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Predicting Non Inertia frame related by Speed of Bobbin Compared by Speed of Rotor

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Abstract

Non inertia frame is one of topic in classical mechanics which can be implemented in textile industry for predicting yarn twist and the relation with the direction of angular bobbin speed in ring spinning and angular rotor speed on OE rotor spinning. Twist is one of important parameters of yarn. Twist determines various characteristics of material such as, hairiness, strength and yarn count. The influenced of S-twist in ring spinning and Z-twist in rotor spinning has been investigated and has been done in this research. The result of this research determines that Z-twist has higher twist than S-twist.

AMS subject classification:
Keywords:

1. Introduction

In textile, spinning is a process to make yarn from cotton fibers. Open end spinning referred to O.E spinning or break spinning is a process in which the fibers is highly drafted, ideally to the single fiber state. The single fiber is collected by the seed yarn that is rotated to twist the fiber into the yarn structure. Ring spinning has a similar process compared with rotor spinning but the direction of rotation of yarn and delivery speed are different. The illustration of yarn movement inside OE rotor spinning and ring spinning can be depicted as Fig. 1.

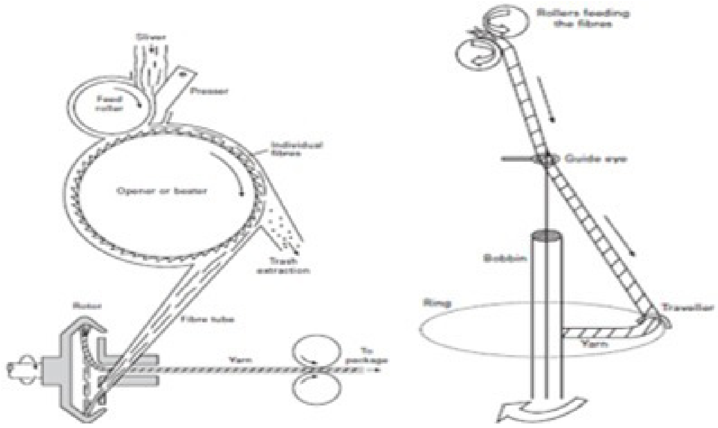

Figure 1: Movement of Yarn inside Open End Rotor Spinning and Ring Spinning.

Twist is characterized by the direction and by the speed of rotation of the rotor and the speed of the delivery yarn [1, 2, 3]. The definition of twist in textile is the number of turns on the yarn per unit length and has a dimension [L]-1 [1, 2, 3, 4, 5, 6, 7, 8, 9]. As in Fig. 1 yarn is twisted by the rotor speed whereas the yarn moves with certain delivery speed toward to navel but in ring spinning, yarn moves toward the bobbin rotated with certain angular speed. According to Moore [10] and also Fowles and Cassiday [11]. In describing the motion of yarn in such a coordinate system, it is frequently convenient and sometimes necessary to make a non-inertial reference frame defined as a frame of reference moving with a certain acceleration. We shall first consider a case of yarn moving in such coordinate as Fig. 2. In general, non-inertial reference frame consists of two frameworks, namely: stationary frame (ground frame K) and vehicle frame (noted as K) as shown in Fig. 2.

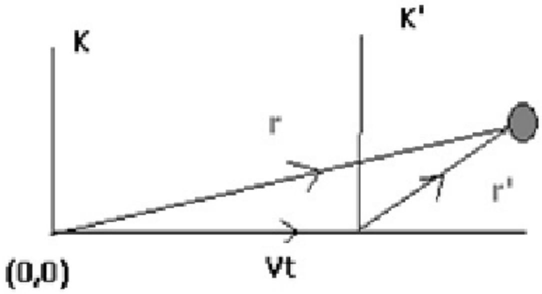

Figure 2: Non Inertia Frame

According to Putra [6] and also Lawrence [7], twist is one of the most important parameters on the formation of the process of making a yarn. In spinning, twist influences the various properties of material, such as hairiness, strength, yarn count etc. the magnitude of twist depends on the rotor speed and the direction of the rotor [8, 9].

According to Putra et al. [5, 6] and Lawrence [7] The relationship between yarn twist and yarn count number can be shown on Fig. 3.

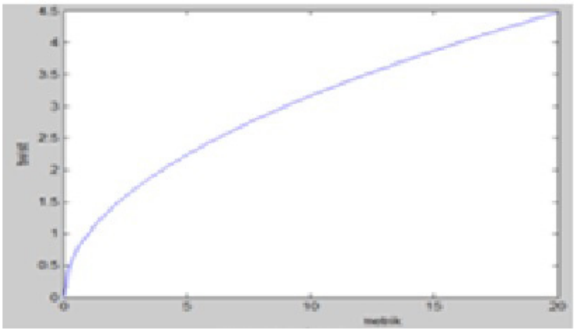

Figure 3: Influence of twist on yarn count and hairiness (Putra, [6])

Putra et al. [6] has shown the value of yarn twist can be related by the yarn count number in solenoid coordinate. Putra et al [5, 6] declared that the prediction of twist could be implemented to measured the magnitude of twist related by the yarn count number. Rohlena [8] reported the differences between the results of measured twist (real twist), T_m, and adjusted twist on machine, T_a. The difference of twist is formulated as Eq. 1. In textile , twist on yarn can be done both by running open end spinning (rotor spinning) machine and by setting ring spinning. According to Rohlena [8], Trommer [9] and Lawrence [7] the value of twist on spinning machine depends on the speed of the rotor (nrotor) on the rotor spinning machine and yarn delivery speed (Vd). Lawrence [7] formulated the twist of ring spinning based on the angular speed of bobbin (n_{Bobbin}) and delivery yarn from front roller (V_d). According to Rohlena [8]. Twist can be divided into two types: Z-Twisted and S-Twisted. S-Twisted is made in which the direction between delivery speed (the speed of yarn) and angular speed of yarn (rotation of yarn either in bobbin or in rotor) have same direction, but for Z-Twisted, The direction of angular speed and delivery speed is in opposite direction. The value of twist depends on the ratio of angular of speed and delivery speed of yarn generally the value of twist in unit length is agreed with Eq. 1. Rohlena [8] and Lawrence [7] also describe that Z-twist made by an open-end spinning formulated by Eq. 2. experimentally all researchers [12, 13, 14, 15] have found and analyzed as: 1) The higher the twist, the higher yarn count Nm; 2) The higher the twist, the lower the strength and 3) the higher the twist, the lower the hairiness of yarn.

$$T = \frac{n_{yarn}}{V_d} = \frac{1}{\eta\pi d_{rotor}} + \frac{n_{rotor}}{V_d} \approx \frac{n_{rotor}}{V_d} \qquad (1.1)$$

$$T = \frac{n_{rotor}}{V_d} \qquad (1.2)$$

Where shrinkage coefficient η, is a constant and the magnitude of $\eta < 1$ generally is around 0.95; rotor diameter, d_{rotor} is in unit length; the angular velocity of rotor n_{rotor}; and V_d is delivery speed of rotor. The relationship of twist and rotor speed (n_{rotor}) and yarn delivery speed (V_d) according to Trommer [9] on rotor spinning machine is agreed with Eq. 3

$$T = \left(\frac{n_{rotor}}{V_d} + \frac{1000}{\pi d} + e_G \frac{1000}{\pi d}\right) \tag{1.3}$$

where,

e_G	=	a constant influenced the yarn movement
V_d	=	yarn delivery speed (m/s)
d	=	diameter of rotor (m)
R	=	radius of rotor (m)
n_{yarn}, n_{rotor}	=	angular yarn speed and rotor (1/s)

According to Trommer [9], the direction of rotation on Z-twist generally is applied and adjusted on rotor spinning, and it can be changed the type to S-twist. The same result has reported by Lawrence [7], as shown on Table-1.

It can be concluded on Table-1 that the type of Z-twisted can be applied both on rotor spinning and on ring spinning, whereas the type of S-twisted just is occurred on ring spinning. According to Lawrence [7], the equation of front roller speed is shown on Eq. 4

$$V_F = \pi(d_B n_B - d_C n_t) \tag{1.4}$$

$$T_a \approx \frac{n_{Bobbin}}{V_F} \tag{1.5}$$

2. Ring Spinning Model

S-twisted can be analyzed on ring spinning machine. The principle of ring spinning machine can be explained in the following way: Bobbin rotates and the yarn follows the circular trajectory and each completed circle of rotation inserts one turn of twist within the length AB as Fig. 4. The yarn passes through the guide eye, which acts at the point A, then moves through to the traveler and onto the bobbin on point B .Yarn is bind on the bobbin and bobbin is adhered on the spindle which is moved by the spindle C^1.

Suppose the angular speed of traveler on ring and bobbin are $\dot{\theta}$ and $\dot{\varphi}$ in which the yarn radius is r and circular trajectory radius is R+r, hence it can be formulated as below

$$(R+r)\dot{\theta} = -\dot{\Psi}r + \dot{\varphi}R = -V_f + \dot{\varphi}R \tag{2.6}$$

$$V_f = \dot{\varphi}R - (R+r)\dot{\theta} \tag{2.7}$$

$$V_f \approx (\dot{\varphi} - \dot{\theta})R \tag{2.8}$$

$$V_f = (n_{Bobbin} - n_{traveller})\pi d_B = n_{Bobbin}\pi d_B \tag{2.9}$$

$$T = \frac{n_{traveler}}{V_f} = \frac{n_{Bobbin}}{V_f} - \frac{1}{\pi d_B} \tag{2.10}$$

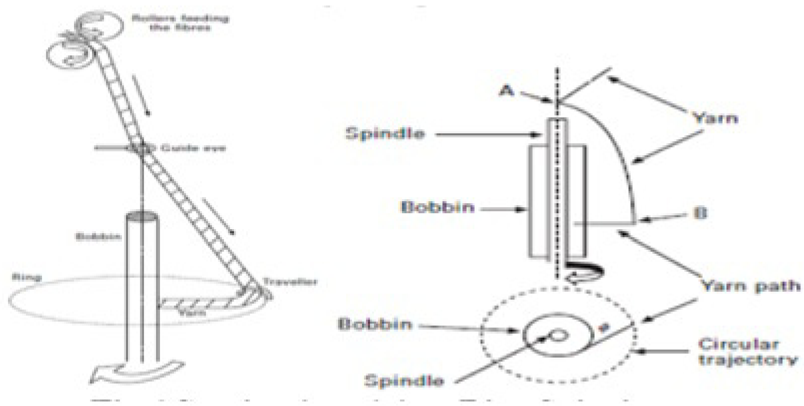

Figure 4: S-twisted model on Ring Spinning

3. Rotor Spinning Model

In rotor spinning model, for Z-twisted on OE yarn can be analyzed by adjusting the direction of rotor (clockwise) as depicted in Fig. 5.

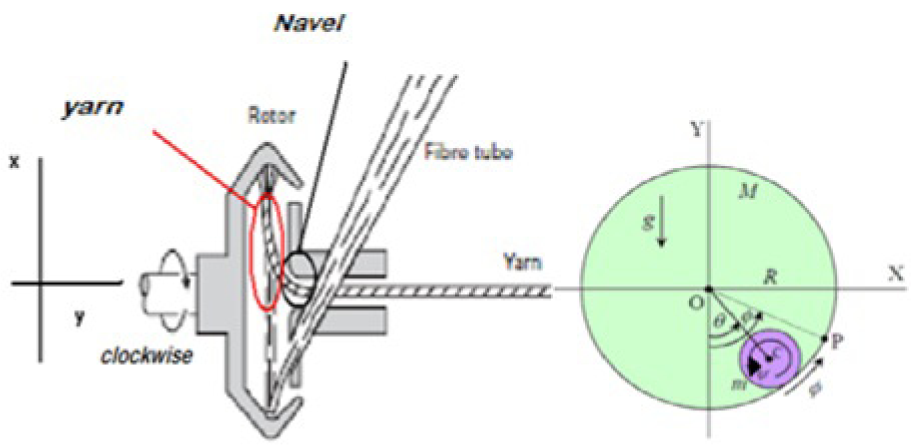

Figure 5: S-twisted model on Rotor Spinning

Suppose that the rotor moves with angular velocity $\dot{\varphi}$ and the yarn moves with angular velocity $\dot{\theta}$ which is the direction as depicted in Fig. 5 For the yarn radius and rotor radius are r and R. It can be formulated the relationship of twist and yarn angular speed as below

$$
\begin{aligned}
(R+r)\dot{\theta} &= \dot{\Psi}r + \dot{\varphi}R = V_f + \dot{\varphi}R && (3.11)\\
V_f &= \dot{\varphi}R + (R+r)\dot{\theta} && (3.12)\\
V_f &\approx (\dot{\varphi} + \dot{\theta})R && (3.13)\\
V_f &= (n_{Bobbin} + n_{traveller})\pi d_B = n_{Bobbin}\pi d_B && (3.14)
\end{aligned}
$$

and after some calculations, it can be found

$$
T = \frac{n_{rotor}}{V_d} = \frac{n_{rotor}}{V_d} + \frac{1}{\pi d_{rotor}} \qquad (3.15)
$$

4. Results and Discussion

Twist is characterized by the direction and speed of rotation of the rotor and also the speed of the delivery yarn as all researcher said [1, 2, 3, 4, 5, 6, 7, 8, 9]. Definition of twist is the number of turns on the yarn per unit length and has a dimension $[L]^{-1}$. The result of this research implemented on ring spinning machine is shown as the equations below

$$
\begin{aligned}
T &= \frac{n_{rotor}}{V_d} = \frac{n_{rotor}}{V_d} + \frac{1}{\pi d_{rotor}} && (4.16)\\
T &= \frac{n_{traveler}}{V_f} = \frac{n_{Bobbin}}{V_f} - \frac{1}{\pi d_B} && (4.17)
\end{aligned}
$$

Putra et al. [6] has shown the value of yarn twist can be related by the yarn count number in solenoid coordinate. Putra et al. [5, 6] declared that the prediction of twist could be implemented to measured the magnitude of twist related by the yarn count number. According to this research, the twist of ring spinning is lower than the twist of rotor spinning, therefore the yarn count of ring spinning in metric will be lower than the yarn count in rotor spinning. In this research, the model shows the complete formula to define the twist as Rohlena [8] reported. Lawrence [7] and Rohlena [8] developed and analyzed the differences between the results of measured twist (real twist), T_m, and adjusted twist on machine, T_a. The difference of twist is formulated as Eq. 16 and Eq. 17. In textile, twist on yarn can be done both by running open end spinning (rotor spinning) machine and by setting ring spinning. According to Rohlena [8], Trommer [9] and Lawrence [7] the value of twist on spinning machine depends on the speed of the rotor (nrotor) on the rotor spinning machine and yarn delivery speed (V_d). Lawrence [7] formulated the twist of ring spinning based on the angular speed of bobbin (n_{Bobbin}) and delivery yarn from front roller (V_d). According to Rohlena [8]. Twist can be divided into two types: Z-Twisted and S-Twisted. Based on this research Z-twisted, in rotor spinning, will have higher magnitude than S-twisted, in ring spinning.

5. Conclusion

Twist is one of important parameters of yarn. Twist determines various characteristics of material such as, hairiness, strength and yarn count. The influenced of S-twist in ring spinning and Z-twist in rotor spinning has been investigated and has been done in this research. The result of this research determines that Z-twist has higher twist than S-twist. It has been shown via classical mechanics that there are two kinds of twist which is compared by the direction of delivery yarn speed and angular speed. In OE rotor yarn, the type of twist shows Z-twisted whereas the type of S-twisted can be met in ring spinning. In the second subsection, we shall look into the special case when H is $(0, b_\infty)$-subquadratic, and we shall try to derive additional information.

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