Structure-Property Interrelationship of Denim Yarn Produced Using Ring and Compact Spinning Technology

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Abstract: Ring yarns are increasingly used in Denim fabrics. Fibre arrangement in spun yarn influences the various yarn properties. Spinning triangle in case of compact spinning remains smaller than that of conventional ring spinning process; hence the migration of fibres takes place to different extents in yarns spun using these technologies. As a result with the advent of compact spinning technology overall quality of yarn has improved significantly. In view to study the effect of compacting the fibre batt on fibre migration, denim yarns of count 8Ne and 12Ne have been produced using compaction attachments of pneumatic principle based on Marzoli's Olefil and mechanical magnetic principle based on Rotorcraft's RoCos, on the same spindles of Marzoli ringframe. Fibre migration in terms of mean fibre position, RMS deviation and migration intensity has been determined using tracer fibre technique under CCD camera attached with a computer having image processing software. Experimental results have been analyzed using two way ANOVA with replication technique. It was observed that, migration intensity of normal ring yarns is significantly higher than compact yarns whereas migration intensity of mechanical magnetic compact yarns is significantly higher than that of pneumatic compact yarns. There are no significant changes noted in mean fibre position and RMS deviation. These yarn samples are also evaluated for their various yarn characteristics viz. tensile strength, elongation, unevenness, hairiness, etc to determine the structure-property interrelationship.

Keywords: Fibre migration, mechanical magnetic compact yarn, pneumatic compact yarn, means fibre Position, RMS deviation, migration intensity.

1. Introduction

Fibre arrangement in spun yarn structure influences yarn properties because yarn structure depends on processing conditions and spinning technology used. Physical properties of yarn are influenced by the process variables used in a specific spinning technology. The compact spinning system based on pneumatic working principle is commercially introduced to the market a decade ago, and soon it became a major breakthrough in the ring spinning technology. Since the inceptions of the compact spinning system, yarn produced, has been revealing consistent results. [1-15].

The smaller spinning triangle in compact spinning reduces fibre migration tendency due to lesser differential path distance experienced by fibres in the spinning triangle at different radial positions [16]. It produces yarn with lower hairiness. One such compact spinning system viz. Marzoli's Olefil uses air suction force for compacting the fibre batt before twisting enhances strength even at lesser twist and enables increased production rate. However the consumption of compressed air affects the economy of the process to some extent due to additional energy consumption.

In view to further improve compact yarn properties and enable the yarn production at lower power requirement, recently Rotorcraft introduced the compact spinning system RoCoS, which works on mechanical magnetic principle without the use of air. Aim of the study presented here is to analyze and compare the yarn structures and their effects on characteristic of yarns produced on pneumatic and mechanical magnetic compact spinning systems with that of the conventional ring yarns.

2. Materials and methods

2.1 Yarn samples

In the present study, conventional ring yarn and compact yarn specimens have been produced of yarn counts 8Ne and 12Ne. The compaction attachments viz. pneumatic principle based on Marzoli's Olefil and mechanical magnetic principle based on Rotorcraft's RoCoS have been fitted, on the same spindles of Marzoli Ring frame. A total of six yarn samples (i.e.8 Normal, 8 Olefil, 8 RoCos, 12 Normal, 12 Olefil, 12 RoCos) have been prepared from cotton mixing of

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JFBI Vol. 3 No.2 2010 doi:10.3993/jfbi09201004

LRA, LRA-AT, NHH-44, US 1-1/32 with 1% black tracer fibre added at carding stage.

2.2. Characterization of fibre migration

Tracer fibre technique has been used to study the fibre migration behavior to analyze the yarn structure. The yarn samples containing black dyed tracer fibres have been immersed in methyl sylicylate having same refractive index that of cotton (R.I. 1.53). These yarn samples have been examined under charged coupled device (CCD) camera attached with high power coaxial focusing binocular microscope as shown in Figure 1.Yarn boundaries, peaks and troughs of tracer fibre image have been noted against the scale mounted on the screen of the computer. Image processing software Digipro has been used which facilitated the photo capture of specimen at reading point.

Figure 1 Computerized high power binocular microscope with CCD camera attachment.

Migration behavior of fibre in the yarn can be seen in Figure 2. It is best to express the fibre radial position in terms of the ratio r/R, where r is the radial position of fibre and R is radius of yarn. A plot of r/R against length along the yarn shows the cylindrical envelope of varying radius around which the fibre is following a helical path. [16]

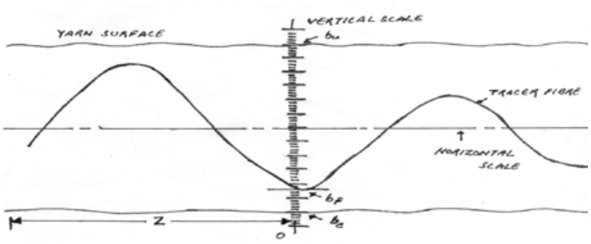

Figure 2 Migration Behavior of Tracer Fibre in the yarn.

$$\frac{r}{R} = \frac{\left(\frac{bu + be}{2}\right) - bf}{\left(\frac{bu - be}{2}\right)} \quad (1)$$

Where
bu is yarn upper boundary measured on the scale
be is yarn lower boundary measured on the scale
bf is tracer fibre position measured on the scale.

The chief features of overall migration behavior have been characterized by parameters such as mean fibre position, RMS deviation of fibre position and migration intensity. These are defined in the following sections.

2.2.1. Mean fibre position

This represents the overall tendency of a fibre position to be near the yarn surface or to be near the axis of yarn and can be calculated from the formula

$$Mean\,Fibre\,Position\,(\overline{Y}) = \frac{\sum Y}{n} \quad (2)$$

$$\text{Where } Y = \left(\frac{r}{R}\right)^2 \quad (3)$$

n= no of observations

2.2.2 RMS deviation of fibre position

It is the magnitude of deviation from the mean position and is represented by Root Mean Square (RMS) deviation i.e.

$$RMS\,Deviation\,(D) = \left[\frac{\sum \left(Y - \overline{Y}\right)^2}{n}\right]^{\frac{1}{2}} \quad (4)$$

2.2.3 Migration intensity

It is rate of change of radial position of fibre in the yarn.

$$Migration\,Intensity\,(I) = \left[\frac{\sum \left(\frac{dY}{dZ}\right)^2}{n}\right]^{\frac{1}{2}} \quad (5)$$