Comparison of different interlining materials of car seat cover under repeated loadings

DOI: 10.35530/IT.071.03.1704

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ABSTRACT – REZUMAT

Comparison of different interlining materials of car seat cover under repeated loadings

In this article, four most commonly used interlining materials (3D spacer fabric, non-woven felt, reticulated foam, and classic Poly-Urethane foam) are tested for comfort and durability. All four layers are tested initially for the air and moisture permeability, then for water vapour permeability under loading and finally tested for compressibility and durability. The repeated loading equivalent to real human pressure was inserted on the samples for 40,000 times to analyse the effect of repeated compression on the interlining materials. This research work gives a very in-depth knowledge of performance of car seat interlining material related to thermophysiological comfort and durability/lifetime.

Keywords: *3D spacer fabric, compressibility, thermophysiological comfort*

Analiza comparativă a diferitelor inserții pentru husele scaunelor auto aflate sub solicitări repetate

În acest articol, patru materiale de tip inserție utilizate cel mai frecvent (material distanțier 3D, material nețesut, spumă reticulată și spumă clasică din poliuretan) au fost testate din punctul de vedere al confortului și durabilității. Toate cele patru straturi au fost testate inițial din punctul de vedere al permeabilității la aer și vapori de apă, apoi din punctul de vedere al permeabilității la vapori de apă sub greutate și în final au fost testate din punctul de vedere al compresibilității și durabilității. Solicitarea repetată echivalentă cu presiunea umană reală a fost introdusă pe eșantioane de 40.000 de ori, pentru a analiza influența compresiei repetate asupra inserțiilor. Această lucrare de cercetare oferă o cunoaștere aprofundată a performanței inserțiilor pentru scaunele auto, din punctul de vedre al confortului termofiziologic și durabilității/duratei de viață.

Cuvinte-cheie: *material distanțier 3D, compresibilitate, confort termofiziologic*

INTRODUCTION

Generally, car seats are composed of the following elements:

- Metal structure;
- Filling, cushion padding;
- Seat cover:
  - Exterior fabric;
  - Foam (interlining);
  - Support material (reinforcement material) [1–2].

The parts of the car seat in cross-section view are shown in figure 1.

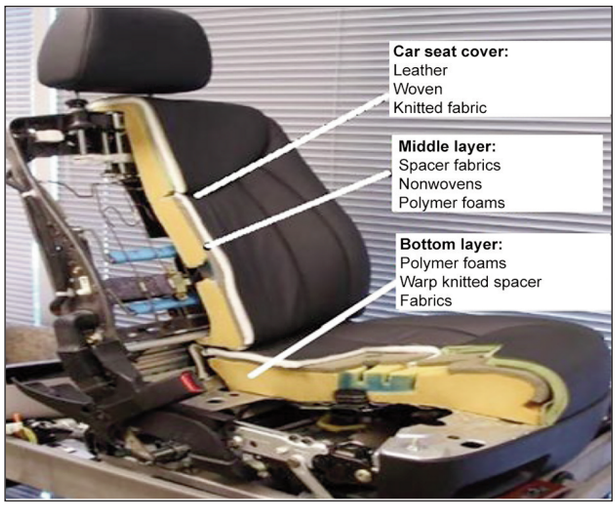

Fig. 1. The parts of the classical car seat [1-2]

On the top of metal frame, the most common filling material as a cushion is molded polyurethane foam. Polyurethane foam is commonly used as padding in car seats despite some problems concerning comfort and recycling. Their thermal properties are poor because they are not breathable [2]. Because of this problem, a lot of research has been made and today the new developments and the testing are going on to improve the thermal comfort of the car seats

Unlike regular, 2D fabrics, Spacer uses two separate fabrics, joined by microfilament yarn, to create a breathable, 3D free space between layers [3] as shown in figure 2.

Spacer textiles in upholstery are made from warp knitted (double-Raschel machine) or knitted (circular knitting machine) fabrics. Spacer structures have an elastic pressure behavior: by pressing on the surface they are compressed. When the pressure is released, they relax in an elastic way. The space between the two layers is an air-filled cavity from which the air is removed during compression, and into which air is sucked during decompression. Unlike foam constructions, these textile constructions are able to breathe [4–7].

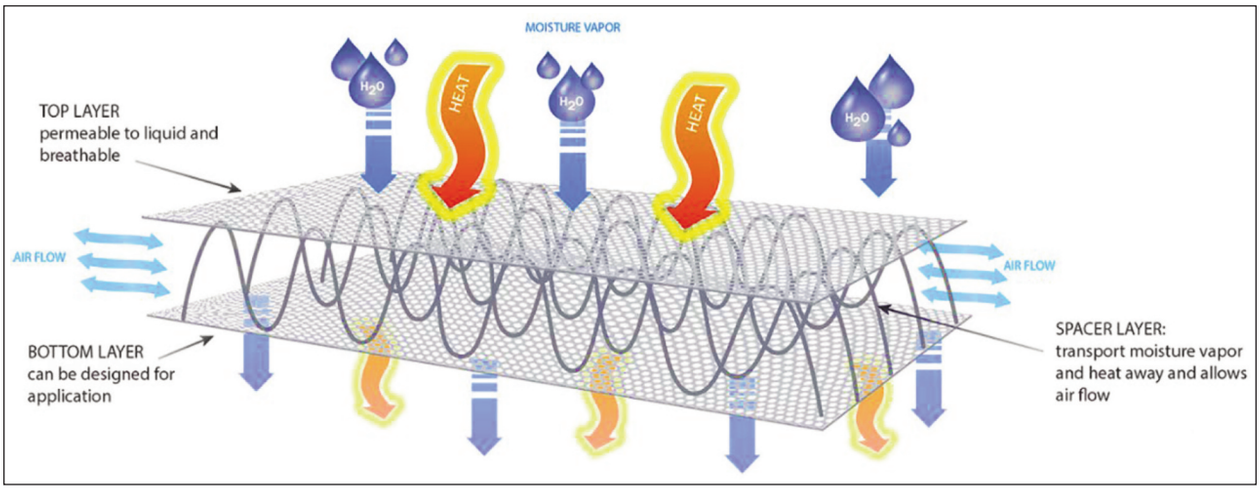

Fig. 2. 3D Spacer Knitted Fabric Schematic design [3]

For the car seat cover on the top of the cushion part of the car seat, many manufacturers find that a three-layer composite fabric is most successful in performance, costing, and in the process of upholstering or trimming the seat. The most common three layers are composed of a top layer which is polyester and a middle layer of polyurethane foam. The foam, varies from 3 millimeters to 12 mm, and it has function of absorbing the seat surface irregularities, improves the comfort (compressibility, resilience) and indicates the stitches of the sewing lines with an adequate depth [8]. The bottom layer is composed by a polyamide knitted scrim [9]. Knit Scrim material has the task to give the dimensional stability to sandwich structure, facilitates the sewing and seam resistance. It can be a polyamide mesh or polyester and a non-woven as well [10–14].

For the last layer of the car seat which is at the bottom is the polymer mesh fabric, highly used material is polyamide, but different polymers also can be used [15–17]. It is a high porous layer so that has high permeability. The biggest reason to use this layer is the PU foam, it smooth the back side of the PU so that the sewing and the covering of the car seat process is easier and faster.

EXPERIMENTAL PART

The seat cover of a car includes the following 3 layers, where: X is top fabric layer which touches the person/driver, Y is interlining layer (focus of research is on this layer), Z is thin porous polyester mesh and P is the thick PU form as cushion material (figure 3).

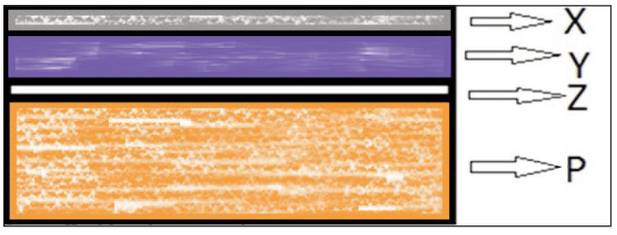

Fig. 3. Seat cover layers

The top layer's properties are shown in table 1. The car seat covers are made of multiple layers and Layer Y (figure 3) is responsible for the non-breathability of the car seat's cover material. Following different kinds of material are tested which are used as layer Y in car seat cover.

Table 1

TESTING OF INTERLINING MATERIALS	
Top layer backing material (layer Y)	**Thickness (mm)**
3D spacer fabric	5
Non –woven felt	5
Reticulated foam	5
Classic PU-foam	5

Considering the comfort part, we need the top layer to be highly breathable, the moisture and air permeability of top layer are shown in figures 4 and 5.

The air permeability is measured using the Air permeability tester (FX-3300) and SDLMO21S by using standard ISO9237 and the water vapour permeability is measured using the The sweating guarded hot plate, skin model (ISO 11092)

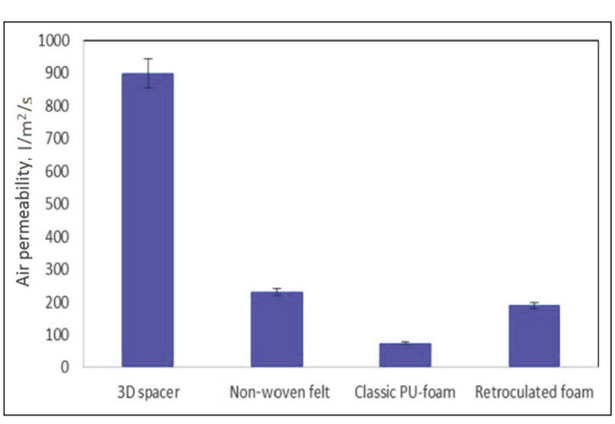

Fig. 4. Air permeability of top layers

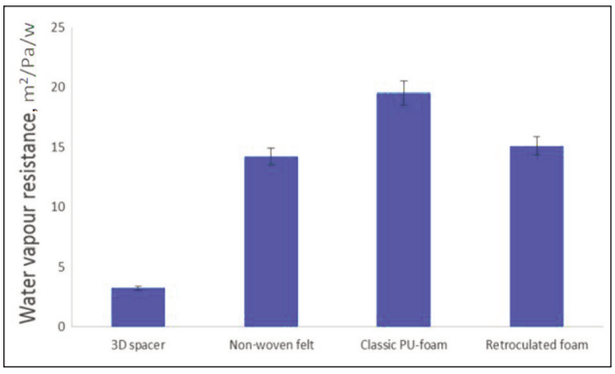

Fig. 5. Water vapour resistance of top layer

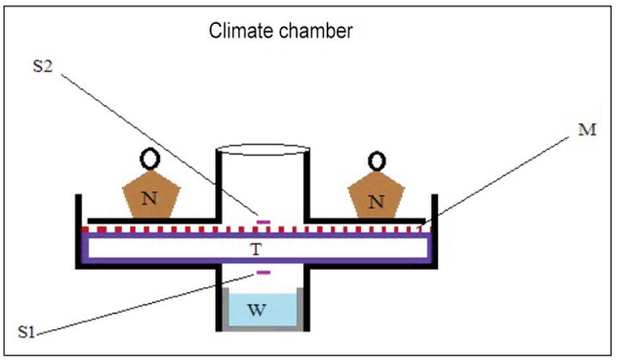

Fig. 8. Schematic diagram of the measuring device under load

It is visible for figures 4 and 5, that the 3D spacer fabric is highly permeable to air and has comparatively lower water vapour permeability.

IMPERMEABLE PU-FOAM

Lastly, it is clearly observed that the PU-foam is almost impermeable to air. The classic PU-foam and 3D spacer fabric are also examined under the X-ray tomography machine to see the internal structure of the material, and shows that the spacer fabric is almost open to movement of air whereas the PU-foam has a close pore structure and pores are not connected from one side to another face of the foam, which makes them impermeable to air.
The figures 6 and 7 clearly shows by X-RAY tomography that the PU-foam has closed pore structure which makes the material almost impermeable to the flow of air and moisture, where as in the case of the 3D space knitted fabric there is high porosity and the air can pass from one side to another side of the material which makes it highly permeable.

MEASUREMENT OF MOISTURE PERMEABILITY UNDER LOAD

The car seat cover materials are compressible, that means that their structure, porosity and thickness changes under load. A driver sitting on a car seat can totally change the defined performance of the car seat material.
A unique modification is made to the classical CUP METHOD for testing the moisture permeability with and without load. A self-fabricated frame is used to hold the testing material with a constant pressure on it by using perforated metal mesh (figure 8). In figure 8, W is distilled water for moisture source, T is the car seat cover material, N is the load on the sample, S1 and S2 are the humidity sensors and M is a porous sheet on the sample to apply even pressure.
Calculation of the water vapour transmission, and permeability is as follows.

$$WVT = \frac{G}{t \cdot A} \quad (1)$$

where G is weight change (g), t – time (h), A – test area of 20 cm^2, WVT – rate of water vapour transmission (g/h·m^2).
The experiment is performed in climate chamber with a controlled environment according to standard ASTM E 96-66. The sample properties are shown in table 2.

Table 2

SAMPLE PROPERTIES	
Sample	**Thickness (mm)**
3D spacer-1	10
3D spacer-2	5
PU-foam 1	5
PU-foam 2	3
Retroculated foam	5
Non-woven felt	5

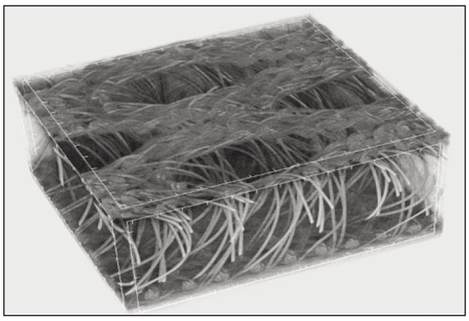

Fig. 6. X-ray tomography image of 3D spacer fabric

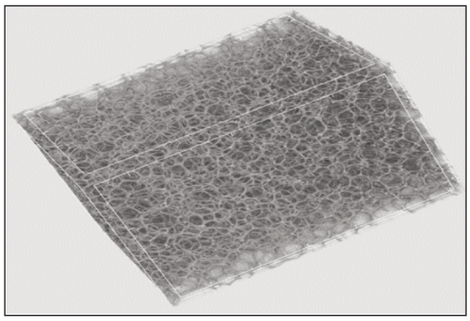

Fig. 7. X-ray tomography image of PU foam

To see the effect of the pressure on the moisture permeability the car seat materials are tested with and without loads. The moisture permeability of different car seat materials under two different pressure (5 and 10 kPa) and without pressure is

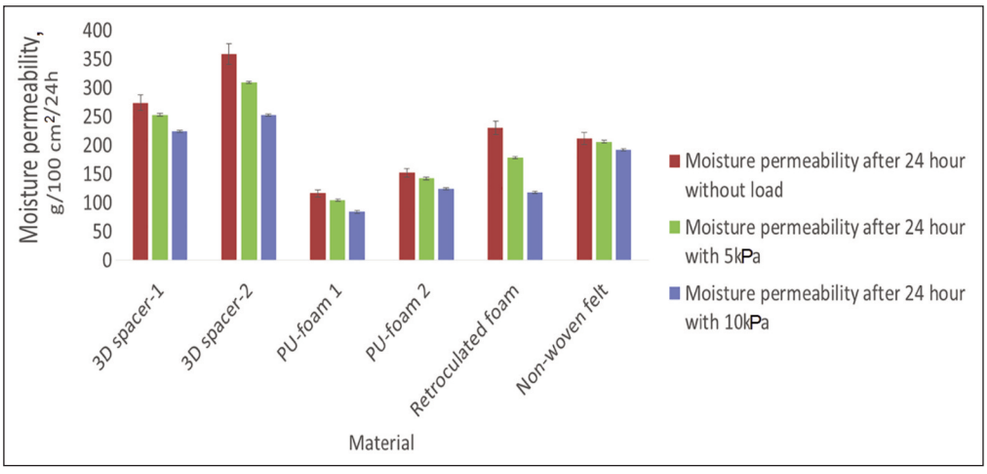

Fig. 9. Moisture permeability under load

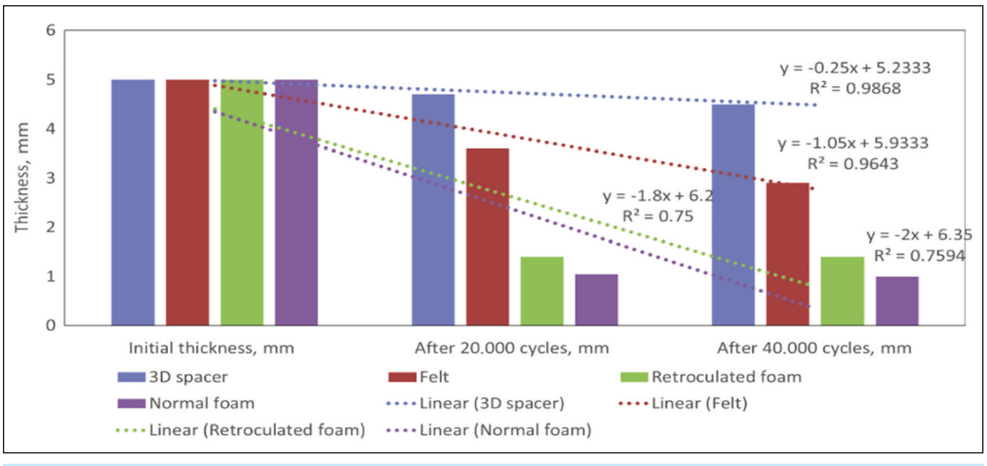

Fig. 10. Compressibility properties of the car seat cover

shown in figure 9. The experiment was performed 5 times for each sample and the error bars in the graph represent standard deviation.

The figure 9 shows that there is a significant effect of pressure on the permeability of the car seat material. This test method is unique and can show us experimentally how material behaves under load. It is visible that there is a significant decrease in moisture permeability when there is pressure on the car seat cover, which can be because of the closing of pores due to the pressure. All the materials are affected by the pressure but the permeability of 3D spacer is still higher as compared to any other material even after loading.

The effect of repeated loading of 40,000 cycles is shown in the figure 10 and 3D spacer shows better properties even after 40,000 cycles of repeated loading of 13 kPa.

Figure 10 clearly shows that the 3D spacer fabric has shown better compression properties and maintained its reasonable thickness after repeated loading of 40,000 times, followed by the nonwoven felt, reticulated foam and classic PU foam.

Whereas the classical PU-foam and reticulated foam loses its thickness in very early stages of the compression testing and then maintain a fixed compressed thickness. This shows that for the durability of car seats it's better to use 3D spacer or non-woven felt and considering the breathability, 3D spacer inhibit better performance than any other car seat material.

CONCLUSION

The research work shows an in-depth comparison of interlining car seat cover materials. Mostly the research focuses on the air and moisture permeability of different layers related to comfort. But in this research the performance of textile layers after static pressure and also compressibility properties of material after repeated loadings is tested. The results show that the 3D spacer fabric is the most permeable, followed by reticulated foam, non-woven web and classic PU foam, respectively. This research shows that 3D spacer fabrics are good alternatives for classic materials with better thermo-physiological comfort properties and better lifetime.

ACKNOWLEDGEMENT

This work was supported by the Ministry of Education, Youth and Sports in the Czech Republic under the "Inter

Excellence – Action programme" within the framework of project "Micro-struCtural imaging as a Tool for modelinG fibrOus materiALS (μ-CT GOALS)" (registration number LTAUSA18135).This work was also supported by the Ministry of Education, Youth and Sports of the Czech Republic and the European Union – European Structural and Investment Funds in the frames of Operational Programme Research, Development and Education – project Hybrid Materials for Hierarchical Structures (HyHi, Reg. No. CZ.02.1.01/0.0/0.0/16_019/0000843).

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