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Research Article

An Investigation on the Influence of Main Vacuum and Additional Suction Pressure on the Quality of Rotor Yarn

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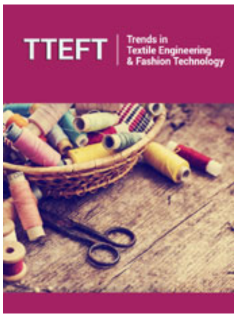

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Abstract

The qualities of rotor spun yarn greatly depend on the fibre properties as well as processing parameters especially when the yarn is manufactured from 100% waste cotton. The purpose of this work was to observe the effect of the main vacuum pressure of the transfer channel and the additional suction pressure for the trash removal on the quality of rotor yarn produced from 100% waste cotton. Mixing of spinning waste and virgin cotton is a common phenomenon in the case of producing rotor yarn but yarn manufactured from 100% waste cotton is a very rare case. Very limited study has been performed in this research field. For that reason, the experimental work was done in order to observe the influence of main vacuum and additional suction pressure on the quality of rotor yarn manufactured from waste cotton. Quality parameters such as mass variation (CV_m %), imperfection index, tenacity, and elongation of six 10Ne rotor yarn samples were investigated by varying different main vacuum pressure as well as additional suction pressure. The results revealed that 6kPa main vacuum pressure and 0.5kPa additional suction pressure were the ideal values considering the overall quality of yarn.

Keywords: Rotor spinning; Transfer channel; Main vacuum pressure; Additional suction pressure; Yarn irregularity

Introduction

Yarn properties diverge significantly depending on the conversion methods of fibers into yarn [1-2]. These conversion techniques are very complex processes that require a lot of exploration as well as innovative technical & technological explanations [3]. For manufacturing better quality yarn from lower grade of fiber is a great challenge for spinners. Rotor spinning is the best process for utilizing the cotton waste that was obtained from carding, comber and ring spinning due to lower production cost, ample reduction in space and workforces and flexibility to automation. Now, it has been getting a stronger position in the field of spun yarn manufacture day by day [4-8]. Several investigations have clarified the matter that machine parameters affect the yarn properties ominously [9-11].

The main parts of a rotor spinning machine primarily are a rotor, feed roller, opening unit, navel, and a delivery unit. Slivers are fed to the opening roller through the fiber inlet and the evenly dispersed teeth of this combing roller executes the fiber opening task mostly. After combing into individual fiber or a group of single fiber, these fibers are then transferred to the rotor groove from the conical rotor wall by centrifugal forces in the rapidly rotating rotor, and also by airflow which is the main vacuum pressure and there is also an additional vacuum pressure situated after opening roller which draws the trash particles from opened fiber strands to trash chamber. Lastly, the yarn produced in the rotor is continuously drawn out by the delivery channel and wound onto a cross wound package. Some investigations have already been performed to identify the effect of rotor speed, opening roller speed and modification of transfer channel, the air drag characteristics etc. on fiber orientation, configurations and yarn properties through experiments and simulations [12-16]. The air flow inside the transport channel is critically affected by the channel geometry [17,18]. The performance of the inside air drags a crucial factor in the determination of yarn properties because it influences the fiber configuration by decreasing the number of fibers with trailing and leading hooks considerably [19]. Limited experimental work has been carried out in case of determining the optimal main and additional vacuum pressure for producing better quality yarn. Moreover, no investigation is carried out using sliver of 100% waste cotton fiber in this regard. Waste cotton are already processed fibers. These fiber properties are not same as compared to virgin cotton or mixed fibers. Therefore, the controlling of additional vacuum & main vacuum pressure is important to get optimum yarn quality resulting from continuous running of rotor machine for getting the consistent productivity. In this research work, an attempt has been taken in order to find out the suitable main and additional suction pressure for getting good quality rotor yarn.

Materials and Methods

Materials

In this study, slivers of 0.1 hank were used by mixing of flat strip, dropping 1, noil and pneumafil as raw materials. Flat strip and dropping-1 taken from carding section whereas noil and pneumafil obtained from combing and ring section. The properties of cotton fibers are summarized in Table 1.

Table 1: Properties of raw cotton.

Parameters	Value
Spinning Consistency Index (SCI)	108
Micronaire (μg/inch)	5.52
Maturity Index	0.89
Upper half mean Length(mm)	27.25
Uniformity Index (%)	80.4
Short fiber index (%)	11.1
Strength (g/tex)	29.3
Elongation (%)	6.7
Moisture (%)	7.2
Reflectance (%)	70.9
Yellowness (degree)	10.8

Methods

The experimental work was performed at NZ Textiles Limited, Narayanganj, Bangladesh. At first, 0.0833 Ne carded sliver was produced from 50% Flat strip and 40% recycle Dropping-1 +5% Pnuemafil+5% Noil (Figure 1). The required proportions of waste cotton were mixed in the blow room section. After that, the carded sliver was fed into the draw frame and produced drawn sliver of 0.1hank. Finally, six samples of 10 Ne rotor yarn produced against different main and additional suction pressure from this drawn sliver. The technical parameters of rotor frame are shown in Table 2. Controlling additional and main vacuum pressure were controlled by altering setting at control panel. The observed parameters were mass variation (CV_m%), imperfection index (IPI) which indicates the summation of number of thick places (+50%), thin places (-50%) and neps (+280) per 1km of yarn, hairiness, tenacity (gm/tex), and elongation. Tensolab-2512 A (Mesdan, Italy) instrument was used to calculate yarn tenacity. Average of ten tests was selected for ultimate result at each trial. All trials were executed at standard testing conditions (temperature 20±2 °C and relative humidity 65±2%).

Figure 1: a) Flat strip, b) Dropping-1.

Table 2: Technical parameters of Rotor Frame.

Parameters	Values
Feed roller speed	1.146m/min
Opening roller speed	9700rpm
Rotor cup diameter	36mm
Rotor speed	75000rpm
TPI	17.07
T.M	5.4

Results and Discussion

The test results of yarn samples against different main and additional vacuum suction pressure are summarized in Table 3. The obtained test results for 6kPa main vacuum and 7kPa were plotted in Figure 2 & Figure 3 against different additional suction pressure such as 0.4kPa, 0.5kPa and 0.6kPa respectively. From figures, it can be said that yarn quality parameters such as mass variation (CV_m%), imperfection index, hairiness, tenacity, elongation influenced with changing the main vacuum pressure. This is happened because with the increment of main vacuum pressure, streamlines located at the junction of the opening roller and transfer channel progressively form a vortex that influences the fiber configuration negatively and deform [17]. Comparatively lower vacuum pressure provides the perfect turbulence that is reduced the yarn quality deterioration [18]. Though the probability of fiber leading end being straightened and simultaneously aids the fiber transportation to the rotor increases with the intensification of air velocity at the transfer channel inlet, this escalation in air velocity along the transfer channel could barely have special effects on straightening these fibers due to the entangled fibers which are highly crimped [19]. In this work 100% waste fibers were used which contains a significant amount of entangled and highly complex configurational fibers. For these reasons CV_m% and IPI values of yarns are lower at lower main vacuum pressure. Hairiness is also comparatively lower at 6.0kPa because increased turbulence boosts the disengagement which consequences in adverse yarn hairiness properties [4]. The decrease in the number of fibers with leading and trailing hooks contributes to the improvement of yarn tenacity mainly [19]. Elongation of yarn is also significantly higher at 6.0kPa main vacuum pressure may be due to the well fiber orientation on yarn body. The resulting data also indicate that additional vacuum pressure also play some important roles in yarn properties. It is necessary to reduce the trash in the collecting groove of the rotor to improve the yarn quality and better trash removal efficiency [17]. Among three additional suction pressure used in the experiment yarn quality parameters are better at 0.5kPa. From the data, it has been found that lower additional suction pressure like 0.4 kPa is not enough to remove sufficient amount of trash from the fiber strand in rotor grove and higher suction pressure like 0.6kPa eliminates significant amount of good fibers with the trash. So, 0.5kPa additional suction pressure is ideal one for better trash removal efficiency.

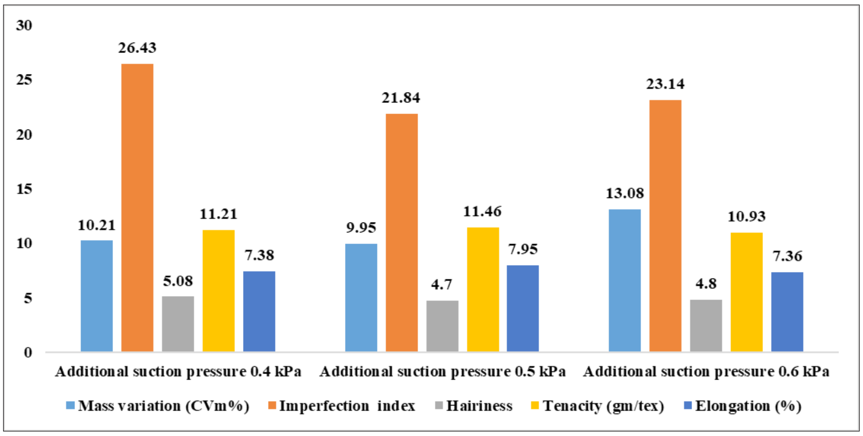

Figure 2: Effects of main vacuum pressure 6kPa against different additional suction pressure on yarn quality.

Table 3: Testing results for 10Ne of different yarn samples.

Yarn Quality Parameters	Main Vacuum Pressure 6kPa			Main Vacuum Pressure 7kPa		
	Additional suction pressure 0.4kPa	Additional suction pressure 0.5kPa	Additional suction pressure 0.6kPa	Additional suction pressure 0.4kPa	Additional suction pressure 0.5kPa	Additional suction pressure 0.6kPa
Mass variation (CVm%)	10.21	9.95	13.08	9.99	12.82	13.09
Hairiness	5.08	4.7	4.8	5.14	5.12	5.15
Imperfection index	26.43	21.84	23.14	24.43	23.15	24.68
Tenacity (gm/tex)	11.21	11.46	10.93	10.98	11.02	10.88
Elongation (%)	7.38	7.95	7.36	7.42	7.33	7.55

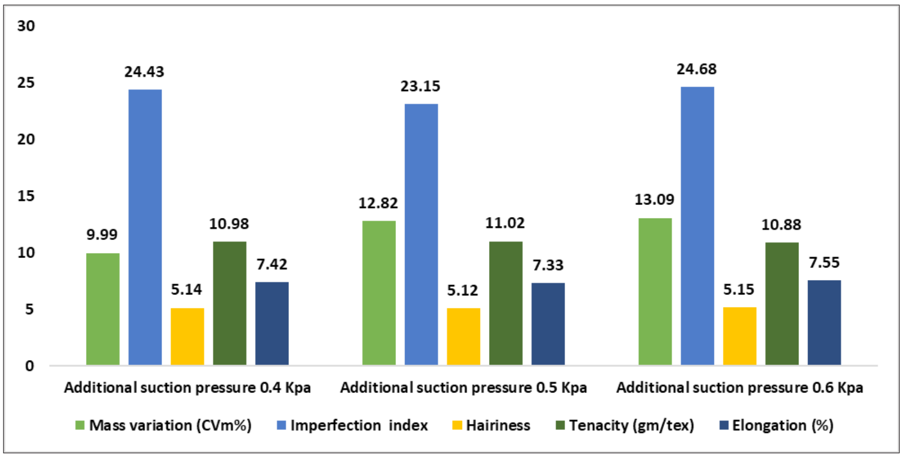

Figure 3: Effects of main vacuum pressure 7kPa and different additional suction pressure on yarn quality.

Conclusion

This study found that various properties of yarns are significantly affected by main vacuum pressure and additional suction pressure of transfer channel in rotor spinning. The mass variation (CV_m%), imperfection index (IPI) and hairiness of 10Ne rotor yarn showed significant improvements on lower main vacuum pressure (6kPa) than 7kPa, and on 0.5kPa additional suction pressure. Yarn strength demonstrated through tenacity(gm/tex) and yarn elongation were decreased with the higher main vacuum pressure and with the fluctuation from 0.5kPa additional suction pressure. These results justified the significance of the airflow characteristics inside the rotor unit which considerably affect fiber configurations and the yarn properties subsequently. There are a lot of scopes for future work to be done on manufacturing quality yarn of different counts from other mixing ratio of fibers using both virgin and waste cotton to rationalize this investigation.

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