Alexandria Engineering Journal (2016) 55, 851–856

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Alexandria Engineering Journal

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ORIGINAL ARTICLE

Determination of loop length, tightness factor and porosity of single jersey knitted fabric

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Received 6 May 2014; revised 1 January 2016; accepted 20 February 2016
Available online 9 March 2016

KEYWORDS

Single jersey;
Loop length;
Compact;
Super compact;
Tightness factor;
Fabric porosity

Abstract After fabric relaxation, there is a reduction in wale and course density due to a reduction in loop length and this actually will affect the fabric properties. Then, it is useful to find a relation between loop length and courses and wales per unit length as well as the yarn thickness because wales and courses per unit length can be easily measured at any state while it is difficult to measure the loop length in the knitted fabrics. Therefore, it is required to find an equation, through which the value of loop length can be easily calculated from the measured values of courses and wales per unit length at any state after the knitting process. In this work estimated equations to calculate the knitted loop length for open to normal structure and for normal to compact structure are developed. By comparing the value of the loop length predicted from this work with the other mentioned models, it was found that the calculated values are very near to the L value of the case study; so the developed equations are acceptable. The tightness factor and the porosity of single jersey fabrics were also calculated theoretically.

1. Introduction

The important loop dimensions are loop length, loop width (wale spacing) and loop height (course spacing). Besides the loop dimensions, which has a great effect on fabric quality and the physical, mechanical and dimensional properties of the cotton single jersey knitted fabric, are the machine gauge, needle type, cam type, yarn feeding system, number of feeders, take down system, cloth rolling or spreading, monitoring and control systems, etc. After fabric relaxation whatever is dry or hot and also after washing there is a reduction in wale and course density due to a reduction in loop length and this actually will affect the other fabric properties. A standard loop shape is shown in Fig. 1 for single jersey structure. The geometrical shape of a standard loop should have same curvature for crown and sinker loop (normally sinker loops are larger than crown). Both the arms of loop should be in the same plane. The bending of crown and sinker loop should be to an equal depth and without twisting or turning. The shape factor, ratio of width to height of the loop should be about 1.3 [1].

Prakash and Thangamani [2] found that at dry-relaxed state, the values of courses per inch and wales per inch vary with respect to loop length and also any increase or decrease in courses per inch and wales per inch are a reflection of any change in the loop length. Also there was an increase in the

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Peer review under responsibility of Faculty of Engineering, Alexandria University.

http://dx.doi.org/10.1016/j.aej.2016.02.006
1110-0168

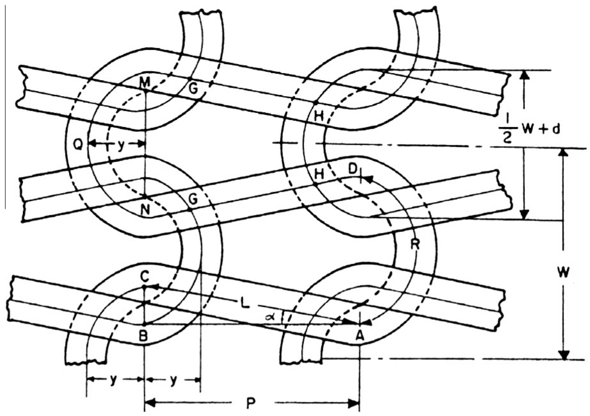

Figure 1 Loop shape of jersey knitted fabric by Benltoufa et al. [22].

initial courses per inch values, while a decrease in wales per inch value was observed during wet relaxation process. They also found that courses per inch values vary with respect to loop length and also a considerable increase in the course per inch after hot washing. Wales per inch values vary with respect to loop length and also decrease after hot washing. It was also found that, loop length values vary before and after wet relaxation and found a minimal change in the loop length after hot washing. Also their results showed that width of fabric values varies with respect to loop length and also a decrease in the width of fabric after hot washing and thickness of fabric values varies with respect to loop length and also an increase in the thickness of fabric after hot washing. Haji [3] concluded that the loop length had a significant effect on the air permeability, bursting strength, dimensional change, crease recovery angle and fabric weight. The loop length had the most significant influence on pilling resistance rating. Marmarali [4] stated that, it was apparent that as the amount of spandex increases loop length values remain nearly the same and the course and wale spacing values decrease.

Kumar and Sampath [5] said that, geometric properties such as course density, stitch density, areal density and tightness factor were found to be inversely proportion to the stitch length at all the relaxation states. Herath and Kang [6] found that, fabric tightness affects significantly the structural behavior of cotton and cotton/spandex structure during relaxation.

Mikučionienė and Laureckienė [7] found that, plain jersey knitted fabric shrinks in longitudinal direction 3.1%, and in transverse direction – 2.9%. The shrinkage values of plain jersey knitted fabrics after three washing and drying cycles were less than −1%, because in single structure knitted fabrics the zero-shrink-potential is achieved faster than double structure knitted fabrics. Anand et al. [8] stated that, this work demonstrated that changes occurring after laundering were largely due to alterations in the loop shape, rather than yarn or loop length shrinkage. The fabrics had taken up their fully relaxed dimensions after five wash and dry cycles and appropriate conditions for laundering had been applied. Quaynor et al. [9] studied the effects of laundering and laundering temperatures on surface properties and dimensional stability for plain flat knit silk, cotton, and polyester fabrics with varying cover factors. The fabrics were subjected to relaxation processes and an extended series of wash and tumble-dry cycles in laundering baths of various temperatures. The results revealed that the dimensional stability of silk was sensitive to a particular temperature. The highest shrinkage was recorded with slackly knitted cotton at the highest temperature. There was a considerable effect of wet relaxation on dimensional stability as well as on surface properties. Silk's coefficient of friction was the highest, and the lowest surface friction for cotton higher friction than tightly knitted fabrics. The coefficient of friction had a tendency to decrease with increasing tightness, while the surface roughness showed an opposite tendency. There was a good correlation between stick–slip motion and ribs on the fabrics. Therefore, the loop length can be varied after knitting production i.e. during dry relaxation, wet relaxation, at stretch level, and before and after washing, whatever was cold or hot washing. Then, it was interesting to find a relation between loop length and courses and wales per unit length because wales and courses per unit length can be easily measured at any state while it was difficult to measure the loop length in the knitted fabrics. Therefore, it is required to find an equation, through which the value of loop length can be easily calculated from the measured values of courses and wales per unit length at any state after manufacturing. This theoretical value of loop length will be an equivalent loop length value which is applicable to the measured values of wale and course density.

2. Estimation of loop length of single jersey knitted fabric

Loop length (L) is influenced by yarn input tension, knitted fabric take-down tension, knitting velocity, friction in the knitting zone, machine gauge, machine cam setting, yarn structure, yarn linear density, etc. [10].

A more detailed review of the most noted geometrical knitted loop models, including Leaf and Glaskin's, Munden's and Korlinski's model, is presented elsewhere [11]. In these models, the loop length is defined as the function of parameters other than loop width ($1/W$) and height ($1/C$), and yarn thickness.

Peirce [12] presumed that a knitted structure is normal when adjacent yarns within a knitted fabric are joined in contact points only. The projection of the loop onto the fabric plane is composed of the circular needle and sinker arcs connected with straight lines i.e. loop legs. The loop is three-dimensional, which means that the loop arcs and legs lay on the cylinder surface with curvature radius ($\boldsymbol{R}$) and the axis parallel to the course direction. For a normal structure, loop length (L) depends only on yarn thickness ($\boldsymbol{d}$) [12]:

$$L = 16.66\ d \tag{1}$$

The loop length of the open knitted structure (ℓ) defined by Peirce [12] is:

$$L = 2A + B + 5.94\ d \tag{2}$$

where A = loop width, B = loop height, d = yarn thickness.

Peirce's loop model was verified through experimental work by Fletcher and Roberts [13–15].

According to Dalidovich [16], loop length ($\boldsymbol{L}$) is a function of loop width ($\boldsymbol{A}$), loop height ($\boldsymbol{B}$) and yarn thickness ($\boldsymbol{d}$). Assuming the simplifications that the loop is planar,

$$L = 1.57A + 2B + \Pi d \tag{3}$$