Indian Journal of Fibre & Textile Research
Vol. 41, June 2016, pp. 129-137

Effects of OE spinning parameters on cotton rotor-spun yarn hairiness

Mohammad Javad Abghary[1], Majid Safar Johari[1] & Sanaz Hassanzadeh[2, a]

[1]Department of Textile Engineering, Amirkabir University of Technology, Tehran 159 14, Iran

[2]Department of Textile Engineering, Isfahan University of Technology, Isfahan 84156 83111, Iran

Received 25 August 2014; revised received and accepted 5 December 2014

The effect of different spinning parameters on cotton rotor-spun yarns has been studied. Three different groups of variables related to the three main sections of spinning process including the carding (main cylinder speed and licker-in roller speed), the draw-frame (total draft, number of slivers fed into the drafting zone, and distance between rollers of break-draft zone), and the rotor (opening roller speed, rotor speed, navel type, yarn count and yarn twist) have been considered in this investigation. Twenty-nine different samples have been produced and the hairiness tests are carried out using the Shirley method. The results reveal that all the considered variables could significantly affect the yarn hairiness. For reducing number of hairs, the optimum conditions must be applied to the variables, such as 750-800 rpm licker-in speed of carding machine; 51-53 mm distance between drawing rollers in draw-frame; 7500 rpm opening roller speed in rotor-spinning followed by 55000 rpm rotor speed; 17-20 Ne yarn fineness; and 800-900 TPM yarn twist. Moreover, decreasing the main cylinder speed as well as increasing the number of fed slivers to draw-frame, result in hairiness decrement.

Keywords: Cotton yarn, Carding parameter, Draw-frame, OE-spinning, Rotor-spun yarn, Yarn hairiness

1 Introduction

Most of the quality defects and production problems appeared during the yarn manufacturing process could eventually cause various limitations for further textile processes including weaving, knitting, and tailoring[1]. Throughout the spinning system, both the production consistency (yarn evenness and imperfection) and the surface integrity of the products (yarn hairiness) are considered as fundamental aspects regarding yarn quality improvement[2-4].

Among different matters of concern related to the yarn quality, the hairiness phenomenon is known as one of the most important problems[5], which can be defined as a number of fibres protruding out of the yarn body[6]. Besides the yarn undesirable appearance caused by the hairiness, it has significant effects on yarn physical properties such as strength. The hairiness also decreases the spinning efficiency and might cause difficulties during the weaving or knitting process. It has been also mentioned that existing hairs on the yarn surface lead to have some negative influences on the resultant fabrics appearance, such as the pilling formation or uneven dye picking-up[7-12]. Usta and Canoğlu[9] classified the yarn hairiness into six different groups as illustrated in Fig. 1, which individually have its own reason.

There are different parameters by which the hairiness level either positively or negatively could be varied. Researchers have identified three main effective factors on yarn hairiness that include the physical properties of fibres, the yarn characteristics, and the parameters of machinery involved during the production process[9]. Barella and Manich[13] focused on the cotton fibres properties affecting the yarn hairiness. In the study performed by Altaş and Kadoğlu[14], it was aimed to examine the effects of fibre properties and yarn linear density on cotton yarn hairiness. They also applied a multiple regression analysis on their results and found that the yarn linear density is the most effective parameter. Krupincova [15] investigated the effects of yarn construction parameters (yarn count and yarn twist) and quality characteristics of cotton fibres on hairiness. In this study, a predictive model for estimating the hairiness based on fibres and yarn quality was also designed. The other parameter investigated by Canoğlu and Yukseloglu[16] was the fibres blend ratio. They employed polyester/viscose ring-spun yarns with five different blend ratio and measured some of the yarn properties including tenacity, elongation, irregularity and hairiness.

[a]Corresponding author.
E-mail: s.hassanzadeh@tx.itu.ac.ir

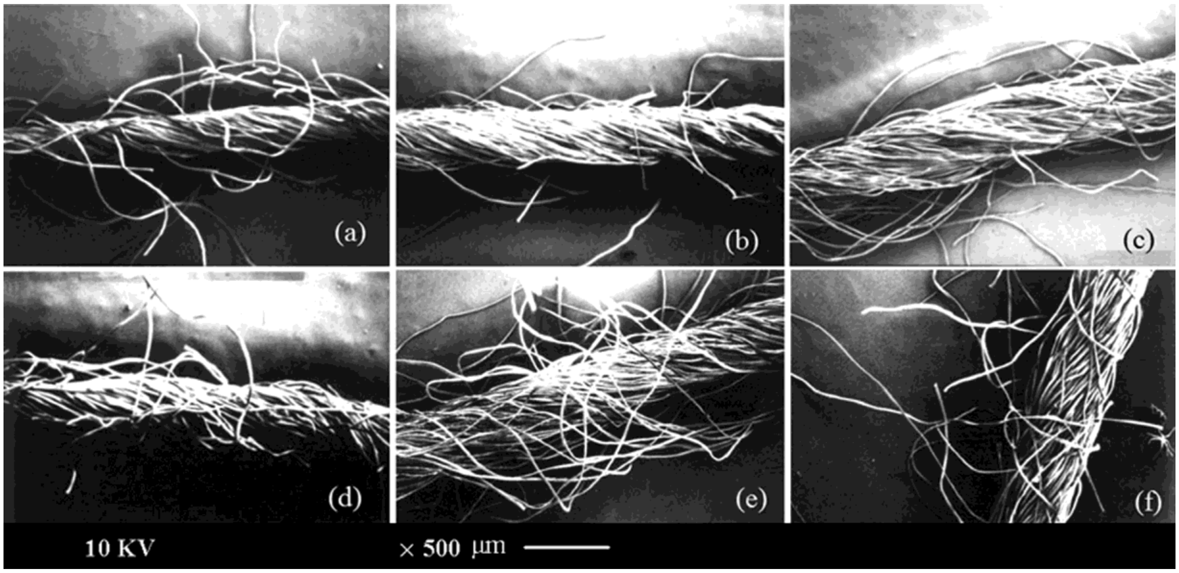

Fig. 1 — SEM images of yarn hairiness[9] (a) short-fibre yarn, (b) long-fibre yarn, (c) fibre bridges, (d) fibre loops, (e) loose-spun yarn, and (d) vertically protruding fibres

Besides studying the effects of fibre and yarn parameters on the hairiness, many other researchers have also investigated the effects of machinery parameters in their studies. Ishtiaque *et al*.[17] studied the effect of carding parameters on fibre openness and yarn quality. El-Sayed *et al.*[18] investigated the effect of carding machine delivery speed on the quality of cotton compact-spun yarns. Also, the effects of card cylinder speed, card production rate and draw frame doubling on cotton yarns quality characteristics were studied by Jabbar *et al.*[19]. Haghighat *et al.*[20] studied the influence of drafting system parameters (drafting angle, overhang of the top delivery rollers, covering of the top roller, the back-zone setting, and break draft) and some other yarn parameters (yarn count and twist) on the hairiness of polyester/viscose yarn. Yu and Sun[21] studied the effect of carding plate gauge under the licker-in roller on polyester ring-spun yarn hairiness. Arian *et al.*[22] studied on rotor spinning parameters and investigated the effects of rotor speed, yarn twist and yarn linear density on cotton yarns hairiness. They also developed a statistical model to predict the yarn quality characteristics according to the factor levels employed in their investigation. Taher *et al*.[23] studied the influence of different rotor parameters on the hairiness of cotton waste-fibre yarns. To sum up their results, yarn count and rotor type have the most important effect on the hairiness. According to the results reported by Hasani *et al*.[24], the gray relational analysis shows that the parameter rotor speed is the most effective factor on the cotton yarns. For a conventional ring spinning system, Usta and Canoğlu[9] showed that some of the ring traveler parameters (weight, type and coating) would also have significant effect on the yarn hairiness. Their results revealed that increasing the traveler weight, regardless of changes in their type or coating, leads to decrease in yarn hairiness.

The present study has been focused on investigating the influence of some machine parameters on yarn hairiness during the open-end (OE) spinning process. Three different groups of machine variables, viz. carding machine variables (main cylinder speed and licker-in roller speed); draw-frame variables (total draft, the number of slivers fed into the drafting zone, and the distance between rollers of break-draft zone); and rotor spinning machine variables (opening roller speed, rotor speed, type of the navels, yarn count and yarn twist) have been considered.

2 Materials and Methods

2.1 Samples Preparation

In this study, 4.1 μg/in cotton fibres with average length of 30 mm were used to produce different rotor-spun yarns by considering different variation levels defined for each variable. The measurements of fibre fineness and length were performed according to ASTM D1448-97 and D1440-96. Details of variables and their variation levels are listed in Table 1. It should be noticed that all the variation levels were selected by considering any limitation

Table 1 — Variables and their levels of variation used for producing the cotton rotor-spun yarns

Parameter	Variation level
Carding machine	
Main cylinder speed, rpm	400 / 450 / 500
Licker-in speed, rpm	
Main cylinder speed (400 rpm)	542 / 684 / 928
Main cylinder speed (450 rpm)	609 / 770 / 1045
Draw-frame	
Total draft + number of fed slivers[a]	6 / 7 / 8
Roller distance in break draft zone, mm	45 / 50 / 56
Rotor spinning machine	
Opening roller speed, rpm	4500 / 6000 / 7500 / 9000 / 10000
Rotor speed, rpm	25000 / 40000 / 55000 / 65000
Navel type	SN/FIS = Steel navel with flat inner surface
	SN/4GIS = Steel navel with flat inner surface
	SN/8GIS = Steel navel with 8-groved inner surface
	CN/FIS = Ceramic navel with flat inner surface
Yarn count, Ne	10 / 15 / 20 / 26
Yarn twist, TPM	650 / 800 / 1050 / 1250

[a]In order to have constant sliver count, both "total draft" and "number of fed slivers" must be changed simultaneously.

of machines operational capacities as well as the previous studies reports.

Using a conventional OE spinning system comprising a carding machine (Marzoli, *Italy*, 2003), a draw frame (Marzoli, *Italy*, 2001) and a rotor-spinning machine (Savio, *Switzerland*, 1997), cotton yarn samples were produced under a standard condition of 20±2°C temperature and 40±5 % relative humidity. Data, as reported in Table 2, are of the initial adjustments applied to the machineries used during the production procedure.

As shown in Table 1, nine different variables were chosen for investigating the yarn hairiness. During the yarn spinning process, when one variable was varied, the others were remained constant. Detailed information about the combination of variables and their levels used for each sample production are given in Table 3. As it can simply be seen from this table, 29 samples were prepared; but it should be considered that all of the variables are not totally independent and might have influence on each other. In other word, it couldn't be expected to produce yarn with exactly the same count in one particular group.

Table 2 — Initial setting of machinery involved in the OE spinning process

Carding machine	
Main cylinder speed, rpm	450
Licker-in speed, rpm	1450
Production rate, m/min	190
Sliver count, Nm	5
Draw-frame	
Total draft	7
Break draft	1.46
Roller Distance in break-draft zone, mm	52
Number of fed slivers	7
Slivers count, Nm	4.7 - 5
Rotor spinning machine	
Opening roller speed, rpm	6000
Rotor speed, rpm	40000
Navel type	Steel with flat inner surface
Total draft	160
Yarn count, Ne	20
Yarn twist, TPM	800

2.2 Hairiness Measurements

There are different methods for hairiness measurement which the previous researchers have employed in their investigations[5,6,25-29]. Testers developed according to the Shirley, Zweigle and USTER concepts are commonly used for the hairiness measurement but for some reason these techniques might have some deficiencies [5]. Fibres fineness, test speed and the air drag action on the fibres during the test, would affect the test results. Somehow, due to the bending of hairs, the measured length achieved

Table 3 — Variables combination used in samples production

Sample code	Cylinder speed, rpm	Licker-in speed, rpm	Total draft	Number of fed slivers	Roller distance mm	Opening roller speed, rpm	Rotor speed, rpm	Navel type	Yarn count, Ne	Yarn twist TPM
S1	400	1045	7	7	52	6000	40000	SN/FIS	20	800
S2	450	1045	7	7	52	6000	40000	SN/FIS	20	800
S3	500	1045	7	7	52	6000	40000	SN/FIS	20	800
S4	400	542	7	7	52	6000	40000	SN/FIS	20	800
S5	400	684	7	7	52	6000	40000	SN/FIS	20	800
S6	400	928	7	7	52	6000	40000	SN/FIS	20	800
S7	450	609	7	7	52	6000	40000	SN/FIS	20	800
S8	450	770	7	7	52	6000	40000	SN/FIS	20	800
S9	450	1045	6	6	52	6000	40000	SN/FIS	20	800
S10	450	1045	8	8	52	6000	40000	SN/FIS	20	800
S11	450	1045	7	7	45	6000	40000	SN/FIS	20	800
S12	450	1045	7	7	50	6000	40000	SN/FIS	20	800
S13	450	1045	7	7	56	6000	40000	SN/FIS	20	800
S14	450	1045	7	7	52	4500	40000	SN/FIS	20	800
S15	450	1045	7	7	52	7500	40000	SN/FIS	20	800
S16	450	1045	7	7	52	9000	40000	SN/FIS	20	800
S17	450	1045	7	7	52	10000	40000	SN/FIS	20	800
S18	450	1045	7	7	52	6000	25000	SN/FIS	20	800
S19	450	1045	7	7	52	6000	55000	SN/FIS	20	800
S20	450	1045	7	7	52	6000	65000	SN/FIS	20	800
S21	450	1045	7	7	52	6000	40000	SN/4GIS	20	800
S22	450	1045	7	7	52	6000	40000	SN/8GIS	20	800
S23	450	1045	7	7	52	6000	40000	CN/FIS	20	800
S24	450	1045	7	7	52	6000	40000	SN/FIS	10	800
S25	450	1045	7	7	52	6000	40000	SN/FIS	15	800
S26	450	1045	7	7	52	6000	40000	SN/FIS	26	800
S27	450	1045	7	7	52	6000	40000	SN/FIS	20	650
S28	450	1045	7	7	52	6000	40000	SN/FIS	20	1050
S29	450	1045	7	7	52	6000	40000	SN/FIS	20	1250

by the test apparatus might be lower than the actual value[30]. Recently, it has been found that image possessing based investigations would provide more accurate results about the yarn hairiness. Here in this study, it was decided to use the concepts of the hairiness testing method developed by Yuvaraj *et al.*[5]; but due to some laboratory limitations, the Shirley Method was eventually employed for measuring the hairiness of cotton rotor-spun yarn samples. Finally, the results were statistically analyzed using SPSS software.

3 Results and Discussion

The results of yarn hairiness for each sample and the produced yarns specifications are given in Table 4. The yarn hairiness values are determined by averaging 5 measurements for each specimen.

3.1 Effect of Carding Machine Parameters

As previously stated, the cylinder speed and the licker-in speed are the carding machine parameters selected for this research. The effect of both cylinder speed and licker-in speed on yarn hairiness are illustrated in Figs 2 (a) and (b) respectively.

According to the statistical analysis, both variables (cylinder speed and licker-in speed) have significant effects on the yarn hairiness (p-value>0.05). Also, the one-sample t-test analysis reveals that the selected levels of changes in each variable are statistically significant (95% confidence level).

From Fig. 2(a), it is obvious that increasing the main cylinder speed from 400 rpm to 500 rpm leads to more yarn hairiness; an increment of about 15%. Although the higher carding cylinder speeds might result in better carding action (based on the

Table 4 — Yarn hairiness results

Sample code	Yarn count Ne	Yarn twist TPM	Number of hairs/m
S1	21.1 (12.5)	812 (5.4)	2.683 (8.1)
S2	20.5 (6.7)	805 (7.7)	2.754 (10.8)
S3	21 (17.1)	820 (12.3)	3.077 (5.6)
S4	19.8 (13.5)	793 (12.5)	3.574 (11.1)
S5	20.3 (10.8)	809 (10.3)	2.683 (9.5)
S6	21.4 (12.6)	815 (6.5)	2.947 (3.4)
S7	20.7 (4.3)	827 (11.0)	3.446 (10.7)
S8	19.5 (3.7)	795 (3.9)	2.203 (9.2)
S9	21.1 (12.9)	791 (9.6)	2.294 (12.4)
S10	21.5 (15.2)	790 (5.5)	3.111 (6.3)
S11	20.3 (5.5)	788 (4.3)	4.509 (10.2)
S12	21.5 (18.1)	805 (7.7)	3.114 (13.2)
S13	20 (19.5)	818 (12.5)	4.431 (5.4)
S14	20.9 (4.5)	809 (9.2)	4.951 (9.6)
S15	19.9 (7.7)	823 (12.0)	1.234 (8.8)
S16	21.7 (10.5)	793 (14.5)	2.346 (11.9)
S17	21.2 (12.8)	802 (17.5)	3.123 (3.1)
S18	21.2 (5.0)	820 (5.8)	2.991 (7.2)
S19	20.8 (2.7)	796 (3.8)	1.849 (5.4)
S20	21.5 (13.5)	815 (2.5)	2.200 (10.6)
S21	21 (8.5)	809 (10.8)	3.797 (19.5)
S22	20.4 (10.4)	815 (9.2)	6.023 (4.6)
S23	19.6 (14.7)	790 (12.8)	1.706 (12.0)
S24	11.7 (12.0)	795 (13.5)	5.994 (7.3)
S25	15.8 (7.6)	812 (3.7)	3.157 (5.5)
S26	27.2 (14.8)	809 (17.4)	3.571 (15.3)
S27	21.3 (9.5)	665 (7.8)	5.083 (12.7)
S28	20.7 (16)	1063 (13.5)	3.129 (11)
S29	20.4 (18.8)	1255 (17)	4.017 (3.4)

Values in parentheses are CV%.

nep removal) [19], it causes more damage to the fibres stream between the carding elements. Fibres breakage at the carding stage via the cylinder speed increment, would eventually result in fibres shortening. As it is well known, short fibres are the main elements affecting the yarn hairiness because they are not well located within the yarn structure[6]. So, the higher speed of carding cylinder would increase the number of short fibres which could be easily protruded from the yarn body and form hairiness on the yarn surface.

In the cases of increasing the parameter licker-in speed from 542 rpm up to 928 rpm when the main cylinder speed is adjusted at 400 rpm, and from 609 rpm up to 1045 rpm when the main cylinder speed is adjusted as 450 rpm, it can be seen that there is an initial decrement of about 25-36% in the yarn hairiness. Then from a certain point in which the main cylinder and licker-in speeds are almost 400 rpm and 684 rpm (or 450 rpm and 770 rpm) respectively, an increase in hairiness from 10% to 25% is observed. Licker-in speed is one of the machine based carding parameters which could be responsible for the fibres openness and the subsequent yarn quality[17]. According to Ishtiaque *et al.*[17], the fibres opening increases rapidly with the increase in licker-in speed. This, in turn, allows the fibres to be effectively contributed into the yarn structure; this is because the more uniform twist could be taken up by the fibres involved within the twist-triangle zone. As a result, increasing the licker-in speed significantly decreases the yarn hairiness. Increasing the licker-in speed more than an optimum value (between 684 rpm and 770 rpm in this study) results in shortening of the fibre length; thus the number of shortfibres which are responsible for the yarn hairiness, would be increased.

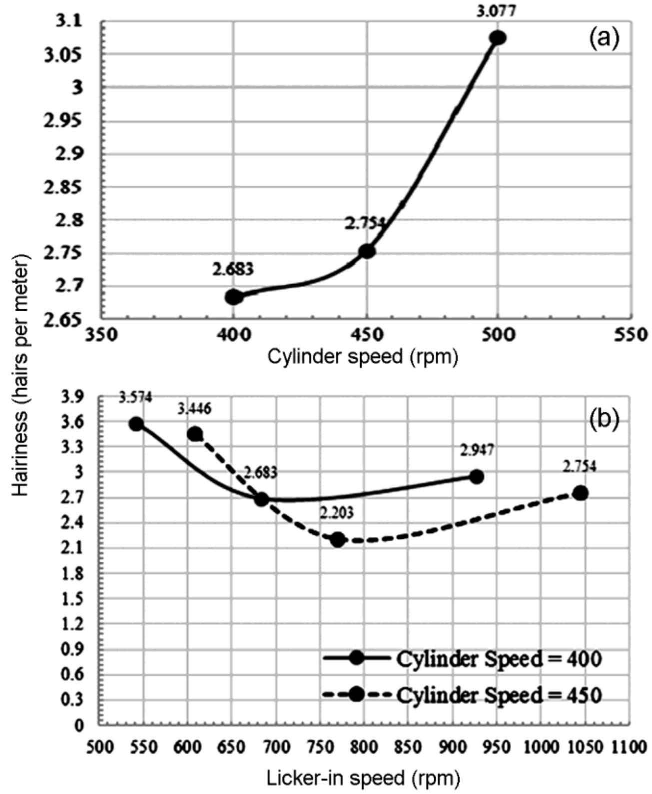

Fig. 2 — Effect of carding parameters on cotton rotor-spun yarns hairiness (a) cylinder speed, and (b) licker-in speed

3.2 Effect of Draw Frame Parameters

There are lots of literatures wherein the effects of some draw frame parameters on yarn evenness and physical properties have been investigated[19,31-33]. Among the variety of investigated parameters, only “total draft” and “roller distance” are selected in this study and their effects on the hairiness are illustrated in Figs 3(a) and (b) respectively. As it has been previously mentioned, in the case of parameter total draft, the number of fed slivers is also varied simultaneously in order to have drawn slivers with the same counts at each trial cases.

Considering Fig. 3, it is obvious that increasing the amount of total draft (from 6 to 8) leads to increase the yarn hairiness about 35.6%. The observed increasing trend of yarns hairiness from 2.3 to 3.1 hairs per meter in this research is due to the reduction of the inter-fibre cohesion when more doubling is applied to the slivers[19]. These results are also evaluated via statistical analysis and a significant effect at 5% confidence level for the said parameter is achieved. As reported by Jabbar *et al.*[19], by increasing the total draft, less inter-fibre cohesion would be happened due to the more fibres straightening. This, in turn, allows the fibres to easily come out from the fibre stream and eventually forms hairs on the subsequent yarn surface.

Das *et al.* [33] claimed that increasing the roller setting (such as roller distance) at all drafting stages during the yarn spinning process, significantly leads to initial hairiness decrease up to a specific point and then increase. As it can be seen from Fig, 3(b), the similar results are also achieved through this investigation in which the yarn hairiness undergoes 40% initial decrement while the roller distance varies from 45 mm to 52 mm and then increases rapidly from 2.8 hairs/m to 4.4 hairs/m by the future increment in roller distance up to 56 mm. Increasing the roller distance in break-draft zone up to an optimum condition (here ~ 52 mm) results in more hooks removal due to the fibre straightening within the drafting zone, which, in turn, could considerably reduce the yarn hairiness; but further increase in roller distance leads to decrease in control levels to the fibres stream which eventually results in high number of floating fibres in the drafting zone and greater yarn hairiness[19].

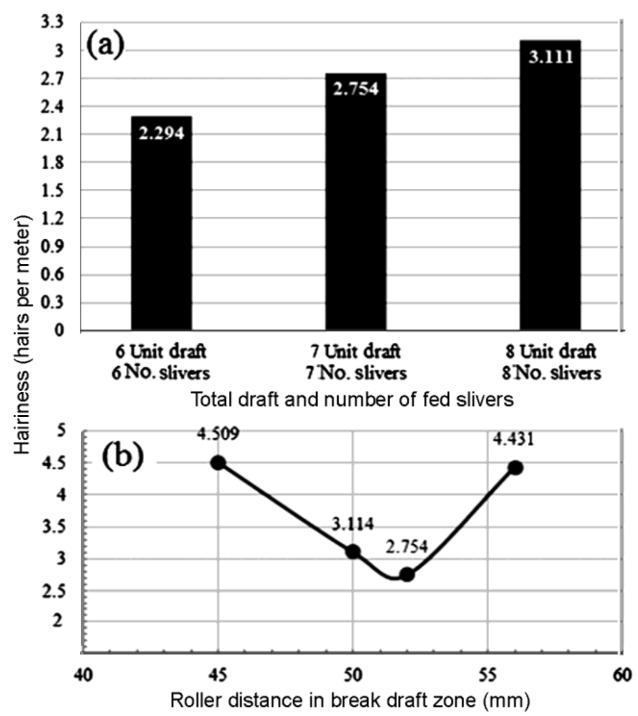

Fig. 3 — Effects of draw frame parameters on cotton rotor-spun yarns hairiness (a) total draft and numbers of fed slivers, and (b) distance between break draft rollers

3.3 Effect of Rotor Spinning Machine Parameter

According to Table 1, five different parameters in association with rotor spinning machine are considered in this investigation. The effect of these parameters on the hairiness is evaluated individually and their results are given hereunder. Statistical analysis proves that all parameters have significant effects on the yarn hairiness (p-value < 0.05)

3.3.1 Opening Roller Speed

Figure 4(a) shows the variation in yarn hairiness with the change in opening roller speed. As illustrated,

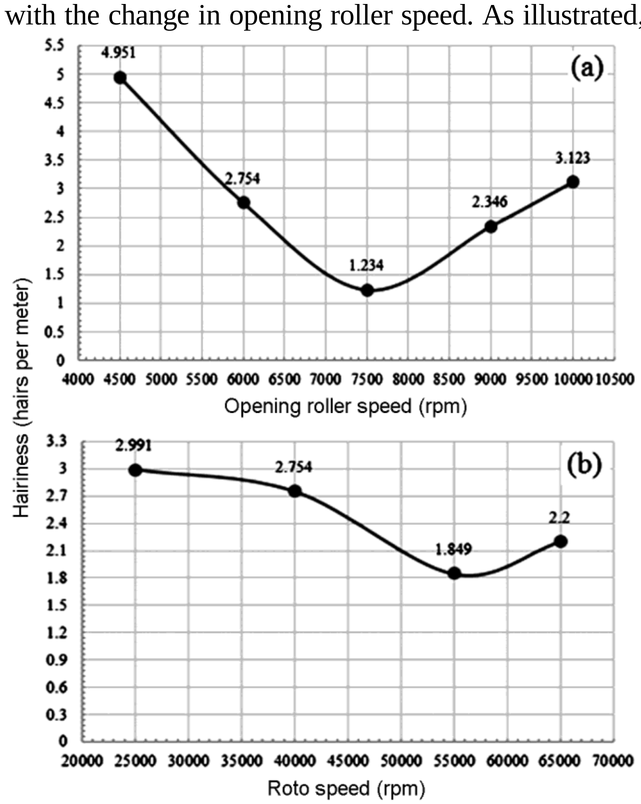

Fig. 4 — Effect of (a) opening roller speed, and (b) rotor speed on hairiness of cotton rotor-spun yarns

the hairiness decreases initially from 5.0 hairs/m to 1.2 hairs/m by increasing the opening roller speed from 4500 rpm to 7500 rpm and then undergoes a relatively rapid increment from 1.2 hairs/m to 3.1 hairs/m by further increase in opening roller speed up to 10000 rpm.

The initial decrease in hairiness via increasing the opener speed could be explained by better fibres openness which have been mentioned previously. Tyagi [34] claimed that at higher opening roller speed, the hairiness increases. He believed that increasing the opener speed leads to greater friction of opened fibres, which, in turn, results in more sever abrasion of the yarn with the naval while moving toward the winding section. For this reason, the produced yarn becomes heavily hairy. In other hand, more fibre breakage is obvious at higher opening level which simply would result in the increase in yarn hairiness[34].

3.3.2 Rotor Speed

The effect of rotor speed on yarn hairiness is given in Fig. 4(b). It can be understood that the increase in rotor speed from 25000 rpm to 55000 rpm results in about 38% decrement in yarn hairiness initially and then the further increase in rotor speed up to 65000 rpm leads to increase the number of hairs protruding from the yarn surface (1.8–2.2 hairs/m). These results were also supported by Tyagi [34]. At higher rotor speed, the friction time of the yarn in the region between the rotor groove and the exit zone would be decreased. So, the lower number of hairs might be allowed to be protruded from the yarn surface and eventually the hairiness decreases. When the rotor speed exceeds from the optimum value, the probability of wrapped fibres on the yarn surface would be increased and more yarn hairiness would be expected.

3.3.3 Navel Type

The effect of navel type on the yarn hairiness has been studied by many researchers[35-37]. Due to the surface design and structure, the navel type is considered as one of the most important parameters affecting the yarn quality[36]. Results of hairiness values of cotton rotor-spun yarns corresponding to the navel types used in this investigation are given in Fig. 5.

From the results, it can be concluded that the minimum hairiness values would be achieved when the navel of type CN/FIS (ceramic navel with flat inner surface) is employed, while the navel with 8-grooved inner surface contributes to the higher yarn hairiness. These results are similar to those reported by Hasani and Tabatabaei[35]. More friction between the yarn and the navel with 8-grooved surface is the main factor responsible for the higher hairiness.

3.3.4 Yarn Count and Yarn Twist

The effects of parameters yarn count and yarn twist on the cotton rotor-spun yarn hairiness are illustrated in Figs 6(a) and (b) respectively.

Yarn count and yarn twist are known as important yarn geometrical parameters affecting the yarn

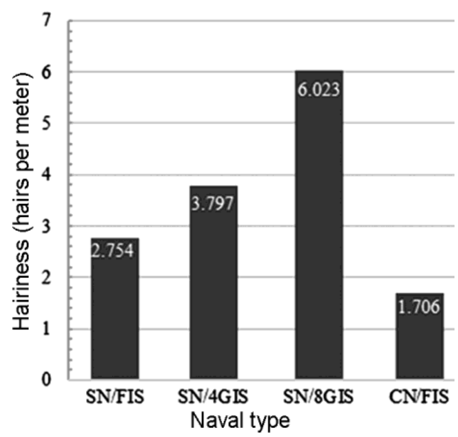

Fig. 5 — Effect of navel type on hairiness of cotton rotor-spun yarns

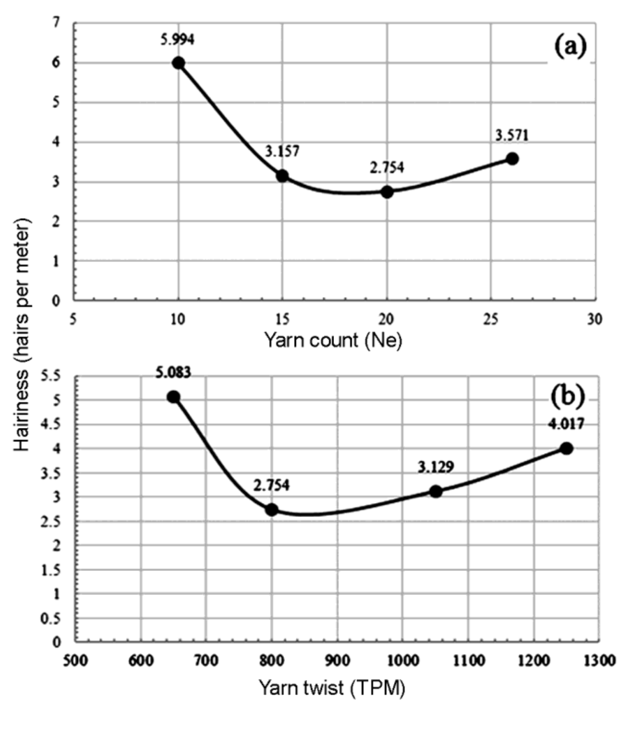

Fig. 6 — Effect of yarn parameters on hairiness of cotton rotor-spun yarns (a) yarn count, and (b) yarn twist

hairiness. Considering the higher linear density and the lower twist factor, yarn hairiness is expected to be increased[14]. Increasing the yarn linear density (or decreasing the yarn count based on indirect numbering system) results in higher numbers of fibres in the yarn cross-section. This, in turn, increases the probability of fibres protruding out of the yarn body. This state is similar to what is shown in Fig. 6(a). As the yarn count increases from 10 Ne to 26 Ne (yarns become finer), the hairiness decreases initially from 6.0 hairs/m to 2.7 hairs/m and then increases with a slight slope from 2.7 hairs/m to 3.6 hairs/m.

According to Fig. 6(b), increasing the yarn twist from 650 TPM to 1250 TPM leads to 45% decrement in yarn hairiness up to 800 TPM and then hairiness increases from 2.8 hairs/m to 4.0 hairs/m, as the higher twist is applied to the yarns. This can simply be explained considering the fact that increasing the yarn twist causes the fibre to be effectively contributed within the yarn structure; but further increase in the yarn twist results in increase in the lateral forces which eventually would be followed by more fibres breakage and thus the more yarn hairiness.

4 Conclusion

The hairiness of 29 cotton rotor-spun samples was measured according to the Shirley test method. The statistical analysis reveals that all three different groups of variables significantly affect the yarn hairiness. Increasing the main cylinder speed, leads to more hairiness due to more damages applied to the fibres strand between the carding elements. The increase in licker-in speed initially results in more fibre openness, which, in turn, causes hairiness decrement, further increase leads to increase in yarn hairiness due to the more fibres shortening. Considering the draw-frame parameters, it is simply observed that increasing the total draft values results in inter-fibre cohesion reduction and so the yarn hairiness increases. Increasing the rollers distance in break-draft zone up to an optimum value decreases the yarn hairiness, and the further increase leads to the higher hairiness level. In the case of parameter opener speed, it is observed that increasing the roller speed up to a certain point results in decrease in yarn hairiness initially, while the further increase leads to the higher number of hairs protruded out of the yarn surface due to the higher damages applied to the fibres. It is also concluded that the hairiness variation trend corresponding to the rotor speed is same as in the rotor speed. The navel type, as one of the most important parameters affecting the yarn quality (hairiness), is also considered in this investigation. The results show that ceramic navel with flat inner surface exhibits the lower hairiness, while the use of navel with 8-grooved surface increases the yarn hairiness. Yarn count and yarn twist, known as the yarn geometrical parameters, affect the yarn hairiness significantly. It is found that the optimum conditions of 17–20 Ne count and 800–900 TPM result in decrease in yarn hairiness.

Acknowledgement

Authors are thankful for the financial support by Amirkabir University of Technology, Tehran Polytechnic, and Iran Sun Yarn CO.

References

1 Harpa R, *Bul Inst Polit Iasi*, 57 (61) (1) (2011) 9.
2 Patnaik A, Rengasamy R S, Kothari V K & Ghosh A, *J Text Apparel Tech Manage*, 4 (4) (2005) 1.
3 Kalyanaraman A R, *J Text Inst*, 83 (3) (1992) 407.
4 Cheng K P S & Li C H L, *Text Res J*, 72 (12) (2002) 1079.
5 Yuvaraj D & Nayar R C, *Indian J Fibre Text Res*, 37 (2012) 331.
6 Waithaka A W, Ochola J R, Kinuthia L N & Mwasiagi J I, *Proceedings, Rmutp International Conference: Textiles & Fashion* (Rajamangla Univrsity of Technology, Bankok), 2012, 1.
7 Thilagavathi G, Udayakumar D & Sasikala L, *Indian J Fibre Text Res*, 34 (2009) 328.
8 Barella A, *Text Prog*, 13 (1) (1983) 3.
9 Usta I & Canoğlu S, *Indian J Fibre Text Res*, 28 (2003) 157.
10 Candan C, Nergis U B & Iridag Y, *Text Res J*, 70 (2000) 177.
11 Yao G, Guo J & Zhou Y, *Text Res J*, 75 (3) (2005) 274.
12 Chang L, Tang Z & Wang X, *Text Res J*, 73 (11) (2003) 949.
13 Barella A & Manich A M, *Text Res J*, 59 (10) (1989) 632.
14 Altaş S & Kadoğlu H, *Fibres Text East Eur*, 14 (3) (2006) 48.
15 Krupincova G, *Indian J Fibre Text Res*, 38 (2013) 223.
16 Canoğlu S & Yukseloglu S M, *Fibres Text East Eur*, 16 (4) (2008) 34.
17 Ishtiaque S M, Haudhuri S C & Das A, *Indian J Fibre Text Res*, 28 (2003) 405.
18 El-Sayed M A M, König G, Schaller J & Sanad S H, *Int J Text Sci*, 1 (2) (2012) 1.
19 Jabbar A, Hussain T & Moqeet A, *J Eng Fibres Fabrics*, 8 (2) (2013) 72.
20 Haghighat E A, Johari M S & Etrati S M, *Fibre Text East Eur*, 16 (2) (2008) 41.
21 Yu X Z & Sun P Z, *Adv Mater Res*, 937 (2014) 400.
22 Arain F A, Tanwari A & Sheikh H U R, *Mehran Univ Res J Eng Technol*, 31 (1) (2012) 119.
23 Taher H M, Bechir A, Mohamed B H & Faouzi S, *J Eng Fibres Fabrics*, 4 (3) (2009) 36.
24 Hasani H, Tabatabaei S A & Amiri G, *J Eng Fibres Fabrics*, 7 (2) (2012) 81.

25 Carvalho V, Cardoso P, Belsley M, Vasconcelos R M & Soares F O, *Fibre Text East Eur*, 17 (1) (2009) 26.
26 Fabijánska A & Strumiłło L J, *Mach Vis Appl*, 23 (2012) 527.
27 Li Z, Qin Z & Jie Z, *Tianjin Text Sci Tech*, 2 (2008) 5.
28 Guha A, Amarnath C, Pateria S & Mittal R, *J Text Inst*, 101 (3) (2010) 214.
29 Kilic M & Okur A, *Indian J Fibre Text Res*, 39 (2014) 49.
30 Wang X & Chang L, *Text Res J*, 69 (1) (1999) 25.
31 Ishtiaque S M, Mukhopadhyay A & Kumar A, *J Text Inst*, 99 (2008) 533.
32 Kumar A, Ishtiaque S M & Salhotra K R, *J Text Inst*, 97 (2006) 463.
33 Das A, Ishtiaque S M & Niyogi R, *Text Res J*, 76 (2006) 913.
34 Tyagj G K, *Indian J Fibre Text Res*, 29 (2004) 35.
35 Hasani H & Tabatabaei S A, *Fibre Text East Eur*, 19 (3) (2011) 21.
36 Erbil Y, Babaarslan O & Baykal P D, *Fibre Text East Eur*, 16 (2) (2008) 31.
37 Çoruh E & Çelik N, *Fibre Text East Eur*, 21 (2) (2013) 38.