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Characteristics of fabrics knitted with basic knitting structures from combed ring and compact yarns

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The abrasion resistance, pilling tendency, *Lab* values, *K/S* value and burst strength of fabrics with basic knitting structures of RL-jersey, RR-ribbed, RR-interlock forms produced from 100% combed cotton ring and compact yarns have been studied and compared. It is observed that the differences between the structures of ring and compact yarns play a significant role on the fabric properties. The fabrics produced from compact yarns are found to have better abrasion resistance, higher burst strength, less pilling tendency, better dye absorption, and dyeability in more vivid colors.

Keywords: Burst strength, Compact yarn, Pilling, Ring yarn, Weft knitted fabric

1 Introduction

Combed ring yarns have always been considered as a quality reference among all the yarns produced by other new spinning systems in textile industry. However, combed ring yarns are not faultless. Although various improvements and developments have taken place in the ring spinning machine which uses ring traveller, these efforts could not reduce the spinning triangle which is considered as the weakest point and the most troublesome area. For this reason, the improvement efforts are now being made towards the better contribution of fibres to the yarn structure and increased production speed with a more ordered yarn structure, less yarn breakage and decreased spinning triangle. Compact spinning machines have been developed as a result of research studies on improvement of the performance and components of ring spinning machines.[1-4]

The twist which is given to the yarn in the spinning process is centered along the curve between the traveller and the front roller wheel. The twisting in this region occurs in the opposite direction of the yarn movement. The traveller applies the twist to the fibres which have just been drawn (yarn in spread form) in the place closest to nipping point after the front wheels. However, the twist cannot reach the nipping point, because the fibres have a tendency to align in the yarn axis direction after leaving fronts wheels. The fibres with different lengths and stresses in the inner and outer parts of the yarn lead to the formation of a spinning triangle. Due to the spinning triangle, the fibres which constitute the outer part of the yarn are exposed to a considerably higher stress (under the influence of twist and balloon stress) compared to the fibres in the inner part and these outer fibres partially participate in the yarn structure. As the high number of fibres which leave the roving can cause the formation of spinning triangle, the fibres which partially participate in the yarn structure can also lead to this situation. The yarn formation shows a spinning triangle in the classical ring spinning which is not present in compact ring spinning.[5]

Compact spinning system works between drawing and yarn formation steps and serves as a interlocutory region. In this interlocutory region, fibre form which is ready to be drawn is densened by air pressure (aerodynamic forces), mechanical means or magnetic effect. In this case, the fibre bunch is densened before applying the twist and as a result, the spinning triangle is minimized or removed. Hence, all the fibres which fall out of the triangle are collected without causing fly formation in this process. Figure 1 shows the classical ring spinning system and compact ring spinning system. In compact spinning, the fibres participate more closely in the yarn structure. Thus, the produced yarns become less hairy, stronger and more lustrous with higher elongation. Fabrics which have been produced from these yarns are softer and stronger, have better abrasion resistance, and give better patterns when printed. As a result, the number of process steps which the yarn will undergo after

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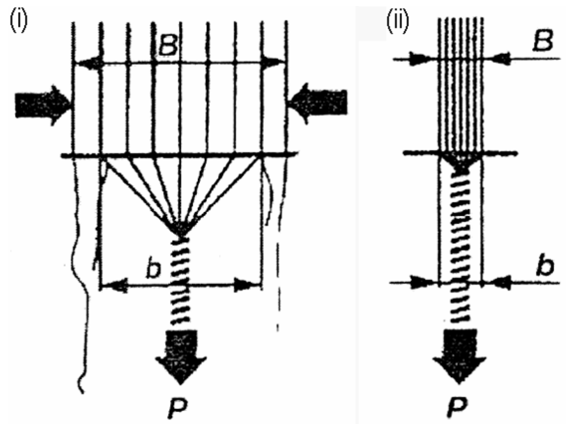

Fig. 1—(i) Classical ring spinning system, and (ii) compact ring spinning system[5]

spinning can be reduced or the process durations and consequently the expenses can be minimised.[1, 2, 5, 6]

Due to less pilling, less hairiness, higher strength and better processibility and wearing behavior characteristics, the number of application areas of compact yarns in knitting is increasing. Compact yarns can be used without waxing or with less amount of wax in a lot of knitting mills. Hence, the contamination in the knitting machine is also reduced, and some problems which occur due to faulty or uneven waxing can be prevented. Moreover, as the dust content of these yarns is low, the erosion of the guides and needles is reduced and the service lives of the machines are lengthened.[7, 8]

High strength also helps in reducing the buckling tendency which occurs often in yarns with low twist and hairiness. The ability to lower the twist numbers and the capability to use different twist numbers broadened the application areas of these yarns in knitting. Especially as the yarns with low twist numbers are fluffier and softer, the final product has a higher cover factor and softer hand. Fabrics which are produced from one-ply compact yarns which replace plied yarns have brighter, clearer and smother surfaces.[6, 7, 9 - 11]

In this work, the effect of yarn production techniques on the physical properties of basic weft knitted fabrics has been studied. The fabrics knitted from ring combed and compact yarns were used for the study and comparison.

2 Materials and Methods

Combed ring and compact yarns having linear densities Ne 30/1 and Ne 40/1 were produced on Rieter K44 and Rieter G33 spinning machines respectively. The yarns were produced from the same 100% combed cotton roving. The physical testing results of these yarns are given in Table 1.

Table 1—Characteristics of yarns used in the production of knitted fabrics

Yarn characteristic	Combed ring		Compact ring	
	30 Ne	40 Ne	30 Ne	40 Ne
Twist, turns/m	820	924	750	846
Tenacity, cN/tex	17.31	16.08	20.54	18.81
Breaking elongation, %	4.68	4.6	4.82	4.92
Hairiness (Uster), H	5.79	5.7	5.04	4.36
Unevenness (Uster), % U	9.15	9.97	8.9	9.73
Thin places (50%), km	0	1.2	0	1.2
Thick places (+ 50 %), km	7	9.4	4	10.4
Neps (+ 200 %), km	14	37.6	11.4	24.6

Table 2—Physical properties of knitted fabrics

Fabric construction	Gauge of knitting machine	Machine diameter (Ø)	Fabric weight g/m^2	Wale density wpc	Course density cpc
Ne 40/1 jersey					
Combed	E 28	32	101	13	21
Compact	E 28	32	102	13	21
Ne 30/1 ribbed					
Combed	E 18	34	160	9	19
Compact	E 18	34	162	9	19
Ne 40/1 interlock					
Combed	E 24	30	167	12	18
Compact	E 24	30	170	12	18

Knitted fabrics with the basic knitting forms of RL-jersey, RR-ribbed and RR-interlock were produced from these yarns. The physical characteristics of these fabrics are given in Table 2. The reason for using yarns with different linear densities is the lack of machines which can process yarns with one linear density in the knitting mill, where the experiment was carried out.

All the grey fabrics of the compact and conventional ring-spun yarns were processed in the same baths to eliminate any variations during these processes. The grey fabrics were first scoured with hydrogen peroxide maintaining the bath ratio at 1:12. Following scouring, the hot washing, acetic acid processing and rinsing processes were carried out in succession. Then, all the fabrics were dyed in blue color with remazol dyes on a jet dyeing machine. During dyeing, the fabrics were processed at 25°C and then the temperature was increased to 60°C for 45 min. Following this, cold rinsing with 0.5 g/L acetic acid and 3 % softener respectively was applied. Afterwards, the tube slitting, drying and sanforing processes were carried out.

The produced knitted fabrics were subjected to abrasion resistance, pilling tendency and burst strength tests using standard methods. *Lab* values and *K*/*S* value of these fabrics were also measured.

3 Results and Discussion

3.1 Dyeing Behavior

The *Lab* values and *K*/*S* value of the fabrics were measured according to CIE Lab color difference evaluation criterion in a Minolta 3600-D spectrophotometer. The results are given in Table 3.

In order to determine the color differences between the fabrics of ring and compact combed yarns which have been dyed in the same dye bath, the fabrics are tested in a spectrophotometer under day light conditions (D65). As reference samples, dyed fabrics of each three knitting structures were also used. It is observed that the colors of the compact yarn fabrics are darker (D*L*) and more vivid (D*C*).

Table 3—*Lab* values of different fabrics

Fabric	*L*	*a*	*b*	*C*	*H*
Ne 40/1 jersey fabric					
Combed	37.57	-1.82	-17.83	17.92	264.17
Compact	37.18	-1.57	-18.00	18.06	265.01
Ne 30/1 ribbed fabrics					
Combed	35.12	-1.58	-17.46	17.53	264.83
Compact	36.72	-1.77	-17.48	17.57	264.22
Ne 40/1 interlock fabrics					
Combed	36.45	-1.60	-17.83	17.90	264.87
Compact	37.90	-1.64	-17.93	18.01	264.79

D65 10 deg: For jersey fabric—D*L*-0.39, D*a* 0.25, D*b*-0.17, D*C* 0.14, D*H* 0.26, D*E* 0.50; For ribbed fabric—D*L* 1.61, D*a*-0.19, D*b*-0.02, D*C* 0.04, D*H* -0.19, D*E* 1.62; For interlock fabric—D*L* 1.46, D*a* -0.03, D*b* -0.10, D*C* 0.11, D*H* -0.03, D*E* 1.46.

The fabrics knitted from compact yarns show darker color compared to the fabrics knitted from ring combed yarns. From this, it can be concluded that the compact yarns have a higher absorption capability. Moreover, it is found from Table 3 that there are significant color differences between the compact and the ring fabrics even though the yarns are knitted on the same machines and the fabrics are dyed in the same bath. The *K*/*S* values of fabrics are shown in Fig. 2.

3.2 Abrasion Resistance and Pilling

Both grey and dyed fabrics are tested for abrasion resistance and pilling tendency. The tests have been carried out in Martindale abrasion and pilling tester according to standard ASTM-D 4970-02. The abrasion resistance values of grey and dyed fabrics are given in Table 4. It is found that the compact yarn fabrics of all different constructions have higher abrasion resistance values compared to the ring yarn fabrics with the same fabric constructions. On the other hand, grey fabrics have lower abrasion resistance compared to dyed fabrics with the same construction. The interlock and jersey fabrics are found to have the best and the least abrasion resistances respectively.

The test results of the pilling tendency are given in Table 5 and Fig. 3. It is observed that the pilling tendencies of fabrics which have been knitted from compact yarns are lower than that of the fabrics knitted from ring combed yarns. When the hairiness values of both yarns (Table 1) are analyzed, it is found that the compact yarns have lower hairiness. This situation may be the cause of lower pilling tendency in compact yarn fabrics.

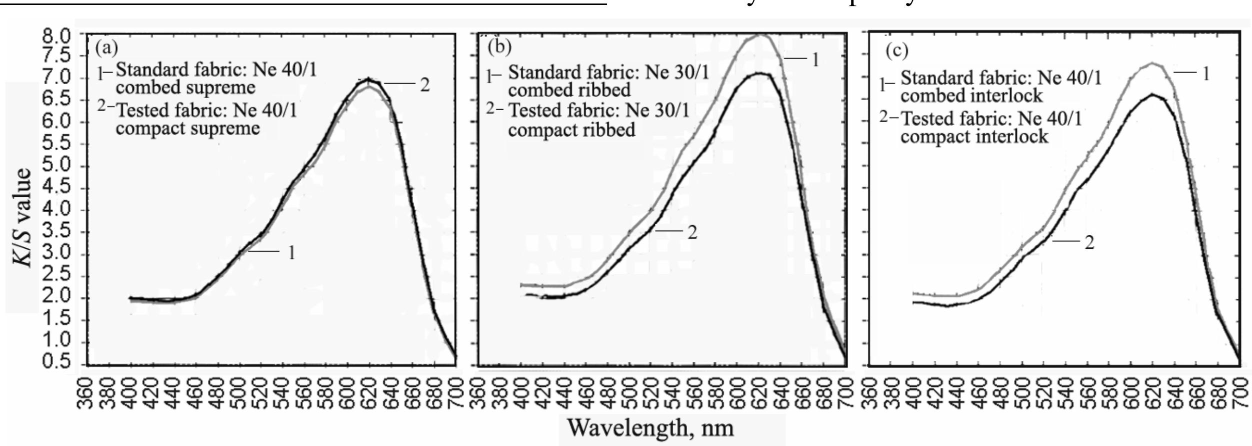

Fig. 2—*K*/*S* values of different fabrics [(a) RL- jersey fabric, (b) RR- ribbed fabric, (c) RR- interlock fabric]

Table 4—Results of abrasion resistance[a]

Fabric	Ne 40/1 jersey		Ne 30/1 ribbed		Ne 40/1 interlock	
	Combed	Compact	Combed	Compact	Combed	Compact
Grey	16 600 rpm	20 200 rpm	27 200 rpm	30 500 rpm	26 500 rpm	31 300 rpm
Dyed	22 700 rpm	24 300 rpm	42 800 rpm	49 100 rpm	51 300 rpm	54 700 rpm

[a]According to ASTM-D 4970-02 standard, the abrasion resistance values given as rpm are friction cycle number meeting the perforation occurring first on the fabric sample subjected to a test. As this value increases, corrosion resistance of that fabric increases.

Table 5—Pilling evaluation grades of fabric samples[a]

Speed, rpm	Ne 40/1 jersey		Ne 30/1 ribbed		Ne 40/1 interlock	
	Combed	Compact	Combed	Compact	Combed	Compact
500	4	4	4	4	4	4
1000	3	4	3	4	3	4
2000	3	3	3	4	3	3
5000	2	3	2	3	2	3

[a]According to ASTM-D 4970-02 standard, pilling level of fabrics was evaluated on the grading scale of 1-5. Grading 1 indicates the densest and grading 5 indicates the least surface pilling effect.

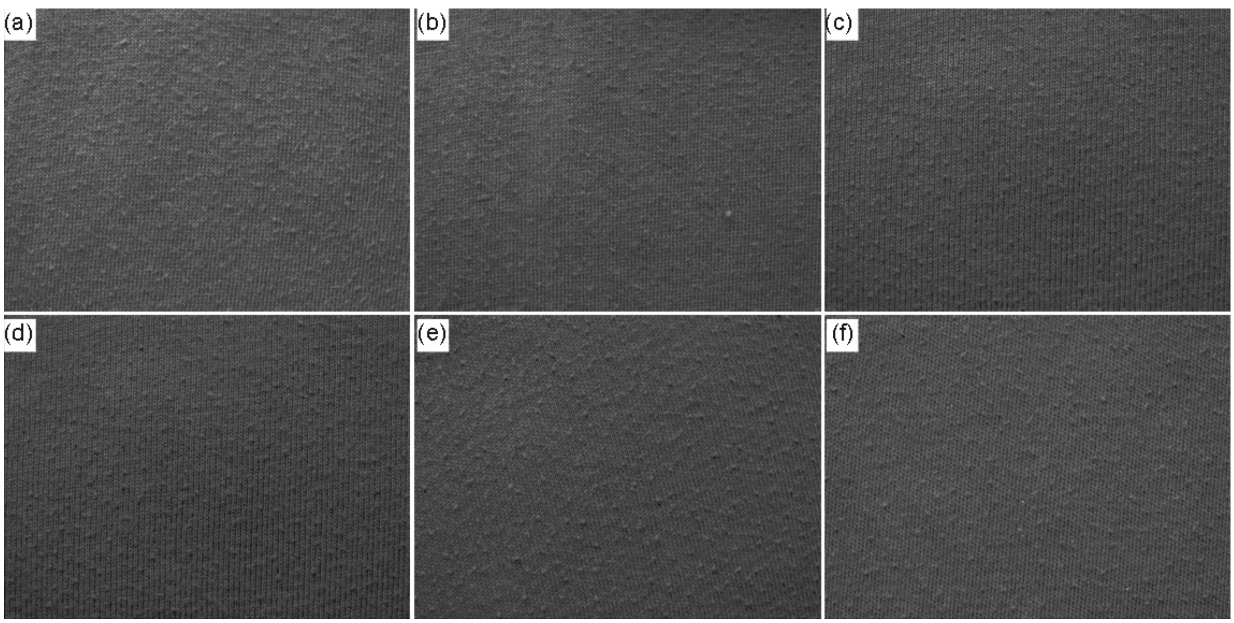

Fig. 3—Fabric samples showing the pilling [(a) Ne 40/1 ring combed jersey, (b) Ne 40/1 compact jersey, (c) Ne 30/1 ring combed ribbed, (d) Ne 30/1 compact ribbed, (e) Ne 40/1 ring combed interlock, and (f) Ne 40/1 compact interlock]

3.3 Burst Strength

Burst strength test has been carried out for the same fabric using the hydraulic testing method on Mullen type tester. The burst strength (N/cm^2) values are found to be: for Ne 40/1 ring jersey fabric 542.26 (combed) and 602.40 (compact); for Ne 30/1 ring ribbed fabric 789.40 (combed) and 846.26 (compact); and for Ne 40/1 ring interlock fabric 704.80 (combed) and 908.53 (compact).

It is found that the burst strength values of the compact yarn fabrics are higher than that of the combed ring yarn fabrics as in the case of pilling resistance. When the physical properties of both the yarns (Table 1) are compared, it is found out that the compact yarns have a higher breaking strength and higher elongation, as expected. It is possible to talk about a direct relationship between the burst strength of fabrics and the strength and elongation of yarns which constitute the fabric.

4 Conclusions

4.1 The compact yarn fabrics of the three knitting constructions show darker and more vivid color using the same dyeing machine under the same dyeing conditions. This may be due to the fact that the compact yarns absorb more dye because they have lower twist numbers, and are softer and more voluminous.

4.2 The compact yarn fabrics have higher abrasion resistance and lower pilling tendency. This may be due to the less hairiness, stronger structure and higher elongation of compact yarns because of the participation of all fibres out of spinning triangle in compact spinning system.

4.3 The compact yarn fabrics show higher burst strength due to higher strength and elongation of compact yarns.

4.4 It is found that the knitting structure affects the burst strength, similar to yarn characteristics. RR-interlock fabrics having a tighter and closer structure are found to have the highest burst strength.

Industrial Importance: Today when consumers show interest in buying better and more beautiful products, this experimental study will help in improving the quality of knitted fabrics.

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