IMPACT OF HEAT ON RECOVERY EFFICIENCY OF CAR SEATS FABRICS

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Abstract: *This paper deals with investigating performance of car seat fabrics in terms of their compression and recovery properties influenced by heat degradation. Polyurethane foam, nonwoven and 3D knitted spacer fabrics are commonly used as padding (in middle layer) in car seats cover. The current work presents an alternative approach to evaluate effectivity of car seat fabrics, namely behaviour of their middle layers before and after heat degradation which simulates hot summer condition. In summary, results show that 3D spacer is the most appropriate middle layer for car seat cover because of its recovery properties is very good at both before and after heat degradation (about 94% from original thickness) on the contrary PU foam. The PU foam is very good at recovery behaviour under standard ambient conditions (temperature about 25°C) on the other hand PU foam recovery significantly decreases (about 40% against 3D spacer) after impact of high temperature.*

Keywords: *car seats cover, compression, recovery, heat degradation.*

1 INTRODUCTION

There are approximately 3-5 kg car seat cover fabrics used in each car [1]. Car seat covers are often composed of several layers of different materials, usually polyester fabric (or leather or synthetic leather) laminated to polyurethane foam (or 3D knitted spacer or nonwoven) backing by an adhesive. Each part of car seat cover brings different properties which affect both their durability and comfort in automotive seating. One group of researchers prefer polyethylene terephthalate (PET) fibres for automotive application (both for top and middle layers) due to their superior properties, like a high tenacity, abrasion, light, heat and chemical aging, UV resistance, dimensional stability, recyclability etc. [2-5]. The others are in favour of modified PU foam (in middle layer) because of their excellent elasticity and very good recovery to compression [4]. Study on comparison of quality for different types of seat cover padding was carried out from aspects of physiological properties and relaxation behaviour after static and dynamic loading [6]. The result of this study showed that warp knitted spacer fabrics demonstrate better recovery to compression, better thermal properties and better breathability as compared to PU foam [6]. The other research found out that fabrics using monofilament as spacer yarn generally have higher compression resistance than multifilament yarns [2, 7]. Major car manufacturers evaluate degree of car seat durability, including relaxation behaviour after cyclic loading by special equipment, which uses the robot. This robot allows realistic simulation, of someone getting into and out of the seat (ingress/egress test), or of strong pulsation or vibration during driving [8]. The current study is focused on investigating performance of car seat fabrics in terms of their compression and recovery properties influenced by heat degradation which simulates hot summer condition.

2 EXPERIMENTAL

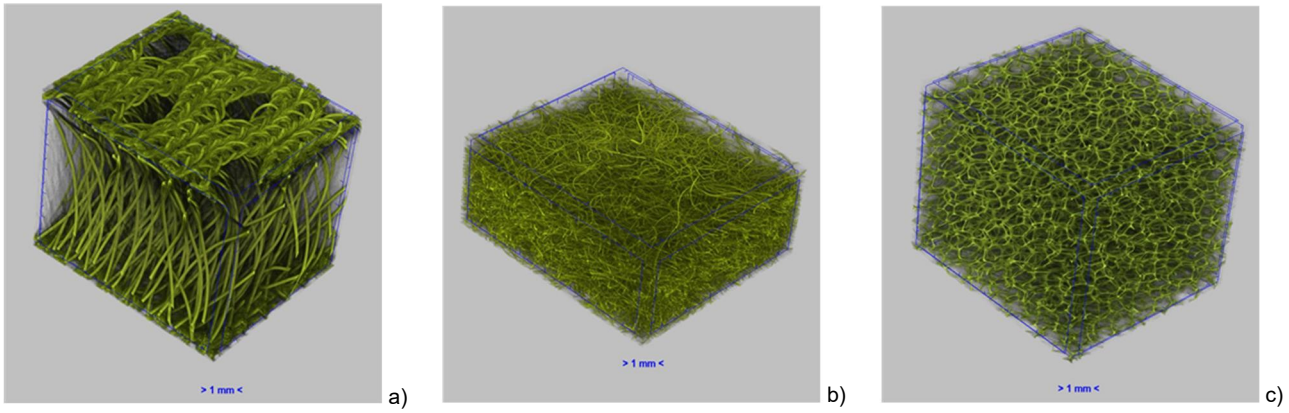
2.1 Materials

Tested materials were designed in order to understand the role of middle layer of textile sandwich car seats from point of view of their compression and relaxation behaviour. There were used different middle layers (polyurethane foam, nonwoven and 3D spacer) in the tested samples. Material in top layer was the same – PES woven fabric. Basic characteristics of all tested car seat fabrics are shown in Table 1.

The Figures 1a-1c show 3D structures of all tested middle layers by means of micro tomography system. Before being tested, the samples had been washed and conditioned for 24 hours. The measurement was carried out in an air-conditioned room under constant relative humidity of 65% and the temperature of 21°C. Measurements of thickness were performed under 100 Pa.

Table 1 Basic characteristic of the tested samples

Code	Structure	Raw material	Thickness [mm]	Weight [g/m^2]
		Top layer		
	woven fabric, twill	100% PES, twill	0.7	203
		Middle layer		
A	3D warp knitted spacer	100% PES	6.2	408
B	nonwoven	70% PES / 30% wool	5.7	230
C	foam	100% PUR	4.1	247



a) b) c)

Figure 1 a) 3D spacer, b) nonwoven, c) foam

2.2 Methods

The compression and relaxation behaviour were investigated before and after degradation of tested samples in autoclave which simulates hot summer conditions. It is important to uncover how cyclic compressive loading combined with above mentioned degradation influence recovery of car seat cover for the lifetime period.

The results were compared and discussed in order to understand the real performance of tested materials. Final values (means) of all tested parameters correspond to five measurements on average. The coefficients of variation for all tests do not exceed 10% and therefore not statistically significant.

Simulation of sample degradation by heat

Generally, the autoclave is a piece of equipment used for sterilizing various requirements in the lab by wet sterilization method. Car producer very often use this device for testing car seat fabric to simulate accelerated degradation by high temperature corresponds to hot summer conditions.

Principle autoclave is following. When water is heated in a closed container, saturated steam is produced under pressure. According to Boyle's Law, when volume of the steam is kept constant, the temperature is directly proportional to pressure. If the pressure is reduced, it boils at a lower temperature. If the pressure rises, it boils at a greater temperature. The autoclave Sano LA-MCS was used for degradation of samples, see Figure 3. Applied conditions for degradation were: 120°C during 20 hours.

Compression and relaxation behaviour

Repeated compression - recovery test was carried out by the device developed by Technical University of Liberec [9] as shown in Figure 2. This simple device consists of transparent Perspex cylinder (diameter of base is 14 cm) and pressure plate for set of required compression. Loading time was set to 24 hours and the pressure of static loading was 12 kPa. Value of pressure corresponds to maximum real loading of car seat during sitting of driver [10]. Relaxation behaviour given by the thickness recovery of samples was investigated after above mentioned compression test, when load was removed The measurement of recovery was carried out immediately, 10 min, 20 min, 40 min, 1 h, 2 h and 3 h after test. The referred compression - recovery test was repeated 5 times for each sample. The thickness of tested samples was measured by compression tester SDL M 034A according to EN ISO 5084 both before and after loading (pressure 1000 Pa). The recovery R [%] were determined by means of equations (1), see below. Recovery is given as the degree which a sample mass recovered to its original height upon unloading.

$$R = \left(\frac{h_2}{h_1}\right) * 100 \quad [\%] \tag{1}$$

where h_1 is the original height of the samples,
h_2 is the height of samples after removal of load.

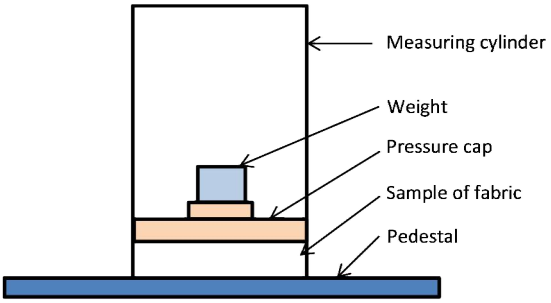


Figure 2 Schema of recovery measurement

Figure 3 SanoClave LA MCS

3 RESULTS AND DISCUSSION

The results of the recovery tests are presented in Figure 4 and Figure 5.

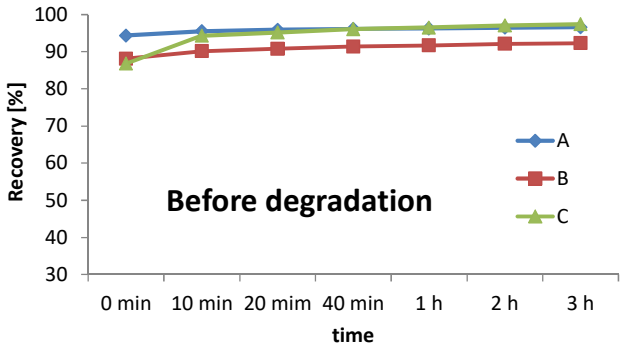


Figure 4 Recovery of tested samples before degradation

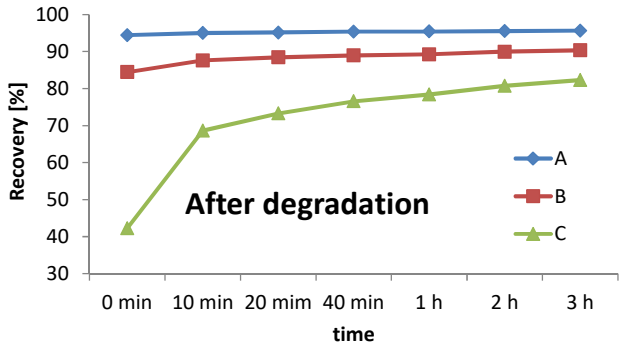


Figure 5 Recovery of tested samples after degradation

The results, as shown in Figures above, indicate that the difference between the groups was significant. The recovery before degradation of Group A (3D warp knitted spacer in middle layer) was equal to recovery after degradation, i.e. 94.4% immediately 96.2% after 40 min and 96.6% after 3 hours. Group B (nonwoven) reports decrease of recovery after degradation about 2% than before degradation. The impact of degradation was most pronounced in Group C (foam) when recovery before degradation was 86.8% immediately, 96.1% after 40 min and 97.4% after 3 hours and recovery after degradation was 42.2%, 76.6% and 82.3%.

4 CONCLUSIONS

The results of this study are consistent with data obtained in other researches which studied using of 3D spacer in car seat cover. The most obvious finding to emerge from this study is that 3D spacer is the most appropriate middle layer for car seat cover in view of the fact that its recovery properties is very strong in both before and after heat degradation (about 94% from original thickness) on the contrary PU foam. The PU foam is very good at recovery behaviour under standard ambient conditions (temperature about 25°C). On the other hand PU foam recovery significantly decreases (about 40% against 3D spacer) after impact of high temperature. PU foam is degraded by combination of hydrolysis and thermal oxidation, which causes shortening of the polymer chains. Further research could usefully explore compression and relaxation behaviour of tested materials using not static but dynamic loading. A further study might also focus on determining relaxation behaviour after lower degradation temperature than standardized 120°C.

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5 REFERENCES

1. Fung W., Hardcastle J.M.: Textiles in automotive engineering, Woodhead Publishing limited Cambridge, England, UK, 2000, 384 p., ISBN 9781855734937
2. Yip J., Ng S.P.: Study of three-dimensional spacer fabrics: Physical and mechanical properties, Journal of Materials Processing Technology 206(1-3), 2008, pp. 359-364, https://doi.org/10.1016/j.jmatprotec.2007.12.073
3. Koc K.S., Mecit D., Bozaci B., Ornek M., Hockenberger A.: Effect of filament cross section on the performance of automotive upholstery fabric, Journal of Industrial Textiles 46(3), 2015, pp. 1-15, https://doi.org/10.1177/1528083715598652

4. Jerkovic I., Pallares J.M., Capdevila X.: Study of the abrasion resistance in the upholstery of automobile seats, Autex Research Journal 10(1), 2010, pp. 14-20
5. Glombikova V., Komarkova P., Havelka A., Kolinova M.: Approach to evaluation of car seats fabrics performance, Industria Textila 69(2), 2018, pp. 96-103, ISSN 1222-5347
6. Ye X., Fangueiro R., Hu H., de Araujo M.: Application of warp - knitted spacer fabrics in car seats, Journal of the Textile Institute 98(4), 2007, pp. 337-343, https://doi.org/10.1080/00405000701489677
7. Chen S., Long H.R.: Investigation on compression properties of polyurethane-based warp-knitted spacer fabric composites for cushioning applications, Part II. Theoretical and experimental verification, Industria Textila 65(6), 2014, pp. 340-344
8. Stewart R., O'Bannon T., Müller M., Beeh F.: Creating the Next Generation Ingress/Egress Robot, SAE Technical Paper 1999-01-0628, 1999, https://doi.org/10.4271/1999-01-0628
9. Glombikova V.: Apparatus for measuring compressibility of volume textile structures, national utility model application, 2013, Application number: 2013-27589, Registration number: 25543, Website: http://isdv.upv.cz/webap/webap.pts.det?xprim=1949313&lan=cs&s_majs=&s_puvo=%25Glomb%C3%ADkov%C3%A1%2%20viera&s_naze=&s_anot=
10. Mazari F.B., Havelka A.: Pressure distribution of car seat at different angle of backrest, Vlákna a textile (Fibres and Textiles) 22(3-4), 2015, pp. 33-39