relaxation processes compress them in the longitudinal direction between adjacent pricks. Under the impact of these processes and forces acting during them, fabric may pucker in the place of a seam.

Analyzing the obtained pucker height h results at different sewing modes, it was determined that the pucker height increases with growing rotational frequency of the main shaft φ usually (Fig.2). This tendency was observed in all cases of the fabrics investigated. Performing correlation analysis, it was obtained that correlation coefficient R between pucker height h and rotational frequency of the main shaft φ dominated from 0.75 till 0.98. In the case of M3 fabric the correlation became weaker (~0.65), when pressing force increase.

Difference between pucker heights h pronounced on lower rotational frequency φ (from 200 min^{-1} till 900 min^{-1}); with increase of this sewing parameter the pucker height h stabilize and the variation not so clear. Increase of rotational frequency φ doesn't influenced seam pucker height h of weft specimens prepared from fabric M2, as well as height h of M3 fabric weft specimens stabilized, when rotational frequency φ seek 1 600 min^{-1}.

The highest puckers are typical of the specimens prepared from fabric M1, which features the lowest friction coefficient μ and the highest cover fabric factor e_f among all the fabrics investigated. Negligible friction between fabrics and metal surfaces touched by fabrics in the process of sewing could determine insufficient grip and therefore the feeding process was impeded. Sewing threads inserted into fabric at the moment of stitch formation bent fabric threads in the place of a prick, whereas at a higher fabric cover the cavities between threads are smaller. A sewing thread is pressed more and deformation passes to the larger area.

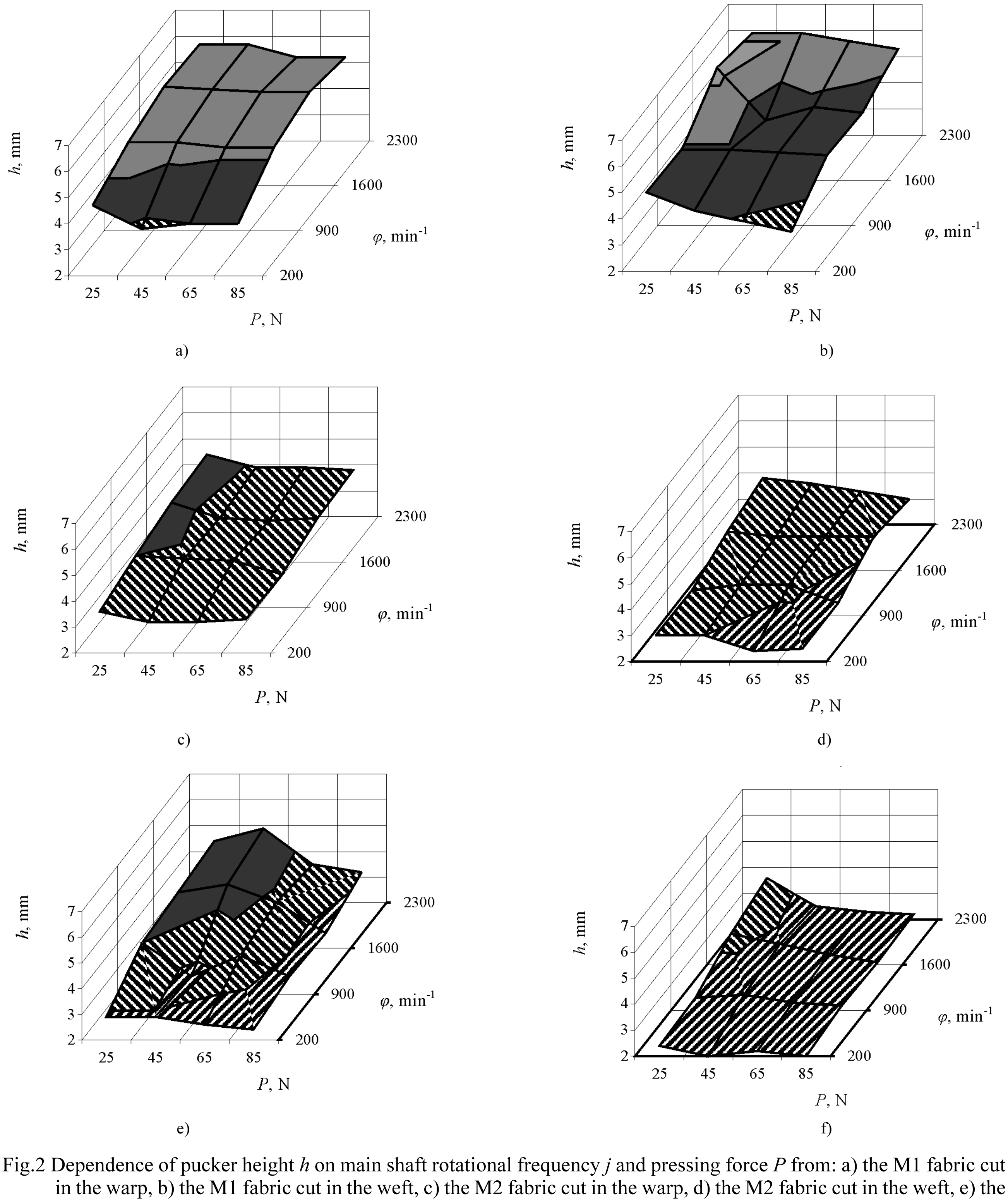

Fig.2 Dependence of pucker height h on main shaft rotational frequency j and pressing force P from: a) the M1 fabric cut in the warp, b) the M1 fabric cut in the weft, c) the M2 fabric cut in the warp, d) the M2 fabric cut in the weft, e) the M3 fabric cut in the warp, f) the M3 fabric cut in the weft

(– 6-7, – 5-6, – 4-5, – 3-4, – 2-3)

The smallest puckers were observed in the weft direction specimens from fabric M3. In this case, increasing force of a pressing foot P leads to the fact that pucker height h falls within the limits of lower values compared to other fabrics even at higher speed. A fabric cover factor e_f of this fabric is the lowest among all the fabrics investigated, whereas friction between fabrics is almost twice as high as one typical of fabric M1. Other feature point of the puckers height h distribution in specimens of this fabric is that a range of this characteristic values is the widest (2.4-3.6 mm) and the nature of creasing differs significantly in the directions of warp and weft. In the cease of lower rotational frequency of the main shaft φ the puckers of warp specimens are approximate to ones in weft, whereas increasing of mentioned sewing parameter determined that results are similar to puckers results of warp specimens of fabric M2.

The specimens from fabric M2 cut in different directions puckers unevenly as well. Different puckering of the specimens cut in the directions of warp and weft is determined by anisotropy of textiles and this fact confirms once again the influence of fabric properties on the seam puckering. In the directions of warp and weft, structural properties of fabric M3 featuring the highest anisotropy differ considerably.

By its structural and friction characteristics, fabric M2 is similar to investigated fabrics M1 and M3; however, unlike the latter it is plain weave fabric. The structure of fabric with such weave is more coherent compared to the structure of combined fabric where floats of threads are higher. Due to this reason, there is less space for retraction of interlacing loops of upper and lower threads inside the fabric without buckling warp and weft threads and without changing its structure. Together with the factors formerly discussed in the cases of other fabrics, this could influence puckering of seams.

On analysing the influence of pressing force P on pucker height h, it was established the tendency that puckers decrease with increasing size of pressing force P. In this case the high correlation (R seek 0.82 – 1) was found between mentioned parameters. At different sewing conditions, however, the variation of this characteristic is not as significant as in the case of speed increase. In most cases when force grows seam pucker does not change or changes by a negligible value that is insignificant. Only in weft specimens of fabrics M1 and M3 was observed clear decrease of pucker height h increasing force from 25 N to 45 N. Pucker height h in specimens cutted in warp directions of M3 fabric stabilizes at 65 N.

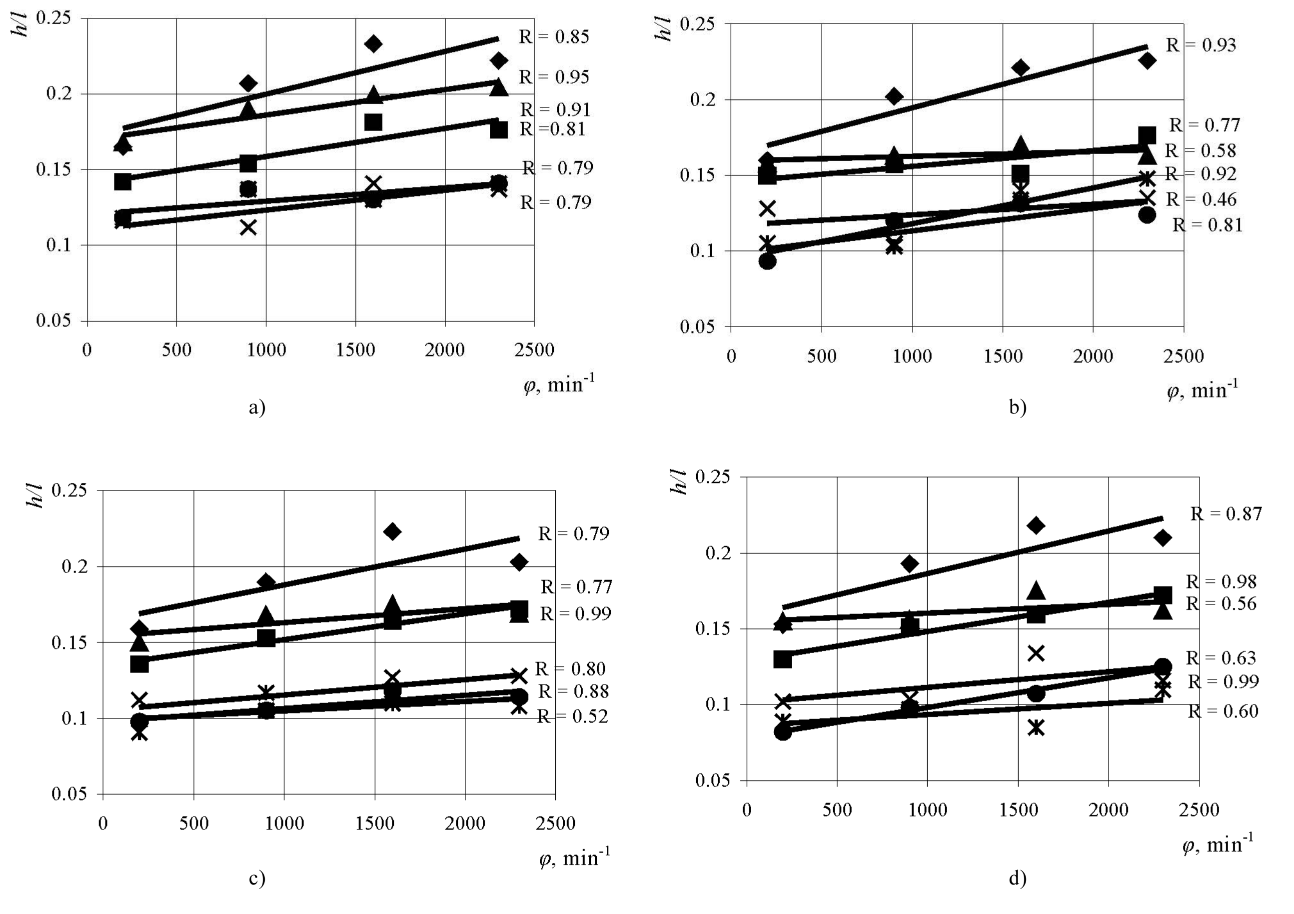

Fig.3 Dependence of pucker sharpness h/l on main shaft rotational frequency φ when pressing force P is: a) 25 N, b) 45 N, c) 65 N, d) 85 N

(◆ – M1 warp, ✕ – M1 weft, ■ – M2 warp, ✱ – M2 weft, ▲ – M3 warp, ● – M3 weft)

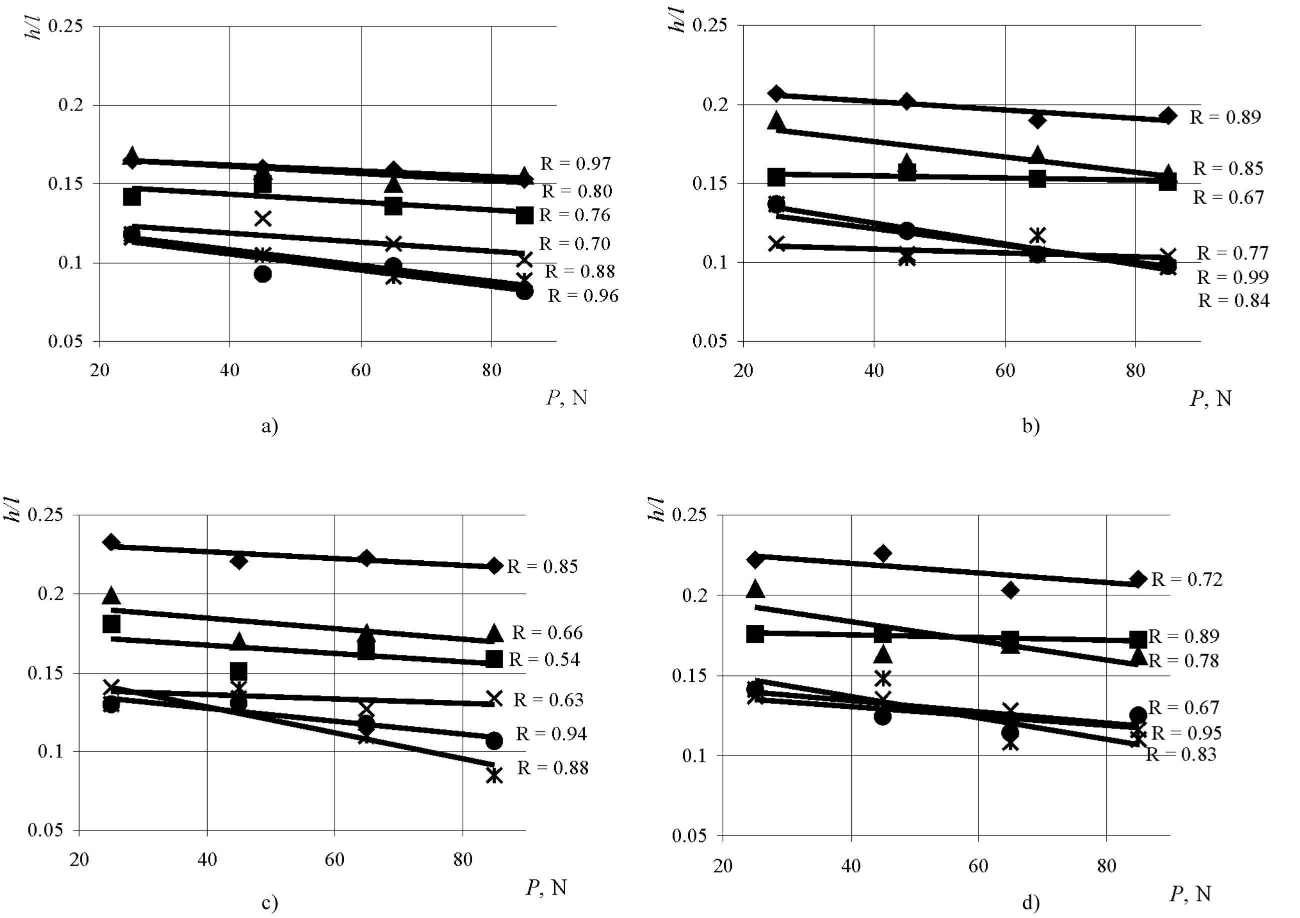

Fig.4 Dependence of pucker sharpness *h/l* on pressing force, when main shaft rotational frequency is: a) 200 min^{-1}, b) 900 min^{-1}, c) 1 600 min^{-1}, d) 2 300 min^{-1}
(◆ – M1 warp, ✕ – M1 weft, ■ – M2 warp, ✱ – M2 weft, ▲ – M3 warp, ● – M3 weft)

It may be seen that in seams of different fabrics, subject to their properties and sewing modes, puckers of different height and length are observed. Even when puckers are equal or approximate by their height but different by length, the nature of creasing will differ significantly. To define the general nature of puckering, pucker sharpness characteristic *h/l* comprising both geometric performances of a pucker and their relation is applied. In this study, the influence of pressing force *P* and rotational frequency of the main shaft φ on sharpness *h/l* was analysed (Fig.3 and 4).

On the base of correlation analysis, the strength of the relationship between this characteristic and parameters of different mode was evaluated. After calculating empirical correlation coefficient *R*, it was established that the pucker sharpness *h/l*, thus the puckering nature of different fabric seams, is closely related to the values of pressing foot force *P* and rotational frequency of the main shaft φ. Besides, variation tendencies are analogous to the formerly discussed tendencies of pucker height *h*. Pucker sharpness *h/l* grows with increasing rotational frequency φ of the main shaft and decreasing force of a pressing foot *P*.

The strongest linear correlation dependence was established between sharpness *h/l* and rotational frequency φ of the main shaft for fabric M1 (R=0.72-0.97), whereas in the case of fabric M3 R was 0.56-0.95, as well as in the case of fabric M2 R was 0.77–0.99. Dependence of the sharpness *h/l* upon the size of pressing foot force *P* at different rotational frequency of the main shaft is very strong as well.

Hence, it is concluded that the occurrence of seam pucker is closely linked with same sewing machine parameters, such as the size of rotational frequency of a sewing machine main shaft and pressing force, as well as fabric properties.

4. Conclusions

The amount of seam pucker depends on present sewing machine parameters herewith fabric properties. It was established that in all cases the pucker height increases with growing rotational frequency of the main shaft, and decreases, increasing pressing force. When sewing conditions are the same, the size of the seam pucker height is influenced on fabric structural and mechanical properties, such as friction coefficient, fabric cover factor, weave. According to the obtained results it has been seen that the pucker sharpness is closely related to the values of pressing foot force and rotational frequency of the main shaft. The higher the rotation frequency and the lower pressing force, the higher the pucker sharpness. Taking into consideration the results of the correlation analysis, it may be concluded that the pucker sharpness, thus the puckering nature of different fabric seams was influenced on pressing foot force and rotational frequency of the main shaft.

References:

[1] ISO 7770: Textiles. Method for Assessing the Appearance of Seams in Durable Press Products after Domestic Washing and Drying Technical Bulletin (1985); http//www.iso.ch.

[2] Belser R.B. et al: Instrument for Grading Seam Pucker, Textile Research Journal **69** (1968) 3, 315-318

[3] Shiloh M.: The Evaluation of Seam-puckering, Journal of Textile Institute **62** (1971) 176-180

[4] Kwong, Mei-Ying et al: Development of Judgment Method for Evaluation of Overfeed Seam in Shape Formation of Jacket The 78th world Conference of the Textile Institute, Greece, May, (1997) 329-344

[5] Stylios G., J.O. Sotomi: Investigation of Seam Pucker in Lightweight Synthetic Fabrics as an Aesthetic Property. Part II: Model Implementation Using Computer Vision Journal of Textile Institute **4** (1993) 601–610

[6] Park J.C.K. et al: New Evaluation of Seam Pucker and its Applications International Journal of Clothing Science and Technology **9** (1997) 1/3, 252-255

[7] Park J.C.K., T.J. Kang: Objective Evaluation of Seam Pucker Using Artificial Intelligence. Part I: Geometric Modeling of Seam Pucker Textile Research Journal **69** (1999) 10, 735-742

[8] Park J.C.K., T.J. Kang: Objective Evaluation of Seam Pucker Using Artificial Intelligence. Part II: Method of Evaluating Seam Pucker, Textile Research Journal **69** (1999) 11, 835-845

[9] Fan J. et al: Objective Evaluation of Pucker in Three-Dimensional Garment Seams, Textile Research Journal **69** (1999) 7, 467–472

[10] Fan J. et al: Towards the Objective Evaluation of Garment Appearance, International Journal of Clothing Science and Technology **11** (1999) 2/3, 151–159

[11] Fan J. et al: The Use of A-2D Digital Filter in the Objective Evaluation of Seam Pucker on 3D Surface, Journal of Textile Institute **90** (1999) 3, 445-455

[12] Schwartz P.: Effect of Jamming on Seam Pucker in Plain Woven Fabrics Textile Research Journal **69** (1984) 1, 32-34

[13] Fan J., W. Leeuwner: The Performance of Sewing Threads with Respect to Seam Appearance Journal of Textile Institute **89** (1998) 1, 142–154

[14] Dobilaite V., M. Juciene: The influence of Mechanical Properties of Sewing Threads on Seam Pucker International Journal of Clothing Science and Technology **18** (2006) 5, 335-345

[15] Stylios G., D.W. Lloyd: Prediction of Seam Pucker in Garments by Measuring Fabric Mechanical Properties and Geometric Relationship, International Journal of Clothing Science and Technology **2** (1990) 1, 6-15

[16] CSIRO Division of Wool Technology, The FAST System for the Objective Measurement of Fabric Properties – Operation, Interpretation and Applications (SCIRO, Sydney), 1989

[17] Ito K.: Problems in Recently Manufactured Worsted Men‘s Suiting from the Point of View of Suit Quality International Journal of Clothing Science and Technology **9** (1997) 3, 200–202

[18] Stylios G., J. Fan: An Expert System for the Prediction of Fabric Sewability and Optimization of Sewing and Fabric Conditions in Garment Manufacture (Sewability System (SS)) Textile Objective Measurement and Automatization in Garment Manufacture, Elis Harwood Limited, (1991) 139-147

[19] Dobilaitë V., A. Petrauskas: The Effect of Fabric Structure and Mechanical Properties on Seam Pucker Material Science (Medžiagotyra) **8** (2002) 4, 495-499

[20] Hunnable J.: The Technology of Threads and Seam Coats Marketing, London (1996) 181

[21] Technical Sewing Information from Gűtermann. Seam Pucker: Causes and Solutions, Technical Bulletin; www.guetermann.com.

[22] Information for the Sewing Industry: Sewing of Ultra-lightweight Fabrics, Technical Bulletin; www.amann.com.

[23] Eberle H. et al: Clothing Technology from Fibres to Fashion Europa-Lehrmittel, Nourney, (1996) 256

[24] Šomođi Ž., G. Nikolić: Dynamic model for estimating friction effect on the sewing regularity, Book of Proceedings, 2nd International Textile, Clothing & Design Conference, Dubrovnik, Croatia, 3th -6th October 2004, 617-623

[25] Dobilaitė V., A. Petrauskas: The Method of Seam Pucker Evaluation Material Science (Medžiagotyra) **8** (2002) 2, 209–212