Development of the Warp Knitted Spacer Fabrics for Cushion Applications

XIAOHUA YE, HONG HU* AND XUNWEI FENG
College of Textiles, Donghua University
Shanghai 200051, PR China

ABSTRACT: Polyurethane (PU) foam is a common material used in seats, sofas and mattresses, etc. However, the use of PU foam presents some problems concerning comfort and recycling. Compared with PU foam, warp knitted spacer fabrics can solve these problems. This paper presents work in the development of the warp knitted spacer fabrics for cushion application. Three kinds of the properties, i.e., pressure distribution, air permeability, and heat resistance of the fabrics developed are evaluated and compared with those of the PU foam. The results show that the warp knitted spacer fabrics have better pressure relief properties, higher air permeability, and lower heat resistance than PU foam, and thus could be used to substitute PU foam, especially in the case where the comfort and recycle are highly required.

KEY WORDS: warp knitting, spacer fabric, compressibility, cushion, padding material.

INTRODUCTION

POLYURETHANE (PU) FOAM has widely been used as padding material in seat, sofa, and mattress manufacturing for many years due to its good compression characteristics. However, PU foam is not an ideal and unique material to be chosen in these applications. Besides difficulty for washing, the use of PU foam can also cause some problems concerning comfort and

*Author to whom correspondence should be addressed.
E-mail: huhong@dhu.edu.cn

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recycling [1,2]. PU foam normally has very low air permeability. In some occasions, PU foam makes people feel too warm and fuggy, especially in the warm environment. PU foam also delivers out poisonous gases during burning. Disposing of the products made of PU foams also creates a big problem because PU foam must be separated from other materials. This makes recycling process of PU foam very complicated. In order to overcome these shortcomings, different attempts have been made, for example, by using special cutting process to give PU foam 'open' surface and by adapting high porosity to enhance its 'breathability' [2]. Even with these efforts, most of the problems with PU foam can not be solved thoroughly.

In recent years, the use of technical textiles has grown very fast. These fibrous materials, which have a variety of technical end uses may be used to substitute some conventional materials with advantages in specific applications [3]. Warp knitted spacer fabrics (WK spacer fabrics) are in this class and they are very interesting structures, which could be used to substitute conventional PU foam used in seats, sofas and mattresses, etc. The advantage of WK spacer fabrics consists in the combination of good compressive characteristics, air permeability, and thermoregulation by their unique 3D structure. WK spacer fabrics can easily be recycled because they are also made from fiber materials, and thus they can overcome the recycling problem presented by PU foam.

Although a lot of investigations have been made for WK spacer fabrics, there are still few detailed works on the thick WK spacer fabrics for cushion applications. The objective of this work consisted in developing this kind of WK spacer fabrics, which could be used to substitute PU foam for cushion application. The properties of the fabrics thus developed were also evaluated and compared with those of the PU foam.

STRUCTURE CHARACTERISTICS AND KNITTING PROCESS

A WK spacer fabric consists of two surface layers and a layer of the yarns called as spacer yarns. As shown in Figure 1, the spacer yarns connect two surface layers to form a special 3D structure. For cushion application, the spacer yarns also play a supporting role and avoid the 3D structure to be crushed under body pressure. It is evident that selecting spacer yarn with proper bending rigidity and connecting method between two surfaces are very important during the structure design.

WK spacer fabrics are normally produced on the warp knitting machine with two needle-beds and six yarn guide bars. As shown in Figure 2, while bars 1, 2 and bars 5, 6 are respectively used to knit the front and back surface layers, bars 3 and 4 are used to knit the spacer yarn layer. In order to

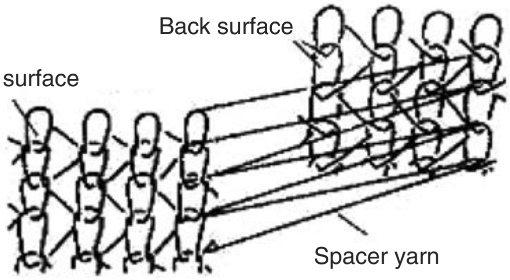

FIGURE 1. 3D Structure of a warp knitted spacer fabric.

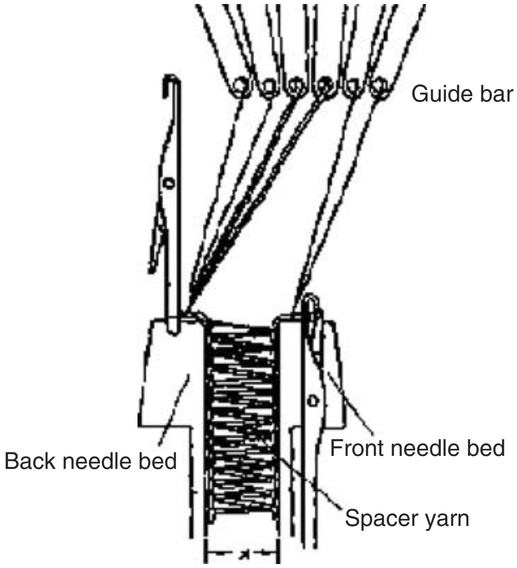

FIGURE 2. Warp knitting machine for spacer fabric.

connect two surface layers together, bars 3 and 4 must feed the spacer yarns on both front and back needles. They normally make symmetrical lapping movements to get better connecting effect.

There are different methods used to connect two surface layers. Figures 3 and 4, respectively show two commonly used connecting methods. In Figure 3, the two surface layers are connected by the vertical spacer yarns. However, the structure with this kind of the connection is not very stable because the spacer yarns tend to incline along the horizontal direction under the pressure. In order to enhance the stability of the structure, the two surface layers are normally connected with two systems of the symmetrical inclined spacer yarns, as shown in Figure 4. The different inclination angles of the spacer yarns can be obtained by changing the underlap amounts of

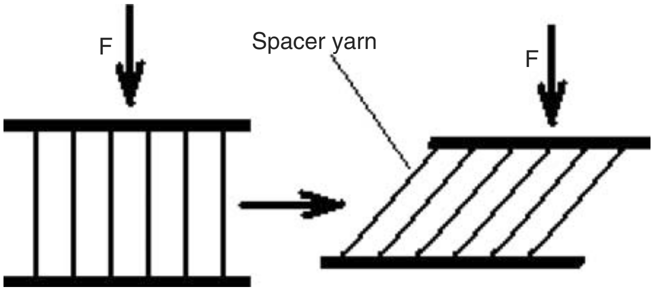

FIGURE 3. Connection with vertical spacer yarns.

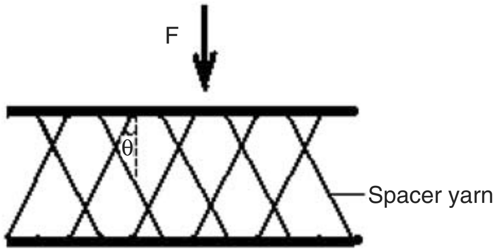

FIGURE 4. Connection with inclined spacer yarns.

the spacer yarns in order to satisfy different end-use requirement. It is evident that the bigger underlap will lead to higher inclination of the spacer yarns.

Besides different connecting methods, the two surface layers of a spacer fabric can be knitted with same or different structures. For the commonly used spacer fabrics, two surface layers are normally knitted with same structures. The surface structures can be plain structures or meshes with different opening sizes. One of the commonly used structures is a mesh structure formed with pillar and laying-in yarns as illustrated in Figure 5. This structure is widely used in the spacer fabrics for cushion application because it gives not only good structural stability but also good air permeability.

The space between two surface layers is also an important structural feature of a WK spacer fabric. For cushion application, higher fabric thickness is needed. According to different application situations, the thicknesses of the cushions may vary from 10 to 100 mm or higher. However, the thickness of WK spacer fabrics is limited by the distance between the two needle-beds of the warp knitting machine. The thickest spacer fabric currently produced on the warp knitting machine is about 65 mm. There are three different kinds of the distance arrangements between

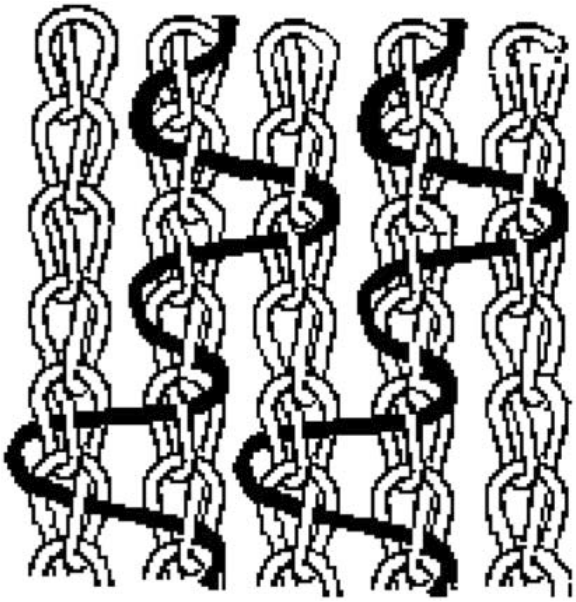

FIGURE 5. Diagrams of a mesh surface formed with piller and laying-in yarns.

the two needle-beds of the warp knitting machines: 3–12 mm, 12–30 mm, and 25–65 mm. For some cushion application situations, two or more layers of WK spacer fabrics are needed to be put together to obtain higher thickness, because the spacer fabrics with very high thicknesses are more difficult to be knitted.

PRODUCTION OF THE SAMPLES

The WK spacer fabrics developed for cushion application in this work were produced on a Karl Mayer Raschel machine RD 6 DPLM/30 with two needle-beds and six guide bars. The gauge of the machine was E16. Although the distance between needle-beds of the machine could vary between 12 and 30mm, this distance was set at 20mm and fixed during the production of all the samples.

One kind of PES multifilament and two kinds of PES monofilaments were respectively selected as the surface layer yarn and spacer yarns. According to the machine gauge and thickness of spacer yarn, 400 dtex PES multifilament was selected for knitting the surface layers. However, for the spacer yarns, as they have to support the body pressure, the use of the yarns with high bending rigidity is required. Because of this, PES monofilaments with two

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