A Study of yarn imperfections for basofil/cotton rotor spun yarn

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Abstract— A rotor spun yarn of 50/50 Basofil/cotton blend ratio was spun, and a study of the influence of rotor speed, opening roller speed and twist factor (TF) on the yarn total imperfections (Neps, thin places and thick places) were investigated using statistical models. The results obtained in this research work indicated that an increase of opening roller speed increased thin places/km but decreased neps and thick places/km. Neps, thick and thin places/km increased with increase of TF. Increase of rotor speed decreased neps and thick places/km, but increased thin places/km. The combined effect of two variables yielded lower neps and thick places/km for low rotor speed and high TF values but higher rotor speed and lower TF gave low thin places/km. Low opening roller speed and high TF gave low neps and thick places/km but low opening roller speed and low TF values gave low thin places/km. High rotor speed and high opening roller speed values gave low neps and thick places/km. Low thin places/km can be obtained by using high rotor speed and low opening roller speed.

Keywords— *Basofil, cotton, yarn imperfections, rotor speed, opening roller speed, twist factor.*

I. INTRODUCTION

Basofil fibre is a melamine-based inherently flame resistant (FR) fibre, which has several outstanding FR properties, [1], [2] and could therefore be used in civilian, domestic, transport and defence applications, where FR qualities are mandatory. Some of the important methods of manufacturing a fabric are weaving and knitting, which require a yarn. Yarn can be manufactured using several techniques which include ring and rotor spinning. Rotor spinning is an established spinning system especially for medium and course counts. The yarn characteristics of rotor spun yarn are affected by many factors mainly related to raw material, machine and processing parameters. The characterization of rotor yarn include the measurement of tensile properties, evenness, neps, thick and thin places. Thin places are weak and hence lead to lower yarn strength. Thin places also affect the total appearance of the yarn and hence the final fabric appearance. The same can be said about thick places and neps. As noted by both Tyagi *et al* [3] and Kong *et al* [4] the CV of count and imperfections (thick places/km, thin places/km and neps/km) for cotton yarn increases with increasing rotor speed and twist factor but decrease for a while and then starts to increase with further increase of opening roller speed. Kaushik *et al* [5] reported that CV of count and imperfections for polyester/viscose blends increase with increasing twist factor. The spinning of basofil fiber on rotor spinning machine has been reported by several researchers. While the spinning of cotton blended yarn is a well covered topic, few researchers have reported the spinning of basofil/cotton yarn on the rotor machine. Murugesan and Gowda [6] has reported the study of the flammability and mechanical properties of rotor spun basofil/cotton blends. Tensile properties and hairiness of basofil/cotton yarn has been reported by Mwasiagi et al [7], [8]. There is however no reports available in the public domain for the study of yarn total imperfections (neps, thin and thick places) for basofil/cotton rotor spun. This study was therefore aimed at investigating the influence of rotor speed, opening roller speed and twist factor on yarn imperfections (neps, thin and thick places) characteristics of rotor spun Basofil/cotton blended yarn, using statistical models.

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II. MATERIALS AND METHODS

A. Materials

The silver used to spin the yarn samples had a blend constituent of 50/50 and was made using flock blending. The specifications of the fibres used are given in table 1.

Table 1
Fibre Properties for Cotton and Basofil

Fibre Property	Fibre Type	
	Cotto n	Basofil
Fibre fineness (dtex)	1.6	2.8.
Staple length (mm)	32.6	-
Weighted average length	28.9	54.7
(mm)	25.7	52.3
CV (of length) (%)	6.4	13.5
Short fibre %	3.7	2.0
Tenacity (cN/dtex)		

The counts in ktex for the carding, first passage drawframe and second passage drawframe were 3.08, 2.76, and 2.7 respectively. Yarn samples of count 36 tex, 50/50 blend ratio were spun using a rotor diameter of 54 mm navel diameter of 18 mm, doffing tube diameter of 2.5 mm and opening roller diameter of 65 mm.

B. Methods

The effect caused by changes in the variables was studied by monitoring changes in the yarn imperfections characteristics, which were designated as responses. To study the relationship between the variables and the responses universal rotatable design [9] was used, where the variables were rotor speed, opening roller speed and twist factor. While setting the experimental design the rotor speed, opening roller speed and twist factor were varied between 55000 to 35000 rpm, 7500 to 5500 rpm and 500 to 400 respectively. The spun yarn samples were subjected to yarn testing under standard conditions. The yarn qualities measured were; yarn tenacity, CV of tenacity, B-Work (specific work of rupture), B-Force (initial modulus), elongation at break, hairiness, neps, thin places and thin places. This paper will concentrate on the study of neps, thin places and thick places, where the data obtained from the three imperfections characteristics were investigated using regression equations [9,10]. Regression models for linear, second order and logarithmic types were fitted and the most optimal selected.

III. RESULTS AND DISCUSSIONS

A. Neps/km

The changes in neps/km with the three variables can be expressed using a first order regression equation (equation 1) with a correlation coefficient (R^2) of 0.756.

$$Neps/km = 193.2 - 4.22X_1 - 10.2X_2 + 7.02X_3 \text{.......(1)}$$

Neps/km increased with increase of twist. Increase of opening roller speed however caused decrease in neps, which is a desirable scenario. Fig. 1 shows the changes in neps/km for the three factors considered on factor at a time.

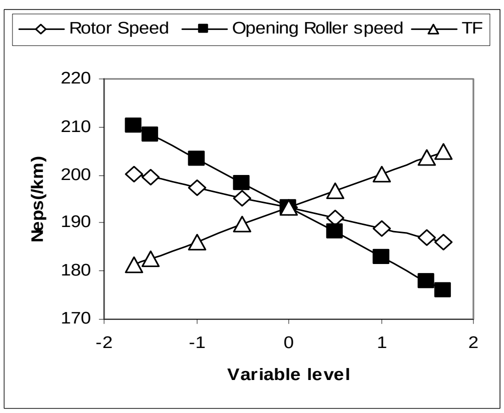

Fig.1 The effect of single variables on Neps/km

Neps increased with increase of twist (TF). Increase of opening roller speed caused decrease in neps, which is desirable. Increase in rotor speed, which normally leads to more production, lead to decrease in neps/km.

The combined effect of rotor speed and opening roller speed on neps/km, while twist was kept constant showed that lower (desirable) values of neps/km can be obtained by using high rotor speed and high opening roller speed (Fig. 2). For a given rotor speed, neps/km reduced with increase of opening roller speed, and for a given opening roller speed, neps/km also reduced as the rotor speed was increased.

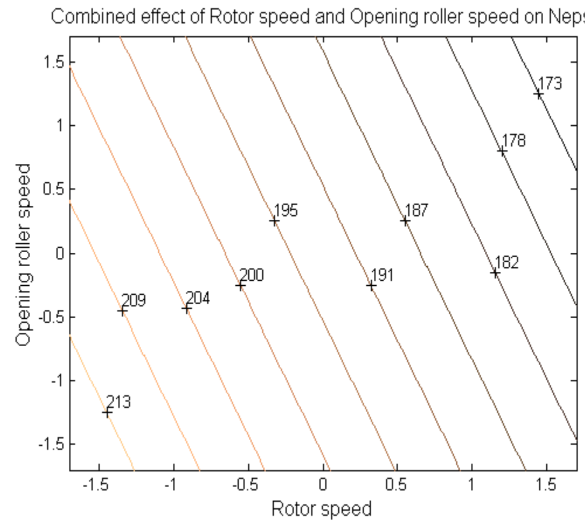

Fig. 2 Combined effect of rotor and opening roller speeds on neps/km

Increase in opening roller speed leads to improved fiber individualization which leads to fewer neps/km. Increasing rotor speed on the other hand increased the vacuum created by the rotor. As a result the conditions for stripping fibers from the opening roller and straightening the fibers in the feed tube, especially at the exit feed tube are improved leading to fewer neps/km.

The combined effect of rotor speed and twist on neps/km, while opening roller speed was kept constant (Fig. 3) showed that a combination of low rotor speed and high twist levels gave the lowest levels of neps/km. At a given rotor speed, neps reduced with increasing twist levels, while for a given twist level neps increased with increase of rotor speed.

Higher twist level leads to low production, which actually means that the fibers spend more time in the opening roller region. This could have lead to improved fiber opening hence reduced neps/km. Increase in rotor speed however increases production and this has the effect of reducing fiber opening efficiency hence the increase in neps/km.

Fig. 4 shows the graphical representation of the combined effect of opening roller speed and twist at constant rotor speed on neps/km. According to the diagram lowest levels of neps/km can be obtained by using high twist levels combined with low opening roller speed. For a given opening roller speed neps/km reduced with increased twist, while neps/km increased with increasing opening roller speed at constant twist.

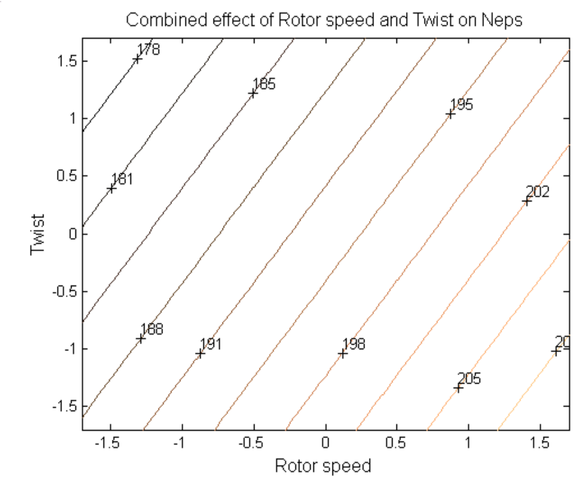

Fig. 3 Combined effect of rotor speed and twist on neps/km

Increasing twist leads to lower production which actually means that the time the fibers spend in the opening roller region is increased. This results in better fiber opening hence neps/km is reduced. Increase in opening roller speed either leads to better fiber opening or fiber damage if the opening is severe. In this case it seems that the conditions lead to severe fiber opening leading to increased neps/km.

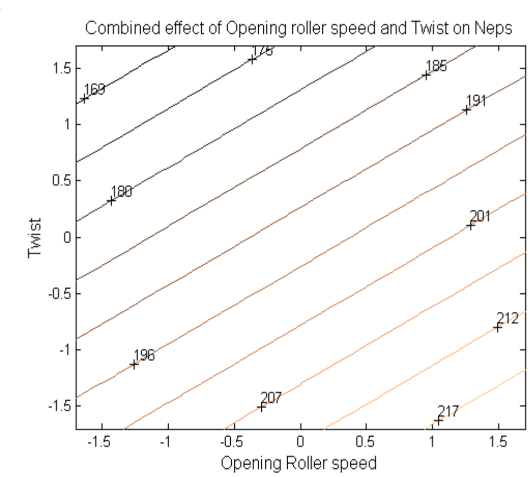

Fig. 4: Combined effect of opening roller speed and twist on neps/km

B. *Thick places/km*

Using the data obtained in this project, regression equations were fitted and a first order model (equation 2) was deemed to be the most suitable to study thick places. The optimum regression equation for thick places/km had a correlation coefficient (R^2) of 0.754.

$$\text{Thick places/km} = 160.7 - 3.26X_1 - 11.33X_2 + 1.73X_3 \quad ..(2)$$

The effect of single variables on thick places shown in Fig. 5, indicated that thick places reduced with increase in rotor speed. The same effect was recorded when opening roller speed was increased, but thick places increased with increase in twist.

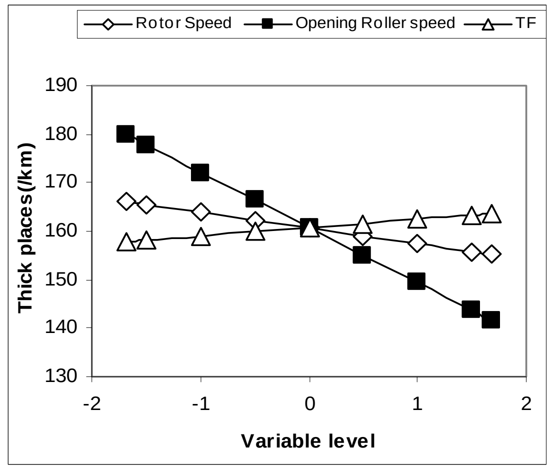

Fig. 5: The effect of singles variables on thick places/km

The combined effect of rotor speed and opening roller speed on thick places/km shown in Fig. 6 can be studied by keeping twist constant.

The lowest level of thick places were recorded when using a combination of high rotor speed and high opening roller speed. For a given rotor speed thick places/km reduced with increasing opening roller speed and the same trend is noticed for changes in rotor speed at a fixed level of opening roller speed.

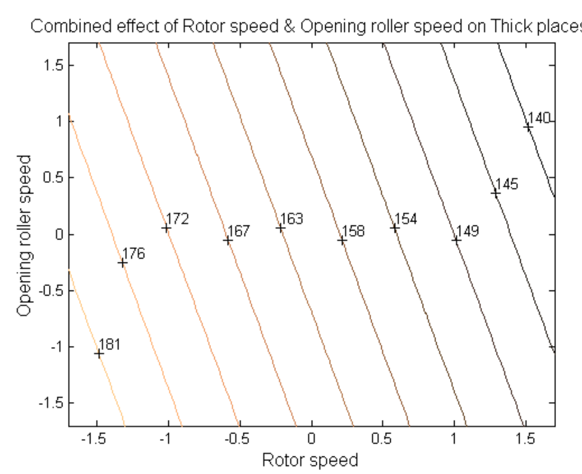

Fig. 6: Combined effect of rotor and opening rollers speeds on thick places/km

High opening roller speeds leads to better fiber individualization up to some limited value above which higher opening roller speeds leads to fiber damage. If there is better fiber individualization, then the incidences of thick places/km will reduce. High rotor speeds on the other hand tends to increase the vacuum in the rotor which improves the conditions for striping of fibers from the opening roller and straightening the fibers in the feed tube, especially at the exit point of the feed tube. This will also lead to reduced thick places/km.

Fig. 7 gives the combined effect of rotor speed and twist on thick places/km at constant opening roller speed. A combination of low rotor speed and high twist levels give low levels of thick places/km.

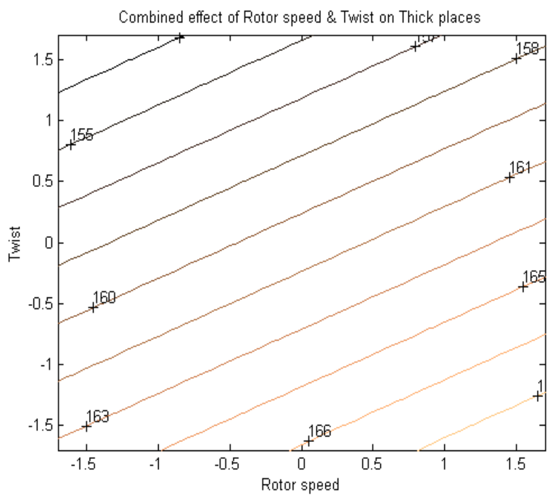

Fig. 7: Combined effect of rotor speed and twist on thick places

At a given rotor speed, thick places/km reduce as twist levels were increased, in contrast, thick places increased as the rotor speed increased at a given twist level.

Increase of twist at a given rotor speed results in better fiber compactness which leads to reduced thick places/km. Increasing rotor speed at a fixed twist level leads to more fiber output and since the twist is kept constant, this is likely to lead to twist imbalances which may increase thick places/km. Increase in rotor speed also leads to higher ratio of wrapping fibers. This is likely to increase the incidence of thick places.

The combined effect of opening roller speed and twist on thick places at constant rotor speed is given in Figure 8. Low levels of thick places/km can be obtained by using a combination of high twist and low opening roller speeds. For a given opening roller speed thick places/km reduced with increasing twist level, while for a given twist level, thick places/km increased as the opening roller speed were increased.

Increasing twist at fixed opening roller speed leads to lower yarn production, which may lead to better fiber individualization. Higher twist levels also lead to better fiber compactness. The above mentioned reasons could lead to reduced thick places/km. On the other hand increasing opening roller speed at a fixed twist level may lead to better fiber opening. If on the other hand the opening is severe, fiber damage occurs. In this case it seems increased opening roller speed lead to fiber damage hence higher incidence of thick places.

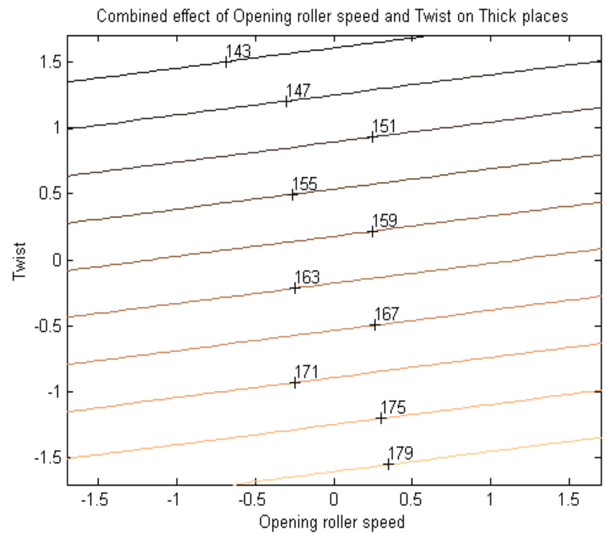

Fig. 8: Combined effect of opening roller speed and twist on thick places

C. Thin places/km

Using the data obtained in this project thin places/km can be expressed by using a logarithmic regression model (equation 3), which showed a correlation coefficient (R^2) 0.719.

$$Thin \quad places/km = 10^{0.62+0.21X_1+0.02X_2+0.06X_3} \text{..................(3)}$$

Considering one variable at a time (Fig. 9) it is clear that thin places/km increased with increase in rotor speed, opening roller speed and twist, although rotor speed caused a higher rate of increase.

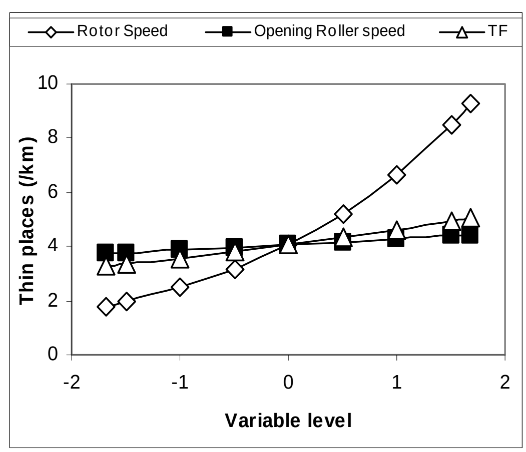

Fig. 9: The effect of single variable on thin places/km

The combined effect of rotor speed and opening roller speed on thin places/km, while keeping twist constant, is given in Fig. 10. Low levels of thin places can be obtained by using low rotor speed and low opening roller speed. For a given rotor speed, thin places/km increased with increasing in opening roller speed and the same trend is noticed for changes in rotor speed at fixed opening roller speed.

Increase in opening roller speed leads to better fiber opening. If the spinning conditions are such that the increase in opening roller speed acts to damage the fibers, the incidence of thin places is likely to increase. Higher rotor speed leads to increased ratio of wrapping fibers and at the same time fiber individualization will be lowered due to the increased output. Increase in the ratio of wrapping fibers coupled with reduced fiber individualization is likely to lead to more incidences of thin places

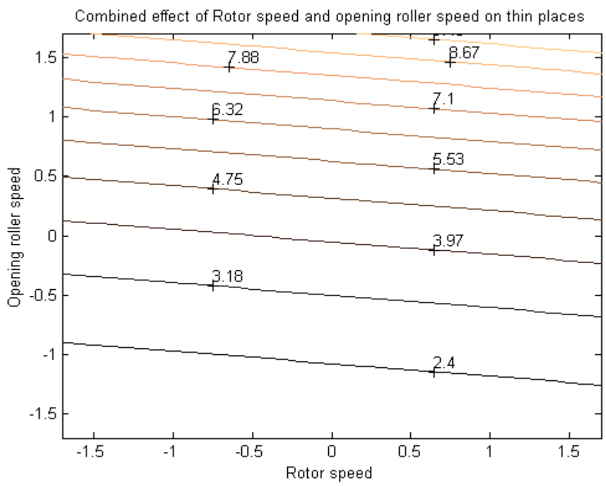

Fig. 10: The combined effect of rotor speed and opening rollers speed on thin places/km

Fig. 11 gives the results for the combined effect of rotor speed and twist on thin places at constant opening roller speeds. A combination of low rotor speed and low twist level gives lower values of thin places/km.

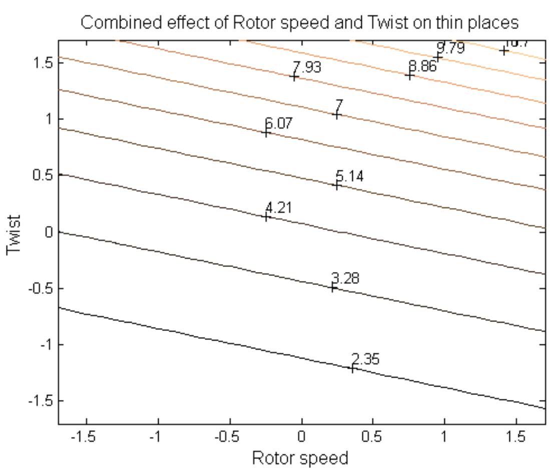

Fig. 11: The combined effect of rotor speed and twist on thin places/km

At a given rotor speed thin places/km increased as twist was increased, while at constant twist level, thin places also increased as the rotor speed was increased. Increase of twist at a given rotor speed may result in poor twist propagation leading to higher incidences of thin places. Higher rotor speed causes higher incidences of thin places.

The combined effect of opening roller speed and twist on thin places/km while keeping rotor speed constant is given in Fig. 12. Low levels of thin places/km can be obtained by using a combination of low twist and low opening roller speed.

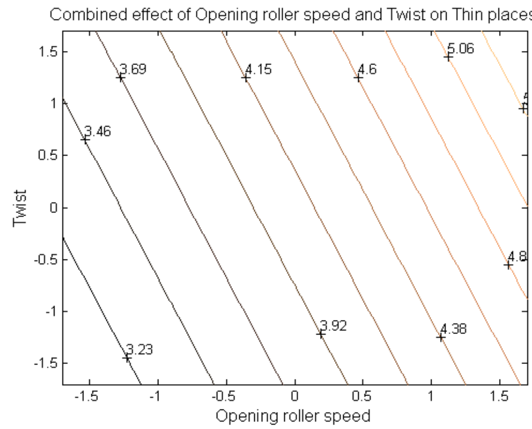

Fig. 12: The combined effect of opening roller speed and twist on thin places

For a given opening roller speed thin places/km increased with increasing twist level, while for a given twist level, thin places/km showed an increasing trend as the opening roller speed was increased.

Increasing twist at fixed opening roller speed may lead to poor twist propagation resulting in higher incidences of thin places/km. On the other hand increasing opening roller speed at a fixed twist level may lead to increasing fiber damage if the fibers are subject to more than enough opening. This inevitably leads to increased thin places/km.

IV. CONCLUSION

For rotor spun Basofil/cotton 50/50 rotor spun yarn, Neps decreased with increase of rotor speed. Increase of twist factor increased neps but increase of opening roller speed decreased neps. Thick places per km reduced with increase in rotor speed. Increase in twist factor increased thick places but increase in opening roller speed reduced thick places per km. The combined effect of two variables on thick places per km gave low thick places per km for high rotor speed and high opening roller speed, low rotor speed and high twist factor and low opening roller speed and high twist factor. Thin places per km increased with increase in any of the three factors (rotor speed, opening roller speed and twist factor). The combined effect of two variables on thin places yielded low thin places per km for high rotor speed and low opening roller speed, high rotor speed and low twist factor and low opening roller speed and low twist factor.

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