A Novel Approach to a Modified Spinning Technique of Staple Yarn: Systematic Investigation on Improvement of Physico-Mechanical Characteristics of Cotton Ring Spun Yarn

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Abstract

Producing yarn from natural fibres without creating irregularities in structure or having fibres protruding from the surface, remains the goal of spinners. This is a shortcoming, as structural irregularities such as hairiness, unevenness affect subsequent fabric manufacturing processes and the aesthetics of the final fabric. Sustainability of a noble false twister device and its influence on physical properties of staple cotton yarn has been studied in this research. A false twister has been installed in the ring frame to modify the yarn path of conventional ring spinning system to improve physico-mechanical characteristics of cotton ring spun yarn. This work therefore focused on investigating the effects of varying the spindle speed of a ring spinning frame on the structure of yarn (i.e., its surface regularity and hairiness), its strength with a view to optimizing the spindle speed with this novel false twister. For this, yarns with counts of 15, 20, 25, and 30 tex were produced from 785 tex roving at five different spindle speeds ranging from 6,500 to 8,000 rpm with an interval of 2,000 rpm. All other parameters were kept constant, including the draft for a particular count, the type and weight of the traveller, and the diameter of the ring. Yarn strength, irregularity (u %), co-efficient of variation (CV %), actual count (Tex) and actual twist (T/10cm) has been investigated, analysed by YG173A yarn Hairiness Tester, YG133B/M Evenness Tester 4 and YG (B) 021DX tensile strength tester. The results from numerical simulations of modifies spinning system indicate that, physico-mechanical characteristics of cotton ring spun yarn has been improved in a considerable value. Thus points the speeding up of productivity of the yarn manufacturing.

Keywords— *False twister, Staple Yarn, Yarn strength, Irregularity, Hairiness.*

I. INTRODUCTION

Ring spinning is a popular yarn spinning technique of yarn production for its easy operation principle, Greater irregularity, higher hairiness, average strength and less productivity is an undesirable part of this spinning system [1]. In recent years, it is a trend to spin yarn by ring-spun technology with low linear density, high strength and smooth[2].Along with its profound advantages there are some major disadvantages such as irregularity, hairiness, average strength of spun yarn and less productivity of spinning machine are introducing ring spinning system as a defective spinning process[3, 4].Numerous attempts have been made to improve the quality of ring spun yarns[5-7].In the ring spinning process, the fibre strands rotate around the axis and the width begins to decrease when twist is inserted into fibre strands coming from the draft zone. Then, the fibres on both sides of the axis fold gradually and move into the centre of the spun yarn, and the spinning triangle forms consequently [8]. In this zone, individuals or bundles of fibres are twisted and consolidated to form a yarn structure. Therefore, this critical region in the spinning process of staple yarn and its geometry influences the distribution of fibre tensions and affects the properties of spun yarns, especially the yarn strength, irregularity and hairiness[8-10].Variation in the strength of a yam is of fundamental importance in all processes where yarn is being manipulated, in spinning because of its close relation to efficiency of spinning (rate of end breakages) and in twisting, winding, warping and weaving because of similar considerations of processing efficiency.

Yarn irregularity in its broadest sense covers irregularities produced in the processes of yam manufacture, also those introduced in the mechanical processes between spinning and weaving. yam properties like weight per unit length, diameter, color, turns per inch of twist and strength have influences on yarn irregularity, neps, slubs, knots and hairiness[11].Irregularities, lower strength and hairiness has always been a problem and many attempts have been undertaken in the past to reduce these drawbacks in order to introduce new application on conventional yarns. New technologies, like compact spinning, have shown to reduce yarn hairiness and have gained a lot of commercial prominence in the recent years[12-14], Many researchers indicated lower hairiness, greater strength, and higher elongation properties of compact yarns compared with that of the conventional ring-spun yarns [15, 16], some researcher indicates that, compact-jet spinning system is mainly effective on yarn hairiness and compact-jet yarn is superior compared with other yarns [17]but their production cost is so high that their commercial application has been minimized[3, 17]. Rather than expensive noble spinning system hairiness can be reduced by conventional techniques such as sizing for short staples and two-folding for long staples. However the yarn structure depends primarily upon the raw material, spinning process, spinning unit, machine, machine settings and twist [18]. Many of these have been investigated in the past and optimized already for particular end used.

In the last fifteen years there has been an intensive examination of the possibilities of improvement of productivity industrial production processes [19-22].With this aim and to avoid extra capital investment in aforementioned novel spinning methods, the principle of conventional spinning system was analysed. Then, a simple device installed on a ring frame to conduct a verified experiment. Thereafter, spun yarn properties were investigated and contrasted with traditional one. Spinning with a new device on preinstalled ring spinning system introduces as a simpler and productive method to improve physical properties and productivity of yarn.

II. EXPERIMENTAL

A. Materials

The raw material used on this research was 100% Cotton in the form of roving, to conduct the research cotton roving was collected from local textile spinning industry. After that, the cotton fiber and roving was characterized. Table-1 and 2 displays the physical characteristics of raw cotton and roving.

TABLE-1 CHARACTERISTICS OF COTTON FIBRE

Parameter	Value
Strength	30 g/tex
Micronaire Value	4.5-5.0 mic
Fiber Elongation	6.0%
Specific Gravity	1.54
Tenacity	3.0-4.9 g/Den
Elasticity	Relatively Low
Moisture Regain	8.5%

TABLE-2 USTER® REPORT OF ROVING

Sl. No.	U%	Cvm %	Cvm % 1m	Cvm % 3m	Rel cnt ±
1	4.35	5.48	1.48	1.05	1.1
2	4.43	5.55	1.59	0.73	0.6
3	4.33	5.42	1.64	0.81	-1.2
4	4.36	5.44	1.66	0.92	-0.4
Mean	4.37	5.47	1.59	0.88	0.0
Max	4.43	5.55	1.66	1.05	1.1
Min	4.33	5.42	1.48	0.73	-1.2

B. Testing Equipment's

Yarn hairiness was tested by using YG173A yarn Hairiness Tester and evenness was tested onYG133B/M Evenness Tester 4 and YG (B) 021DX was used for testing of tensile strength of yarn. Yarn linear density was tested by measuring the yarn length and weight. The electronic scale was used to weigh the yarn. In every test at least five samples were tested then the average was calculated for all tests. Testing laboratory environment was in optimum testing relative humidity and temperature.

C. Methodologies

1) Theoretical Explanation of New Spinning System

A modified ring spinning system is shown in Fig. 1. Yarn is delivered from the front rollers A. After leave front roller the yarn goes to the hollow gate of a false twister. There two pre-installed disk driven indirectly by front roller insert false twist to the yarn before yarn caught by traveler D to the winding point E mounted to the spindle in the ring rail. The direction of spindle rotation was clockwise thus it inserting s twist on the yarn producing by this modified spinning system.

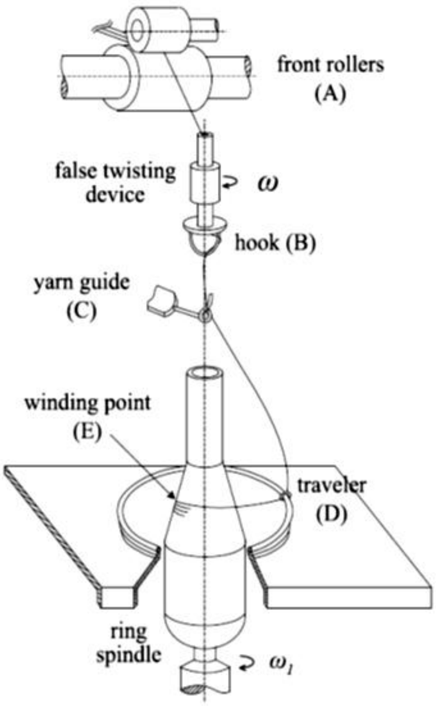

Fig 1 Yarn Path Of Modified Ring Spinning System

Experiment was directed to analyze the performances and change of yarn properties availed by the modified system. Different trials had been conducted and data collected on different spinning factors to clearly recognize the variation on physical properties and characteristics of new modified yarn.

Cotton Roving was spun into yarns with counts of 15, 20, 25, and 30 tex at four different spindle speeds ranging from 6500 to 8000 rpm with an interval of 500 rpm. A total of twenty yarn types were made to investigate irregularity, hairiness index, strength, and coefficient of variation of yarn. Among all aforementioned yarns 25 tex yarn shows better average physical characteristics. As 25 tex yarn shows relatively better performance, in this research 25 tex yarn were spun with this new device to analyze and contrast. To avail this goal, all parameters were kept constant, including the draft for a particular count, the type and weight of the traveler, and the diameter of the ring for both conventional and modified spinning system.

III. RESULT AND DISCUSSION

Improvement of physical properties

This analysis reveals the significances of a novel false twister mounted in a convention ring spinning system and get the information regarding physical properties of yarns such as strength, irregularity and co-efficient of variation with respect to the variation in spindle speed and count has been shown in Table-3, Table-4 and Table-5.

TABLE-3 ANALYSIS OF IRREGULARITY OF YARN

Spindle Speed	Strength (gf/tex)			
	15tex	20tex	25tex	30tex
6000r/min	222.10	454.60	443.50	654.25
6500r/min	226.80	407	598.20	592.20
7000r/min	232.70	429	451.10	549.60
7500r/min	241.30	375.80	607	573.90
8000r/min	242	398	624.80	618.90

TABLE-4 ANALYSIS OF STRENGTH OF YARN

Spindle Speed	Irregularity (u %)			
	15tex	20tex	25tex	30tex
6000r/min	10.95	10.47	8.52	8.13
6500r/min	11.22	10.61	9.04	8.31
7000r/min	11.02	9.89	9.02	8.12
7500r/min	11.27	10.54	8.73	8.41
8000r/min	11.30	10.13	8.78	8.29

TABLE-5 ANALYSIS OF COEFFICIENT OF VARIATION OF YARN

Spindle Speed	Co-efficient of Variation (CV %)			
	15tex	20tex	25tex	30tex
6000r/min	14.01	13.85	10.96	10.33
6500r/min	14.40	13.73	11.58	10.54
7000r/min	14.16	12.73	11.34	10.38
7500r/min	14.38	13.57	11.22	10.71
8000r/min	14.35	12.96	11.22	10.56

Figure 2 shows that, Yarn strength kept on increasing as the spindle speed was increased from 6,000 rpm up to 8,000 rpm. This trend also noticed with the increasing of linear density of yarn. This can be ascribed based on the fact that as when the spindle speed increase, the applied twist increases and internal roughness increases. 30 tex yarn spun in spindle speed about 7,500 to 8,000 rpm having twist of 70 twist per 10 cm found as stronger in strength than others shown in figure 3. Figure 3 and table 1 shows that, the yarn of 30 tex, spun by spindle speed of 6,500 rpm having 70 twist per 10 cm shows the highest point of yarn strength and yarn of 15 tex spun spindle speed of 6000 rpm and same twist factor shows lowest value of strength analysis.

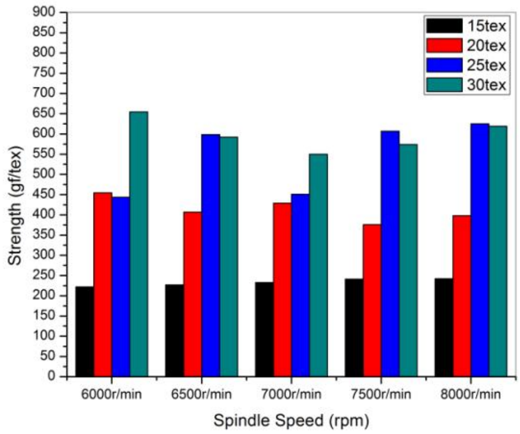

Fig 2 Yarn Strength In Contrast With Yarn Count And Spindle Speed

Average strength of yarn in different spindle speed varied from 6000 rpm to 8,000 rpm with an interval of 500 rpm was analyzed for 15, 20, 25 and 30 tex yarn. Yarn of 30 tex shows highest average strength having value of 597.77 gf/tex where average strength availed by 6000 rpm shows lowest index among our experiments, this phenomena is due to amount of fiber in a particular area of yarn. Higher the amount of fiber in a region leads to higher strength.

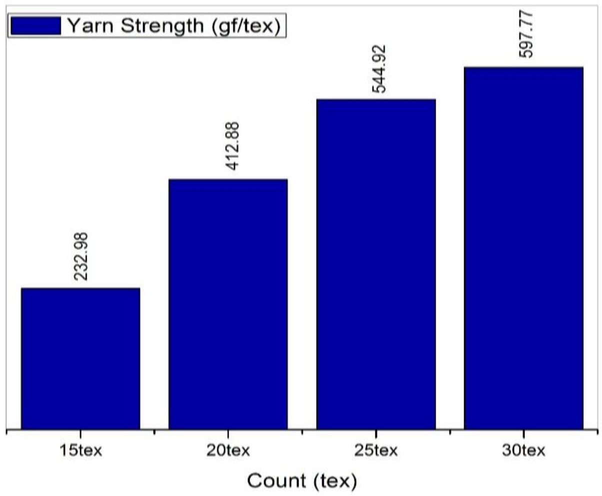

Fig 3 Average Yarn Strength In Contrast With Yarn Count And Spindle Speed

Figure 4 and Figure 5 explaining the irregularity and coefficient of variation (CV%) of traditional yarn, it seems that both the parameter is in decreasing trend as the spindle speed was increased from 6,000 rpm up to 8,000 rpm. This looks opposite trends in contrast to strength. This trend can describe as the coarser yarn entangles most of fibres together which lowers the irregularity and co-efficient of variation of resultant yarn. 15 tex yarn spun in spindle speed about 7,500 to 8,000 rpm having twist of 70 twist per 10 cm found as highest irregularity and CV% than others shown in figure 5 and Figure 6. Figure 5 and Figure 6 also explaining that, the yarn of 30 tex having 70 twist per 10 cm shows the lowest irregularity and CV% of the yarn.

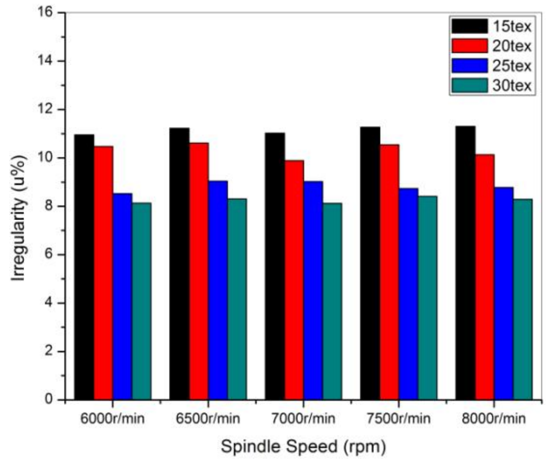

Fig 4 Irregularity (U %) Of Yarn In Contrast With Yarn Count And Spindle Speed

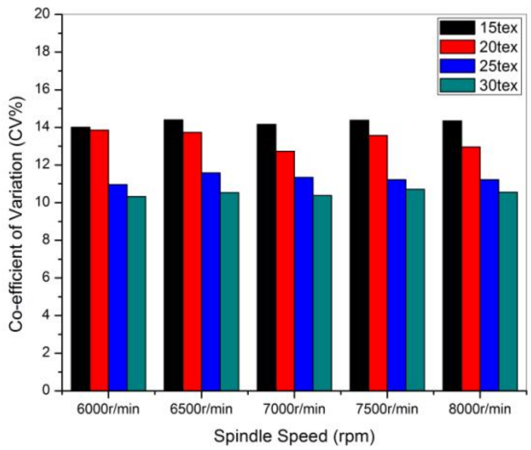

Fig 5 Co-Efficient Of Variation (CV %) Of Yarn In Contrast With Yarn Count And Spindle Speed

As 25 tex yarn shows relatively closer performance than 30 tex, but as 30 tex is coarser than 25 tex in this research performance of 25 tex yarn were considered as best average. Figure 6 describes the strength and figure 7 shows the irregularity and figure 8 shows coefficient of variation of yarn.

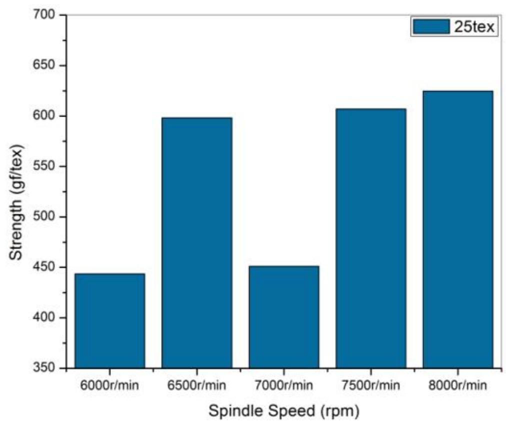

Fig 6 Strength Of 25 Tex Yarn In Contrast With Spindle Speed

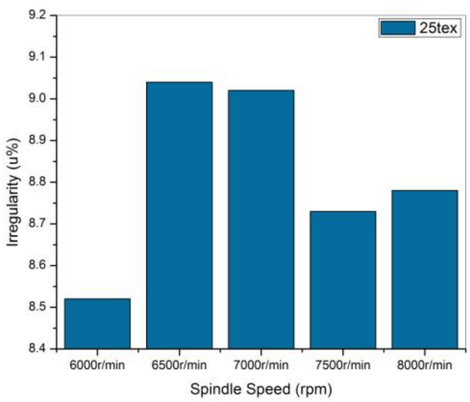

Fig 7 Irregularity Of 25 Tex Yarn In Contrast With Spindle Speed

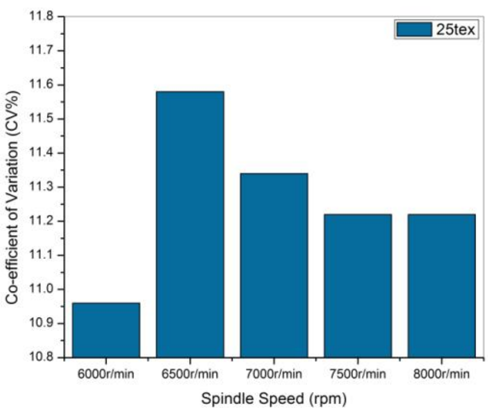

Fig 8 Co-Efficient Of Variation (CV %) Of 25 Tex Yarn In Contrast With Spindle Speed

Figures indicating that co-efficient of variation and irregularity of conventional yarn shows closer reading for all considered spindle speed lies between 10.96 to 11.58 and 8.52 to 9.04 correspondingly. But the strength of resultant yarn differ with the change of spindle speed most strong yarn can be found at spindle speed of 8000 rpm having strength of 624.80 gf/tex, in contrast with other spindle speed 6500 rpm also shows better strength properties, lowest strength availed by spindle speed of 6000 rpm and 7000 rpm.

IV. CONCLUSION

Most of the manufacturers try to run their manufacturing process with a higher productivity but sometimes is costs a lot for them. From the experiments it can be concluded that with this device manufacturer can produce better quality yarn with higher productivity rate by a minimum investment. In this research the structure of yarn was found to be more regular, strong and less hairy than traditional yarn which gives yarn more price and carries these advantages when being woven in terms smoother fabric surface and lesser surface pilling.

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