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Experimental Analysis of Spherical Compression of Warp-Knitted Mesh Spacer Fabrics

Pengfei Liu, Yunmei Wu, Guanyi Lu, Xiao Liu, Hongling Liu, Zhaoqun Du*

Key Laboratory of Textile Science & Technology, Ministry of Education, College of Textiles, Donghua University, Shanghai 201620, China

Abstract

Warp-knitted mesh spacer fabrics are widely used as seat mattress for their excellent pressure-relief performance and heat and moisture comfortability; however, action and reaction between human body and spacer fabrics are still not well-known, which is attributed to the unknown contacting geometry. The main content dealt with in the paper is to measure surface geometry of warp-knitted mesh spacer fabric under spherical compression, and also to discuss the influence of sphere with different diameters on compression behaviour. Resin curing method was utilized to fix the surface geometry of compressed warp-knitted mesh spacer fabric, so as to obtain surface geometry functions of spacer fabrics. Experimental results demonstrate that the cross-sectional curves of both the non-contacting part and contacting part are exponential function and circular function, respectively. Moreover, correlations of maximum compressional strain between spherical compressions from different spheres were calculated, which reveals that there exist a good correlation between maximum compressional strain decrease and increasing diameter of sphere. The paper is helpful for studying compression behavior of warp-knitted mesh spacer fabrics and its interaction with different parts of the body in mattress materials.

Keywords: Spacer Fabric; Contact Geometry; Spherical Compression; Compression Strain

1 Introduction

Warp-knitted mesh spacer fabrics are constructed by two separate warp-knitted mesh fabrics which make the upper and bottom layers, and flexible filaments which make the middle layer. They are designed into special textile mattress products as they possess valuable properties such as the ability to create a large void volume in the middle layer, and having better pressure distribution, air permeability and heat conductivity than Polyurethane foams [1] used in bed mattress, seat mattress, transportation and bra support. These intimate textile products are greatly dependent on the compression behaviour of spacer fabric. It necessitates many researchers to investigate physical and compression properties under low stress by manufacturing different

*Corresponding author.
Email address: duzq@dhu.edu.cn (Zhaoqun Du).

structure spacer fabrics; wherein, functional mattresses and wheelchair are greatly processed as pressure release products for reducing peak pressure to avoid the pressure concentration on the body [2-5].

In order to effectively assess the ergonomic performance of warp-knitted mesh spacer fabrics in relation to the different shapes of the human body, the action and reaction between body part and spacer fabrics are simulated in the interaction between sphere and spacer fabrics. There are two major reasons to adopt sphere to simulate parts of the human body. Firstly, spacer fabric is not only used as cushion but also used as mattress for protecting kneecap and cuff. The human parts contacting with spacer fabric are also almost arc-shaped, as a result, it is necessary to feature an effective and convenient method, i.e., the use of standard sphere to simulate parts of the human body. Secondly, a standard method is needed to evaluate the compression properties when compressing spacer fabric by adopting sphere to simulate the human body, which helps to set up a compression theoretical model to better analyze relations between spacer fabric structure and compressional property. It is also important to understand compression properties under different spherical compression conditions. Although several experimental and theoretical investigations on the compression properties of knitted spacer fabrics have been carried out [6-10], these investigations focuses on the compression behavior under plane and spherical compression. However, there are few papers reporting contacting geometry and non-contacting geometry between sphere and spacer fabric, which is important in demonstrating pressure distribution, air permeability and heat conductivity of spacer fabric under compression. Moreover, warp-knitted mesh spacer fabrics are widely used as seat mattress for excellent pressure-relief performance; however, the action and reaction between human body and spacer fabrics are still not well-known, due to unknown contacting geometry.

The present paper aims to obtain both the contacting geometry and the non-contacting geometry between warp-knitted mesh spacer fabric and sphere under spherical compression. The spherical compression tests are conducted and the compression strain at the maximal compression point of the spherical ball are calculated based on Hertz theory developed for elastic homogeneous materials, and effects of sphere diameter on compression properties are analyzed by maximum compression strain of spacer fabric under spherical compression.

2 Experimental

2.1 Sample Preparation

Five warp-knitted mesh spacer fabrics with double-sided symmetrical surface structures and various mesh size were selected and labeled as A, B_1, B_2, C and D. They are all manufactured by warp knitted technology, where the feeding forms of yarns of the two surface layers are selected as chain stitch and weft inlaid yarns. Spacer yarns are knitted into the chain stitch structure of the upper surface and bottom surface to connect the two surfaces into a whole fabric. Mesh size in the upper and bottom surfaces are designed to be different varying from 11.5/10 cm to 25/10 cm to study effects of mesh size on contact geometry. These samples were balanced at a standard condition (20 ± 3 °C, $65 \pm 5\%$ RH) for over 24 hours, and the experiments were conducted on the above standard condition. The specifications of samples are listed in Table 1 and surface structures of samples are shown in Fig. 1.