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Comparison of the Properties of Knitted Fabrics Produced by Conventional and Compact Ring-Spun Yarns

Abstract
The new compact yarn spinning system appears to eliminate the spinning triangle problem in the conventional ring spinning process, and is claimed to bring many advantages of yarn quality. However, the benefits of this new concept are still to be investigated extensively. In this research work, we produced plain knitted fabrics by using conventional ring-spun and ring-compact yarns. These fabrics were knitted and dyed under identical conditions. We then tested these fabrics for their appearance after different washing cycles, their pilling behaviour, their colour differences and bursting strengths. The change in the surface of the fabrics after washing in different cycles shows that fabrics of compact yarns maintain their appearance, while others seriously deteriorate. Pilling test results show that the pilling tendency of fabrics of compact ring yarns is much better compared to those of conventional yarns, as expected. On the other hand, test results regarding colour difference indicate that there are significant differences, as the fabrics of compact ring yarns have darker shades. Finally, fabrics of compact ring yarn have generally higher bursting strength, but the differences become less significant as the loop lengths increase in the fabrics.

Key words: *ring-spun yarn, compact ring-spun yarn, conventional ring-spun yarn, knitted fabrics, fabric properties.*

Introduction

It is well known that one of the weakest points of the ring spinning system is the spinning triangle. For this reason, following previous research works which focused on this particular problem, a new approach known as compact ring spinning was developed by ITV of Germany. First exhibited at ITMA 1995, this system is regarded as being entirely new, although it still has the classical spinning components of ring spinning [1,2].

This new concept is aimed at diminishing the spinning triangle by condensing the fibre bundles before they leave the drafting system in the conventional ring spinning system. This should offer a significant advantage for ring spinning when competing with its rivals, as it claims to offer many advantages in terms of yarn structure (i.e. yarn hairiness, appearance, strength etc.), leading to a much better idealised yarn structure [3,4]. However, the production costs of this system were significant at this early stage of the development, but recent claims indicate that these costs can be significantly reduced [6].

As a result of improvements in yarn structure, various compact spinning designs by different textile machinery manufacturers are on the market. For instance, in Air-Com-Tex 700 by Zinser, a perforated apron is added to the classical drafting system of a ring machine [7], while ComforSpin® by Rieter uses a perforated drum to condense fibres in the drafting region [8,9]. On the other hand, the EliTe® system from Suessen differs significantly from both systems [10,11].

The number of independent research works about the pros and cons of compact systems is small, since many of the available publications come from the machinery manufacturers themselves.

The works reported so far mainly deal with the comparison of compact and conventional ring-spun yarn properties (e.g. hairiness, strength, irregularity etc.), the performance of the yarns in downstream processes, as well as fabric performances such as pilling, surface appearance etc. [1-5, 12-16]. These works showed that compact yarns have a much less hairy yarn surface, and they do not tend to entangle in weaving as expected. It has also been reported that compact yarns perform better in terms of strength, irregularity and breaking extension. In terms of the cost benefit of such systems, it is possible to work with a much smaller amount of twist with compact yarns to obtain the same strength level of conventional ring-spun yarns [15,17]. More recently, Artzt has indicated that compact spinning system offers new perspectives for using these systems for spinning both man-made fibres as well as woollen fibres [13].

Interestingly, Ethridge, Hequet and Krifa reported that there are no significant differences in the irregularities of the yarns produced on the Suessen Fiomax 1000 compared to the conventional ring-spun yarns [14]. However, more recently Cheng and Yu indicated that the compact yarns produced on Rieter K44 had much higher irregularity [12]. In the same work, it is also reported that Rieter's compact spinning system is only suitable for producing finer yarns (i.e. beyond Ne 60) using longer staple cottons, indicating that it has some limitations in terms of yarn count and quality. Similarly, Oxenham indicates that the compact system has not been well received in the USA, although it is claimed to have made some significant inroads in Europe [18].

Table 1. Properties of the fibre blend used in yarn production.

Parameter	Conventional ring spun yarns	COM4 yarns
%2.5 SL	29.06	29.43
Micronaire	4.32	4.66
Unf. ratio	82.8	84.08
Tenacity, g/tex	31.20	29.16
Elongation of break, %	7.5	6.12
+b	10.09	8.43
Rd	76.56	77.6
Colour grade	31-3	31-3
SFC	23.3	18.3
Maturity ratio	0.89	0.90
Nep, cnt/g	239	75
Dust, cnt/g	916	688

Table 2. Yarn properties.

Yarn features	Parameters	Conventional ring spun yarn	COM4 yarn
Count, Ne	mean	29.66	29.00
	CV%	1.00	1.13
Twist, tpm	mean	910.35	866.9
	CV%	4.6	5.19
	TM	40.7	38.8
Strength, g	mean	319.6	398.17
	CV%	9.29	8.91
Evenness	U	12.54	9.45
	CVm	15.97	16.12
Imperfection	thin places (-50%)	5	0
	thick places (+50%)	285	7.5
	neps (+200)	387.5	10.0

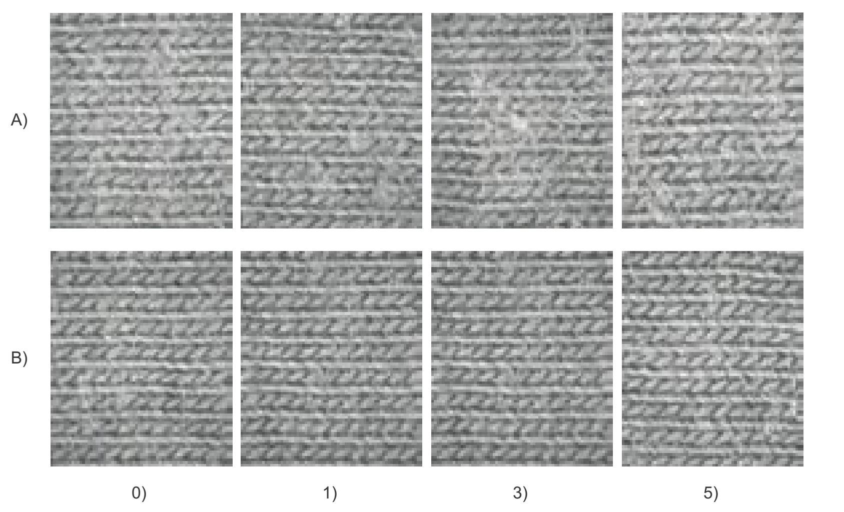

Figure 1. Appearance of knitted fabrics manufactured from A - ring spun yarn, B - compact ring spun yarn; before and after 1, 3, and 5 washings; magnification 250×.

Therefore, we aimed to compare the properties of knitted fabrics produced by conventional carded ring-spun yarns and carded compact ring-spun yarns in this work, in order to obtain a deeper idea and better understanding about the main advantages of compact spinning systems in terms of yarn and fabric performance.

Experimental

Fibre particulars

The carded ring-spun yarns consisted of a fibre blend of 70% Greek and 30% Iranian cottons, while the carded compact ring yarns were produced by Aegean cottons. The compact yarns, known as COM4®, were spun on a Rieter K44. Table 1 shows the properties of the fibre blend used in yarn production. As the data in the table show, both yarns have similar raw material properties, while the cotton of the COM4 yarn appears stronger, cleaner and has fewer neps.

Yarn particulars

In this research work, single yarns of carded ring and carded compact yarns of 20 tex were produced. Table 2 gives the details of yarn properties. The data in the table indicates that the COM4 yarns show less irregularity, higher strength, much fewer thin and thick places and neps.

Knitted fabric production

We produced plain knitted fabrics on a Monarch-Vanguard Supreme circular knitting machine with a gauge of 28, diameter of 24 inches and 72 systems. The production was arranged so that the fabrics could have three different levels of loop lengths (i.e. short, medium and long loop lengths). Then, the average loop lengths were measured by taking the yarns from 100 loops in the same course for each type of fabric. We took the measurement after hanging a 10 g weight on the yarn samples, as Smirfitt earlier indicated that a 10 g weight is good enough to open yarn crimps [19]. On the other hand, we carried out these measurements only for grey state fabrics, since Postle and Kurbak reported that any change in the loop length after wet relaxation processing, which is around 2%, could be ignored [20,21]. The results of this investigation are given in Table 3.

Fabric dyeing and finishing

We processed all the grey fabrics of compact and conventional ring-spun yarns in the same baths, to eliminate any variations during these processes. The grey fabrics were first scoured with hydrogen peroxide. The bath ratio was 1/15. The scouring conditions were as follows:

- anti-creasing agent 0.3 g/l
- hydrogen peroxide 1.5 g/l
- caustic soda 2.5 g/l
- wetter 1 g/l
- stabiliser 0.5 g/l

The following scouring, hot washing, acetic-acid processing and rinsing processes were carried out in succession. Then, all the fabrics were dyed into blue with direct dyes in a jet-dyeing machine. The dye-bath consisted of the following elements:

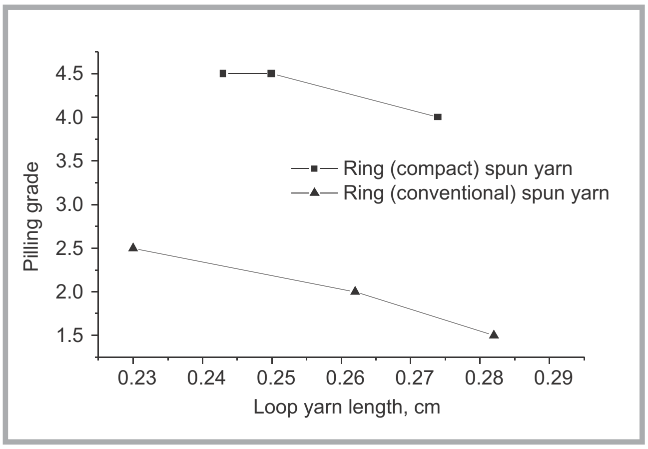

Figure 2. Pilling test results.

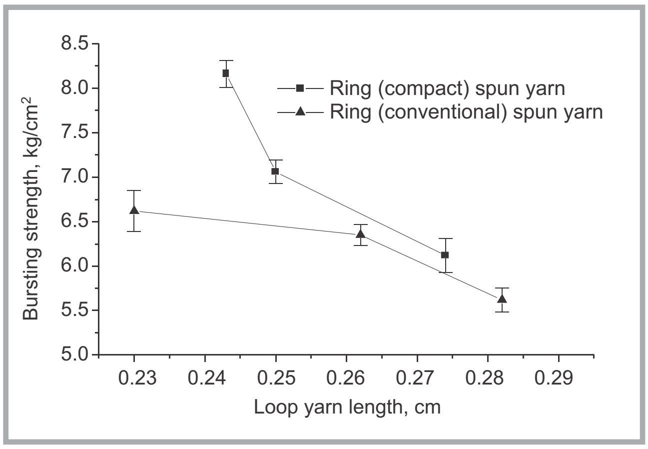

Figure 4. Bursting strength test results.

- anti-creasing agent 0.3 g/l
- sequestering agent 0.5 g/l
- liquid salt 160 ml/l
- liquid soda 65 ml/l
- dye-stuff 0.042%

During dyeing, we processed the fabrics at 40°C at the beginning, and increased to 60°C for 60 minutes. Following this, cold rinsing with 0.5 g/l acetic acid and 3% softener respectively was applied. Afterwards, the tube slitting, drying and sanforising processes were carried out.

With the fabrics in a finished state, we first compared their appearances after different cycles (i.e. 1, 3, and 5 washing) in a Wascator FOM 71 to see the differences in the fabrics' surfaces. The washing conditions were chosen according to standard EN ISO 6330 at 40±3°C. The surfaces were closely examined under an Olympus SZ-CTV Stereo microscope. Later, the fabrics were tested for their pilling performance. The pilling tests were carried out on a Martindale abrasion and pilling tester according to standard ASTM-D 4970-02. The fabrics were also tested for their bursting strength and colour differences. We used a Mullen-type tester, which applies the hydraulic test method, for the bursting strength, and a Minolta 3600-D model spectrophotometer for colour tests.

Test Results and Discussion

Change in the fabric appearance after washing cycles

The surface appearances of the fabrics before washing and after 1, 3 and 5 washing cycles are shown in Figure 1. When the surfaces are examined, the fabrics of conventional yarn have a very hairy surface, as expected, and even after only 1 washing, the surface becomes seriously deteriorated; the surface of fabrics of the compact yarn, however, seem to maintain its original state. A similar trend is followed after 3 and 5 washings. Although there is deformation on the fabrics of the compact yarns, it is to a much lesser extent compared to the fabrics of the ring-spun yarns.

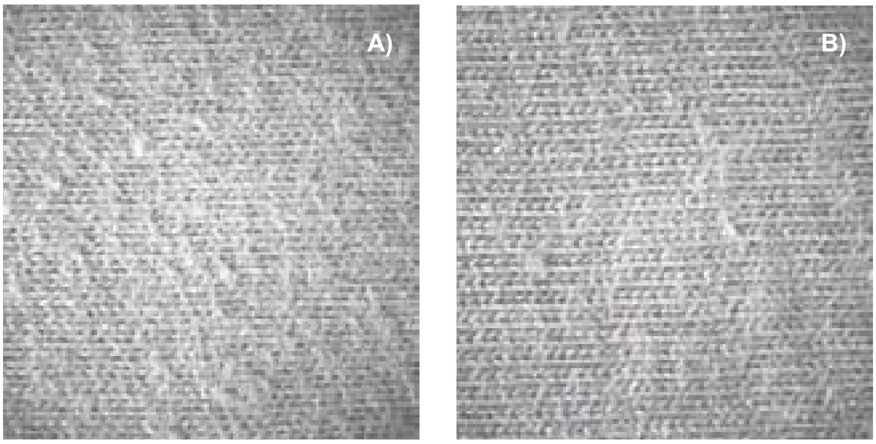

Figure 3. Fabric appearance after pilling test; A - manufactured from ring spun yarn, B - manufactured from compact ring spun yarn; magnification 110×.

Pilling behaviour

The pilling test results are shown in Figure 2. The results indicate that pilling behaviour of all fabric types worsen as the loop lengths of the fabrics are increased, as expected. However, the fabrics consisting of compact yarns exhibit much better pilling performance compared to the fabrics produced by conventional ring-spun yarns. A similar performance in terms of pilling was also reported by a compact yarn spinning machine manufacturer, as indicated above. The fabric's appearance after pilling is also given in Figure 3,

*Table 3. The lengths of 100 loops in the same course and average loop lengths (*average loop length).*

Yarn features	Parameters	Fabric of conventional ring spun yarn	Fabric of COM4 yarn
Short loop length	mean length of 100 loops	22.99	24.31
	CV%	0.63	2.01
	L, cm*	0.230	0.243
Medium loop length	mean length of 100 loops	26.16	25.03
	CV%	1.28	1.00
	L, cm*	0.262	0.250
Long loop length	mean length of 100 loops	28.24	27.43
	CV%	0.63	0.80
	L, cm*	0.282	0.274

to give a better idea of how the hairs on the fabric's surface contribute to pilling.

Comparison of colour

We also wanted to see if there was any colour difference between the knitted fabrics of these two types of yarns, so we tested the samples on a spectrophotometer under daylight conditions (D65). We took a dyed fabric sample consisting of conventional ring-spun yarn of short loop length as the reference sample. The test results are given in Table 4. They indicate that there is a significant colour difference between the fabrics of conventional ring-spun yarns and compact spun yarns, although they were knitted and dyed under identical conditions.

We also wanted to compare how the colour shades of the fabrics change, so Table 5 shows the test results. The findings indicate that the fabrics of compact yarns have darker shades compared to the fabrics of conventional ring-spun yarns. This result reveal that much less dye can be used for the fabrics of compact yarns, so their dyeing cost might be lower for the same depth of shade, in comparison to the fabrics of conventional yarns.

Bursting strength

The test results indicate that the bursting strength of the fabrics produced from compact yarns is generally higher than conventional yarns, as might be well expected since compact yarns have higher strength (Figure 4). However, the bursting strengths of these fabrics decrease as the loop length increases, so the differences between two types of fabrics is not very significant as the loop lengths in the fabrics increase. This result indicates that the bursting strength of fabrics is mainly affected by yarn strength, but that fabric cover factor is also an important factor.

Table 4. *Test results regarding colour difference (*DE values greater than 1.0 indicate significant colour difference compared to the reference sample).*

Fabric type	DE
Ring (medium loop length)	0.558
Ring (long loop length)	0.646
Compact (short loop length)	1.216*
Compact (medium loop length)	1.261*
Compact (long loop length)	1.171*

Table 5. *The change in the colour shade of the fabrics.*

Fabric type	K/S (Colour yield)	
Ring (long loop length)	5.76	from lighter
Ring (medium loop length)	5.81	
Ring (short loop length)	6.06	to
Compact (long loop length)	6.69	
Compact (medium loop length)	6.27	
Compact (short loop length)	6.54	darker

Conclusions and Discussions

- Ring compact-spun yarns are claimed to offer many advantages over conventional ring-spun yarns in terms of yarn structure, and thus to have a significant potential to change the future of the conventional ring-spinning system. However, such claimed advantages are reported mainly by the machinery manufacturers or by the institutions which developed this system; thus properties of yarns and fabrics still need to be extensively investigated by independent researchers.
- In this work, we first produced plain knitted fabrics with different loop lengths, using conventional ring-spun and compact ring yarns, which were then processed under identical dyeing and finishing conditions. Then, the fabrics were tested for their performance after several washing cycles for pilling behaviour, bursting strength and colour differences.
- The test results show that the fabrics of compact yarn maintain original surface structure without any serious deterioration, while the fabric surfaces of conventional ring yarns become rather fuzzy. Similarly, the pilling tendency of the fabrics from compact yarns is much better than the conventional ones.
- The test results regarding colour difference indicate that there is a significant colour difference between the fabrics of conventional ring-spun yarns and compact ring-spun yarns. Furthermore, the results show that the fabrics of compact yarns have darker shades, even though they were dyed in the same bath. This indicates that fabrics of compact yarn might need less dye to reach the same depth of shade than the fabrics of conventional ring yarns, which therefore contributes to reducing the costs of dyeing.
- In terms of bursting strength, fabrics of compact yarn have generally higher strength, but the differences between two types of fabrics become less significant as the loop lengths in the fabrics increase. This indicates that fabric cover factor is also important for bursting strength, as is yarn strength.

Acknowledgement

The authors would like to thank the Turkish textile companies Anteks, Sunteks and Ekoten for permitting us to use their production and testing facilities.

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Received 24.03.2004 Reviewed 05.11.2004