The Biaxial Tensile Elastic Properties of Plain Knitted Fabrics

Yi-Ping Zhang[1, 2*], Hai-Ru Long[1]

[1]*College of Textiles, Donghua University, Shanghai, 201620, P.R. China,*
[2]*Henan Institute of Engineering, Zhengzhou, Henan, 450007, P.R. China,*

Abstract: The biaxial tensile elastic properties of polyester and cotton plain knitted fabrics were investigated. Firstly, these fabrics were tested on a biaxial tensile instrument and subjected to biaxial extension at a fixed extension or a fixed load; the result shows that the coursewise and walewise stress and strain of fabric samples were affected by each other. Then the strip biaxial tensile (the fabric is stretched in one direction and the other direction is restricted) elastic properties of plain weft-knitted fabrics were measured at a fixed extension. An analytical model was used to predict the strip biaxial tensile property, and the theoretical predictions agree well with the experimental data.

Keywords: Plain knitted fabrics, biaxial extension, elastic properties, fixed extension.

1. Introduction

The biaxial tensile elastic properties of knitted fabrics play an important role both in processing and in end use of knitted materials. Moreover, the elastic properties of knitted fabrics influences the garment design and wearer comfort. Some papers presented the research on the uniaxial tensile elastic properties of knitted fabric [1-6], especially plain knitted fabrics, because of its basic structure.. This paper investigated the biaxial tensile elastic properties of polyester and cotton plain knitted fabrics.

Firstly, these fabrics were tested on a biaxial tensile instrument and subjected to the biaxial extension at a fixed extension and a fixed load; the result shows that the coursewise and walewise stress and strain of knitted fabrics were affected by each other. Then the strip biaxial tensile [7,8] (the fabric is stretched in one direction and the other direction is restricted) elastic properties of plain weft-knitted fabrics were measured at a fixed extension by a biaxial tensile tester, the result shows that this is a practical method.

2. Experimental

2.1 The biaxial tensile tester

To perform the test, a homemade biaxial tester was used [9]. The fabrics were subjected to equal biaxial extension ($\varepsilon_x=\varepsilon_y$) on a biaxial tensile instrument during testing, the tensile speed is at a constant rate (100mm/min) both in the wale and in the course direction, either during extension or return. Each sample size was set to 150 mm × 150mm and the testing size was 100 mm × 100mm.

2.2 Samples

Both polyester and cotton plain knitted fabrics were used to investigate their tensile elastic properties; the specifications are listed in Table 1. All samples were prepared and conditioned at 65% relative humidity and temperature of 20 ℃ for 24 hours before measuring. The preloading force was 1N to tighten the sample. Each testing was repeated for five times.

Table 1 Specifications of knitted fabric samples

No.	Yarn Specifications	Stitch Length l(mm)	Stitch density	
			P_A (Wales /50mm)	P_B (Courses /50mm)
1#	18tex Cotton	3.168	73	90
2#	11.1 dtex/36f PET	2.800	62	105

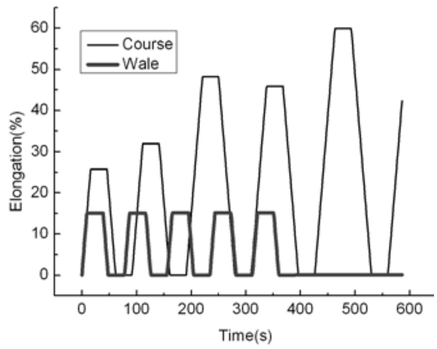
2.3 Testing

There are two different ways of tensile elastic tests: one is that the fabric is stretched to a fixed load of 10N for 30min, the jaw was returned to the initial pretension for 30min, the samples are cycled to the given load five times; the other one is that the fabric is held at a fixed extension of 15% for 30min, the jaw was returned to the initial length for 30min, the samples are cycled to the given load five times. The sample is clamped and is stretched along the walewise

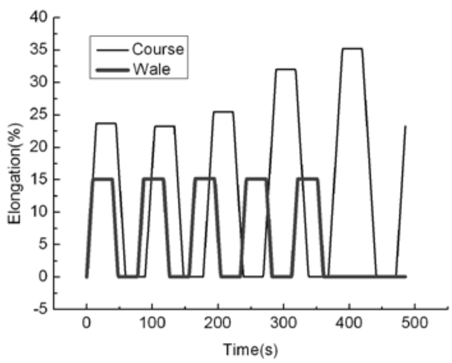
*Corresponding author's email: zhangyiping@mail.dhu.edu.cn

and coursewise direction up to a maximum load or a maximum extension.

The relationship between the elongation and time is illustrated in Figure 1. It shows typical curves at a fixed extension of 15% for plain knitted fabrics 1# and 2#. The thick line is in walewise direction and the thin line is in coursewise direction. The curve indicates that in five cycles ,specially the last three cycles, does not really show the biaxial extension of plain knitted fabrics, because the extension in the coursewise direction of fabrics is very easy than in the walewise direction ,which means that the deformation and recovery are different in two directions, the sync extension can not be obtained.



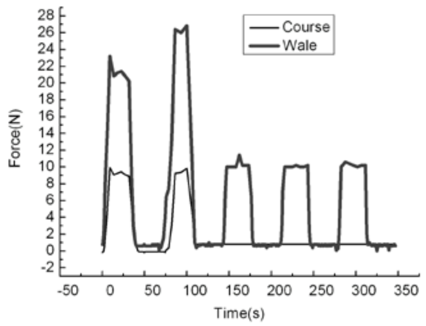
(1) Sample 1#



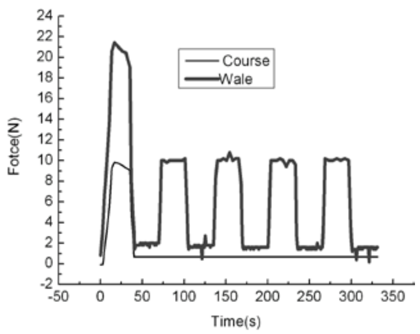
(2) Sample 2#

Figure 1 Relationship between elongation and time.

Figure 2 shows the elongation-time curves for plain knitted fabrics 1# and 2# with the machine set at a fixed load of 10N, the thick line is in walewise direction and the thin line is in coursewise direction. It indicates that there is no possibility of reaching the same load in two directions at equal biaxial extension ($\varepsilon_x=\varepsilon_y$). If the x-direction force is 10N, the y-direction force will be bigger than 10N, but if only considering y-direction extension, the force in y-direction will arrive at 10N.This is because the tensile properties in these two directions are very different, the stress of the coursewise direction is different from the walewise direction at the same strain.



(1)Sample 1 #



(2) Sample 2#

Figure 2 Relationship between force and time.

So the strip biaxial tensile property (the fabric is stretched in one direction and the other direction is restricted) was used in this study and the machine was set at a fixed extension of 15%.

3. Theory

According to TAIBI's theory [10], the linearity of the tensile deformation of fabrics is always lower or equal to 1, linearity functions for tensile and recovery can be respectively approximated as follows:

$$IT(\varepsilon) = B\varepsilon + 1 \quad \text{.with B is a constant<1} \qquad (1)$$

$$IT'(\varepsilon) = B'\varepsilon + 1 \quad \text{.with } B' \text{ is a constant<1} \qquad (2)$$