

# Design and Fabrication of Air Jet Nozzles for Air Vortex Ring Spinning System to reduce the Hairiness of Yarn

K Ramachandralu, *Non-member*

B S Dasaradan, *Non-member*

*With the objective of reducing the hairiness of cotton yarns, two types of air jet nozzle differing with each other in the direction of inclination of orifice and suitable for air vortex ring spinning system have been designed and fabricated. The drafted cotton roving strand emerging from the front roller nip and passing through the air jet nozzle has been subjected to the air vortex of compressed air which tucks the protruding hairs and subsequently as the yarn emerges out of the nozzle they are bound by the mechanical twisting agency and results in the reduction of hairiness. The performance of these two types of nozzle has been evaluated in terms of reduction in the hairiness and improvement in other properties of 30 s carded yarn processed under 0.5 bar air pressure of compressed air, administered into the nozzle. It has been observed that the best results are achieved with the air jet nozzle in which the direction of rotation of the air vortex created is in the direction same as that of the yarn twist. Using this nozzle the hairs in the 30 s carded yarn decreased by 50% at 0.5 bar air pressure. There has been marginal increase in tensile proprieties and 11.5% fall in imperfection level.*

*Keywords:* Air jet nozzles; Air vortex ring spinning; Hairiness

## INTRODUCTION

It is a well known fact that high speed spinning today has achieved excellent results in terms of productivity, but has not done satisfactorily on yarn quality, especially in terms of the important characteristic namely hairiness. The ability of the spinner to keep the hairiness under control during spinning would help him to minimise the increase in imperfections in winding. The fibres can be bound into the yarn only if there can be a mechanism before the fibre strand is delivered out of the front roller nip, as in the compact spinning<sup>3</sup>. Otherwise a mechanism which can influence the fibre strand in such a way that the surface fibres are bound inside the yarn is required. That is what precisely an air jet nozzle has got to offer. Attempts had been made in the past for using an air jet nozzle in ring spinning. All these investigations used a particular nozzle design and the effects of varied design aspects of nozzle on quality of yarn have not been dealt with. Kalyanaraman's<sup>1</sup> study shows that the hairiness level in ring spinning of cotton yarns considerably decreases with the employment of a pressure column in-between the front roller nip and the lappet hook. Using jet ring spinning system which introduces an air jet nozzle below the spinning triangle of the worsted ring frame, Wang, *et al*<sup>2</sup> could achieve reduction in hairiness of yarn by the upward swirling air against the yarn movement and twist, which facilitates the tucking of protruding fibres into the body of the yarn by loosening and tightening up of the fibre strand. Hence, the utility of air jet has to be considered

with serious interest in view of its immense potential in influencing the surface properties of yarn. The air vortex ring spinning system combines air jet and ring spinning technologies. Cotton being a finer and shorter fibre would present more ends per unit length, which increases the number of fibres protruding out of the yarn surface and affects its surface and structural properties. Hence, it has been considered for this research work which makes an attempt on studying the effect of air vortex ring spinning system on reduction of hairiness and improvement of other properties of cotton yarn. Further, it examines the effect of direction of rotation of the air vortex produced by the swirling air current on the hairiness and other properties of yarn.

This research work aims at design and fabrication of two types of air jet nozzles for the air vortex ring spinning system; employment of these nozzles in the air vortex ring spinning system to be fitted in between the front roller nip and lappet hook of the ring frame; and evaluating the performance of these nozzles with respect to the hairiness reduction and improvement of other properties of yarn.

The air vortex ring spinning system is given schematically in Figure 1.

## METHODOLOGY

### Materials and Method

A roving of 1.2 hank was produced in the usual manner and taken for this study. The ring spinning process parameters are given below in Table 1.

The yarns produced with the two types of air jet nozzle differing in direction of rotation of air vortex were tested for hairiness, tenacity, elongation, evenness and imperfections.

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K Ramachandralu and B S Dasaradan are with the Department of Textile Technology, PSG College of Technology, Coimbatore 641 004.

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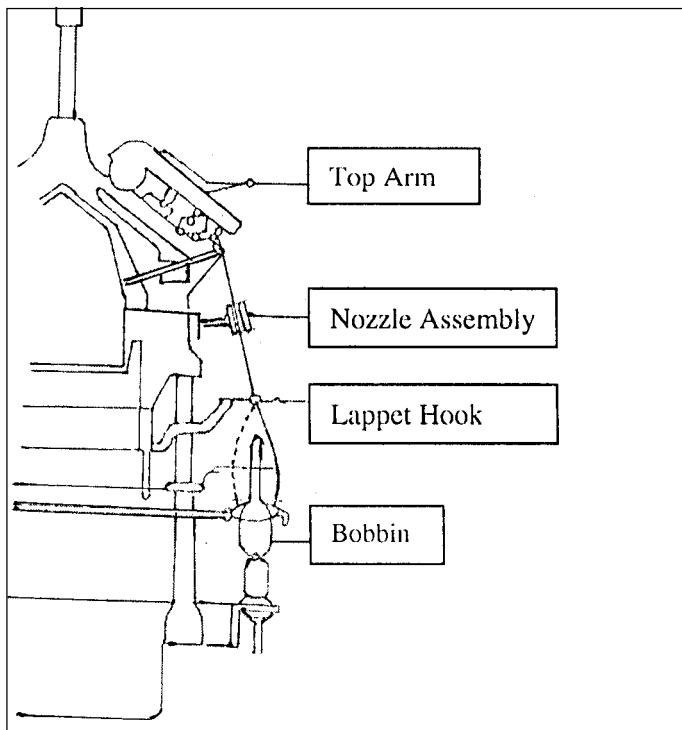


Figure 1 Air vortex ring spinning system

Table 1 Ring spinning process parameters

Spindle speed, rpm	13000
Roving hank	1.2
Yarn count, Ne	30 <sup>s</sup> K
TM	4.06
Direction of twist	Z
Air pressure, bar	0.5

### Design and Fabrication of Air Jet Nozzle

Two air jet nozzles were designed and fabricated for this study. They are similar in all dimensions, but different in the direction of inclination of the orifices. Type 1 nozzle will produce air vortex in the direction same as that of air twist, *ie*, in Z direction. Type 2 nozzle will produce air vortex in the direction opposite to that of yarn twist, *ie*, in S direction. A suitable air jacket with inlet for compressed air to surround

Table 2 Properties of parent yarn spun without using air jet nozzle

Hairiness (Number of Hairs above 3 mm/ 100 mts)	Tenacity, g/tex	Elongation, %	U, %	Imperfections/km			
				Thin - 50%	Thick + 50%	Nep + 200%	Total
150.9	20.77	5.41	15.49	125	884	1054	2063

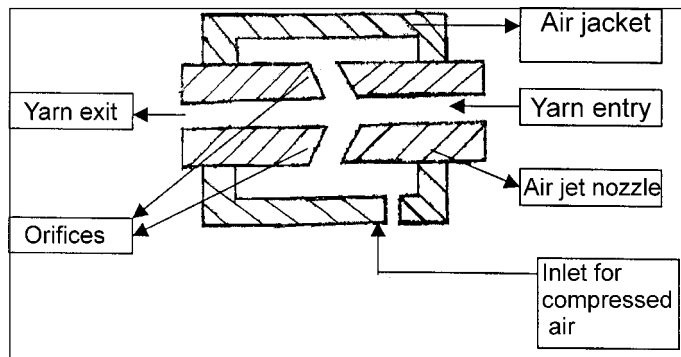


Figure 2 Design of air jet nozzle assembly

these nozzles was designed and fabricated. This schematic diagram of the air jet nozzle assembly comprising of the air jet nozzle and the air jacket is shown in Figure 2.

## RESULTS AND DISCUSSION

Table 2 given below lists the properties of parent yarn spun without using the air jet nozzle.

Table 3 given below lists the properties of yarn produced with the two types of nozzle.

It is observed from Table 3 that the employment of air jet nozzle contributes to hairiness reduction and that the hairiness has got a bearing on the type of the nozzle with respect to the direction of rotation of vortex.

The comparison of properties of yarns namely hairiness, tenacity, elongation, evenness and imperfection using air jet nozzles (both types) with those of the parent yarn are depicted in the form of histograms in Figures 5, 6, 7, 8 and 9.

### Effect of Direction of Rotation of Air Vortex on Hairiness

Analysis of test results shows that employment of air jet nozzles reduces the hairiness level in the yarn, and the quantum of reduction is more with Type 1 nozzle when compared to that achieved with Type 2 nozzle. The comparison of air vortex ring spun yarns with parent yarn with respect to hairiness is shown in the form of histogram in Figure 5.

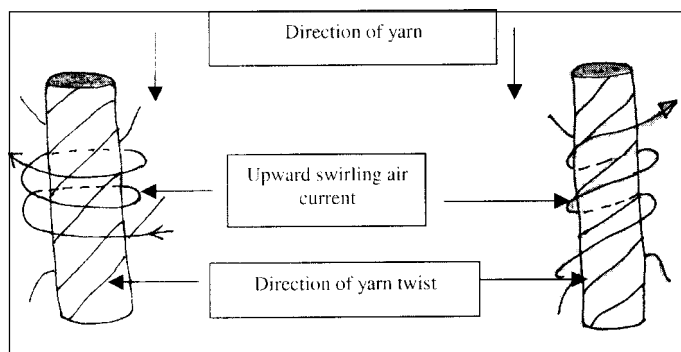
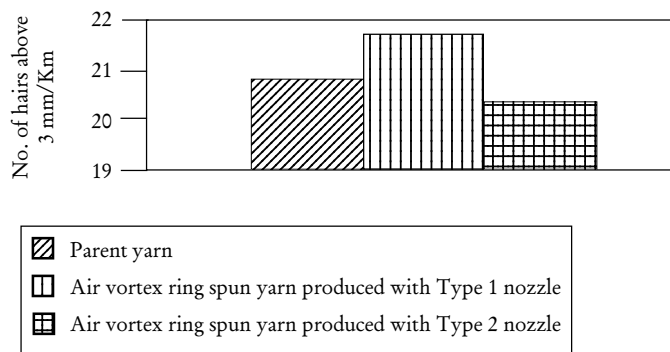


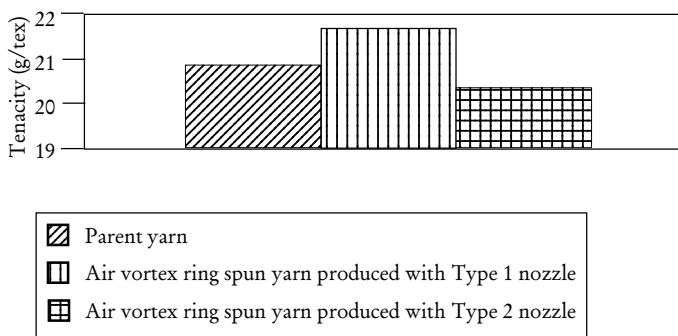
Figure 3 & Figure 4 Air vortex in Z direction and air vortex in S direction respectively

**Table 3** Properties of air vortex ring spun yarns

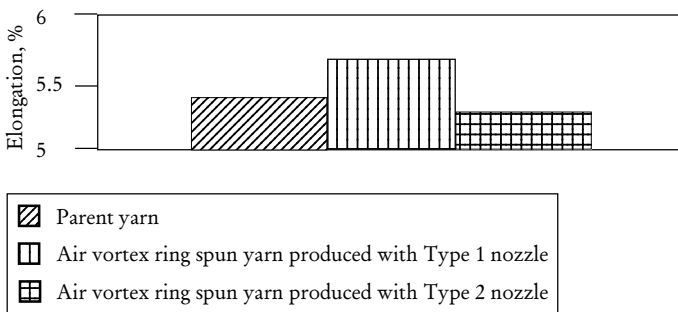
Type of Nozzle with Direction of Rotation of Vortex	Hairiness (Number of Hairs above 3 mm/100 mts)	Tenacity, g/tex	Elongation, %	U, %	Imperfections/km			
					Thin - 50%	Thick + 50%	Nep + 200%	Total
Type 1 with Z direction	74.5	21.60	5.71	14.91	257	799	968	1824
Type 2 with S direction	109.5	20.36	5.31	15.45	114	889	980	1983



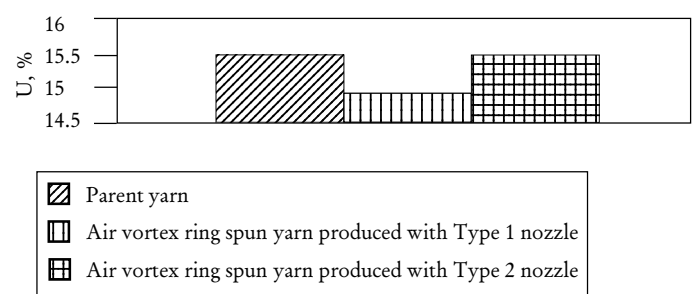
**Figure 5** Comparison of air vortex ring spun yarns with parent yarn with respect to hairiness



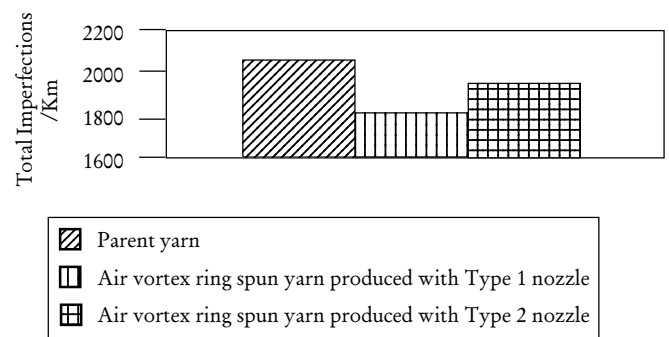
**Figure 6** Comparison of air vortex ring spun yarns with parent yarn with respect to tenacity



**Figure 7** Comparison of air vortex ring spun yarns with parent yarn with respect to elongation



**Figure 8** Comparison of air vortex ring spun yarns with parent yarn with respect to evenness



**Figure 9** Comparison of air vortex ring spun yarns with parent yarn with respect to total imperfections

The hairiness reduction with Type 1 nozzle is 50.6%, whereas the hairiness reduction with Type 2 nozzle is 27.4%.

The reduction of hairiness observed in the study requires an explanation. In general, the ring spun yarn has more fibre ends protruding in the trailing direction<sup>4,5</sup>. When the yarn passes through the nozzle it encounters with the air vortex created by the upward swirling air current, gyrating in the opposite direction. In case of Type 1 nozzle the air vortex false-twists the partially twisted yarn in the direction same as that of yarn twist, *ie*, in Z direction which is schematically shown in Figure 3. This air vortex produced by the upward swirling air current tucks the protruding fibres, particularly the trailing hairs, onto the yarn surface. When the yarn comes out of the

nozzle the tucked hairs are bound into the yarn structure as the mechanical twist created by the revolving traveller flows towards the nozzle. The sweeping action of the air vortex, which effects in the realignment of the fibres, contributes greatly to reduced hairiness. In case of Type 2 nozzle, the air vortex produced by the upward swirling air current false-twists the partially twisted yarn in the direction opposite to that of yarn twist, *ie*, in S direction, which is shown schematically in Figure 4. The upward swirling air current against the movement of yarn and twist, loosens the fibre strand, when by the tucking of fibres on to the body of the yarn takes place. As the yarn comes out of the nozzle the loosened fibre strand gets tightened by the flow of twist from the mechanical twisting agency, when by the binding of the tucked fibres takes place as explained by Wang, *et al*<sup>2</sup> in their study of air jet spinning. The reason for achievement of better reduction with Type 1 nozzle could be due to the better wrapping of protruding fibres by the sweeping and binding action of the air vortex current twisting the strand of fibres in the direction same as that of the yarn twist.

#### Effect of Direction of Rotation of Air Vortex on Tensile Properties

The test results on tensile properties are given in Table 3 and the comparison of air vortex yarns with parent yarn with respect to these properties are shown in the form of histograms in Figures 5 and 6. The test results show that the employment of Type 1 nozzle increases the tenacity and elongation percentage marginally by 4% and 7.3%, respectively over parent yarn, where as with the employment of Type 2 nozzle there is not much difference in the tensile properties over parent yarn. This could be explained as follows: with Type 1 nozzle there is a reduction of 50% in hairiness. This substantially reduced hairiness in the yarn structure makes all the component fibers to share the tensile load which results in increased tenacity as well as elongation percentage, which is in fair agreement with the general theory. In case of Type 2 nozzle, even though there is a reduction of hairiness to the tune of 27.4%, it has not resulted in any significant improvement in tensile properties.

#### Effect of Direction of Rotation of Air Vortex on Evenness and Imperfections

The test results on evenness and imperfections are given in Table 3 and the comparison of the air vortex yarns and parent yarn is given in Figures 7 and 8. They show that there is marginal difference in evenness between the parent yarn and air vortex ring spun yarn, produced with Type 1 nozzle and very little difference between the parent yarn and the air vortex ring spun yarn produced with Type 2 nozzle.

With respect to imperfections it could be noticed that the reduction in imperfections level works out to 11.5% with the Type 1 nozzle whereas there is very little reduction (3.85%) with Type 2 nozzle. Probably the substantial reduction in hairiness with Type 1 nozzle has reduced the imperfections level as better wrapping of the protruding fibres could have covered up the imperfections present in the yarn to certain extent.

#### CONCLUSION

1. Air vortex ring spinning system in general improves the quality of cotton yarn with marked reduction in hairiness.
2. Air vortex ring spinning system fitted with air jet nozzle creating the air vortex in the direction same as that of the yarn twist gives better results in terms of hairiness reduction, increase in tenacity and elongation and reduction in imperfection level when compared to that with the air jet nozzle creating the air vortex in the direction opposite to that of the yarn twist.

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