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Effect of Double-Nozzle Jet on Mechanical Properties of Interlaced Self-Twist Yarn

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Abstract: Earlier investigations have demonstrated that air interlacing improves the mechanical properties of Self-Twist (ST) yarns. In following of previous efforts, this paper discusses improving of mechanical properties of ST yarn by using double-nozzle jet. In the present work, at first, a Murata jet was attached to Repco ST yarn machine which the air pressure and distance of double-nozzle jet from twisting rollers were varied. For the experimental work, the distance of jet from twisting rollers was adjustable from 255 mm to 505 mm. Also, a wide rang of the air pressure has been supplied. The results showed that elongation and tenacity of yarns increase relatively by increasing of mentioned distance up to 355 mm. Also, the results showed an improvement of tensile properties of yarn when the air pressure of first and second nozzle are 1 and 4 bars, respectively.

Key words: Self-Twist Yarn · Mechanical Properties · Double-Nozzle Jet · Zero-Twist Parts · Air Pressure

INTRODUCTION

During recent years, different researches have been done for improving properties of ST yarns, because ST yarn offers high productivity and low production cost [1]. One of the most important problems of ST yarn is the presence of zero-twist parts in the structure of it. Researchers have attempted to decrease the zero-twist parts in the structure of ST yarn [2]. Different techniques of modifying ST yarn can also be found in the literature. “Trupie and Marsland” [3] used nylon filament and wool fibers to produce wrapped cross-spun yarns on the Repco ST yarn spinning machine. With only minor machine modifications, wool stretch yarns were made on the ST machines by incorporating either textured nylon or fine elastan [4]. “Miao and Lui” [2] attached an air-jet nozzle on the Repco ST yarn machine and produced interlaced ST yarn. They found that the air pressure was the most important parameter affecting yarn mechanical properties. “Zeng and Yu” [5] by simulating the air flow inside the nozzles concluded that with increasing the air pressure, tensile properties of yarn increases.

Also, “Cheng and Li” [6] investigated effect of distance between the front roller nip and the nozzle inlet. They concluded that in the Jet Ring spun yarns, the distance between the front roller and jet has only a marginal effect on yarn hairiness.

At it is said, previous researches have shown that the air pressure have considerable effect on properties of ST yarn. Using of two nozzles to produce interlaced ST yarn increases the number of zone of air pressure exertion. In this work, we try to find the optimum air pressure for each nozzle of double-nozzle jet. Also, we focus on effect of distance of jet from twisting rollers on properties of ST yarn.

In double-nozzle jet, two nozzles are used, one to produce, say, S twist at the exit of the twist triangle, followed by a nozzle producing the opposite twist. The second nozzle removes the false twist from the core and completes the wrapping of the outer fibers about the cores. Directions of twist can be reversed to produce a yarn that simulates the opposite yarn twist but this requires different nozzles or settings [7].

Instrumentation: As shown in Figure 1, a standard Murata air jet was attached to Repco ST yarn machine. The double-nozzle air jet was located on the region between the convergence point and the guide leading to the winding package.

Murata jet has two nozzles which are in opposite sides. The first nozzle turns the yarn in clock wise direction and second nozzle turns it in anti-clock wise direction.

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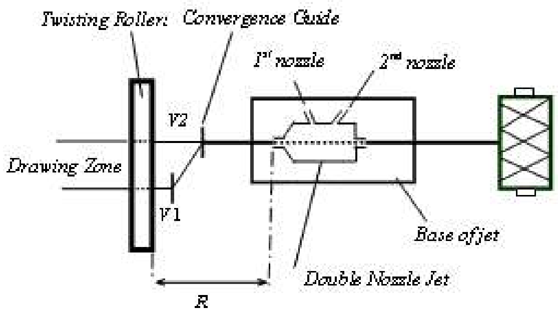


Fig. 1: Attached double-nozzle jet (Murata Jet) on Repco self-twist yarn machine

For laying the double-nozzle jet in suitable position, we had to set up a base on the machine. Then the double-nozzle jet was put on the base. The air pressure of each nozzle is adjustable from 0 to 4 bars (0, 1, 2, 3 and 4).Also; the distance of double-nozzle jet from twisting rollers(R) vary from 205 mm to 505 mm.

As it is clear, Murata jet has two nozzles which one of them apply to produce "S" twist and another nozzle produce the opposite twist (Z).

MATERIALS AND METHODS

The yarn samples used in the present study were produced from acrylic fibers. To simplify the counting of twists of yarn, we used two colors of fibers. The characteristics of them are shown in Table 1.

For setting the machine, some initial experiments were carried out. At first, finding the optimum pressure on twisting rollers was tested. Then, the optimum distances of guides from twisting roller were adjusted.

The results of the initial experiments showed that the best pressure was exerted on twisting rollers by 1756 g weight. Also, the second series of experiments showed that the best distance of V_1 and V_2 were 19.3 mm and 27 mm, respectively.

Due to position of attached base to the machine, the distance of double-nozzle jet from twisting rollers was adjustable from 255 mm to 505 mm. During the setting of distance of jet, two states of air pressure of nozzles were used. In first state, 1 bar and 1.5 bars are supplied by first and second nozzles respectively. For second state, the air pressure of first and second nozzles are 1 bar and 4 bars. During the tests, we used anti-static materials such as talk powder spreading on rollers to prevent adhesion and winding of fibers around the rollers.

Table 1: Characteristic of used fiber

Color	Tenacity (cN)	Elongation (%)	Fine (den)	Length (mm)
White	5.97	19.6	2.69	118.33
Black	9.43	14.45	5.027	123.65

The number of samples for each test were 30 specimens and all of tests were done at 25±2°C and 50±5% RH.

The most important properties of ST yarns which is investigated, are: tenacity, elongation and length of zero- twist parts. For each parameter related diagram was plotted.

RESULTS AND DISCUSSION

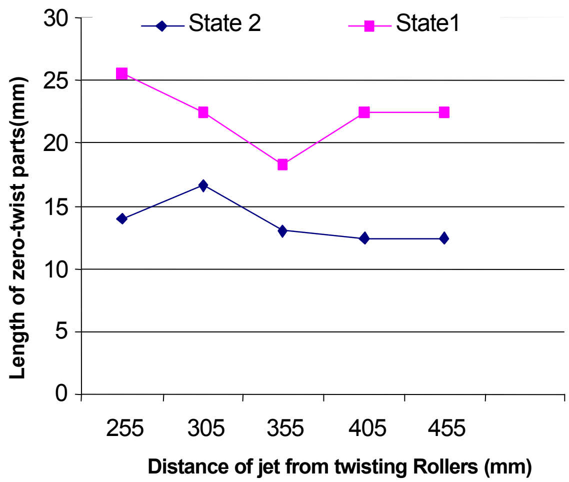
It is clear that the most important properties in tensile behavior of yarn are elongation and tenacity. Because of presence of zero-twist parts in the structure of ST yarn, elongation and tenacity are restricted. So, we can conclude that by decreasing the length of zero-twist part in the structure of ST yarn, tensile behavior of yarn will be improved.

In following, we investigated the effect of distance of jet from twisting rollers and air pressure of double-nozzle jet on tensile properties of ST yarns.

Influence of Distance of Double-nozzle Jet from Twisting Rollers on St Yarn Properties: To investigate effect of distance of jet from twisting rollers on ST yarn, the double-nozzle jet sets on different positions on the machine. This distance was adjustable from 255 mm up to 505 mm.

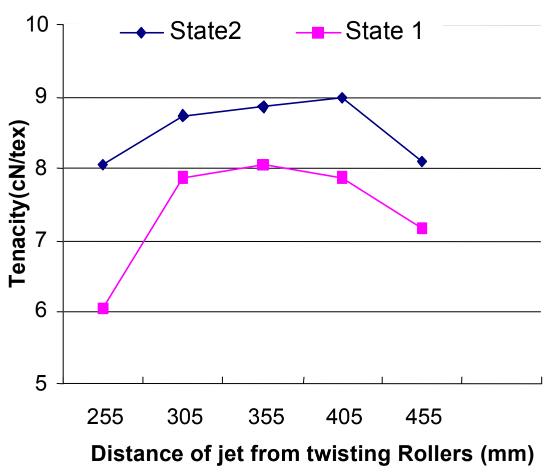
Length of Zero-Twist Parts: Fig. 2 shows the relationship between distance of jet from twisting rollers and length of zero-twist parts. As it is clear in Fig. 2 in state 1, by increasing the distance of jet from twisting rollers up to 355 mm, the length of zero-twist parts decreases. Then, there is a trend to increase up to 405 mm. After that the length of zero-twist part remains approximately constant. In state 2, we can see a trend to increase the length of zero-twist parts at the beginning of increasing of distance, but in follow the length of zero-twist parts decreases. By comparing two diagrams, it can be seen that the lowest length of zero-twist parts attributed to distance of 355 mm for both states.

Tenacity: Fig. 3 shows the relationship between distance of jet from twisting rollers and tenacity of ST yarn. This figure shows a general trend of increased yarn tenacity by



State 1: air pressure of 1st and 2nd nozzle is 1bar and 1.5 bars
State 2: air pressure of 1st and 2nd nozzle is 1bar and 4 bars

Fig. 2: Length of zero-twist parts at different distance of jet from twisting rollers

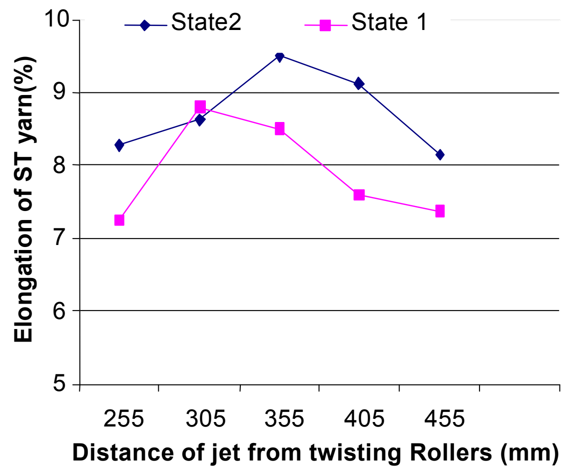


State 1: air pressure of 1st and 2nd nozzle is 1bar and 1.5 bars
State 2: air pressure of 1st and 2nd nozzle is 1bar and 4 bars

Fig. 3: Tenacity of ST yarn at different distance of jet from twisting rollers

increasing the distance of jet from twisting rollers up to 305 mm for both states. The tenacity was then maintained approximately constant until it started to decrease at the distance of 405 mm. This suggests that there is a relatively wide range of distance for gaining the maximum tenacity.

Elongation: To study effect of distance of jet from twisting rollers on ST yarn elongation, specimens of ST yarn were tested. The results of tests are shown in Fig. 4.



State 1: air pressure of 1st and 2nd nozzle is 1bar and 1.5 bars
State 2: air pressure of 1st and 2nd nozzle is 1bar and 4 bars

Fig. 4: Elongation of ST yarn at different distance of jet from twisting Rollers

As it can be seen in this figure, by increasing the distance of jet from twisting rollers up to 305 mm for first state, the elongation of ST yarn increases, but by increasing distance of jet from twisting rollers from 305 mm to 455 mm, the elongation of ST yarn decreases. Also, this figure shows that in second state by increasing the distance of jet from twisting rollers up to 355 mm, the elongation increased. Then it decreases. It means that the best distance of jet from twisting rollers is a range between 305 mm and 355 mm.

Influence of Air Pressure of Nozzles on St Yarn Properties: After finding the distance of jet from twisting rollers (355 mm), we tried to obtain the optimum air pressure of each nozzle of jet. Hence, different air pressures for each nozzle were supplied.

Length of Zero-twist Parts: In order to investigate the effect of air pressure on length of zero-twist parts in structure of ST yarn, air pressure of each nozzle is changed from 0 to 4 bars. Table 2 shows the results of measured length of zero-twist parts for each condition.

As it is shown in Table 2, the minimum length of zero-twist part occurs when the air pressures are 1 and 4 bars for first and second nozzle, respectively. It means that by setting the double-nozzle jet, first nozzle, gives a false twist to the yarn and second nozzle removes the false twist and gives to the fibers on opposite twist.

Table 2: Length of zero-twist parts for different air pressure (mm)

	Air pressure of first nozzle (bar)				
	0	1	2	3	4
0	28	26.1	20.4	27.7	27.9
1	-	22	25	20.8	22.7
2	14.5	14.9	26	26.3	24
3	15.9	17	24	25	23.3
4	21.2	13	17.2	23.5	20.8

Table 3: Tenacity of ST yarn (cN/tex)

	Air pressure of first nozzle (bar)				
	0	1	2	3	4
0	7.95	6.40	6.20	7.21	7.05
1	-	6.76	8.14	7.90	6.97
2	6.75	7.54	7.77	7.40	7.39
3	7.32	8.33	5.90	7.31	5.37
4	7.98	8.87	7.98	6.19	5.78

Table 4: Elongation of ST yarn (%)

	Air pressure of first nozzle (bar)				
	0	1	2	3	4
0	9.13	8.38	8.48	7.69	7.28
1	-	7.87	7.89	8.85	7.08
2	7.39	8.85	8.1	8.12	7.7
3	7.61	9.28	9.14	7.82	5.53
4	8.34	9.5	9.45	9.25	6.47

The ANOVA statistical analysis showed a significant difference among data. In the other hand, by exerting mentioned air pressure to the yarn, the length of zero-twist parts decreases, significantly.

Tenacity: To investigate effect of air pressure on ST yarn tenacity, produced yarns with different pressures of each nozzle were tested. The results of tests demonstrated in Table 3. The data of Table 3 show that the maximum tenacity of ST yarn is obtained when the air pressure of first nozzle is 1 bar and of second nozzle is 4 bars. Statistical examination showed a significant difference among data.

As expected from earlier discussion, by supplying these pressures, the zero-twist parts in yarn structure will decrease. It is clear that presence of zero-twist parts decrease tenacity of ST yarn. So, by decreasing the length of zero-twist parts, it is expected that the yarn tenacity increases.

It is inferred from above discussion, applying double-nozzle jet imports intermittent nips in zero-twist parts so as to prevent separation and breakage of fibers. The first nozzle by supplying air pressure of 1 bar and excreting false twist, gives an initial strength to the yarn. Then, second nozzles give a higher level twist in opposite direction and enhance strength of yarn significantly.

Elongation: Table 4, shows the result of elongation test on air interlaced ST yarn. As it is shown in this table, the greatest elongation occurs when the first and second nozzles supply air pressures of 1 bar and 4 bars, respectively.

It is implied from the obtained results and also previous discussion that the optimum air pressures for first and second nozzles are 1 and 4 bars, respectively. It means that with supply air pressure of 1 bar and 4 bars for first and second nozzles respectively, apart from tenacity, the elongation of ST yarn improves.

CONCLUSION

During this study we found that two variable parameters of double-nozzle jet (Murata Jet) affect the properties of ST yarn. One of them is the air pressure of each nozzles and another is distance of jet from twisting rollers.

The results of the present work showed that with supply the air pressure of 1 bar and 4 bars for first and second nozzle respectively, optimum tenacity, elongation and length of zero-twist parts occurs in ST yarn structures. Also, the results showed that by increasing the distance of jet from twisting rollers up to 355 mm, length of zero-twist parts decreases, but tenacity and elongation of ST yarn increases.

In the other hand, the optimum pressures of first and send nozzle for producing interlaced ST yarn by double-nozzle jet are 1 and 4 bars, respectively.

In addition, the optimum distance of air jet from twisting rollers is a rang between 355 mm and 405 mm.

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