ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

[1.] IVANA DOSEDĚLOVÁ

DETERMINATION OF SEWN SEAM IMPACT STRENGTH

Abstract:
This article defines strength as the fundamental function property of the seam which characterizes possibilities of using of technical ready-made products. Strength is the force which the seam resists. There are presented the measuring methods of seam strength in dependence on the method of strain. According to the method of strain the seams have to resist the forces which act quasi statically or at impact. It is necessary to differentiate and define impact strength and to known how to measure it.

Keywords:
strength, impact, technical ready-made product, force, strain

INTRODUCTION

The study of strength of the sewn seam is necessary for production technical ready-made products. The sewn seams are used in new zones of an application and the diversity of application become greater. They are evolved new textile fabric with new using properties and new manufacturing technology.

The production of the technical ready-made products means processing of the flat textiles with the seams to the three-dimensional products, which serve special purposes and have to resist special and often very severe conditions of application. In some applications of technical ready-made products (parachutes, airbags, safety belts ...) there are the activities at which the impact forces rise and act on the fabric and its seams. In some cases the human life can be in danger by the malfunction of these products. That's why a great stress is put on the seam strength as its fundamental function property. Literature about these problems isn't known. Properties of the seams was analysed in [1, 2] and problems about technical ready-made products production are solved for example in [3].

THEORETICAL DETERMINATION OF SEWN SEAM STRENGTH

Strength of the sewn seam

Strength of the sewn seam can be less than strength of a textile fabric. It is the property which represents behaviour of connected fabric in conditions of mechanical action. It characterizes seam from the view of the ability to resist impacts of external forces without any defect.

Transversal seam strength characterizes resistance of the seam to external strain which impacts perpendicularly to an orientation of the seam. It represents the force which is needed for destruction of the seam by nonreversible change (destruction of the sewn thread, destruction of the connecting material, moving of the tread on the seam).

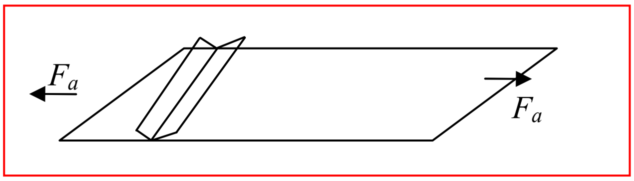

Figure 1: The graphic presentation of seam mechanical tensile strain

Theoretical transversal seam strength is maximal value which is able to reach. It is defined as a linear function of thread strength in a loop and quantity of tied points belonging to the length of the seam.. Real transversal seam strength (Fs) is less than theoretical because the strength of the sewing thread decreases during the formation of stitch. It is characterized by the coefficient of the damage of the thread, which is the rest of the strength of the thread after the sewing.

The prediction function

The prediction function for the theoretical calculation of the real seam strength has this form:

$$F_s = 2 \cdot 10^{-4} \cdot d_s \cdot l_s \cdot \alpha \cdot F_t \cdot F_{rtl} \cdot F_{rts} \qquad (1)$$

where:
F_s …real strength of the seam [N]
F_t …strength of the thread [N]
F_{rtl} …relative thread strength in the loop [%]
F_{rts} …relative strength of the thread after sewing [%]
d_s … density of the stitch [cm^{-1}]
l_s …width of the sample (length of the seam) [mm]
α … coefficient of the seam

The influential factor

There are three groups of the influential factors:
- *the material influential factors (connecting material, threads)*
- *the parameters of connecting (type of the seam, type of the stitch, width of the seam, density of the stitch, direction of the sewing)*
- *the method of strain (quasi static, impact)*

Measured values of strength are dependent on the speed of material deformation.
When the speed of deformation is higher all mechanisms of plastic deformation aren't able to open wide, so the material is broken at higher value of tension, but at lover value of elongation. It means material presents as fragile [4].
The values of strength measured at static tests and at impact tests will be different. This difference in behaviour of material represents the value of impact coefficient C_I

$$C_I = \frac{A_{defI}}{A_{defS}} \qquad (2)$$

where A_{defI} (A_{defS}) is average value of deformation work by impact strain (by static strain).

Impact strength can be calculated when this forces values are considered as static and multiplied by impact coefficient which can be determined by test..

Experimental Measuring Of Sewn Seam Strength

Methods for measuring of the strength

Mechanical characteristics present quantitative level of effect of mechanical strain. They are determined by mechanical tests.

Mechanical tests – static test
- *the test sample is strained by external force which is increased slow by lower speed then the speed of propagation of plastic deformations in normal conditions till damage of the sample*
- *the value of force for deformation or for destruction of the sample is measured at this test*

Mechanical tests – impact test
- *the test sample is strained by external force which is acting quickly by impact of other solid with defined speed of fall (Charpy pendulum hummer)*
- *the value of using work for deformation or for destruction of the sample is measured at this test*

Impact strength
The measuring of impact strength of textile fabrics and its seams is a difficulty solvable technical problem. The pendulum hammer is used at impact test. It is constructed so that the material will be broken when passes zero position.
The apparatus for measuring impact strength on the laboratory textile sample was projected and constructed on Technical University of Liberec, Department of Technology and Management of Apparel production (figure 1).

Description of apparatus
The apparatus is composed of a frame (1), swing hummer (2), fixative yaws (3, 4), gauging device (5, 6), brake (7). Basic measuring element is angular scale (5), where pointer (6) enabling read the angle of swing is placed. The fixative yaws are placed in direction acting force. The front edges are perpendicular to direction acting force. The fixative surfaces are on the same plane – on plane of strain textile (8), they are knurled for reliable holding of the sample without slippage but they can't cut through or

damage the sample. The left yaw is turning – it makes possible swing, the right yaw is fixed.

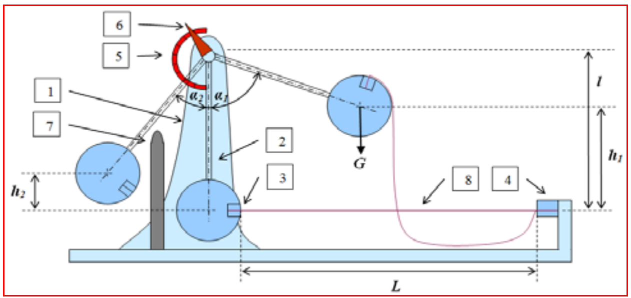

Figure 1: The apparatus for measuring the impact strength of the textile fabric and seams

The apparatus is hand-controlled. It enables positioning of swing hummer to three position (the swing angle is 45°, 90°, 135°) for another samples. The fixed length which makes possible swing is defined as 1, 2 m..

Principle of the method

The sample is fixed into the jaws down (basic) position. The turning jaw gets potential energy E_{P1} when swings to height to h_1 (or by angle α_1).

The geometry position of the sample just before destruction is determined for impact strength. This method supposes strain of a sample in centre of impact of the hummer. When we drop the jaw, we can imagine that after the thrust of a sample the impulse of force will be acting at impact, perpendicularly to the seam, in the direction of sample length.

The sample will be destructed in the lowest position. The pendulum will swing to opposite position to height h_2 (or by angle α_2 which is registered on a scale). This position corresponds to the residual energy E_{P2}.

Absorbed deformation energy E_{def} is given by difference potential energies:

$$E_{def} = E_{P1} - E_{P2} = m\,g\,(h_1 - h_2) \qquad (3)$$

Decrease of energy is direct proportional to the expended deformation work. The calculation model was get from the difference between initial and final state and form the well-known goniometric formulas:

$$h_1 = l\,(1 - \cos\alpha_1) \qquad (4)$$
$$h_2 = l\,(1 - \cos\alpha_2) \qquad (5)$$

There is the calculation model of deformation work A_{defl}:

$$A_{defl} = m\,g\,l\,(\cos\alpha_2 - \cos\alpha_1) \qquad (6)$$

The basic for calculation of deformation work is the initial value of the setting angle and the final value of the swing angle, when the weight of the hummer (m = 21,1 kg) and the length of the hummer (l = 802,5 mm) are known. The length of the hummer is the distance between the centre of gravity of the hummer and the axis of rotation.

***Measuring procedure*:**

Examinational sample is fixed one end to the jaw of the swing hammer in the basic position and the second end to the stationary gripping jaw (fig. 1). Sample must be fixed so, that it is tight – to this purpose serves initial tension through small weight (50 g).

Pendulum is swung in the angle (α_1) and is locked (fig. 1 position 1). After unlocking follows free-fall, position energy is changed to kinetic energy, which is maximal in the down position. Impact force acts to the sample. Textile is broken and pendulum is swung to the opposite position (fig. 1 position 2). Angle value (α_2) is read from the scale, angle is equal to the rest energy.

***Sample preparation*:**

Samples are prepared according to the norm EN ISO 13935-2 with following differences:

Laboratory sample (fig. 2) is made from textile material size 1200mm x 1400mm, which is folded so, that the edge of the fold is parallel with the shorter side of the sample. In defined distance from the fold (usually 20mm) is made up demanded seam. Sample is cut in the fold before sewing together (when it is the lapped seam material is lapped). Seams are sewn in direction of the weft or according to the demands. Sewing machine must be rightly set up, sewing must be straight and every stitch must be perfectly bound from the beginning to the end of the sewing. Both sides of the laboratory sample are cut of 100mm waste.

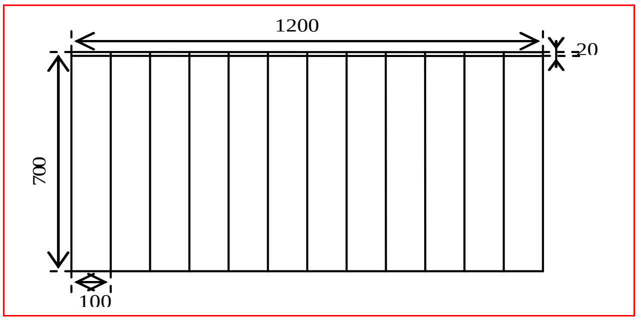

Figure 2: Laboratory sample for impact test

Set about ten examinational samples 100 mm x 1360 mm is cut and modified on defined shape (fig. 3) from the laboratory sample with the seam. Every examinational sample is four times notched until 33 mm in distance 20 mm from the seam. The rest of the material is cut off so, that the real width of the sample will be 34 mm. Length of the examinational sample is given according to the seam (usually 1360 mm).

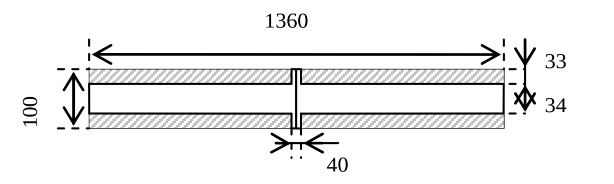

Figure 3: Examinational sample for impact test

EXPERIMENTAL RESULTS AND EVALUATION

Measuring values

The output values from impact test are initial angle of fall (α_1) and final angle of swing (α_2). The output values from static test are values of strength (F), elongation of sample (Δl) and graphic record of course of test..

Treatment of measuring values

Absorbed deformation work at impact strain A_{defI} was calculated according to model (6). Absorbed deformation work at static strain A_{defS} was calculated from graphic record of course of test:

$$A_{defS} = \int_0^{\Delta l} F \cdot dl \qquad (7)$$

The integral present area of figure which is limited by l-axis and by graph of function F(l) given by tensile curve. The trajectory is given by elongation of sample.

Evaluation of impact coefficient

The measuring value absorbed deformation work at impact strain A_{defI} was compared with value absorbed deformation work at static strain A_{defS}. The results of measuring (table 1) confirm hypothesis that absorbed deformation work at impact strain will be always higher than absorbed deformation work at static strain and the value of impact coefficient will be always higher than one. It means that deformation resistance is lower at impact strain.

Table 1: The results of strength valuation

seam type	stitch type	A_{defS}[J]	A_{defI}[J]	C_I
1.01.01	1 x 301	1,172	7,877	6,72
2.01.01	1 x 301	1,138	8,070	7,09
2.01.03	2 x 301	2,190	8,201	3,74
2.01.04	3 x 301	3,710	11,007	2,96
2.02.01	1 x 301	0,857	8,632	10,07
2.04.01	1 x 301	0,886	8,632	9,74

It is needed criticize dependence of deformation work not only on impact force (strength) but also on trajectory (elongation of sample).

CONCLUSION

The problems of prediction of seam strength are evolved theoretically. The universal model of function dependence for calculation of the real perpendicular strength of seam was elaborated. It has important application in projecting of seam. The difficulty of mechanical impacting on components of the seam causes that this model isn't enough exact for all of the seams. Many of different influences impact into the strength and it is needed to analyze them.

The using properties of technical ready-made products are given not only by using textiles but also by technological ready-made procession. The knowledge of strength characteristic not only at quasi static strain but also at impact strain is necessary condition for successful projecting to the seams.

The test of the impact strength of textiles and seams determined its behaviour at sudden grown of acting force. This test evaluated the impact strength by objective method and on the standardizing samples. We can reproduce the test with the same condition.

This test makes possible to evaluate the other properties of textiles and seam and to guarantee quality and rightness of using.

REFERENCES

[1] Nahtquerfestigkeiten, Die Naht – Nähtechnische Informationen von Gütermann, 1986, Nr. 86, S. 6

[2] DOSEDĚLOVÁ, I.: The Strength of the Sewn Seam – the Prediction Function, the Influential Factors, In Structure and Structural Mechanics of Textile Fabric, Technical University of Liberec, 2005, ISBN 80-7372-002-7, 335-340

[3] KUNZ, O.: Konfekcionování technických textilií, sborník z odborného semináře Problematika konfekcionování technických textilií, KKV Prostějov 2001

[1] KOŠKOVÁ, B., KOŠEK, M.: Struktura a vlastnosti vláken, VŠST Liberec, 1991

AUTHORS & AFFILIATION

1. IVANA DOSEDĚLOVÁ

1. DEPARTMENT OF TECHNOLOGY AND MANAGEMENT OF APPAREL PRODUCTION, TECHNICAL UNIVERSITY OF LIBEREC