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Investigation on the Effect of Spindle Speed and Traveller Weight on the Tensile Properties of 21^s Ne Cotton Ring Spun Yarns

***Kathirrvelu Subramanian[1], Daniel Mulugeta[2], and Gashaw Ashagre[3] ,**
Textile Production RIC, Ethiopian Institute of Textile and Fashion Technology, Bahir Dar University, Ethiopia.
***Email: drskathirrvelu@gmail.com**

ABSTRACT

This study focused on the effect of spindle speed and traveler weight on the tensile properties of 21s Ne 100% cotton carded ring spun yarns. A set of five different traveler weights and three different spindle speeds were used for ring spinning of 21's Ne 100% cotton yarn under working conditions so as to optimize these two parameters for spinning carded ring-spun yarns good tenacity. The 21's Ne 100% cotton carded ring-spun yarns thus produced were tested for their tensile properties such as tenacity and breaking elongation using ASTM standards. The results showed that the combination of 13000 rpm spindle speed and the traveler weight of 45mg produced the optimum tenacity ring spun yarns.

Key words: carded ring-spun yarn, spindle speed, traveler weight, tensile properties

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1. INTRODUCTION

Until the early 60s, the main type of spinning machines used in the spinning industry were ring spinning frames, which were used in all types of spinning systems. In the 70s, open end spinning was developed, mainly rotor spinning, with reference to cotton and cotton like yarns. However, even today, ring spinning frames are still comparable in relation to rotor spinning machines. In fact, ring spinning is by far the most widely used spinning process, setting clear standards in terms of yarn quality, field of application and flexibility. Because of ring spinning's versatility in terms of fiber types that can be handled, the range of counts that can be spun and the quality of the yarns produced, it is still the standard against which other systems of spinning are judged. One of the major limitations of the ring spinning technology is the metal to metal rubbing contact between the ring and the traveler, which restricts the spindle speed (Das and Ishtiaq, 2004). Although air jet spinning and friction spinning produce yarns at superior speeds than ring spinning, ring spinning is widely used for textile applications as it produces yarns with highest quality when compared to the other methods of production. Currently, the ring frame normally has maximum speed of 25000rpm whereas the rotor spinning machines run at speeds of up to 120000 rpm (Kona, 1999). Spindle is often referred as 'heart of spinning' as it is the main part of a ring frame which helps in twisting, winding the yarn simultaneously. Traveler is the tiniest and simple mechanical element in ring frame which does the most important functions like simultaneous twisting, winding, guiding the yarn through the ring spinning frame in conjunction with the spindle and ring. Traveler does not have a drive of its own. It gets dragged along behind the spindle. Since the spindle rotates at a high speed, a high contact pressure is generated between the ring and traveler during winding, mainly due to centrifugal force. The pressure introduces strong frictional forces which in turn lead to significant generation of heat. It is the most important problem of ring/traveler.

The effect 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 effect of spindle speed on jute yarn properties was studied and reported and it was shown that the increase in speed generally, resulted in the decrease in hairiness for a certain range of spindle speeds (between 10000rpm and 14000 rpm) before increasing above a certain speed (about 15000 rpm)(Ghani et al, 2009).

The results for the effect of spindle speed on yarn tensile strength are such that as the spindle speed increases from 11,000 rpm up to 17,000 rpm the breaking strength correspondingly increases. However, it decreases gradually as the speed is increased beyond 17,000rpm. Strength of the yarn is dependent on the fiber strength initially and then the alignment 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 17,000 rpm have better strength as compared to other yarns spun at lesser or high spindle speed. A number of authors have found that with the increase in traveler weight, there is a reduction in the hairiness of the yarn [Usta and Canoglu, 2002, Pillay, 1984). The reduction was up to a certain weight before it begins to increase again (Barella and Manich, 2002) It was reported that yarn quality parameters can be improved by proper traveler weight selection, which results in reduced yarn breakages, mass variation, twist variation and hairiness. It was also reported that light weight travelers are recommended for spinning the fine yarns and heavier weight travelers for coarser yarn spinning (Merril, 1959, Usta and Canoglu, 2002). It was reported that the variation in traveler weight has a significant impact on yarn twist (turn per meter, tpm). Generally, when ring frame operates at constant spindle speed having the same traveler weight, the yarn turns per meter does not change. It was observed that the lighter weight traveler (3.2 gm) produced a yarn of 725 turns per meter and the heavier weight (9.8 gm) traveler produced 670 twists per meter. In other words, the twist decreases with increasing traveler weight. This is because lighter weight travelers have high surface speed as compared to heavier weight traveler (Usta and Canoglu, 2002).

Although many researchers have done studies concerning the effect of spindle speed and traveler weight on yarn quality and properties, this study was an attempt with an aim to investigate the interaction between traveler weight and spindle speed on yarn strength for a particular count in a textile factory of Ethiopia with an intention to optimize these parameters for optimizing the carded ring-spun yarn strength. In other words, this investigation is done to study the effect of spindle speed and traveler weight so as to optimize these two parameters for spinning good quality of 21 Ne 100% cotton ring spun yarn.

2. MATERIALS AND METHODS

2.1 Materials

Cotton fiber was used in this study as it is the dominant raw material in textile factories of Ethiopia. The data was collected from M/s. Bahir Dar Textile Share Company, Ethiopia. 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 parameters 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 using HVI test by taking random samples from five 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. These fiber properties are provided to indicate that the yarns for this study are produced from the same fiber only.

Table 1. Fiber properties

Fiber Properties						
Type of fiber	Origin	Staple length(mm)	Short fiber (%)	Strength (g/tex)	Elongation (%)	Micronaire
Cotton (100%)	Ethiopia	27.66	11.9	27	6.5	3.92

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	0.1	0.0002	0.2214
Sliver from draw frame	0.11	0.0002	0.1852
Roving	0.82	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 type	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	45.0.	T4
Bracker ISO 6/0	50.0	T5

Table 1. Spindle Speeds in rpm

Spindle speed (Notation)	Speed (rpm)
Sp1	12 000
Sp2	13 000
Sp3	14 000

Table 5. 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 2. Combinations of spindle speeds and travelers used for sample yarns spinning

Combination (C)	Spindle speed RPM	Traveler type
Combination 1 (C1)	Sp1	T1
Combination 2 (C2)	Sp1	T2
Combination 3 (C3)	Sp1	T3
Combination 4 (C4)	Sp1	T4
Combination 5 (C5)	Sp1	T5
Combination 6 (C6)	Sp2	T1
Combination 7 (C7)	Sp2	T2
Combination 8 (C8)	Sp2	T3
Combination 9 (C9)	Sp2	T4
Combination 10 (C10)	Sp2	T5
Combination 11 (C11)	Sp3	T1
Combination 12 (C12)	Sp3	T2
Combination 13 (C13)	Sp3	T3
Combination 14 (C14)	Sp3	T4
Combination 15 (C15)	Sp3	T5

2.2 Method

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:

i. Testing the cotton for its fiber properties using HVI
ii. Testing the back process material characteristics using wrap block
iii. 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.
iv. Testing the tensile properties of the sample yarns spun by using Uster Tensorapid yarn testing instrument.
v. The yarn test results will be analyzed using Statistical analysis.
vi. Finally conclude and report the study

The data was collected from M/s. Bahir Dar textile Share Company as well as from EiTEX laboratory. Relevant data related to effect 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 tensile testing

3. RESULTS AND DISCUSSION

3.1 Yarn Tenacity and Elongation Test Results

The ratio of load required to break the specimen and the linear density of that specimen is called tenacity and it is given in 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 different samples to illustrate the effect of spindle speed and traveler weight on yarn strength are shown in Tables 1, 2 and 3. Figure 1 shows the graph plotted 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).

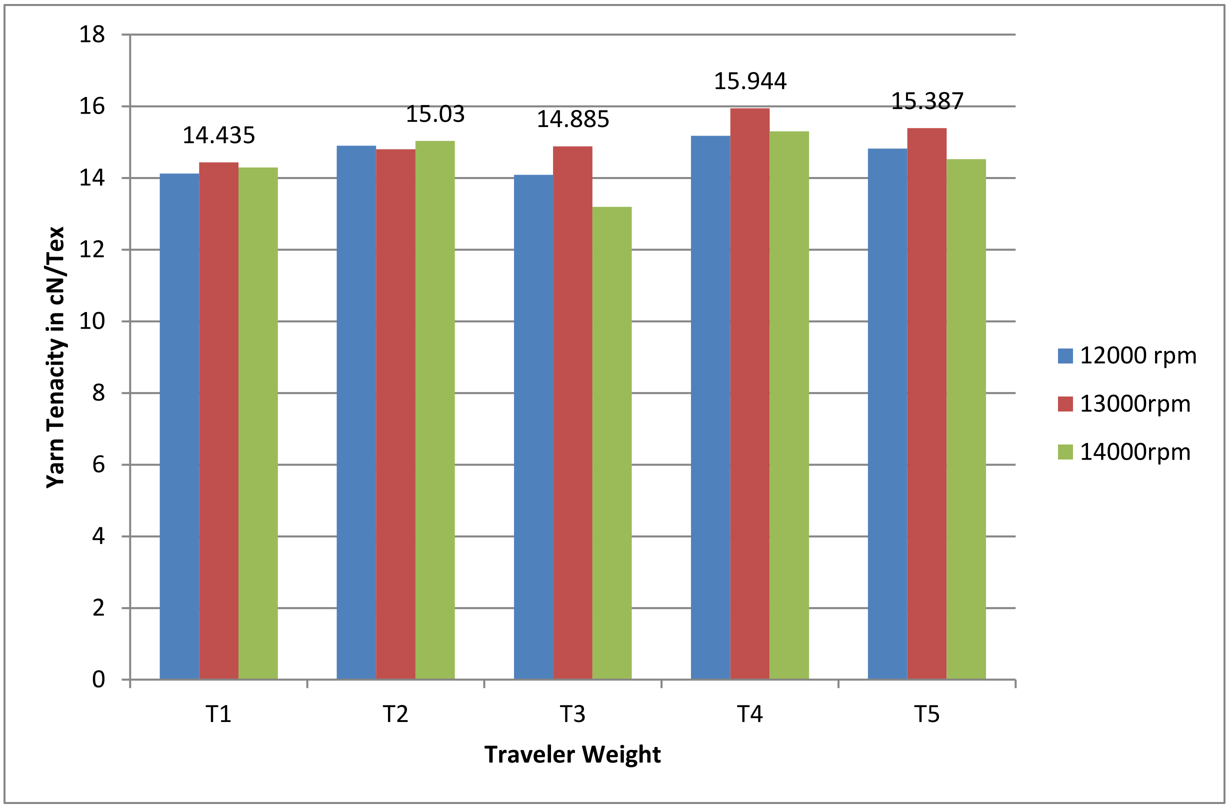

Figure 1. Effect of Traveler weight and spindle speed on yarn tenacity

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 traveller where the friction between the traveler and yarn resulted in the staining of the yarn.

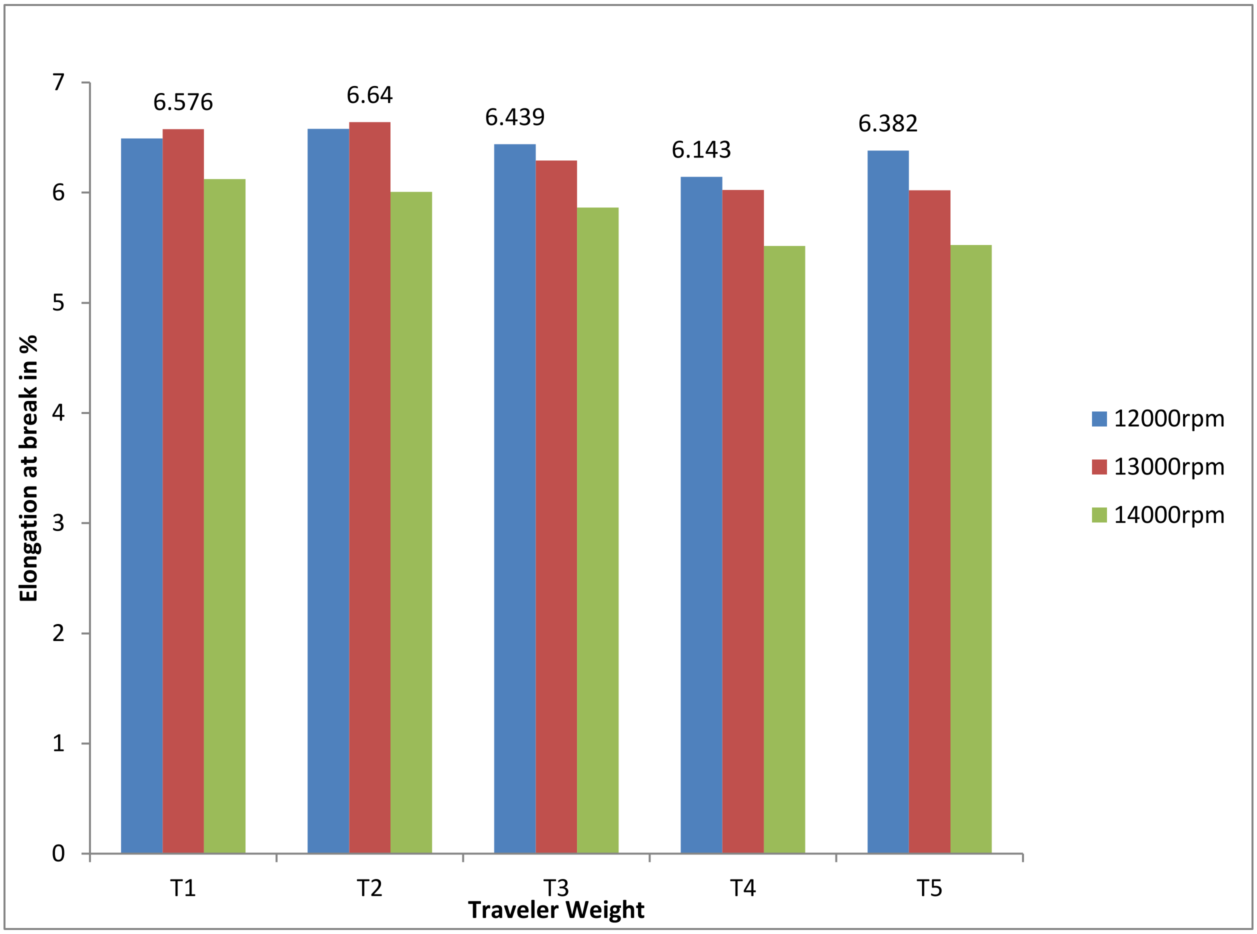

Figure 2. Effect of Spindle Speed and Traveler Weight on Elongation at break

From the results of elongation at break of shown in Fig 2, it can be seen that there is a clear trend of lower spindle speed and lower traveler weight giving higher elongation at break than higher spindle speed and traveler weight. This can be appreciated from the fact that as the spindle speed and weight increase, the spinning tension increases and this in turn reduces the elongation at break at higher spindle speeds and traveler weights (Sengupta and Kapoor, 1978).

4. CONCLUSIONS

The effect of spindle speed and traveler weight on the tensile properties of yarn namely the yarn tenacity and elongation at break was investigated for the different combinations of spindle speeds and traveler weights (3 speeds and 5 traveler weights) for 21 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 21 Ne 100% cotton carded ring-spun yarn. From the result, it can be seen that for such coarse count a relatively heavy traveler weight (T4-45mg) 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 conditions of a factory in Ethiopia.

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REFERENCES

Das, A,. And Ishtiaque, S. M. (2004). End Breakage In Rotor Spinning: Effect Of Different Variables On Cotton Yarn End Breakage. AUTEX Research Journal 4(2), 52-59.

Khona, V. (1999). Increasing Speed Of Yarn Spinning. The Triz Journal. Retrieved From Https://Triz-Journal.Com/Increasing-Speed-Yarn-Spinning/

Rengasamy, R, S., Ishtiaque, S, M., and Ghosh, A. (2004). Optimization of Ring Frame Process Parameters for Better Yam Quality and Production. Indian Journal of Fibre and Textile Research 29, 190-195.

Rengasamy, R. S.,Ishtiaque, S. M.,Ghosh, A.,Patnaik, A., and Bharati, M. (2004). Analysis of Spinning Tension in Ring Spinning. Indian Journal of Fibre and Textile Research 29, 440-442.

Wang X, and Chang L. (2003). Reducing Yarn Hairiness with A Modified Yam Path in Worsted Ring Spinning. Textile Research Journal 73(4), 327-332.

Ghani, M. O., Mahabubuzzaman, A. K., and Kabir, M. M. (2009). Effect of Spindle Speed on Textile Properties and Productivity of Fine Jute Yarn. Daffodil International University Journal of Science and Technology 4(2), 1-5.

Cheng, K., and Yu, C. (2003). A Study of Compact Spun Yarns. Textile Research Journal 73(4), 345-349.

Ghosh, A. (2005). Analysis of Spun Yarn Failure. Part I: Tensile Failure of Yarns As A Function Of Structure and Testing Parameters. Textile Research Journal 75(10), 731-740.

Usta, I., and Canoglu, S. (2002). Influence of Ring Traveller Weight and Coating on Hairiness of Acrylic Yarns. Fibres and Textiles In Eastern Europe 39(4), 20-24.

Pillay, K. (1984). A Study of The Hairiness of Cotton Yarns Part I: Effect of Fiber and Yarn Factors. Textile Research Journal 34(8), 663-674.

Barella, A., and Manich, A. M. (2002). Yarn Hairiness: A Further Update. Textile Progress 31(4), 1-44.

Merrill, G. R. 1959. Cotton Ring Spinning. Lowell, Mass., C.

Https://Www.Astm.Org/Standards/D2256.Htm Standard Test Method For Tensile Properties Of Yarns By The Single-Strand Method As Accessed On 21.01.2017.

Sengupta, A., and Kapoor, I. (1978). Effect Of Drafting Speed At Ring Frame On Yarn Strength And Irregularity. Textile Research Journal, 43(2), 121-122.