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〈硏究論文(學術)〉

The Physical Properties of the Worsted Solo Spun Yarns and Their Fabrics

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소모 솔로 스펀 방적사와 직물의 물성

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요약—본 연구에서는 솔로 방적사의 물성과 이들 실로 만들어진 직물의 물성을 분석해 봄으로서 솔로 방적사의 최적 생산조건과 실의 생성 미케니즘을 분석 · 연구하고자 하였다. 이를 위해서 7가지의 솔로 스펀 롤러를 제작하고 이를 이용하여 방적사를 제조한 후 일반 링 방적사와 물성 비교 분석에 의한 최적 생산 조건 및 솔로 스피닝의 미케니즘을 조사하였다. 그리고 최적 솔로 스피닝 롤러에 의해 만들어진 솔로 스펀 방적사를 이용하여 직물을 제직하여 일반 링 방적사 직물과 물성 비교를 통하여 솔로 스피닝 직물의 현장 적용성을 검토하였다.

1. Introduction

The most important problem for weaving single worsted yarn fabric is to get rid of hairy fibres on the single yarn. Some studies[1~4] were done, among them, recently the solo spinning technology[2] was developed by the wool Mark company in Australia. This solo spinning technology is spinning method for making less hairy fibres on the single yarns. Many worsted companies in the world are now using this system, but the optimum processing conditions and wool fiber characteristics pertinent to their spinning equipments are required and have to be investigated. Therefore, in this study, the physical properties of worsted yarns produced by solo spinning technology and the respective fabrics were surveyed. The specimens are made by six kinds of solospun rollers with fixed twist multiplier. The physical properties such as yarn evenness, strength, elongation, yarn cohesion, and yarn hairiness are measured and analyzed with those of regular ring spun yarns. Furthermore, the yarn formation mechanism of solo spinning is investigated by image analysis of white and black jaspe yarns. For analyzing the physical properties of fabrics made of these solospun yarns, 2/2 twill fabrics were designed and woven by a pilot weaving machine using solospun and regular ring yarns. The physical

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properties of these fabrics such as abrasion and pilling were measured and discussed with regard to the physical properties of the solospun and regular ring spun yarns. In addition, the mechanical properties of these fabrics were measured by KES-FB and discussed with respect to the yarn properties and the yarn formation mechanism of solospun yarns.

2. Experimental

2.1 Materials

Wool top used is shown in Table 1.

2.2 Solospun Roller

Solospun rollers were made for investigating the optimum roller condition and for comparing to the roller(100 roller) by the Wool Mark Company. The specification of these rollers are shown in Table 2. Schematic diagram of these rollers are shown in Fig. 1. Ring spinning frame (Zinser 319) attached solospun roller is also shown in Fig. 1.

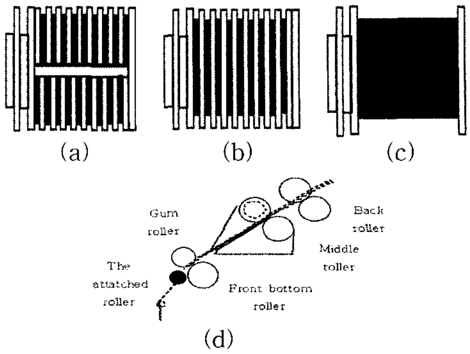


Fig. 1. The shape of rollers.

(a) solospun roller(100) with the slots of width 0.4mm and depth 2mm. (b) 3 rollers were made in this shape with the width of 0.5mm, 0.8 mm & 1.2mm and coded as roller '200', '300', '400' respectively. (c) the roller coded as roller '500'with smooth surface. (d) Schematic diagram of solo spinning.

2.3 Yarn Preparation

Yarn specimens prepared using wool top in Table 1 and solospun rollers in Table 2 are

Table 1. The characteristics of the wool tops used

Wool	Composition	Fineness	Length				Grease content
			Mean	CV%	%≤25mm	%≤30mm	
grade	%	μ	mm	%	%	%	%
A	wool=100	19.11	67.3	42.1	5.5	34.28	0.39
G	wool=100	22.02	76.4	36.7	2.1	5.1	0.56
D	wool=100	20.54	71.2	41.2	5.2	32.75	0.44
M	wool=60	18.62	68.3	43	6.2	34.8	0.38
	mohair=40	26.05	86.0	49.1	3.5	-	0.90

Table 2. The specifications of the rollers

Code	100	200	300	310	400	500	510	Regular ring
Slot width	0.4mm	0.5mm	0.8mm	0.8mm	1.2mm	no slot	no slot	no roller
Shape (Fig. 1)	(a)	(b)	(b)	(b)	(b)	(c)	(c)	-
Material	rubberized plastic	bronze	bronze	plastic (PVC)	bronze	bronze	rubberized plastic	-

Table 3. The yarn spinning plan

Fineness	Yarn count(Nm)	Type of attached roller							Regular ring
		100	200	300	310	400	500	510	
19	1/30	W100	W200	W300	W310	W400	W500	W510	N3
	1/40	X100	X200	X300	X310	X400	X500	X510	N11
20.5	1/30	Y100	Y200	Y300	Y310	Y400	Y500	Y510	N16
22.0	1/30	Z100	Z200	Z300	Z310	Z400	Z500	Z510	N21
20.8(Mo/W)	1/30	M100	M200	M300	M310	M400	M500	M510	N26

Table 4. The improved solospun yarn quality with the modified solospun roller

	Yarn count	Irregu-larity	Thin Places	Thick Places	Hairiness >3mm	Strength	Elongation
	Nm	(CV%)	No/Km	No/Km	No/10mm	Gf	%
Solospun	30.7	14.1	3.67	2	50	256.8	23.4
Modified	30.6	13.9	2.33	1.33	48	263.2	23.7
Regular ring	29.8	13.8	2.33	1.33	118	267.7	21.7

shown in Table 3. Used ring frame was Zinser 319, r.p.m. of ring spindle was 7300. Twist multiplier was 120 for all yarn specimens.

2.4 Yarn Physical Properties

Yarn evenness, strength, elongation, yarn cohesion, yarn number and yarn hairiness were experimented.

2.5 Modified Solospun Rollers

Modified solospun rollers were made, and six kinds of yarns(3 solospun and 3 ring spun yarns) were spun for manufacturing woven fabrics as in Table 4.

2.6 Weaving

Six kinds of fabrics were woven by sample loom as shown in Fig. 2. Grey fabric width was 14 inch, r.p.m. of loom was 20.

2.7 Finishing

Grey fabrics were washed in laundry with 50℃ water and detergent for 20 minutes. After that, washed grey fabrics were rinsed up and down in the 50℃ water twenty times as a simulation of a scouring process. These fabrics were conditioned in the air for 72 hours, and treated with steam press by Biella Shrunk machine. And finally these fabrics were treated by full decatizing machine with 0.8 bar pressure for 6 minutes and were cooled for 6 minutes.

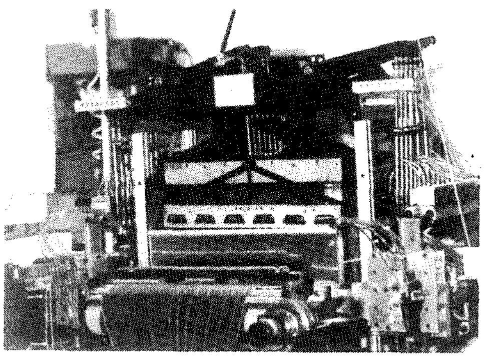


Fig. 2. Weaving loom woven with solospun and ring spun yarns.

2.8 Fabric Physical Properties

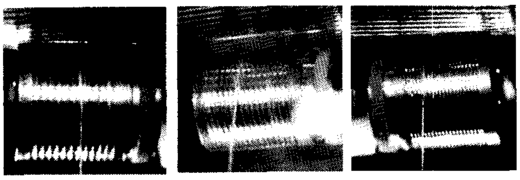
Fabric mechanical properties were measured by KES-FB system for predicting fabric hand.

Fabric pilling test was performed by Brush and Sponging method.

3. Results

3.1 Yarn Formation Mechanism

The fiber migration during solospun yarn formation was investigated for surveying yarn formation mechanism. Fig. 3 shows the fiber migration during solospun yarn formation on the ring frame.



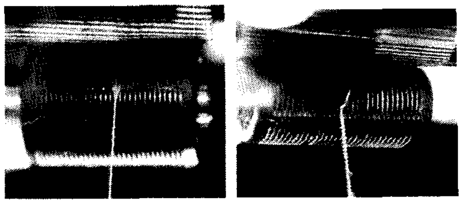
(a) (b) (c)

Fig. 3. (a) The photograph of yarn formation with solospun roller 400.
(b) The photograph of yarn formation with solospun roller 300.
(c) The photograph of yarn formation with solospun roller 200.

As shown in Fig. 3, there are many fibers at the center part on the fluted solospun rollers and it is shown that the remoter from the center on the fluted rollers, the less fibers. Therefore it seems that the narrower between fluted groove distances, the evener fiber distribution between groove. The convergent point on the narrow grooved roller ((c) in Fig. 3) was more stable than those on the wide grooved rollers ((a) and (b) in Fig. 3). Fig. 4 shows conflicted grooved solospun rollers (100 roller).

As shown in Fig. 4(a), the change of fiber migration on the conflicted grooved roller has shown more than that on the strict grooved rollers ((a), (b) and (c) in Fig. 3).

And as shown in Fig. 4(b) which shows twisted yarn configuration with white and black jaspe yarns on the conflicted grooved roller100, each strand is combined with torque on the conflicted grooved roller as siro spun yarn explained by Plate and Lappage[1]. This phenomena make it less hairy fibers on the yarn surface.

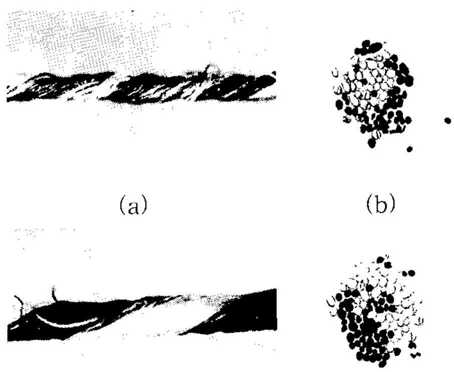


(a) (b)

Fig. 4. (a) The photograph of yarn formation with solospun roller 100.
(b) The photograph of the false twist of strands between the convergent point and the end of slits on the roller 100.

3.2 Yarn Structure

Fig. 5 shows the yarn structure of solospun and ring spun yarns.



(a) (b)

(c) (d)

Fig. 5. The Photograph of solospun and ring spun yarns.
(a) Longitudinal view of solospun yarn.
(b) Cross-section of solospun yarn.
(c) Longitudinal view of ring spun yarn.
(d) Cross-section of ring spun yarn.

3.3 Yarn Physical Properties

Fig. 6 shows yarn linear densities according to the various solospun rollers. It is shown that solospun yarns are finer than ring spun yarn and the narrower the groove interval on the solospun roller, the finer yarn linear density. It seems that this is due to the increase of the floating fibers according to the decrease of groove interval on the solospun rollers. This phenomenon is more evident for the fine linear density(fineness) of the constituent fibers.

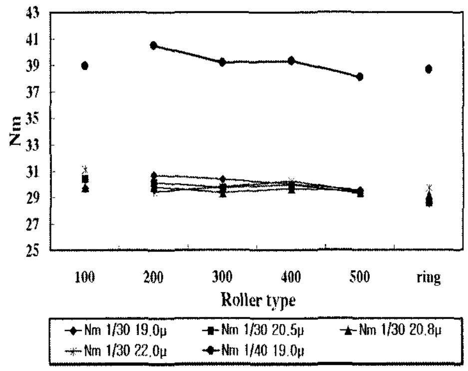


Fig. 6. The effects of roller type on the yarn count.

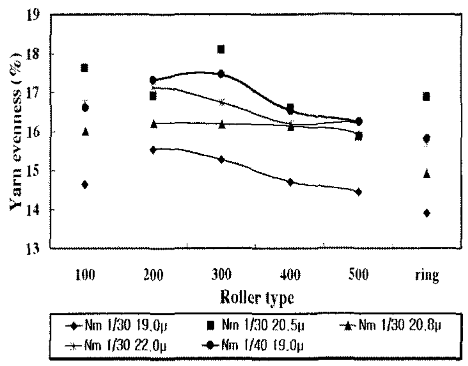


Fig. 7. The yarn irregularity according to the various rollers.

Fig. 7 shows yarn evenness according to the various solospun rollers. It is shown that the wider grooved width, the lower evenness of the yarns. Fig. 8 shows yarn breaking strength according to the various solospun rollers.

The yarn breaking strength is increased with the groove width of the solospun rollers, this is due to the decrease of yarn evenness with the increase of groove width on the solospun rollers as shown in Fig. 7.

Fig. 9 shows yarn breaking strain with the various solospun rollers, which shows the same results as yarn breaking strength shown in Fig. 8.

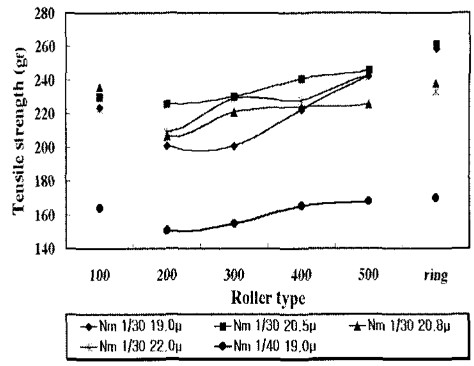


Fig. 8. The yarn breaking strength with roller types.

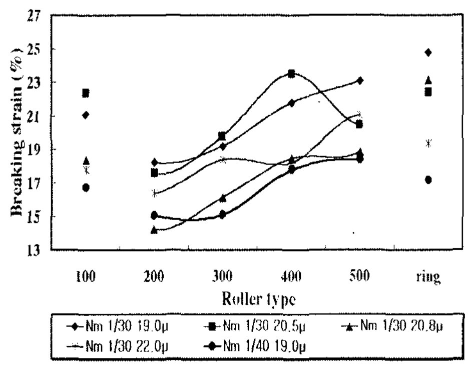


Fig. 9. The yarn breaking strain with roller types.

3.4 Yarn Hairiness

Fig. 10 shows yarn hairiness with the various solospun rollers. It is shown that solospun yarn has less hairy fibers than that of ring spun yarn and the narrower the groove interval on the solospun roller, the less hairy fibers on the yarn surface.

Fig. 11 shows yarn abrasion resistance with the various solospun rollers. Yarn abrasion resistance by straight solospun roller is increased with the groove interval on the solospun roller, which is due to the increase of yarn hairiness according to the increase of groove interval on the solospun rollers but for the conflicted groove roller (type 100), yarn abrasion resistance is highest comparing to the straight groove rollers (200, 300, 400, 500) and ring.

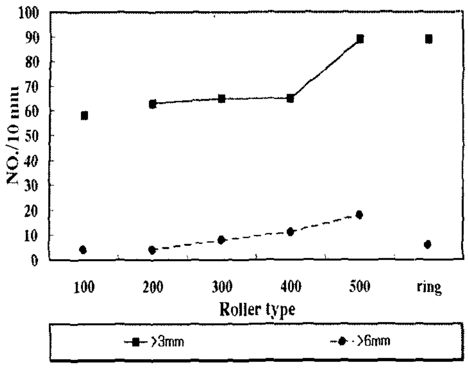


Fig. 10. The effects of roller type on no. of hairy fibers.

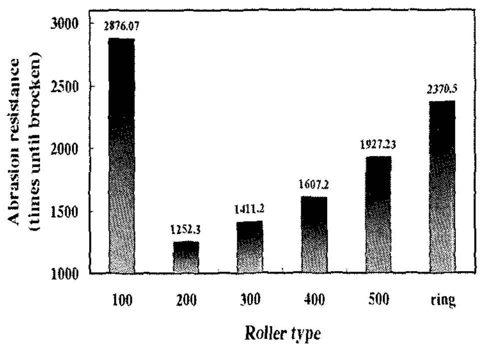


Fig. 11. Yarn abrasion resistance.

3.5 Fabric Physical Properties

For the purpose of analysing the physical properties of solospun fabric, comparison between solospun and ring spun fabrics was performed. Fig. 12 shows fabric extensibility and tensile work of solospun and ring spun fabrics according to the yarn twists.

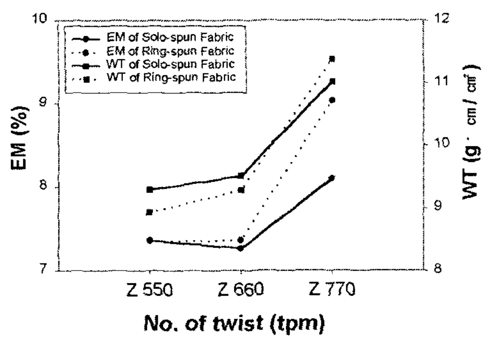


Fig. 12. Extensibility and tensile work of fabrics.

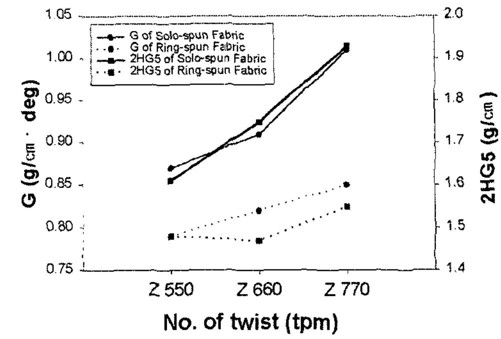


Fig. 13. Shear rigidity and hysteresis of fabrics.

As shown in Fig. 12, fabric extensibility between solospun and ring spun fabrics shows almost same tendency under low twist such as 550 t.p.m. and 660 t.p.m.. But the extensibility of solospun fabric is lower than that of ring spun fabric under the high twist such as, 770 t.p.m., that means that solospun fabric is a little stiff comparing to the ring spun fabric, which is originated from more unstable helical yarn structure of the solospun yarn. Fig. 13 shows fabric shear modulus and shear hysteresis of solospun and ring spun fabrics according to the yarn twists. Shear modulus of solospun fabric is higher than that of ring spun fabric. Shear hysteresis of solospun fabric is also larger than that of ring spun fabric. It seems that this is due to unstable yarn twist structure as fabric extensibility.

Fig. 14 shows fabric bending properties of solospun and ring spun fabrics. As shown in Fig. 14, both bending rigidity and hysteresis of solospun fabric are larger than those of ring spun fabric. It seems that interfibre friction in the solospun yarn is much more than that of ring spun yarn, the reason why is shown in two yarn structures in Fig. 15.

Fig. 16 shows fabric compressional properties of solospun and ring spun fabrics. Both compressional work and resilience of solospun fabrics show low value comparing to those of ring spun fabrics. These phenomena are due to the stable helical yarn twist model of ring spun yarns.

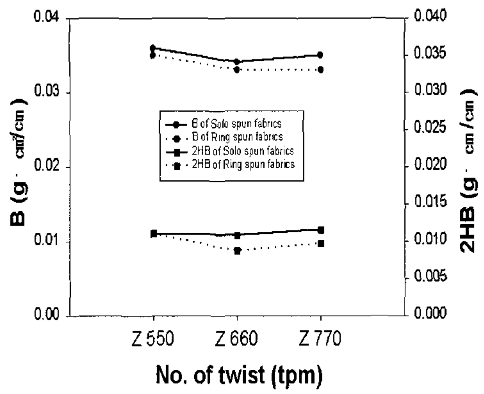
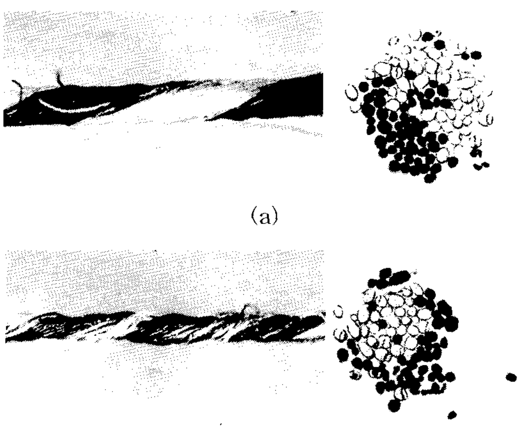


Fig. 14. Bending rigidity and bending hysteresis of fabrics.



(a)

(b)

Fig. 15. Twist structure of ring spun yarn(a) and solospun yarn(b).

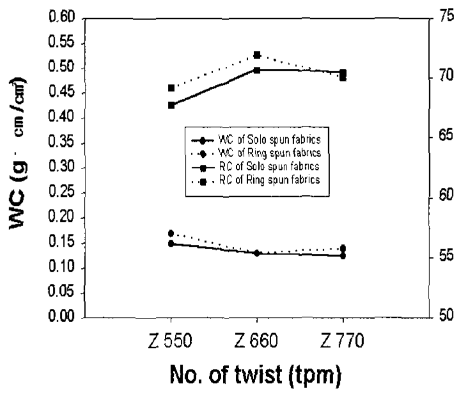


Fig. 16. Compressional energy and resilience of fabrics.

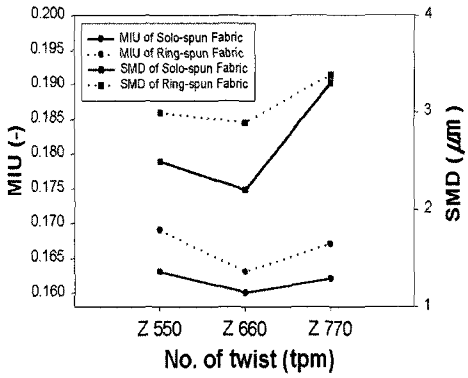


Fig. 17. Surface properties of fabrics.

Fig. 17 shows fabric surface properties of solospun and ring spun fabrics. Both friction coefficient and roughness of solospun fabrics are lower than those of ring spun fabrics, which is caused by less hairy fibers on the solospun yarns and less stable helical yarn structure of the solospun yarns than those of ring spun yarns.

3.6 Fabric Pilling Property

Fig. 18 shows the pilling property of solospun and ring spun fabrics.

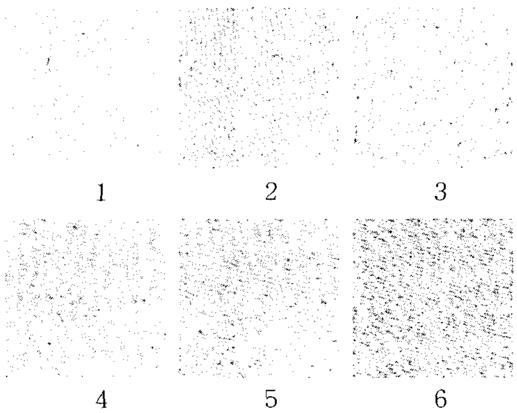


Fig. 18. Comparison of pilling bet. solospun and ring spun fabrics.

As shown in Fig. 18, the pills developed on the surface of the solospun fabrics(no. 1, 2 and 3) are less than those of the ring spun fabrics (no. 4, 5 and 6).

4. Conclusions

1. The grooves on the surface of solospun roller prevent the twist propagation from the spindle to the nip line and have an important role for deviding the strand delivered from front roller into some sub-stands, and the hairy fibers on the sub-strands are trapped by the twist propagated from spindle at convergent point. These hairy fibers are actively migrated and became a wrapping fibers, which makes it reducing the hairiness and improving the abrasion resistance.
2. The grooves of solospun roller cause the fly and make it uneven draft on the yarns. The linear density of solospun yarn becomes finer and yarn irregularity is deteriorated, moreover which are improved with round edge of the grooved wall on the solospun roller. These phenomena were more evident on the conflicted grooved solospun roller than those on the straight grooved one. In the case of straight grooved roller, the yarn linear density and yarn evenness are decreased with increasing groove width. Tensile strength and elongation are also increased with increasing groove width. And also hairy fibers on the yarn surface are increased with increasing groove width.
3. Solospun yarn physical properties are also influenced by fineness of fiber and yarn twist factor besides solospun roller structure. Solospun yarn requires more fibers in the yarn cross section i.e. requires more fine wool fibers and has optimum twist multiplier ranged from 120 to 130 (t.p.m./Nm) for spinning solospun yarn with good physical properties.
4. Solospun fabric is stiffer comparing to the ring spun fabric. Workdone of tensile of solospun fabric is smaller than that of ring spun fabric. Shear modulus and shear hysteresis of solospun fabric are larger than those of ring spun fabric. Bending rigidity and hysteresis are larger than those of ring spun fabric. Compression work and resilience of solospun fabric are smaller than those of ring spun fabric. On the other hand, frictional coefficient and roughness of solospun fabric are smaller than those of ring spun fabric, which is due to less hairy fibers on the solospun yarn surface. Solospun fabric shows lower pills on the fabric comparing to the ring spun fabric.

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References

1. D. Plate and J. Lappage, *J. Textile Inst.*, **73**, 99(1982).
2. The Wool Mark Company, *"Solospun"*, p.5(1999).
3. S. H. Park, S. J. Kim, S. C. Hong, and W. S. Han, *"Proc. of the Korean Textile Conf."*, Vol 32, p.81(1999).
4. D. Plate, *"Textile Horizons"*, **2**(2), p.34 (1982).