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Properties of knitted fabric made from modified ring-spun yarn

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A modified ring spinning system, wherein a kind of airflow twisting device is equipped for improving the twist propagation process of ring spinning system, has been used to spun three different yarns, namely 29.2tex (Ne20), 14.6tex (Ne40), and 9.7tex (Ne60). The properties of corresponding knitted fabric, including the thickness, weight per square meter, distorted angle, bursting strength, and permeability are determined. The results show that the residual torque of spun yarn is reduced with both appropriate anticlockwise and clockwise directions of airflow. It is found that compared to knitted fabric made from conventional ring spinning system, the fabrics spun on modified spinning system show reduced thickness, weight per square meter and spirality angle; increased bursting strength; and improved permeability.

Keywords: Airflow twisting device, Knitted fabric, Ring-spun yarn, Residual torque

1 Introduction

Distorted deformation of knitted fabric is one of the common problems for single jersey, which can not only influence the beauty of clothing greatly, but also reduce the utilization of knitted fabric [1,2]. The existing research results have demonstrated that the residual torque of yarn is the main reason for distorted deformation of knitted fabric [1-3]. In the common ring spinning system, the internal and external transfer of fibres occurs in the spinning triangle due to the tension difference between the boundary fibres and central fibres. The entanglements among fibres produce correspondingly, which leads to residual internal stress directly in the yarn body. The residual internal stress in the yarn body can prevent the torsional deformation of fibres in the yarn, which is the anti-torsion of fibres. The residual internal stress in the yarn body is displayed through residual torque[3]. In the knitting process, the skew of coil and longitudinal direction of knitted fabric are caused by the yarn residual torque, i.e. the distorted deformation of knitted fabric. The distorted angle of knitted fabric is related to yarn residual torque and tightness factor of fabric. In general, the larger the yarn residual torque, the larger is the distorted angle of fabric, and the larger the tightness factor of fabric, the smaller is the distorted angle of fabric[4,5].

In order to decrease the distorted deformation of knitted fabric, three main kinds of methods, viz (i) improving the yarn qualities, (ii) improving knitting technology and (iii) improving finishing techniques have been used, and some corresponding research results are reported[6]. Among them, first method is the most effective one. Meanwhile, the research on improving yarn qualities by changing twisting process of ring spinning was found to attract more and more attentions recently[7-10], especially reducing the yarn residual torque[3,9,10]. For example, a modified ring spinning system with the false twisting devices was manufactured for the production of the modified yarns with smaller yarn residual torque[3,9]. Airflow has been another most important measures for improving ring spinning system[11-13]. In this paper, a kind of airflow twisting devices has been employed for improving the twist propagation process of ring spinning system, in which the twist can be produced by the high vortex airflow and acts on the yarn body. This affects the fibre tension distribution in the spinning triangle and changes the morphology and distribution of the fibres in the yarn body correspondingly.

Motivated by above research works, in this study attempts has been made to investigate the properties of knitted fabric made of one kind of modified ring spinning yarn. Three different kinds of modified yarns, viz 29.2tex, 14.6tex, and 9.7tex, are spun in the modified ring spinning system with a kind of airflow twisting installed, and the qualities of spun yarns are

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measured. The properties of corresponding knitted fabrics including thickness, weight per square meter, distorted angle, bursting strength, and permeability are measured and explained based on the spun yarn qualities.

2 Materials and Methods

2.1 Modified Ring Spinning System

The modified ring spinning system used in this study is shown in Fig. 1, wherein a kind of airflow twisting device is equipped. The airflow twisting device, composed of vortex roving guide and airflow input entrance, is installed on the lower of the front roller. The input airflow pressure can be controlled by pressure relief valve. In this modified spinning system, the pre-twisting will be produced in the vortex guiding channel by the high pressure vortex airflow, which acts on the yarn body directly. Then, the pre-twisting will be transferred to front roller nip along with the normal twisting produced by the rotation of traveller, and this changes the spun yarn qualities.

2.2 Experimental Preparation

Combed roving of 5.22g/10m, with twist factor of 102.3, was used as raw material. When begins to spinning, the initial airflow pressure was set as 0.01MPa. Then, three types of yarns (29.2tex, 14.6tex, and 9.7tex) were spun on this modified ring spinning system with corresponding suitable airflow pressures and two different swirling directions (anticlockwise and clockwise). The spinning parameters used are shown in Table 1.

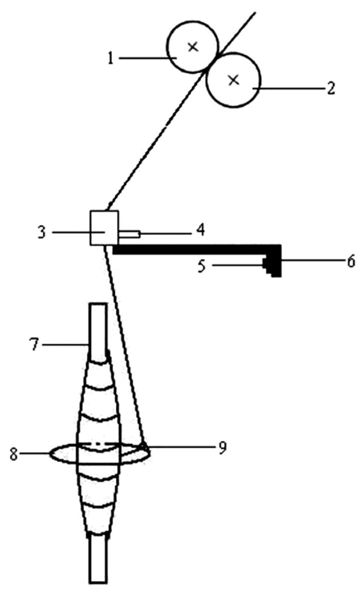

Fig.1—Modified sirospun spinning system with an airflow twisting device[1—Front top roller, 2—Front roller, 3— Airflow twisting device, 4— Airflow input entrance, 5— Screw, 6— Guiding plate, 7—Bobbin, 8—Spinning ring, and 9—Traveller]

2.3 Yarn Properties Test

All yarn simples were placed under the standard conditions of 20±3°C temp. and 65±3% RH for at least 24h before testing. Yarn hairiness, strength, evenness and number of snarling were measured. The hairiness was tested by using YG172A hairiness tester under 30m/min speed, and the breaking force of yarns was tested on YG068C fully automatic single yarn strength tester at a speed of 500 mm/min with a pretension 1.8cN/tex, and the evenness was measured by evenness tester YG135G at a speed of 200m/min. Yarn snarling is used to indicate the level of residual torque of yarn and measured as the number of wet yarn snarls per 25cm by a yarn snarl testing apparatus [14,15]. The measured properties of the spun yarns are shown in Table 2.

2.4 Fabric Properties Tests

Properties of corresponding knitted fabric such as thickness, weight per square meter, distorted angle, bursting strength, and permeability were measured and explained based on the spun yarn qualities. Three kinds of spun yarns were used to braid knitted fabrics respectively, and the braiding parameters are shown in Table 3. Thickness of fabric has great influence on wearability[16], and the thickness of fabrics made of modified yarns was measured using the fabric thickness tester YG141D. The weight per square meter of fabric not only has great influence on wearability, but also is one of the important measurements of fabric quality and economic value. Therefore, the weight per square meter of fabrics made of modified yarns was measured using the

Table 1—Spinning parameters

Yarn tex	Draft multiple	Spinning twist factor	Airflow pressure, MPa		Spindle speed r/min
			Clockwise	Anticlockwise	
29.2	17.91	330	0.06	0.08	14000
		290	0.08	0.06	12000
		250	0.08	0.04	10000
14.6	35.75	340	0.06	0.06	13000
		300	0.08	0.06	11000
		260	0.08	0.06	9000
9.7	53.81	350	0.04	0.06	12500
		310	0.06	0.04	10500
		270	0.06	0.04	8500

Table 2—Yarn properties of the modified yarn

Yarn count, tex	Yarn twist, tpm	Airflow direction	Pressure MPa	Hairiness $10m^{-1}$	Strength, cN	Evenness CV %	Snarling turns/25cm
29.2	330	Clockwise	0.06	24.80	569.6	10.86	48
		Anticlockwise	0.08	27.60	565.7	10.47	41
		Ring spinning	-	66.92	532.1	10.56	56
	290	Clockwise	0.08	51.50	516.5	11.29	38
		Anticlockwise	0.06	57.90	510.8	10.89	35
		Ring spinning	-	96.80	475.6	11.12	49
	250	Clockwise	0.08	88.90	448.2	11.79	29
		Anticlockwise	0.04	90.90	449.8	11.38	25
		Ring spinning	-	128.60	416.9	11.46	38
14.6	340	Clockwise	0.06	11.50	266.8	13.69	75
		Anticlockwise	0.06	18.80	263.5	13.47	68
		Ring spinning	-	45.90	247.6	13.52	89
	300	Clockwise	0.08	31.20	248.9	14.10	55
		Anticlockwise	0.06	35.60	244.8	13.62	51
		Ring spinning	-	67.90	227.6	13.92	70
	260	Clockwise	0.08	59.80	221.9	14.56	46
		Anticlockwise	0.06	65.40	218.2	14.15	44
		Ring spinning -	-	96.60	201.3	14.27	59
9.7	350	Clockwise	0.04	8.40	168.7	15.63	85
		Anticlockwise	0.06	11.50	165.2	15.44	82
		Ring spinning	-	38.40	154.5	15.58	97
	310	Clockwise	0.06	16.20	138.3	15.85	75
		Anticlockwise	0.04	21.60	135.1	15.57	71
		Ring spinning	-	58.90	123.8	15.66	86
	270	Clockwise	0.06	24.60	112.5	16.15	57
		Anticlockwise	0.04	31.20	110.7	15.87	55
		Ring spinning	-	69.80	101.3	15.94	72

Table 3—Braiding parameters

Yarn count, tex	Fabric structure	Loom	Loom type	Knitting gauge G	Speed $m.s^{-1}$
29.2	Plain weave	Computerized flat knitting machine	SES122S	14	1.0
14.6			SES122S	14	0.8
9.7			CMS420TS	16	0.8

electronic balance JA2003. In the knitting process, the skew of coil and longitudinal direction of knitted fabric are caused by the yarn residual torque, i.e. the distorted deformation of knitted fabric, which can not only influence the beauty of clothing greatly, but also reduce the utilization of knitted fabric. The distorted angle of knitted fabric can be used as a characterization parameter of fabric distorted deformation[17]. Therefore, the distorted angles of knitted fabric made of modified yarns and common ring yarns are measured. Mechanical properties of fabrics are found closely related to the wearability. Bursting strength is one of the most important evaluation parameters of fabric mechanical properties. So the bursting strength of the knitted fabrics made of modified yarns and common ring yarns was measured. The test instrument used is fabric strength

Table 4—Properties of fabrics

Properties	Yarn count tex	330tpm			290tpm			250tpm		
		Ring	Clockwise	Anticlockwise	Ring	Clockwise	Anticlockwise	Ring	Clockwise	Anticlockwise
Thickness mm	29.2	1.02	0.99	0.93	0.93	0.88	0.83	0.81	0.76	0.72
	14.6	0.91	0.88	0.85	0.88	0.83	0.80	0.61	0.56	0.53
	9.7	0.67	0.62	0.58	0.53	0.48	0.43	0.42	0.38	0.32
Weight, g/m^2	29.2	258.9	247.5	250.2	230.5	220.7	226.0	226.4	212.0	216.9
	14.6	111.0	105.7	108.5	109.6	102.3	106.1	106.9	100.0	104.9
	9.7	80.4	74.9	76.2	74.6	71.0	72.6	71.1	68.7	70.0
Distorted angle, deg	29.2	6.34	6.01	5.77	5.65	5.38	5.29	5.19	4.93	4.76
	14.6	7.31	7.13	6.70	6.56	6.27	5.95	6.01	5.77	5.19
	9.7	9.46	9.16	8.62	7.91	7.21	7.03	7.50	6.63	6.34
Bursting strength, N	29.2	800.2	801.4	800.9	758.9	760.0	759.2	712.0	714.2	712.9
	14.6	573.1	575.0	574.3	541.8	542.6	541.9	520.4	521.9	521.0
	9.7	389.3	393.1	391.2	365.9	367.4	366.2	339.9	340.9	340.4
Air permeability mm/s	29.2	2700.0	2796.5	2735.8	2499.7	2564.9	2522.8	2045.0	2109.0	2089.4
	14.6	2123.0	2185.9	2156.9	1864.3	1960.5	1900.4	1608.0	1716.4	1665.2
	9.7	3357.9	3419.7	3400.7	3146.9	3234.9	3209.0	2844.8	2900.0	2878.9

tester HD026N, and the measured results are shown in Table 4. Air permeability, another important parameter of fabric wearability, is mainly determined by the number and size of void between warp and weft. The air permeability of the knitted fabrics made of modified yarns and common ring yarn was measured in this study. The test instrument used is Y461 fabric air permeability tester, and the measured results are shown in Table 4.

3 Results and Discussion

3.1 Yarn Properties

Table 2 shows that the swirling direction of airflow has great influence on yarn qualities. Comparing with common ring spinning, for all three kinds of modified yarns on both suitable clockwise and anticlockwise vortex airflow pressure, it is found that the hairiness and strength of spun yarns are improved, and the number of wet snarling is reduced in modified system. Yarn evenness worsens slightly with the clockwise airflow pressure, whereas it improves slightly with anticlockwise airflow pressure. That is, the comprehensive qualities of spun yarn are improved in both suitable directions of airflow pressures. However, as compared with anticlockwise airflow, the hairiness and strength of spun yarn have greater improvement for clockwise vortex airflow, whereas yarn residual torque reduces greatly with anticlockwise airflow.

3.2 Physical Properties

3.2.1 Fabrics Thickness

Table 4 shows the thickness of the knitted fabrics made of modified yarns and common ring yarns. The thicknesses of the knitted fabrics made of all kinds of modified yarns are found to decrease comparing to that of the knitted fabric made of common ring yarn. The thickness of the knitted fabrics made of modified yarns with anticlockwise direction of airflow is found to be smaller than that of knitted fabrics made of modified yarns with clockwise direction. Table 3 shows that the numbers of snarls of all kinds of modified yarn are less than that of ring yarns, especially the modified yarn with anticlockwise direction of airflow, potentially leads to the smaller fabric thickness.

3.2.2 Weight per Square Meter

Table 4 shows that the weights per square meter of fabrics made of all kinds of modified yarns are smaller than that of fabrics made of common ring yarn. Meanwhile, weights per square meter of fabrics made of modified yarns with clockwise direction of airflow are smaller than that of knitted fabrics made of modified yarns with anticlockwise direction. Table 3 also shows that the hairiness value of all three kinds of modified yarn are less than that of ring yarns, especially the modified yarn with clockwise direction of airflow, potentially leads to the smaller weights per square meter.

3.2.3 Distorted Angle

As shown in Table 4, the distorted angles of knitted fabrics made of all kinds of modified yarns are smaller than that of knitted fabric made of common ring yarn. Meanwhile, the distorted angles of knitted fabrics made of modified yarns with anticlockwise

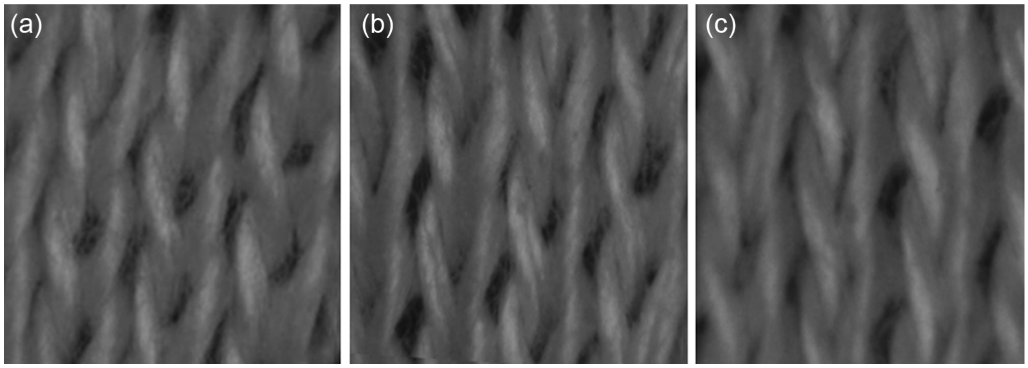

Fig.2 —Appearance and structure of fabrics [(a) common ring yarns, (b) clockwise direction, and (c) anticlockwise direction]

direction of airflow are smaller than that of knitted fabrics made of modified yarns with clockwise direction. The previous research result shows that the distorted angle of knitted fabric is related to yarn residual torque and tightness factor of fabric. In general, the larger the yarn residual torque, the bigger is the distorted angle of fabric. Also, the larger the tightness factor of fabric, the smaller is the distorted angle of fabric [4,5]. Table 2 shows that the numbers of snarls of all modified yarn are less than that of ring yarns, especially the modified yarn with anticlockwise direction of airflow, which potentially leads to the smaller fabric distorted angles. That is, the distorted deformation of knitted fabric made of the spun yarn in a modified ring spinning system can be reduced greatly.

The appearance and structure of knitted fabrics made of 29.2tex common ring yarns and modified spinning yarns with 290tpm are presented in Fig. 2, using the high magnification optical microscope (DZ3), and 50 amplification factor. It is evident that the distorted deformations of the knitted fabrics made of modified yarns [Figs 2 (b) and (c)] are smaller than that of knitted fabric made of common ring yarn [Fig.2 (a)]. Meanwhile, the distorted deformation in case of modified yarns with anticlockwise direction airflow [Fig.2 (c)] is smaller than that of modified yarns with clockwise direction [Fig.2 (b)] due to the smaller yarn residual torque. The knitted fabric made of modified yarns with clockwise direction airflow is found to be smoother due to the less yarn hairiness.]

3.3 Mechanical Properties

Table 4 shows that the bursting strengths of knitted fabrics made of all kinds of modified yarns are slightly larger than that of fabric made of common ring yarn. Meanwhile, the bursting strength of knitted fabrics made of modified yarns with clockwise direction of airflow is found a little larger than that of knitted fabrics made of modified yarns with anticlockwise direction. In Table 4, it is observed that the distorted angles of knitted fabrics made of all kinds of modified yarns are smaller than that of knitted fabric made of common ring yarn, i.e. the distorted deformation of knitted fabric made of common ring yarns is larger, which leads to non-uniform force and this reduces the fabric bursting strength. From Table 2, it is evident that the strength of modified yarns with clockwise direction of airflow is larger than that of modified yarns with anticlockwise direction, which potentially leads to the larger fabric bursting strength.

3.3.1 Air Permeability

Table 4 shows that the air permeability of knitted fabrics made of all kinds of modified yarns is larger than that of knitted fabric made of common ring yarn. Meanwhile, the air permeability of knitted fabrics made of modified yarns with clockwise direction of airflow is larger than that of knitted fabrics made of modified yarns with anticlockwise direction. Table 2 shows that both the snarls numbers and hairiness of all kinds of modified yarns are less than that in ring yarns, which potentially leads to larger fabric air permeability. Meanwhile, the hairiness of modified yarns with clockwise direction of airflow is less than that of modified yarns with anticlockwise direction, which potentially leads to the larger fabric air permeability.

4 Conclusion

It is observed that the residual torque of spun yarn is reduced with both suitable anticlockwise and clockwise directions of airflow, especially with the anticlockwise direction. Corresponding properties of knitted fabric show that as compared to the knitted fabric made of common ring spinning system, the modified spinning system shows reduced thickness, weight per square meter, spirality angle; increased bursting strength; and improved permeability. That is, the comprehensive wearing characteristics of knitted fabrics made of modified ring yarns are improved. Therefore, the modified ring spinning system used in this study is proved to be effective in practice.

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