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Balanced two-ply cotton rotor yarn

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Ply twist required to produce balanced two-ply cotton rotor yarn has been measured by placing the two-ply yarn freely in water. When the two-ply yarns are placed freely in water, the ply twist remaining in the yarn is about 40-45 % of single yarn twist, irrespective of ply-to-single yarn twist ratio used for the production of yarn. The twist liveliness of two-ply yarns both in dry and wet states increases as the ply-to-single yarn twist ratio increases. The ply yarn with 45% of single yarn twist shows the lowest amount of snarling twist both in dry and wet states. The fabrics produced using the two-ply yarn with 45% of single yarn twist show negligible amount of spirality in both dry and wet relaxed conditions.

Keywords: Cotton rotor yarn, Ply twist, Spirality, Tightness factor, Twist liveliness

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1 Introduction

The strands of drafted fibres are twisted together in the spinning machine to impart cohesion between the fibres and to produce continuous length of staple yarn. Once the staple fibres are twisted, the torque is developed in it. The amount of torque developed mainly depends upon the amount of twist given, torsional rigidity of the fibres and yarn diameter. The presence of snarling tendency in the yarn can lead to various problems like bow and skew in woven and knitted fabrics, miss stitch in garments, etc. Heat setting, steaming and plying can reduce or eliminate the torque in the yarn. Heat setting and steaming are mostly used to stabilise synthetic and natural fibres respectively. Twist stabilisation of natural fibre yarn by steaming is not a permanent setting process. The steaming process does not entirely eliminate the untwisting torque in the yarn and its effectiveness lasts up to the time that the yarns and the fabrics are processed with a wet treatment.[1] The most suitable method to remove the torque in the cotton yarn is by ply twisting the single yarn in the direction opposite to single yarn twist.

Fraser and Stump[2] used the theory of the bending and twisting of thin rods of uniform circular cross-section and inextensible centre line to find an equation for the pre-twist that must be inserted into the single strands to create a balanced two-ply yarn of specified ply twist.

Self-plying technique was used to predict the amount of ply twist required to produce torque-free yarn.[3] However, self-plying of yarn in the dry state does not release all the torque in the single yarn.[4] Self-plying of yarn in water will release all the torque in the yarn, thereby producing torque-free two-ply yarn. Also, during the actual usage, the yarns in the form of fabrics undergo several washing operations and hence the prediction of ply twist required to produce torque-free yarn should be done after treating the yarn in water.

The amount of ply twist required to produce a torque-free cotton ring yarn was calculated by placing the two-ply yarn in water. When the short length of ply yarn is left freely in water, the ply yarn will twist either in the direction of ply twist or opposite to it, depending on the direction of residual torque in the yarn. Ply twist present in the yarn after the release of residual torque in water, i.e. balanced ply twist, is the ply twist required to produce a torque-free two ply yarn. Using this method, the amount of ply-to-single yarn twist ratio required to produce two-ply cotton torque-free ring yarn was observed and found to be half of the single yarn twist.[5]

Even though the two-ply rotor yarns are not commercially used for the production of textile end-

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products, it is curious to know the ply-to-single yarn twist ratio required to produce the torque-free cotton two-ply rotor yarn. Since the structure of rotor yarn is entirely different from that of ring yarn, the ply-to-single yarn twist ratio required to produce balanced yarn may not be same for these two yarns.

In the present work, cotton two-ply rotor yarns with different levels of ply-to-single yarn twist ratio have been produced and the snarl twist and ply-to-single yarn twist ratio required to produce balanced yarn measured. To verify the results obtained from yarn samples, the knitted fabrics have also been produced using these yarns and spirality of fabrics studied.

2 Materials and Methods

2.1 Production of Yarn and Fabric Samples

Rotor yarns (98.42, 73.82, 59.05 and 29.53 tex) were spun using Autocoro 380 rotor spinning machine. Each of these yarn samples was ply twisted in the direction opposite to single yarn twist direction at four different ply twist level (45%, 1/2, 2/3 and 3/4 of single yarn twist), except for the 98 tex and 73.82 tex yarns, by passing the yarns through the front roller of Lakshmi G 5/1 ring spinning machine. Since the minimum level of twist insertion possible in Lakshmi G 5/1 ring spinning machine is 2.87 twists/cm, 98 tex and 73.82 tex yarns were not plied at 45% and 50% of single yarn twist as ply twist. The 59.05 tex × 2 yarn was knitted at three different tightness levels (12.39,13.72 and 15.37 $tex^{1/2}$/ cm) using a single jersey knitting machine with single feeder.

2.2 Testing of Yarn and Fabric

The twist liveliness of cotton two-ply rotor yarn samples in dry and wet states, the ply twist present in the ply yarn after allowing it to untwist freely in dry state and ply twist present in the ply yarn placed freely in water were measured as explained elsewhere.[5] The spirality of knitted fabrics was tested both after dry and wet relaxations as explained in earlier paper.[6]

3 Results and Discussion

3.1 Twist Liveliness of Cotton Two-ply Rotor Yarn

Table 1 shows the effect of ply-to-single yarn twist ratio on twist liveliness of two-ply cotton rotor yarns in dry and wet states. All the two-ply yarns show snarling in the direction of single yarn twist (in Z direction) both in dry and wet states. This shows that the ply twists given to the yarns are more than the required twist level to remove the torque present in it. The twist liveliness of the yarn increases as the ply-to-single yarn twist ratio increases. The ply yarn with 45% of single yarn twist shows the lowest amount of snarling both in dry and wet states. The two-ply yarns generate higher amount of snarling twist in water than that in dry state. This state of affair may be attributed to the reduction of torsional rigidity of fibres in water[7] and further release of torsional stresses in water.[4] However, the two-ply yarn with 45% and 1/2 of single yarn twist shows almost same level of snarling twist both in dry and wet states. This shows that the two-ply yarn with 45% and 1/2 of single yarn twist contains negligible amount of residual torque in ply twist direction.

Table 1 also shows that the length at which snarling starts increases as the ply-to-single yarn twist ratio increases. The length at which snarling starts is higher for the yarns tested in water than that tested in dry state.

It can be inferred from the results that the amount of twist set in the cotton rotor single yarn is about 55-60% of single yarn twist and the removal of 40-45% of lively single yarn twist by plying the yarns in the

Table 1—Twist liveliness of two-ply cotton rotor yarn in dry and wet states

Single yarn linear density tex	Single yarn twist twists/cm	3/4				2/3				1/2				45%			
		Length[a] cm		No. of snarl twist[b]		Length[a] cm		No. of snarl twist[b]		Length[a] cm		No. of snarl twist[b]		Length[a] cm		No. of snarl twist[b]	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
98.42	4.62	8.8	16.5	5.5	10.7	6.8	10.7	4.5	7.9	-	-	-	-	-	-	-	-
73.82	5.50	10.5	17.9	8.5	13.4	8.5	12.1	6.6	8.0	-	-	-	-	-	-	-	-
59.05	6.17	12.5	18.6	8.7	17.0	9.4	14.5	6.7	11.4	5.5	2.3	3.3	3.6	1.5	1.5	2.5	2.5
29.53	8.80	16.8	21.0	13.5	23.0	11.8	15.8	10.0	15.5	6.0	2.5	4.0	4.0	1.8	2.0	2.0	2.0

3/4, 2/3, 1/2 and 45% are the two-ply yarn with 3/4, 2/3, 1/2 and 45% of single yarn twist respectively.
[a]At which snarling starts.
[b]In Z direction.

Table 2—Ply-to-single yarn twist ratio after leaving the yarn to untwist freely in dry and wet states

Single yarn linear density tex	3/4		2/3		1/2		45%	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
98.42	59.1	47.9	52.4	46.1	-	-	-	-
73.82	59.6	48.3	53.1	43.8	-	-	-	-
59.05	60.5	45.5	55.8	44.5	42.8	43.1	40.5	38.7
29.53	58.5	43.7	52.4	42.4	42.0	40.4	45.2	39.7

3/4, 2/3, 1/2 and 45% are the two-ply yarn with 3/4, 2/3, 1/2 and 45% of single yarn twist respectively.

Table 3—Spirality of single jersey knitted fabric after dry and wet relaxations

Tightness factor $tex^{1/2}$/cm	3/4	2/3	1/2	45%
	After dry relaxation			
12.4	5.8	6.7	2.7	1.2
13.7	4.7	5.2	2.4	1.2
15.4	2.7	2.7	1.3	1.3
	After wet relaxation			
12.4	6.5	5.3	3.3	2.3
13.7	5.4	5.0	2.9	1.9
15.4	5.2	4.3	1.8	1.4

3/4, 2/3, 1/2 and 45% are the two-ply yarn with 3/4, 2/3, 1/2 and 45% of single yarn twist respectively.

direction opposite to single yarn twist produces balanced two-ply rotor yarns.

If the knitted fabrics are produced from these yarn, it can be expected that the fabric produced from two-ply yarn with 45% of single yarn twist should generate negligible amount of spirality than the knitted fabrics produced from other yarns and the spirality of these fabrics should increase after wet relaxation. In order to verify these predictions, 59.05 tex × 2 yarn was knitted and spirality of the fabrics was measured.

3.2 Ply Twist in Dry and Wet states

The two-ply yarn was cut to a length of about 40 cm. One end of the yarn was held and the other end was left free to allow the yarn to release the residual torque present in it. After untwisting, the amount of ply twist present in the yarn was measured and the results are given in Table 2. The two-ply yarn with 3/4 of single yarn twist has high ply twist after leaving the two-ply yarn freely to untwist followed by two-ply yarn with 2/3 the single yarn twist. There is no significant change in the level of ply twist in case of two-ply yarn with 1/2 and 45% of single yarn twist.

The ply twist present in the ply yarn placed freely in water (wet state) was measured as explain in the earlier paper[5] and the results are given in Table 2. When the two-ply yarns are placed freely in water, the yarns with 3/4, 2/3 and 1/2 the single yarn twist untwist some of its ply twist, whereas there is no significant change in ply twist in case of two-ply yarn with 45% of single yarn twist. It is worthwhile to note that when the two-ply yarns are placed freely in water, the ply twist remaining in the yarn is about 40-45 % of single yarn twist, irrespective of ply-to-single yarn twist ratio. Hence, ply twist required to produce torque-free cotton rotor two-ply yarn is 40-45% of single yarn twist.

The differences in the level of ply twist present in the ply yarn after leaving it freely to untwist in dry state and in the ply yarn placed freely in water can be explained as follows. When the two-ply yarn is left freely in dry state to untwist, the yarn could not release all torsional stress and strain in it. Most of the bending, torsional and tensile strains in the yarn would have been locked in by fibre-to-fibre frictional forces.[4] But when the same yarn is immersed in water, the water molecule penetrates between the fibres and releases all the stress in the yarn.

3.3 Spirality of Knitted Fabrics

Table 3 shows the spirality of single jersey knitted fabrics after dry and wet relaxations. The knitted fabrics produced using two-ply yarn with 3/4, 2/3 and 1/2 the single yarn twist generate spirality in S direction, whereas the fabrics produced using the ply yarn with 45% of single yarn twist generate spirality in Z direction. This shows that in case of 3/4, 2/3 and 1/2 the single yarn twist, all the torque originally present in the single yarn is removed and extra torque is created in the ply twist direction. As predicted from the twist liveliness of the two-ply yarns, the fabrics produced using the two-ply yarn with 45% of single yarn twist show negligible amount of spirality in both dry and wet relaxed conditions.

After wet relaxation, the fabrics produced with two-ply yarn with 3/4 the single yarn twist show the highest spirality followed by the fabric produced using the two-ply yarn with 2/3 and1/2 the single yarn twist.

As the tightness of the fabric increases, the spirality of the fabrics decreases in both dry and wet relaxed conditions. This finding is consistent with the results of earlier investigations done on the fabrics produced using single yarns.[7] In a more tightly knitted fabric, the movement of a knitted loop is restricted and thus spirality is reduced.

4 Conclusions

The twist liveliness of the yarn increases as the ply-to-single yarn twist ratio increases. The ply yarn with 45% of single yarn twist shows the lowest amount of snarling both in dry and wet states.

When the two-ply yarns are placed freely in water, the ply twist remaining in the yarn is about 40-45 % of single yarn twist, irrespective of ply-to-single yarn twist ratio used for the production of yarn. Hence, ply twist required to produce torque-free cotton rotor two-ply yarn is 40-45% of single yarn twist.

The fabrics produced using the two-ply yarn with 45% of single yarn twist show negligible amount of spirality in both dry and wet relaxed conditions.

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