Comparing Properties of the Warp-knitted spacer fabric instead of sponge for automobile seat fabric

Yan Guo*1, Lin Chen 2, Sheng Qiang3, Xian Qian4, Tao Xue1, Fang He1
1School of Textile Science and Engineering, Xi’an Polytechnic University, JINHUA south road, XI’AN, SHANNXI, China
2Shaanxi Textile Science Institute, FANGZHICHENG west road, XI’AN, SHANNXI, China
Email: xaguoyan@126.com

Abstract. The warp-knitted spacer fabric is a new material for automobile seat fabric that can replace sponge in recent years. But its properties of the strength and recovery are very important in laminated car seat fabric. In this paper, the breaking and tearing strength, stress-strain relation was tested and compared. It could be seen that the warp-knitted spacer fabric had excellent performances in strength of breaking and tearing, better air permeability than same thickness sponge. Therefore, it is a good material to replace sponge. Meanwhile, when its thickness was 6mm, the warp-knitted spacer fabric had better ability in the breaking strength, tearing strength, air permeability and the elastic recovery, so it could be used to instead of sponge in lamination car seat fabric for middle layer.

1. Introduction
With the progress of society, people would pay attention to the environment friendly of automobile materials gradually. According to the Recycling Guide for Future Scrapped Automobiles in the United States, the recycling utilization rate of scrapped automobile should be no less than 95% by 2020[1-2]. The European Union's End-of-life Vehicle directive stipulates that after 2015, all Vehicle components must be recyclable over 95%. According to China's "Automobile Product Recycling Technology Policy", the material recycling rate of all automobiles should reach about 90% [3-5]. So, the environmental protection and recyclability of automobile material have become an important thing. The recycling problem and environmental protection problem must be considered in design the car sea textile. In composite fabric of car seat, material of middle layer has an important role of supporting frame, it’s the mechanical properties, compression resilience, slow pressure performance is very important and usually adopt polyurethane foam (commonly known as sponge), but this material is flammable, has poisonous gasses in car spontaneous combustion so that people can lose the chance to escape. A new material is warp knitted spacer fabric as middle layer for car seat cover instead sponge [6-11]. In this paper, the performance of warp knitted spacer fabric and sponge was tested and compared to apply this material in car textile production.
2. Experimental

2.1. Materials parameters
To compare the performance of warp knitted-spacer fabric and sponge, analyse the association in the structure parameters of warp knitted-spacer fabric and its performance, to choose suitable warp-knitted spacer fabric to replace sponge as the middle layer of laminate automobile seat fabric, several the test samples were selected, which were warp-knitted spacer fabric (WSF) and sponge with the same thickness. The parameters of samples were showed in Table 1. Sample NO.1 to NO.4 were warp-knitted spacer fabric and made from polyester, its thickness from 4mm to 10mm. Sample NO.5 to 8 were the sponge, its thickness from 4mm to 10mm too.

| Sample No | Material type          | Yarn count | Density / ends (10cm) | Thickness /mm | Density of spacer silk /ends.cm^-2 | Surface density /g.m^-2 |
|-----------|------------------------|------------|-----------------------|---------------|------------------------------------|-------------------------|
| 1         | WSF(Warp-knitted spacer fabric) | Surface 300D/72F | 90 | 100 | 4 | 43 | 272.5 |
| 2         |                        | Spacer 0.22mm polyester | 85 | 83 | 6 | 65 | 396.0 |
| 3         |                        |             | 80 | 90 | 8 | 97 | 502.3 |
| 4         | Sponge                 |             | 120 | 110 | 10 | 163 | 518.9 |
| 5         |                        |             | / | / | 4 | / | 194.3 |
| 6         |                        |             | / | / | 6 | / | 255.1 |
| 7         |                        |             | / | / | 8 | / | 305.5 |
| 8         |                        |             | / | / | 10 | / | 420.3 |

2.2. Instruction and methods
(1) The instruments were used for experiments, such as UTM4304 Electronic Universal Experimental machine (Shenzhen Sansi-zongheng Technology Co., Ltd., Shenzhen, China), YG026-500 Fabric Strength Tester (Changzhou Shuangguudun Da Electromechanical Technology Co., Ltd., Changzhou, China), YG461L Type Digital Fabric Permeability Tester (Shanghai Biaozhuo Scientific Instrument Co., Ltd., Shanghai, China).
(2) The performances of samples were tested by standards that were GB/T3917.3-2009, Part 3: Determination of Tearing Strength of Trapezoidal Sample, GB/T 5453—1997 Textiles-Determination of the permeability of fabrics to air, and GB/T24442.1-2009 "Determination of Textile Compression Performance Constancy method"[5].
(3) Warp knitted spacer fabric and sponge samples were placed in an experimental environment with temperature (27±2) °C and relative humidity (65±5) % for 24h.

3. Results and Discussion

3.1. Comparison of tensile properties
Figure. 1 showed that the warp knitted-spacer fabric’ breaking strengths of direction warp and weft were better than same thickness ‘s sponge, because warp knitted-spacer fabric was made of polyester and had knitting fabric structure, while sponge was polyurethane foam material and same strength in all directions. Meanwhile, the surface of spacer fabric was woven for different warp and weft densities, which would lead to the difference of tensile breaking strength and affect its tensile breaking strength. Figure. 2 showed that the breaking elongation reached the best, when the thickness of warp knitted spacer fabric was 8mm. In general, the strength of warp knitted spacer fabric was obviously better than sponge of the same thickness. So, replacement of sponges was possible, and 6mm and 8mm WSF perform well in terms of strength, elongation at break. But, from Table 1, this was significantly related to the surface density and warp/weft density of the WSF. Therefore, 6mm and 8mm WSF can be used as alternative materials.
3.2. Comparison of tear performance
The tearing strength of warp knitted spacer fabric was better than sponge too. According to the Figure 3, when the thickness of warp knitted spacer fabric was 8mm, the tear strength of reached the best. It could also be seen that the tearing strength of 6mm and 8mm thickness warp knitted spacer fabric was equal basically.
3.3. Compression recovery of materials

Compression performance was one of the main physical and mechanical properties of textile materials. The compression performance of the laminated seat cover fabric mainly depended on the sponge or warp knitted spacer fabric and compression resilience could directly determine the driver’s sedentary comfort. The compression process of material was related to the structure. Figure 4-7 were curve of different thickness materials in compression stress-strain relation. From Figure 4–7, (a) was stress-strain relation curves of warp knitted spacer, (b) was stress-strain relation curves of sponge. When the same thickness, it could be seen that: (1) In the linear compression stage, the elastic modulus of sponge was greater than warp knitted spacer fabric, which was not easy to be compressed; In yield and compact stages, warp knitted spacer fabrics showed behavior of compressive resistance; (2) When the material was completely compressed, the stress of warp knitted spacer fabric was stronger than sponge and its compressive resistance was better than sponge in general; (3) When the pressure removed off, recovery speed of the sponge was slowly, but its recovery ability was better; (4) The maximum stress of warp knitted spacer fabric decreased with thickness of materials, which was related to density of spacer silk spacer, surface density. The thickness in 6mm and 8mm showed better compression resistance and elastic recovery during compression.

![Compression stress-strain relation curve of 4mm materials](image1)

![Compression stress-strain relation curve of 6mm materials](image2)
3.4. Comparison of permeability

Figure 8 showed that the air permeability of warp knitted spacer fabric was better than sponge, because it had knitted structure and space between yarns. And the air permeability of both two materials decreased with thickness increasing. The air permeability of warp knitted spacer fabric was related to
the surface fabric's density, structure, and spacing silk density. With increases the thickness, the spacing silk density would be increased to provide enough support force.

4. Conclusions
(1) In condition of the same thickness, the warp-knitted spacer fabric had excellent performance in breaking strength, tearing strength and the air permeability. Meanwhile, from stress-strain relation curve, although the elastic recovery of warp knitted fabric was slow, it could stand more pressure. Therefore, it is a good material to replace sponge.
(2) By comparing properties of the warp-knitted spacer fabric in different thickness, the 6mm warp-knitted spacer fabric had excellent comprehensive properties, it could be used in lamination car seat fabric for middle layer.

Acknowledgement
This paper was supported by the Key Research Projects of Shaanxi Province in 2020(NO.2020GY-267) and by the Directive Project of China Textile Industry Federation (No. 2018061) too.

References
[1] CHEN R, LIAO Q B, MAO Y, et al. The development orientation of textiles for automobile after the recycle technology policy for automobile and related has been implemented [J]. Technical Textiles, 2010, 28(8) : 35-38.
[2] GUO Q, YU C W. A research of status quo and tendency of materials for vehicle interior textiles [J]. Shandong Textile Economy, 2012(2): 53-55.
[3] MIAO Xuhong, GE Mingqiao. Indentation force deflection property of cushioning warp-knitted spacer fabric [J]. Journal of Textile Research, 2009, 30(5):43-47.
[4] JIN L Y, CUI Y H, DU S. Composite techniques of automobile seat cover fabrics and its influencing factors [J]. Journal of Textile Research, 2013, 34(1) :151-156.
[5] GUO Xiao fang, LONG Hai-ru. Compression Properties of Warp Knitted Spacer Fabrics Based Spacer—Yarn Arrangement Modeling [J]. Journal of Donghua University (Natural Science), 2013,39(2):175-180.
[6] WU-junjuei. Study on properties of warp knitted spacer fabric with slow compression [D]. Donghua university, 2015.
[7] CHEN M Y, WANG H H, ZHOU Y Y, et al. Optimization of spacer filament parameters by compressive property variation [J]. Textile Research Journal, 2018, 88(9) : 1614-1622.
[8] ZHANG X H, Y D W, MA P B, et al. Compression fatigue resistance of automobile cushion fabric based on three-dimensional warp-knitted spacer structure[J]. Journal of Textile Research, 2017, 38(5) : 64-68.
[9] CHEN M Y, LAI K, SUN R J, et al. Compressive deformation and load of a spacer filament in a warp-knitted spacer fabric[J]. Textile Research Journal, 2017, 87(5) : 631-640.
[10] CHEN M Y, SUN R J, ZHANG C Q, et al. Pressure reduction property of warp-knitted spacer fabric[J]. Journal of Textile Research, 2019, 47(7) : 58-63.
[11] ZHANG X X , CHEN M Y , WU H L. Performance analysis of warp-knitted spacer fabric in medical nursing pad [J]. Journal of Xi'an Polytechnic University, 2018, 32(2) : 132-137.