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Impact of Spindle Speed and Traveler Weight on the Tensile Properties of Yarn Explicitly the Yarn Tenacity and Elongation at Break

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Abstract

This study paying attention on the effect of spindle speed and traveler weight on the tensile properties of 100% cotton carded 24s Ne ring spun yarns. A set of five different traveler weights and three different spindle speeds were used for ring spinning of 100% cotton carded 24s Ne cotton yarn under operational circumstances as to optimize these two parameters for spinning carded ring spun yarns tensile properties. The 100% cotton carded 24s Ne yarns thus products were tested for their tensile properties such as tenacity and breaking elongation using ASTM standards. The results showed that the combination of 12500 rpm spindle speed and the traveler weight of 44-46mg produced the most advantageous tenacity ring spun yarns.

Keywords: *Spindle speed, traveler weight, carded ring-spun yarn, tensile properties, ring spinning, rotor spinning*

1. Introduction

Spindle is heart of spinning as it is the main part of a ring frame which helps in twisting, winding the yarn at the same time. Traveler is the smallest and simple perfunctory element in ring frame which does the most important functions like instantaneous twisting, winding, leading the yarn through the ring spinning frame in combination with the spindle and ring. Traveler does not have a speed of its own. It gets drawn along behind the spindle. Since the spindle turns around at a high speed, a high contact force is generated between the ring and traveler during winding, mainly due to centrifugal force. The force introduces strong frictional forces which in turn lead to significant production of heat. It is the most important problem of ring or traveler. The outcome of spindle speed and traveler weight on spinning tension was studied and it was reported that the spinning tension can be detrimental or beneficial to the production of yarns (Rengasamy et al; 2004). The effect depends on the magnitude of the tension which is proportional to the friction coefficient between ring and traveler, the traveler mass and the square of the traveler speed which is related to the spindle speed (Rengasamy et.al, 2004). On the other hand, the spinning tension is inversely proportional to the ring diameter and the angle between the connecting line from the traveler-spinning axis to the piece of yarn between the traveler and cop. Spinning tension determines hairiness of the yarn both positively and negatively depending on the magnitude of tension count ratio, with lower tension resulting in greater hairiness values than with higher tensions for a given count. This is the reason why heavier travelers result in low yarn tensions, but if the traveler is too heavy, the yarn hairiness will also increase. Spinning tension also affects the strength of the yarn with higher tension producing stronger yarns than with lower tensions. Increase in tension may lead to increased end breakages per 1000 spindles (Xungai and Lingli, 2003).

The results for the outcome of spindle speed on yarn tensile strength are such that as the spindle speed increases from 11,500 rpm up to 16,500 rpm the breaking strength equally increases. Though, it decreases regularly as the speed is increased beyond 16,500rpm, strength of the yarn is dependent on the fiber strength initially and then the arrangement of the fibers in the fiber strand (Cheng and Yu, 2003, Ghosh, 2005). A regular yarn without many hairs on its surface can better with stand the force acting on it. Therefore, it was found that the yarns spun at 16,500 rpm have better strength as compared to other yarns spun at lesser or high spindle speed.

2.0 MATERIALS AND PROCESS

2.1 Materials

Cotton fiber was used in this study as it is the leading raw material of India in textile factories of Bangladesh. The data was collected from Badsha Textile ltd, Bangladesh. To investigate and study the effect of spindle speed and traveler weight on the tensile properties of the ring-spun yarn, first different sample yarns were produced using the same input materials (roving) on a Rieter G35 ring spinning machine keeping all the constraints constant except the spindle speed and the traveler weight and then the different samples of yarns thus produced were tested for the tensile properties in the textile testing laboratory of the said factory. The fiber properties were tested by using HVI by taking random samples from six different bales and the average results are shown in Table 1. Fiber properties included in this work are those from which the sample yarns and fabrics were produced.

Table 1. Fiber properties

Type of fiber	Origin	Staple length (mm)	Short fiber (%)	Strength (g/tex)	Elongation (%)	Micronaire
Cotton (100%)	**CIS**	**8.16**	**10.8**	**26**	**6.5**	**3.81**

The card and drawing frame sliver required for this study (as the back process materials) were produced by C60 carding machine and D45 drawing frame with auto leveler respectively. The roving strand was produced by F15 roving frame machine. The details of the back process materials are given in Table 2

Table 2. Details of back process materials

Material	Average count(Ne)	Standard Deviation	Coefficient Variation %
Sliver from card	**0.14**	**0.0002**	**0.2214**
Sliver from draw frame	**0.16**	**0.0002**	**0.1852**
Roving	**0.84**	**0.0079**	**0.975**

The experimental variables of this investigative study such as the travelers used (Table 3) and the spindle speeds of spinning used on the ring frame (Table 4) for producing the sample yarns are given here in the form of tables. The tensile properties of the sample yarns (tenacity and breaking elongation) thus produced were tested using Uster Tensorapid strength tester and all the tests were carried out under standard atmospheric conditions, i.e. 20±2 °C temperature and 65±2 % relative humidity as per ASTM standards. The samples were conditioned for a minimum 24 hours before the tests.

Table 3. Details of Traveler types used

Description of the Traveler	Average mass (mg)	Traveler type (symbol)
Bracker ISO 2/0	**31.5**	**T1**
Bracker ISO 3/0	**35.5**	**T2**
Bracker ISO 4/0	**40.0.**	**T3**
Bracker ISO 5/0	**46.0.**	**T4**
Bracker ISO 6/0	**50.0**	**T5**

Table 4. Spindle Speeds in rpm

Spindle speed (Notation)	Speed (rpm)
Sp1	**13 000**
Sp2	**14 000**
Sp3	**16 000**

Table 4. shows the different combinations of spindle speeds and traveler weights used for producing the yarn samples of 21 Ne yarns. Five traveler weights and three different spindle speeds were used to produce the samples. All possible combinations between the travelers and spindle speeds were used to give 15 different combinations of traveler weight and spindle speed.

Table 5. Combinations of spindle speeds and travelers used for sample yarns spinning

Combination	Spindle speed RPM	Traveler type
Combination 1	**Sp1**	**T1**
Combination 2	**Sp1**	**T2**
Combination 3	**Sp1**	**T3**
Combination 4	**Sp1**	**T4**
Combination 5	**Sp1**	**T5**
Combination 6	**Sp1**	**T6**
Combination 7	**Sp2**	**T1**
Combination 8	**Sp2**	**T2**
Combination 9	**Sp2**	**T3**
Combination 10	**Sp2**	**T4**
Combination 11	**Sp2**	**T5**
Combination 12	**Sp2**	**T6**
Combination 13	**Sp3**	**T1**
Combination 14	**Sp3**	**T2**
Combination 15	**Sp3**	**T3**
Combination 16	**Sp3**	**T4**
Combination 17	**Sp3**	**T5**
Combination 18	**Sp3**	**T6**

To study the effect of spindle speed and traveler weight on the tensile properties of yarns spun, different data and samples had to be collected. The sample yarns were produced with the same material and machine setting and parameters for the said combinations of spindle speed and traveler weight. The various steps of this investigative study were as follows:

- The data has been collected from Badsha Textile ltd
- Testing the cotton for its fiber properties using HVI
- The different spindle speeds and traveler weight combinations will be used on G 35 ring frame machine for producing the yarn samples using the same back process materials.
- Testing the back process material characteristics using wrap block
- Testing the tensile properties of the sample yarns spun by using Uster Tensorapid yarn testing instrument.
- The yarn test results will be analyzed using Statistical analysis
- Finally finish off and statement the learning

Badsha Textile ltd as well as laboratories relevant data associated to outcome of spindle speed and traveler weight properties include fiber properties, spinning machine parameters, yarn parameters, properties and test results were collected. The ASTM D2256 standard was used for the testing of tensile strength.

3.1 RESULTS AND DISCUSSION

3.1 Yarn Tenacity and Elongation Test Result

The ratio of load required to break the specimen and the linear density of that specimen is called tenacity and it is known as CN/Tex etc. The elongation necessary to break a textile material is expressed by the actual percentage increase in length and is termed as breaking extension. Mathematically, Breaking extension (%) = (Elongation at break / Initial length) × 100%.

The test results of yarn tenacity of the dissimilar samples to illustrate the effect of spindle speed and traveler weight on yarn strength are shown in Tables 1, 2 and 3. Figure 1 show the graph schemed on yarn tenacity vs. Traveler weight at different spindle speeds. From the test results, it can be seen that at the lowest traveler weight of 31.5 mg (T1), the mean tenacity values of the yarn spun at three different speeds are almost the same (14.125, 14.435, 14.29) and when the traveler weight was increased to 35.5mg (T2), the mean tenacity values of the yarn spun at three different speeds also went up (14.903, 14.804, 15.94). When the traveler weight was increased to 40 mg (T3), the mean tenacity values of the yarn spun at three different speeds went down (14.091, 14.885, and 13.196). When the traveler weight was increased to 45 mg(T4), the mean tenacity values of the yarn spun at three different speeds went up to the maximums(15.174, 15.944, 15.3).

When the traveler weights were increased to the maximum value of 50 mg (T5), then the mean tenacity values of the yarn spun at three different speeds once again went down (14.815,15.387,14.52) from the previous values. It can also be seen that the maximum tenacities for the yarns spun at different speeds were at the traveler weight of 45mg (T4) and thus, it can be seen that the traveler weight 45 mg (T4) is the optimum weight irrespective of the speed. When the tenacities of yarns spun at different speeds are compared, the yarns spun at 13,000 rpm showed higher values of tenacities than the other two speeds even at different traveler weights. The maximum value of yarn tenacity amongst all these 15 combinations was given by the 45 mg and 13 000rpm combination (C9).

There were significant differences in the tenacity of the samples although higher results were seen in the 13000 rpm spindle speed at traveler weight T4 (45 mg) with a mean value 15.944cN/Tex. At 13 000 rpm spindle speed, the drafting speed is lower when compared to that at 14 000 rpm. The resulting pulling of the fibers due to tension is therefore lower at the 13 000 rpm spindle speed than at 14000 rpm. The consequence is that there is less strain on the drafted roving and hence a more compact structure is produced by the machine at the spindle speed of 13 000 rpm. At higher speeds, there is a tendency to pull the fibers from the main structure resulting in the reduction of fiber cohesion leading to lower yarn strengths when the tests are carried out. The other result of increasing the spindle speed is that as the traveler speed is increased; the friction between the ring and the traveler is increased leading to increased tension in the spinning system. The increase in the tension applied to the yarn was therefore the result of the increased spindle speed and the friction on the traveler where the friction between the traveler and yarn resulted in the streak of the yarn.

Conclusion

The result of spindle speed and traveler weight on the tensile properties of yarn explicitly the yarn tenacity and elongation at break was examined for the different combinations of spindle speeds and traveler weights (4 spindles and 5 traveler weights) for 23 Ne 100% cotton carded ring spun yarn. This investigation was done with a view to optimize the spindle speed and traveler weight for getting the optimum tensile properties for 23 Ne 100% cotton carded ring spun yarn. From the result, it can be seen that for such coarse count a relatively heavy traveler weight (T4-46mg) and a medium speed (13 000 rpm) gave the optimum values. It must be noted that this optimum was arrived at for a particular cotton mix and yarn count and is applicable to the actual running environment of an industrial unit in Bangladesh.

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