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AN INVESTIGATION ON PROPERTIES OF SIRO-SPUN YARNS

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Abstract: *Conventional ring spinning is known as traditional spinning system and it is most widely used system in textile industry. Despite being the most prevalent system and supplying approximately 60% of short-staple yarn production, there are still some limitations as lower production rate, longer production flow and higher production costs. That is why, researches in textiles started to accelerate to develop alternative spinning systems. Siro-spun spinning system which is an important type of twist spinning, had been developed with the aim of reducing yarn manufacturing costs by eliminating plying and twisting processes in the production flow. The main principle of Siro-spun spinning is to feed two parallel fibre strands in drafting zone and allow these two fibre strands twist together on each other when they leave the front roller. In this study, it was aimed to compare the properties of two ply yarns produced by ring spinning system and Siro-spun spinning system. For this purpose, properties of Ne 40/2 yarns made of cotton, Tencel, polyester and micro Modal were analysed. Results showed that Siro-spun yarns have lower hairiness and unevenness than ring-spun yarns, besides mechanical properties of both spinning systems are approximate. Besides the advantages in terms of production costs, it can be also concluded that Siro-spun spinning system is a strong alternative of conventional system in terms of many yarn characteristics.*

Key words: *Siro-spun spinning, twist spinning, plied yarn, micro Modal*

1. INTRODUCTION

Doubling and twisting processes which are used in conventional spinning technology are generally applied by low productive and low efficient machines. Besides; the fact that the twisting and winding processes are performed by the same element, causes some technological limitations. These limitations triggered new investigations and new developments on spinning technology. One of them is called twist spinning.

It can be modified a conventional ring-spun machine to a twist spinning machine easily by changing and adding couple of machine parts. As we can eliminate doubling and twisting processes, twist spinning technology provides us numerous important advantages such as lower energy and machine costs, lower investments and expenses [1].

Siro-spun spinning is one of the most widely used spinning technology invented by CSIRO and IWS in early 80's [2]. The main principle in Siro-spun is, two parallel fibre strands are drafted simultaneously in the drafting zone. These two fibre strands twist together on each other when they leave the front roller [3].

The most important difference between ring-spun plied yarns and Siro-spun yarns is the twist directions of single yarns which forms two ply Siro-spun yarns and the final twist direction of Siro-spun yarns are same. It means if Z twisted single yarn has been used to form a Siro-spun yarn, the final twist direction will be also Z as shown in Figure 1. That is why Siro-spun yarns have lower hairiness and smaller yarn diameter. According to Figure 2, the fibres of plied yarn with unidirectional twist produced by the twisting machine are orientated at right angles to the axis of the folded yarn. However, with Siro-spun yarns, fibres always have an incline to the axis of the plied yarn [4]. This orientation difference makes ring-spun yarns more voluminous and hairy.

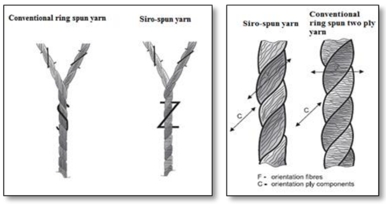

Fig. 1: *Twist directions and fibre orientations of conventional ring-spun yarns and Siro-spun yarns [4]*

In literature, there are many studies on properties of Siro-spun spinning and the comparison between ring spinning and Siro-spinning. Mansour and Tawfik [5] studied on the technology of Siro-spun spinning and its working principle by comparing yarn strength level of Siro-spun yarns and ring-spun yarns. Sun and Cheng [6] compared yarn structures of cotton Siro-spun yarns and ring-spun yarns according to their longitudinal and cross sectional view. Bedez Üte and Kadaoğlu [7] produced ring and Siro-spun viscose yarns in different yarn counts, twist multipliers and strand spacings to investigate effects of multiplicity in production parameters to yarn properties and aimed to compare strength and hairiness of viscose ring and Siro-spun yarns. In the end of this research it was seen that, Siro-spun yarns have lower hairiness and to obtain the maximum level of strength, it is proven to use the optimum stand spacing between two fibre strands.

Siro-spun spinning allows the textile industry to use a wide range of raw material and provides a production in a large variety yarn counts. In addition, we can easily obtain mouline yarns and serve new fabric qualities to the market by using the advantage of feeding two strand at the same time of Siro-spun spinning.

Establishing and adopting innovations instead of conventional systems is a highly costly investment all over the world and has a commercial risk, too. This new system called Siro-spun spinning technology, aims to increase both speed and efficiency of production with some machine parts that can be mounted on the ring spinning machine without requiring a new system to be reconstruct.

2. EXPERIMENTAL

In this study 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester two-plied ring-spun yarns and Siro-spun yarns were used. The yarn counts of Siro-spun and ring-spun yarns are Ne 40/2 for all raw materials. First of all, Ne 40/1 ring-spun yarns in Z twist have been produced by using 1000 TPM. After the application of doubling process the final yarn count of ring two ply yarns became Ne 40/2 in S twist and the last obtained twist amount became 500 TPM for all components. Secondly, Ne 40/2 Siro-spun yarns in Z twist have been produced by using 500TPM.

Table 1 shows linear density and cut length values of raw materials used in this study.

Table 1: *Properties of raw materials used*

Raw material	Linear Density (dtex)	Cut Lenght (mm)
Cotton	1,4	29,5
Tencel	1,3	38
Polyester	1,3	38
Micro Modal	1,0	38

All samples were conditioned in standard atmosphere (65% RH and 20±2°C) and tested according to machine specifications. To compare the physical, structural and mechanical properties of Siro-spun yarns and two-plied yarns such as unevenness, hairiness, imperfections, breaking force and elongation, Uster Tester 5 and Uster Tensorapid were used. Hairiness values (H, sh, S3, S1+2) were tested by Uster Tester 5 S800 and Uster Zweigle Hairiness Tester 5. Lawson Hemphill CTT tester was used to measure friction properties between yarn-to-metal, yarn-to-ceramic and yarn-to-yarn.

3. RESULTS AND DISCUSSIONS

Properties of 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester two-plied and Siro-spun yarns were statically analysed by using ANOVA at $\alpha = 0.05$ and examined by graphs for confidence interval at 95%.

3.1.Hairiness

According to the test results of Uster Tester 5 S800 (H, sh), hairiness values of Siro-spun yarns are lower than ring-spun yarns also in all raw material groups (Figure 2). Besides, according to the test results of Uster Zweigle Hairiness Tester 5 (S3, S1+2), Siro-spun yarns in all raw material types have approximate values of ring-spun yarns (Table 2). A general analyse of the effects of spinning system on hairiness of yarns shows that spinning technology is statistically important for H and sh hairiness values in all raw material groups. S3 and S1+2 values are not statistically important for cotton, Tencel and polyester yarns but important for micro Modal yarns. Table 2 shows the results of analysis of variance.

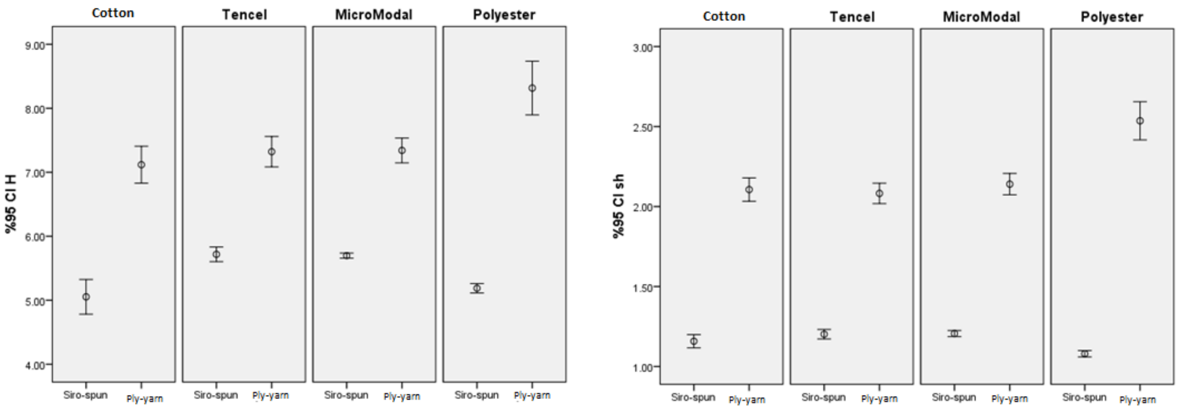

Fig. 2: *Hairiness values of 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester ring and Siro-spun yarns (H, sh)*

Table 2: *Significance (p) levels from ANOVA table for hairiness values*

Raw Material	**Significance (p)**			
	H	**sh**	**S3**	**S1+2**
Cotton	0,000	0,000	0,603	0,340
Tencel	0,000	0,000	0,627	0,132
Micro Modal	0,000	0,000	0,001	0,000
Polyester	0,000	0,000	0,260	0,486

3.2.Unevenness

Comparing unevenness values of two-plied and Siro-spun yarns shows that unevenness values of Siro-spun yarns in 100% Tencel, 100% micro Modal and 100% polyester are lower than ring-spun yarns and 100% cotton Siro-spun yarns have also a very similar test results with ring-spun yarns which can be entitled as competitive. Graphs are given for this values in Figure 3. ANOVA results also show that, spinning technology is statistically significant for unevenness values of Tencel and micro Modal yarns but unappreciable for cotton and polyester.

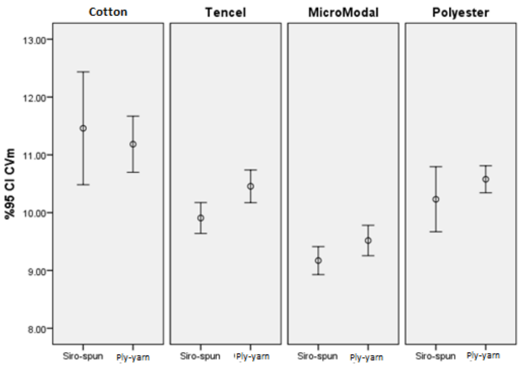

Fig. 3: *Unevenness (%CVm) values of 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester ring and Siro-spun yarns*

3.3 Imperfections

Thin places (-50% /km), thick places (+50% /km) and neps (+200% /km) were measured by Uster Tester 5 S800. Figure 4 shows the graph for confidence intervals at 95% which belong to imperfection values. ANOVA data shows us that spinning technology isn't statistically significant for imperfection values of thin places (-50% /km). Besides, we can generally determine that values of thick places (+50% /km) and neps (+200% /km) are relatively higher for Siro-spun yarns. The most possible reason for this situation could be the uncontrolled strand transportation in the drafting zone while producing the Siro yarns. In addition, Tyagi and his colleagues explain the reason of higher neps quantity as; using more dense fibres in Siro-spinning can be a cause of having more neps on Siro-spun yarns [8].

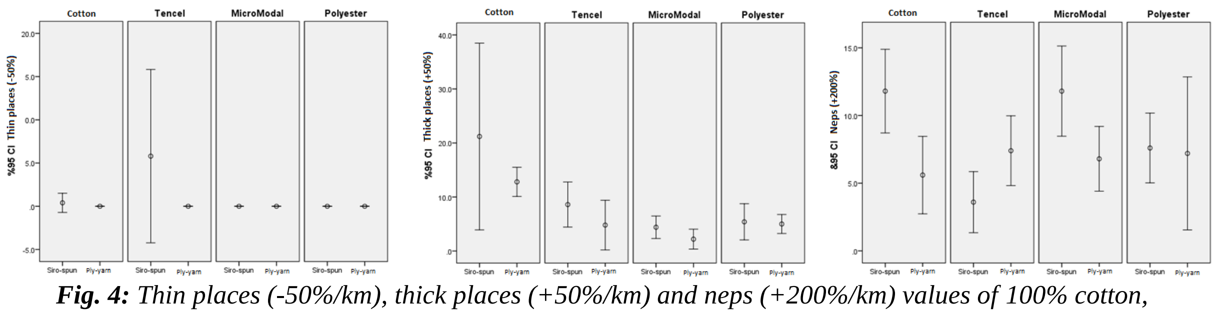

Fig. 4: *Thin places (-50%/km), thick places (+50%/km) and neps (+200%/km) values of 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester ring and Siro-spun yarns*

3.4 Mechanical Properties

In order to compare mechanical properties of yarns, breaking force (cN) and breaking elongation (%) were measured by Uster Tensorapid. ANOVA results show that spinning technology is important for all raw material groups for breaking force. Besides, breaking elongation is statistically significant for 100% Tencel, 100% micro Modal and 100% polyester but not significant for 100% cotton. Although breaking force of polyester Siro-spun yarns are higher, ring-spun yarns shows higher values for other raw materials. Furthermore, breaking elongation values of cotton, polyester and micro Modal Siro-spun yarns are higher than values of conventional ring-spun yarns. Results are illustrated in Figure 5.

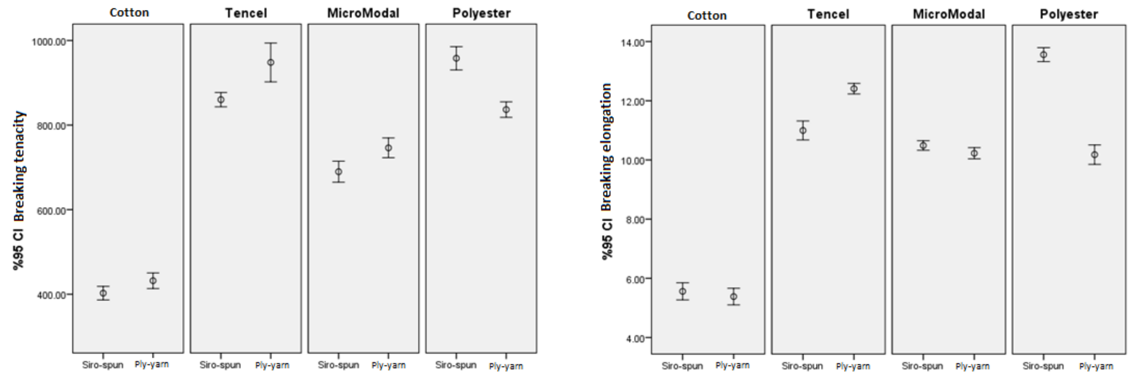

Fig.5: *Breaking force (cN) and breaking elongation (%) values of 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester ring and Siro-spun yarns*

3.5 Friction Properties

To analyse yarn friction properties, tests were performed under three main topics such as yarn-to-yarn, yarn-to-metal and yarn-to-ceramic friction properties. Yarn-to-yarn friction properties were calculated by using Equation 1. Equation 2 was used to calculate yarn-to-metal and yarn-to-ceramic friction properties. Figure 6 shows us, ring-spun yarns and Siro-spun yarns have quite approximate values for yarn-to-metal and yarn-to-ceramic friction. Nevertheless, Siro-spun yarns in all raw material groups show superior values compared to ring-spun yarns in yarn to yarn friction. This result could be concluded as lower value of yarn-to-yarn friction cause lower hairiness level.

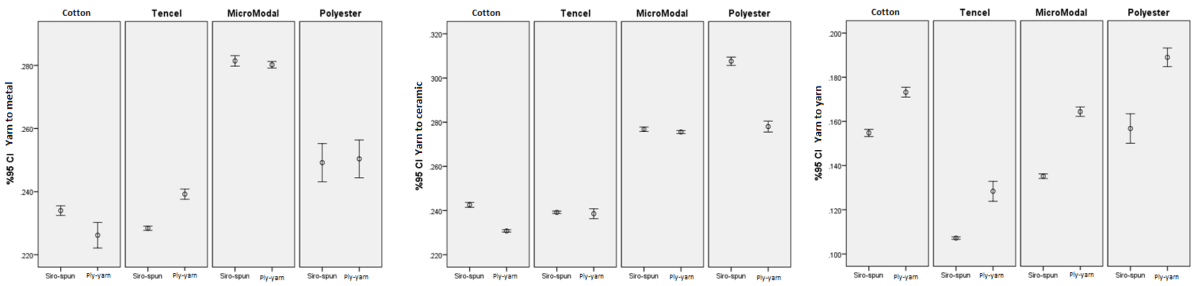

Fig. 6: *Yarn-to-yarn, yarn-to-metal and yarn-to-ceramic friction properties values of 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester ring and Siro-spun yarns*

4. EQUATIONS

$$\mu = \frac{\ln(T_2 / T_1)}{4\pi(n - 0.5)\sin\beta / 2} \qquad \textbf{(1)}$$

$$\mu = \frac{\ln(T_2 / T_1)}{\theta} \qquad \textbf{(2)}$$

5. CONCLUSIONS

In this study 100% cotton, 100% Tencel, 100% micro Modal and 100% polyester ring-spun yarns and Siro-spun yarns were used. It was aimed to compare the Siro-spun and two ply ring-spun yarns in terms of physical, structural and mechanical properties such as unevenness, hairiness, imperfections, breaking force, elongation and friction. Results showed that all hairiness values (H, sh, S3, S1+2) of Siro-spun yarns considering all raw material groups have lower hairiness degree.

For unevenness and imperfection values, results showed us that cotton and polyester Siro and ring-spun yarns have approximate values which makes Siro-spinning a good alternative of ring spinning. In addition, it can be easily found that Siro-spinning has an improving effect on unevenness values of micro Modal and Tencel yarns. Siro-spun yarns and ring-spun yarns have quite approximate quantities of thin places and thick places. Besides cotton and micro Modal ring-spun yarns have lower neps quantities.

In cotton, Tencel and micro Modal Siro-spun yarns, the values of breaking strength is lower than those of ring-spun yarns, but the difference can be ignored for yarn production where strength is not on the priority. In 100% polyester fibers, the tensile strength and breaking extension values of Siro-spun yarns are higher than ring-spun yarns. For Tencel and micro Modal fibers, the Siro-spinning system can be interpreted as a good alternative to the ring spinning system in terms of mechanical properties.

Siro-spun and ring-spun yarns in all material groups shows similar properties in yarn-to-metal friction except Tencel and in yarn-to-ceramic friction except polyester. Polyester Siro-spun yarn has higher coefficient of yarn-to-ceramic friction and Tencel Siro-spun yarn has lower coefficient of yarn-to-metal friction. In all material types, Siro-spinning system has a certain advantage on yarn-to-yarn friction which is a crucial parameter on yarn formation and fabric weaving.

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