THE EFFECT OF TAKE-UP AIR-JET-NOZZLE PARAMETERS ON COTTON ROTOR-SPUN YARN PROPERTIES

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Abstract
In this research, the take-up navel (nozzle) of rotor spinning machine was modified into an air-jet nozzle form. Thus, air-jet nozzles with different structures of 90S, 90Z, 55Z and 45Z (the values of 45, 55 and 90 are screw angles and S and Z are air rotational directions) were constructed and then mounted in the take-up nozzle position of rotor spinning machine. The air-jet pressure was changed at 0.5, 0.75, 1 and 1.5 bar values. The physical properties of cotton rotor-spun yarns with yarn count 30 tex and nominal twist of 850 T.P.M were investigated.
The experimental results indicate that for Z type air-jet nozzle increasing the air pressure up to 1 bar improved the rotor-spun yarn hairiness as well as increased tensile strength, twist and abrasion resistance and decreased yarn elongation. However, further increasing air pressure deteriorated rotor-spun yarn physical properties. Moreover, using S type air-jet nozzle has no significant influence on the rotor-spun yarn physical properties. The results also showed that using 55Z and 45Z air-jet nozzle types has no significant effect on the rotor-spun yarn physical properties in comparison with normal rotor-spun yarns.
Key words: Rotor-spinning, take-up nozzle, air-jet pressure, yarn physical properties

1. Introduction:

Rotor spinning invented in 1967 by the Investa Company (Czechoslovakia), is a comparatively new method of yarn manufacture, which produces yarns with lower breaking strength than that of conventional ring spun yarns [1,2,3,4]. Thus, the rotor spinning is more economical than ring spinning for yarn counts up to Nm 70 [2].

It was well established that the spinning parameters affect the rotor yarn properties [2]. In particular, the navel or nozzle type itself influences the yarn residual twist [5] and physical properties [2,6]. Klien [2, 7] discussed that presenting a stationary navel in rotor spinning creates a false twist, which positively affects the spinning operation especially at higher rotor speeds. Using rotary navel also affects the rotor yarn physical properties [6]. Kon and Harakawa [6] investigated that the rotary nozzle decreased the spinning tension and *peripheral twist extend* (PTE) and hence improved the rotor-spun yarns tensile properties.

Nowadays, there are some efforts to improve the yarn physical properties by utilizing the air-jet nozzle in different spinning systems and processing stages [8,9,10,11,12,13,14,15,16]. In particular, Yu [10] designed the concept of open-end jet spinning and compared the yarn physical properties with those of rotor and air-jet spun yarns. Thus, the aim of this research is to modify take-up nozzle to an air-jet nozzle form in Rotor spinning machine and to investigate and compare the rotor-spun yarn physical properties with those of normal Rotor yarns.

2. Experimental

In this work, a cotton sliver (28 mm cotton fiber length and 3.5 Micronair value) with linear density of 3.7 Ktex was then fed to an Ellitex Rotor-spinning machine. The rotor, opening roller and take-up roller speeds were kept constant at 56400 rpm, 7000 rpm, and 66 m/min values respectively. The take-up navel (nozzle) of the rotor spinning machine was modified into an air-jet nozzle form as shown in Fig.1. Thus, air-jet nozzles with different structures of 90S, 90Z, 55Z and 45Z (the values of 45, 55 and 90 are sub-channel angles to main axis and S and Z are air rotational directions) were constructed and then mounted in the take-up nozzle position of rotor spinning machine. The air-jet pressure was changed at 0.5, 0.75, 1 and 1.5 bar values. Therefore, 16 modified rotor-spun yarn samples with linear density of 30 tex and nominal twist level of 850 T.P.M were produced. Hence, the yarn physical properties including strength, elongation, twist, count, abrasion resistance, irregularity and hairiness were measured and compared with those of normal rotor spun yarns [16]. In order to statistically analyze the effects of take-up air-jet nozzle geometry and air pressure on yarn physical properties, two-way ANOVA and multiple range test methods was performed using SPSS software. A summary of statistical analysis results is shown in Table 1.

3. Results and Discussion

Table 1. A summary of statistical analysis results of rotor-spun yarn physical properties

Jet Type	Air Pressure(bar)	Strength	Elongation	Twist	Hairiness	Irregularity(CV%)	Abrasion Resistance
45Z	0.5	+	*	+	+	-	*
	0.75	+	+	+	+	-	-
	1	+	+	*	+	-	+
	1.5	-	-	-	*	-	-
55Z	0.5	+	*	+	+	*	-
	0.75	*	*	+	+	*	*
	1	*	*	+	*	-	*
	1.5	-	-	-	*	-	-
90Z	0.5	+	*	+	*	*	*
	0.75	+	*	+	+	*	*
	1	+	+	*	+	-	+
	1.5	-	*	-	*	-	*
90S	0.5	*	-	*	*	-	-
	0.75	-	-	*	*	-	-
	1	-	-	-	*	-	-
	1.5	-	-	-	-	-	-

+ *The effect of parameter is statistically significant and improved yarn property*

- *The effect of parameter is statistically significant and deteriorated yarn property*

* *The effect of parameter on yarn property is statistically in-significant*

3.1 The Effect of take-up jet nozzle and air pressure on yarn physical properties

3.1.1 Yarn twist

The yarn twist level against air pressure for four take nozzle types as well as normal rotor-spun yarn (control) is shown in Fig. 1. As can be found in Table 1 and Fig.1, using Z type jet nozzle increase rotor yarn twist. This is more significant for 90Z type nozzle since air-flow effectively rotates the yarn body. It is reasonable to state that the swirling air rotates the yarn in the rotor twist direction resulting to a false-twist effect. The false-twist in-turn penetrates into the rotor groove causes to be more twist developed into the yarn core and hence increasing the yarn twist. However, due to creation of air turbulence at highest air pressure of 1.5 bar, the level of yarn twist is decreased and reached to normal rotor spun yarn. For the case of 90S take-up nozzle, the yarn twist level is almost equal to normal rotor yarn since the air rotates the yarn opposite to rotor direction.

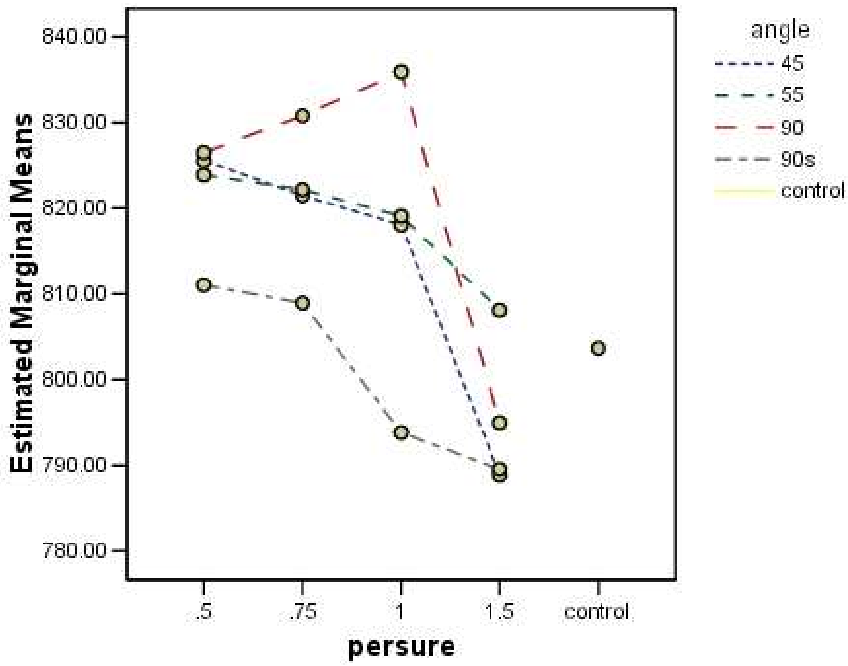

Figure 3. Rotor-spun yarn twist (T.P.M) at different take-up air-nozzle types and air pressure values

3.1.2 Yarn irregularity (CV%)

The yarn irregularity values (CV%) against air pressure for four take nozzle types as well as normal rotor-spun yarn (control) is shown in Fig. 2. As can be found in Table 1 and Fig.2, in general using take-up air-jet nozzle increases yarn irregularity. This is more intensive for 45Z nozzle type since air flow penetrates into the rotor and deteriorates fibre orientation inside the rotor groove.

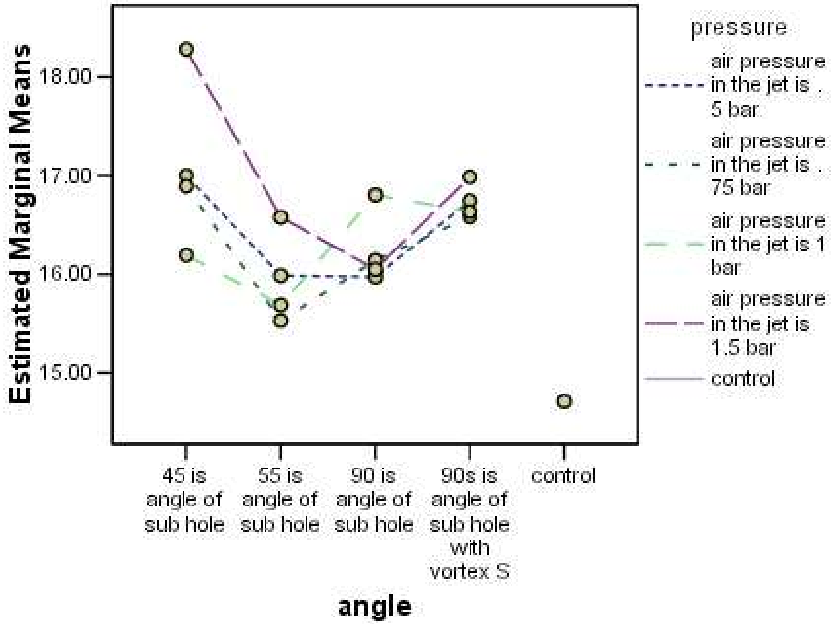

Figure 3. Rotor-spun yarn irregularity (CV%) at different take-up air-nozzle types and air pressure values

3.1.3 Yarn hairiness

The yarn hairiness values against air pressure for four take nozzle types as well as normal rotor-spun yarn (control) is shown in Fig. 3. As can be found in Table 1 and Fig.3, by using 55Z and 90Z take-up nozzle types at air pressures of 0.75 and 1 bar values the lowest yarn hairiness values was obtained. This is because at these nozzle types the air flow affects the yarn body almost in perpendicular direction of yarn axis and hence traps fibre ends into the yarn body. On the other hand, using 90S nozzle type at air pressure of 1.5 bar significantly deteriorates yarn hairiness since the air flow rotates the yarn and fibre ends opposite to main spinning twist direction.

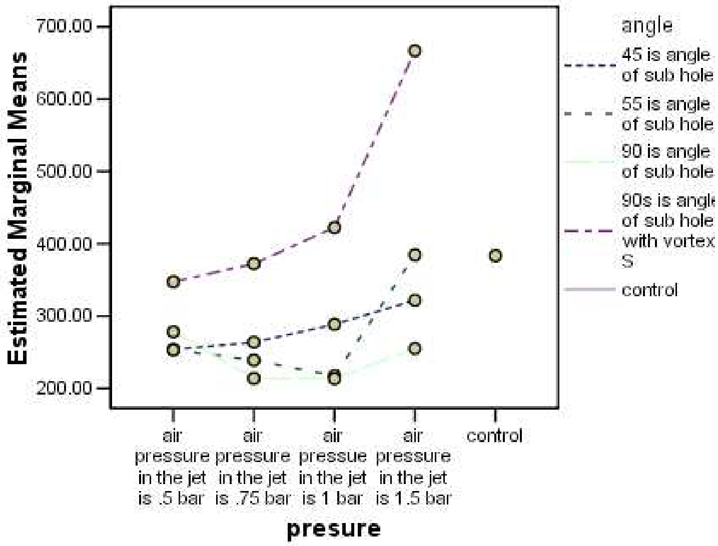

Figure 3. Rotor-spun yarn hairiness at different take-up air-nozzle types and air pressure values

3.1.4 Abrasion resistance

As shown in Fig. 4 and Table 1, using a 90Z take nozzle type at 1 bar air pressure value, significantly increase rotor-spun yarn abrasion resistance. This result is in agreement with that of obtained for yarn hairiness as discussed before. However, increasing air pressure up to 1.5 bar value particularly for 90S take-up nozzle type significantly decreases yarn abrasion resistance. The reduction of yarn twist at this pressure value can be responsible for yarn abrasion resistance loss.

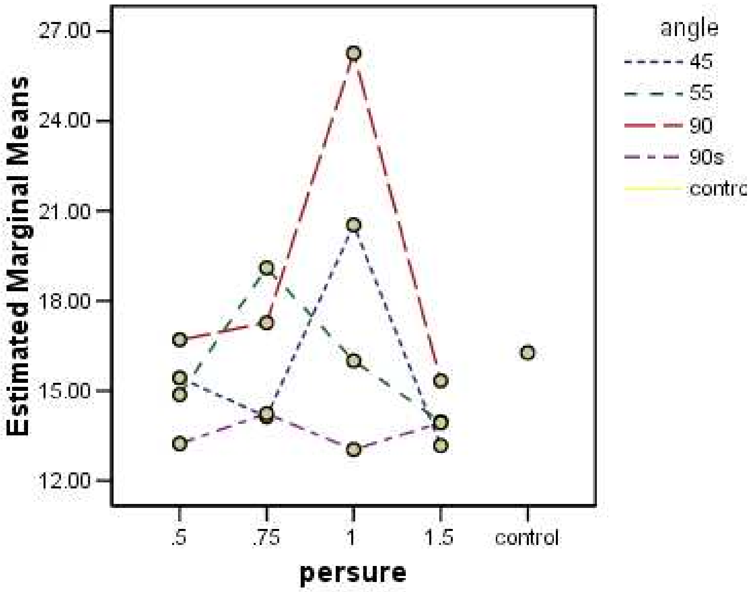

Figure 4. Rotor-spun yarn abrasion resistance at different take-up air-nozzle types and air pressure values

3.1.5 Yarn tensile strength and elongation

The yarn tensile strength values against air pressure for four take nozzle types as well as normal rotor-spun yarn (control) is shown in Fig. 5. As can be found in Table 1 and Fig.5, by using 90Z and 90S take-up jet nozzle types the highest and lowest tensile strength compared to normal rotor-spun yarn were obtained respectively. Similar reasoning for yarn twist variation can be stated for yarn tensile strength. It is reasonable to state that the swirling air rotates the yarn in the rotor twist direction resulting to a false-twist effect. The false-twist in-turn penetrates into the rotor groove causes to be more twist developed into the yarn core and hence increasing the yarn strength [17]. It is also interesting to note that highest tensile strength obtained at 0.5 bar air pressure value while the lowest tensile strength achieved at 1.5 bar air pressure value due to occurrence of air vortex flow into the rotor groove.

Moreover, opposite for tensile strength, as shown in Fig.6, by using 90Z and 90S take-up jet nozzle types the lowest and highest tensile elongation compared to normal rotor-spun yarn were obtained respectively. In addition, rotor-spun yarn exhibits the lowest and highest tensile elongation values at 0.5 and 1.5 bar air pressures respectively. It is deduced that more belt wrapper fibers is created at 0.5 bar air pressure value and vice versa.

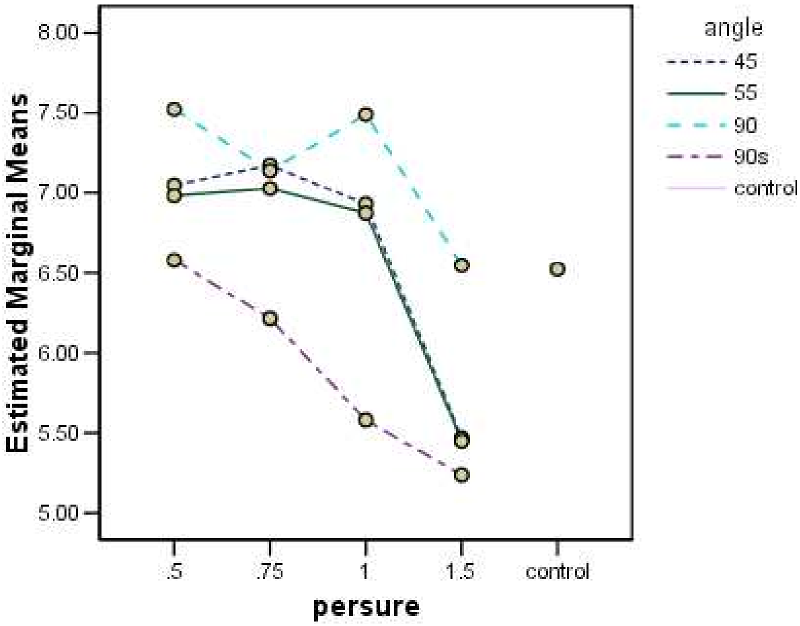

Figure 5. Rotor-spun yarn tensile strength (cN/tex) at different take-up air-nozzle types and air pressure values

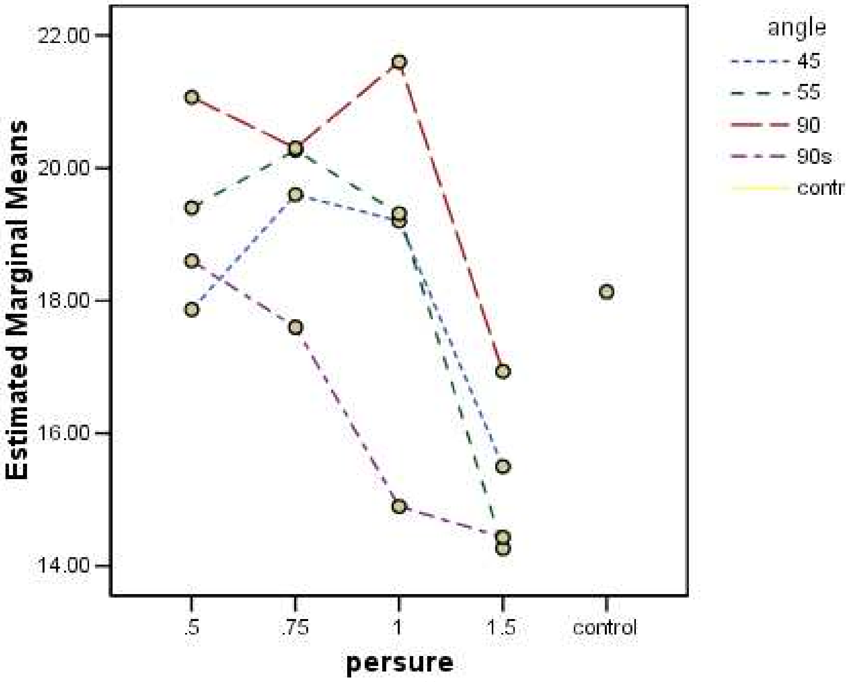

Figure 6. Rotor-spun yarn tensile elongation (%) at different take-up air-nozzle types and air pressure values

4. Conclusion

This paper presents a novel hybrid spinning system which utilizes the modified take-up navel as an air-jet nozzle in rotor spinning machine. Application of a 90Z nozzle imparts a false-twist to the freshly twisted rotor yarn which in turn improves tensile strength, hairiness, abrasion resistance and spinning twist of rotor-spun yarn compared with that of normal rotor yarn while slightly deteriorates yarn irregularity. On the other hand, replacing the Z nozzle by a S-type nozzle would impart a false-twist opposite to the real twist direction resulting to a more opened-yarn structure and thus deteriorates rotor-spun yarn properties.

The experimental results of this paper suggest that the newly developed rotor-spun spun yarn in a hybrid spinning system are superior to normal rotor spun yarns from point of view of properties. Further research studies need to compare the spinning performance and yarn structure of developed rotor-spun yarns with conventional rotor spun yarns.

5. References

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