Effect of cyclic loading on the car seat's seams

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Abstract. The purpose of this work is to find out the influence of thread type, extension ratio and number of cycles to decrease in strength due to stress. In this study four different kind of spun polyester and polyamide threads are used to sew the textile material (used for car seat cover) by a lockstitch sewing machine. The measuring system simulation of cyclic load has been used. The tensile load, which was corresponding to 20 %, 30 %, 40 %, and 50 % of the breaking extension of seam, acting on the experimental specimen. Based on the results of experimental measurements, which were closer to the real using conditions of seat covers, it can be stated that with increasing number of cycles, the strength due to the influence of the stress were decreased.

1. Introduction

The present study is related the field of technical textiles, respectively of car seat covers, where sewn seams and materials are subjected to variable loads, leading to various deformations during the process of product usage [1]. This deformation strongly manifested in the seams. Technical textile for the automobile interiors shall have high elasticity with abrasion resistance and strength at the same time. Special attention is given to the sewing seams mechanical properties, because the strength of sewing seams is less, then the fabric strength [2-4].

Sewing is known one of the main parts in the technical textiles production. As well as safety characteristics are concerned, the seam strength is the chief quality parameter of clothing and technical textiles. The seam characteristics include: strength, elasticity, durability, safety, and appearance. Inconsistency of these characteristics can lead to significant differences in seam behavior and it also can affect their deformation characteristics [5].

The present work is based on experiments which determine the deformation properties of the seams in warp direction in car seat covers depending on the type of sewing thread and extension size under cyclic loading. PES and PA multifilament sewing threads with different linear density were used to sew sandwich type of material. From seams strength at break average with different type of threads, the size of sample extension was calculated. The force needed for loading the specimen under exactly elongation was measured without pretension.

This paper deals the most important influences on the deformation of the sample were monitored, such as:

- The effect of the thread type on the loading;
- The effect of elongation values to the sample deformation;
- Influence of the number of cycles to decrease in strength due to stress.

The seam strength under exactly extension after each cycle and for different type of thread is obtained. For better understanding the mechanical properties of sewing seams with different threads these results were compare between each other. Based on experimental results with the average value

of cyclic load after three cycles is possible to predict the durability of the seam or when seam rupture will occur. Knowing the behaviour of sewn seams during and after cyclic loading probably guess how long these seams will retain its durability.

2. Methodology

In order to have an idea about the real behaviour of the seam in car seats cover, the deformation should be occurring continuously over a period of time. The feed speed of jaws should correspond to real conditions of product usage. For this purpose a measurement sequence of cyclic loading effect on seat cover's seams was developed.

2.1. Materials used

Properties of sewing seam depended of many factors. To know behavior of seam it is necessary to find parameters of seam components.

Sandwich-type of fabric was use for preparing samples for testing mechanical properties of sewing seam under cyclic loading. Exactly parameters of fabric are shown in Table 1.

Table 1. Material properties

Parameter	Value
Width [mm]	1520 ± 30
Weight [g/m^2]	560 ± 40
Thickness [mm]	6.4 ± 0.5
Lamination [kg/m^2]	35 (ESTERFOAM)
Material [g/m^2]	100% PES
Backing [g/m^2]	55 (65% PES/35% CO)

In order to investigate the effect of different sewing threads on seam strength, four different threads were used for specimens preparing. These threads commonly used in industry to sew car seat covers. Tensile testing was performed using standard methods ISO 2060 [6] and ISO 2061 [7], the following table 2 shows the experimentally determined parameters of sewing thread.

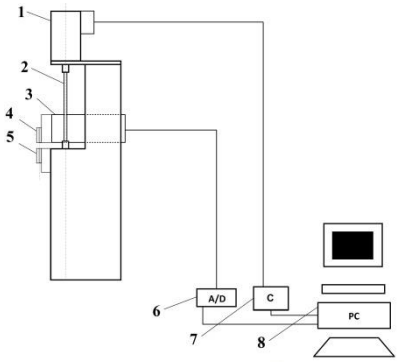
Table 2. Parameters of sewing threads

Property	Type B	Type C	Type H	Type M1
Thread content	PA 6.6	PA 6.6	PES	PES
Actual thread density T [tex]	107,8	79,0	94,8	78,7
Twist [t/m]	347	409	375	416

For this research of effect of cyclic loading seams specimens sewn with the type of the seam 1.01.01/301[8], according to the required standard ISO 13935-1 [9] by lockstitch were prepared. The optimal pretension of upper and lower sewing threads (4 N and 1 N respectively) for quality seam was necessary to set up in sewing machine.

2.2. Applied device

The measuring system simulation of cyclic load has been used, figure 1. Measuring system for programmed measurement and evaluation of mechanical properties of liner and flat flexible materials consists of the measurement hardware with built-in measuring unit with the sensor system for testing tensile and cyclic load and their mechanical deformations [10]. It is composed of:



- Electromotor-servomotor
- Shaft
- Measurement system
- Upper fix jaw
- Lower movable jaw
- Analog-to-digital amplifier
- Control unit of motor
- Computer

Figure 1. Schematic illustration of measuring system of cyclic loading

The computer sends a command to controller. Then, from the controller the control signal transmit to the driver, which generates pulses to the windings of the motor coils, thereby to set it in motion. A force arises on the upper jaw as a result of the lower jaw motion. This force acts on the strain gage. An analogy signal is generated at the output of the strain gauge. Digital transmitter is used for processing this signal. The final results of measurements from digital transmitter transferred to computer.

3. Experimental part

The previously prepared sample was freely positioned centrally between the jaws. For simulation of real conditions of person sitting on the car seat, where mostly we talk about dynamic stress, jaw feed speed was set to 175 mm/s. Decrease of strength due to time and stress depending on specified extension was measured during the experiment. According to the tensile deformation of the experimental seam specimens, the tensile load was determined, corresponding to 20 %, 30 %, 40 % and 50 % of the average value of breaking extension of seam.

$$l_{average} = \frac{l_{\max B} + l_{\max C} + l_{\max H} + l_{\max M1}}{4};\ l_{average} \approx 25mm \quad (1)$$

where:

$l_{average}$ - mean value of the breaking extension of seam for all experimental samples with different types of thread

$l_{\max n}$ - mean value of the breaking extension of seam with a certain type of thread, where the n - type of thread

The breaking extension at seam rupture was determined according to [9].

3.1. Cyclic loading process

The diagram of cyclic loading process, which shows the decrease in strength on the time, is shown in the figure 2.

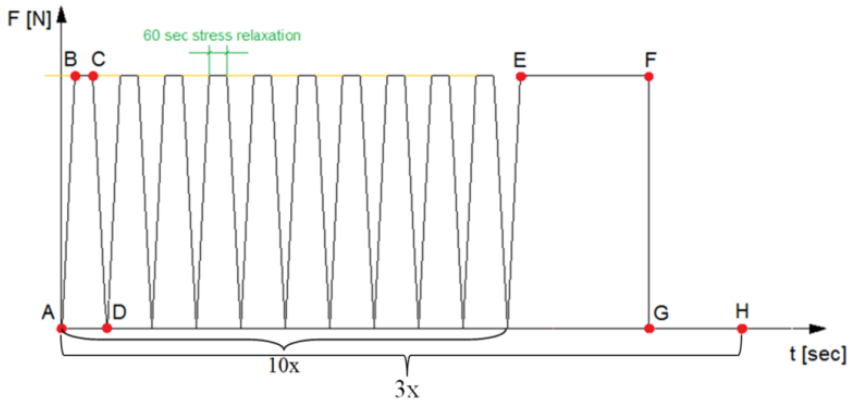


Figure 2. Diagram of cyclic loading process

After loading (AB) sample was remained in the position of stress relaxation for 1 min (BC). After this time the sample was unloaded (CD). This process was repeated 10 times. Stress relaxation followed subsequently during 20 minutes (EF). 10 min of relaxation is followed after unloading (GH). 3 repetition of whole process of cyclic loading was performed.

3.2. Evaluation of cyclic loading of seams

The result is a difference of decrease in sewing seam strength depending on the applied extension under cyclic loading. Based on the measured values, the variation decrease in seam strength due to stress depending on the applied extension was calculate according to [11]:

$$S_{fatigue} = \frac{X - Y}{X} \cdot 100 \tag{2}$$

where:

$S_{fatigue}$ – the magnitude of seam fatigue or the percentage of lost strength after specified number of cycles [%]

X - the maximum force at specified elongation during initial (fixed) repetition [N]

Y - the maximum force at the same specified elongation during follows (fixed) repetition [N]

To evaluate this occurrence in detail the deformation properties of sewing seams under cyclic loading were also determined according to EN 14704-1.

In this research, the difference in seam strength under cyclic loading between 1st and 2nd repetitions and 2nd and 3rd repetitions were calculated in percentage unit.

4. Results *and discussion*

The process of cyclic loading respectively dependence of the seam strength used type C threads for sewn to the elongation of specimen is shows in the figure 3 as stress-strain curve for the selected measurement with the specified extension (10 mm in this case).

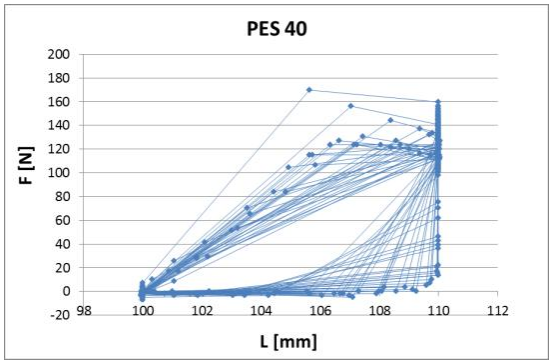


Figure 3. Stress-strain curve of cyclic loading

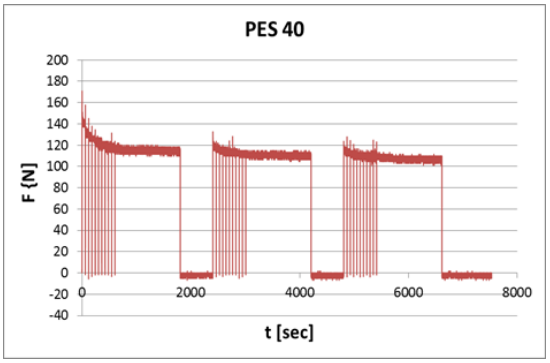


Figure 4. Cyclic loading of the sample at time

From the figure 4, that during the first repetition with 10 cycles and 20 min of stress relaxation, the cyclic curve is decreasing. During stress in 1st repetition of load the force needed for loading was decreased by 18.37%. After a 10 min of relaxation of seam sample, the load of the 1st cycle in 2nd repetition was increased to 7.5% and decrease to 15.72% after full 1st cycle. After 2nd complete cycle the load was increased to 2.8% in 1st cycle of 3rd repetition and the curve was decreasing in amount 3.5% if compare with 1st cycle of 2nd repetition. In all measurements with different size of prolongation and different type of threads used to sew the seams an analogy tendency was observed.

The results of differences in seam strength during cyclic loading for each type of thread with a defined extension are presented graphically in figure 5.

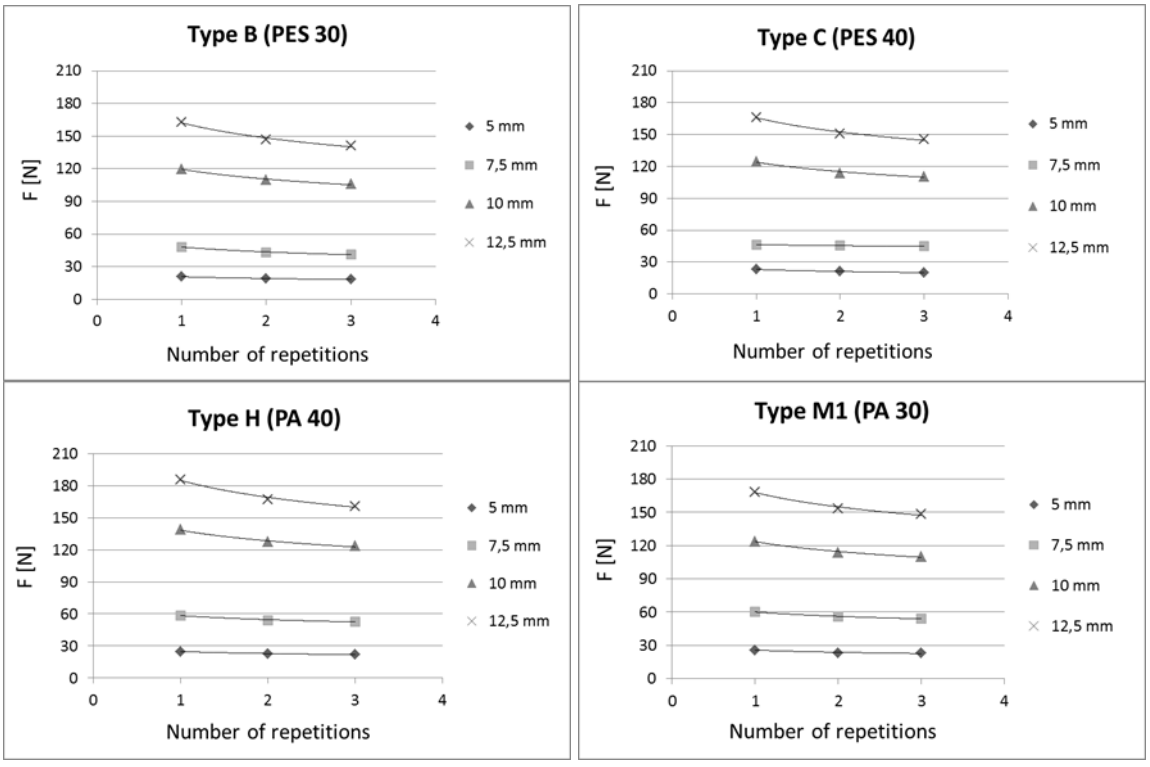


Figure 5. Comparison of the decrease in seam strength under cyclic loading for each type of thread with defined elongation

From series of experimentation of cyclic loading, it was revealed that the strength of the specimen decrease during loading in comparison with different size of elongation for each type of sewing seam.

From the figure 5, it is noted that there was greater difference between the 30 % and 40 % elongation as compared to the difference between 10 % and 20 %, and 40 % and 50 % respectively.

However, a decrease in seam strength was also observed for each seam along with incrementing number of repetition. It might be due to fact that larger elongation of the fabric damages its flexibility and there will be more stretching in the fabric seam in comparison to the fabric itself.

It was also witnessed that there was plastic deformation in all samples, however this deformation enhanced, when the elongation was around 12.5 mm.

From the figure 3 it is evident that with increase in value of elongation, the value of force required for loading of samples is bigger. At the same time, the decrease in stress forces between each repetition is obviously larger in the cases of bigger extension. With higher elongation which applied to the sample, the seam strength at each successive repetition is declining relatively quickly. The difference between loading value of each follows repetitions in case of lower deformations as 20% and 30% of the mean value of the breaking extension of seam for all specimens with different type of sewing treads much less, that in another cases.

5. Conclusion

In this research, the effect of thread properties on the cyclic loading of the car seat seam cover was carried out. The seam strength and durability under cyclic loading was measured for lockstitch seams

From the results, it was analysed that the cyclic loading decreases the seam quality and less stress is required to reach same extension even after 10 cycles.

Further, was investigate, that the seam samples made from PA 40 and PA 30 threads offer less resistance to the extension.

Having analysed effect of cyclic loading on sewing seams in car seat covers, it can be stated that with increasing number of cycles, the seam strength due to the influence of the stress was decreased. At the same time based on experimental results, which were closer to the real using conditions of seat covers, it can be expected, that with further increasing cycles, the strength due to stress will not change.

6. *References*

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Acknowledgments

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