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INFLUENCE OF COTTON FIBER MORPHOLOGY AND SPINNING PROCESS ON THE 3D LOOP SHAPE OF WEFT KNITTED FABRICS IN TERMS OF FRICTION, ROUGHNESS AND THICKNESS

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Abstract

The present study points out that even if cotton yarn physical properties and knitting process have a very light influence on fabric geometrical characteristics, relative to stitch length and fabric tightness, the effects must not be neglected on fabric thickness and roughness. Even a very small difference in the 3D loop shape can change the fabric quality and tactile aspects, and therefore the selling argument of a fabric.

The results are illustrated by an experimental study, which displays the importance of the three scales on the loop geometry: microscopic, mesoscopic and macroscopic relative to the chosen fibers, the yarn structure and the fabric structure. The morphological and structural parameters studied are respectively cotton length, yarn structure (single or plied) and stitch length of the knitted fabrics. 3D loop shape is indirectly characterized by a thickness measurement and a roughness measurement.

1. Introduction

The mechanical properties of knitted fabrics have been studied many years ago by numerous researcher like Doyle [Doyle 1953] Munden, Postle [Postle 1967] and Knapton [Knapton 1968]. Previously, all agreed regarding the fundamental importance of stitch length and further the notable influence of cover factor and the low influence of yarn physical properties. Postle and Hepworth [Hepworth 1976] by modeling and Knapton experimentally have also brought into light the influence of yarn diameter relative to stitch length, i.e. tightness or cover factor, on the loop shape. Later, Shanahan and Postle [Shanahan 1970] have showed in theory the influence of yarn transverse compression, bending and torsion properties and yarn longitudinal extension.
The topic of our study is to show that even a very small change in the material characteristics at different scales i.e. macroscopic (fabric), mesoscopic (yarn) and microscopic (fiber) can totally modify the organoleptic properties of the fabric and therefore its selling price.

2. Experimental

2.1 Fabrics tested

In order to study the influence of fabric, yarn and fiber characteristics, the experimentation had been achieved with one kind of cotton fiber, with and without combing the fibers during the spinning process. Several yarns structures have been processed: ring spun (single yarns at different counts and twist values, plied yarns) and rotor spun. Then several plain-weft-knitted-fabrics had been considered in terms of stitch length and cover factor.

Finally, 43 different knitted fabrics have been tested in order to improve the influence of all the characteristics on the 3D loop shape of the weft knitted fabrics in terms of thickness and roughness. These fabrics had been knitted on a mono-cylinder circular 14 needles/inch machine in the same conditions in terms of yarn tension and take-down tension. Then, they all had been fully-relaxed with water vapor and mechanical agitation after an aqueous bath.

Table 1. The different fiber, yarn and fabric characteristics are summarized in the following table.

Fiber length distribution	Combed and carded
Yarn structure	Single ring spun yarn, two-plied ring spun yarn, single rotor spun yarn

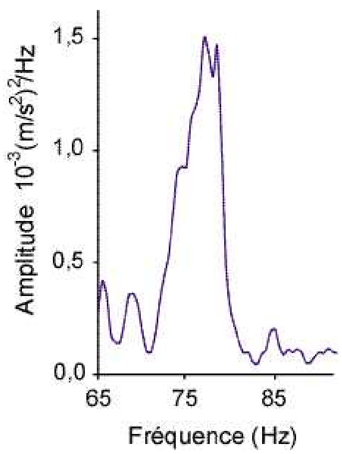
Yarn structure	Single ring spun yarn, two-plied ring spun yarn, single rotor spun yarn
Yarn count	20, 40 and 60 tex
Yarn twist (Alpha tex)	2850 and 3800
Stitch length (cm)	0.26 – 0.52

2.2 Measurement methods

Fabric thickness has been measured by using the transverse compression tester of the KES-F.
Fabric roughness has been evaluated by different methods:

- KES-F friction tester: MIU (friction coefficient), MMD (mean deviation of friction coefficient), SMD (mean deviation of surface profile),
- Self developed tribometer [BUENO 199] (fig 1.) based on a friction / roughness measurement with spectral analysis in order to characterise the signature of the fabric (wales and / or columns) and its impact on the roughness. The given value is a spectral power density for a typical frequency.

Fig.1 Tribometer

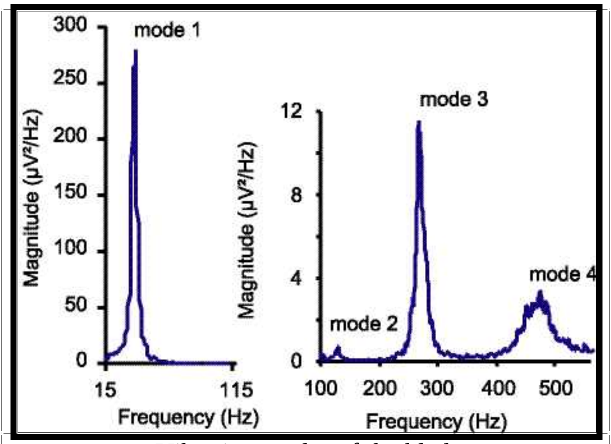


Signature of the knitted fabric (columns)

- Self developed optical roughness-meter [BUENO 2000] based on an optical roughness measurement similar to the previous device but without mechanical contact. The given value is also a spectral power density for a typical frequency.

- Self developed and patented smoothness tester [BUENO 2001] (fig 2.) based on the measurement of the vibrations of a very thin plate excited by friction on the measured surface. The device is particularly relevant for the characterisation of different textile surfaces including nonwowens. The given value is a spectral power density for a given vibration mode of the plate (1, 2, 3, …). Mode 1 is generally sensible to friction. Higher modes are more sensible to roughness.

Fig.2 Smoothness tester



Vibration modes of the blade

Other characteristics as number of wales/cm and weight (g/m^2) have also been measured.

In addition to the physical properties, human attribute have been given with the help of a sensorial panel. 4 characteristics have been evaluated by this method:

- **Soft :** by touching lightly the sample, flat on table top, with fingers in rotating movement.
- **Slipper :** by moving horizontally index, middle and annular fingers across the surface on the direction perpendicular to the knitted wales.
- **Tight :** by evaluating the distance between the wales with index and middle fingers.
- **Limp :** by placing fabric in the hand and close hand to compress.

Finally, all the measurement results have been normalised and represented on a control card. For a given change of a characteristic or a manufacturing condition, the increasing of the measured property shoves an impact between 0 and +1. By decreasing, the same property shoves an impact between 0 and -1.

3. Results

The following table summarizes the influence of several modifications on different scales, on the characteristics of the knitted fabrics. Only impact values higher than 0,7 and lower than -0,7 have been recognized.

Table 2. Summary of the influence of several modifications on the characteristics of the knitted fabrics

	Stitch length increases	Yarn count increases	Yarn twist increases	Single yarn to Plied yarn	Ring yarn to Rotor yarn	Combing of short fibers
Thickness (load	+	+	+	-		+
Roughness Tribometer	+	+	+	-		
Roughness Optical	+	+	+		+	+
Friction (blade mode 1)	+	+	+	-	+	+
Roughness (blade mode 2)		+	+	-	+	+
KES MIU (friction coefficient)						
KES MMD (MIU Mean Dev.)	-		+		+	
KES SMD (Profile Mean Dev.)	+	+	+	-		
GSM (g/m^2)	-	+	+	-	-	
Wales /cm	-	-	+	+	-	
“Soft”	+	-	-	+		+
“Limp”	+	-	-	+		+
“Slipper”		-	-	+	-	+
“Tight”	-	-	-	+		

4. Discussion

The results show different aspects. Each modification at different scales (fiber, yarn and fabric) shoves a real impact on thickness and roughness properties of the knitted fabric. The origin of that behavior is related to the yarn rigidity, which is directly influenced by all the characteristics (count, twist, fiber and yarn structure). Figure 3 gives an illustration of the influence of the yarn rigidity on the loop shape of a plain-weft-knitted-fabric (Jersey).

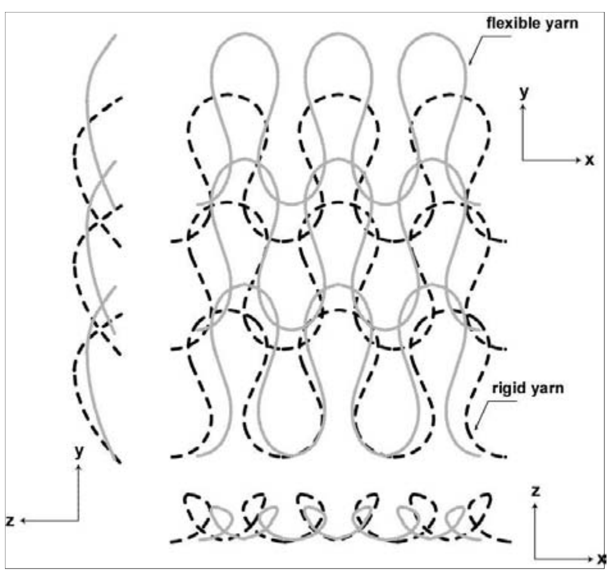


Fig.3 Effect of the yarn rigidity on loop shape

Even a very small difference in the 3D loop shape due to yarn or fiber characteristics modifications can change the fabric quality tactile aspects. With the help of high sensitive mechanical or optical sensors and vibration analysis, physical measurement methods can helpfully complete human evaluation. Nevertheless, in the case of friction and roughness KES evaluation system for fabrics, the friction coefficient (MIU) measurement is not relevant for that kind of investigation. Only the mean deviation values can bring any information.

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