TEXTILE topics

Volume 2003-2
Spring 2003

International Textile Center | Texas Tech University Lubbock, Texas USA

TEXTILE CENTER ANALYZES CLOTH BELIEVED TO BE FROM 1903 WRIGHT FLYER AIRPLANE

The International Textile Center, working with The Wright Redux Association, has concluded testing on a piece of fabric believed to have come from the wing of the 1903 Wright Flyer. This aircraft, constructed by Orville and Wilbur Wright, completed the world's first successful powered, heavier-than-air flight December 17, 1903, at Kitty Hawk, North Carolina.

To commemorate the 100th anniversary of this historic flight, The Wright Redux Association is building an exact replica of the original 1903 Wright Flyer. The Association utilized the resources of the International Textile Center to analyze a small piece of muslin cloth believed to have been used to cover the wings of the original aircraft.

Extensive testing on the original cloth found the construction to be a plain weave with 109 ends per inch in the warp direction and 108 ends in the filling direction, producing a construction that was 217 ends per square inch. Image analysis on the cloth concluded that the fibers exhibited the characteristics and appearance of cotton.

With this information, the Wright Redux Association was able to source a new fabric with a similar construction to ensure their replica was as accurate as possible.

The plane is scheduled to fly on the front lawn of the Chicago Museum of Science and Industry, September 20-21, 2003, as the featured highlight of the City of Chicago's Centennial of Flight Observance this fall.

The *History Channel* is video taping the effort to fly the replica, including the fabric testing work performed at the ITC, for a documentary on the centennial of flight scheduled to be aired on the *History Channel* this fall.

Sharing current research information and trends in the fiber and textile industries.

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U. S. PATENT ISSUED TO ITC RESEARCHERS

On February 18, 2003, the United States Patent Office issued a patent to ITC researchers Eric Hequet and Noureddine Abidi concerning a cotton stickiness detection method.

The method produces a grading system for cotton which can help spinners identify future processing problems that may arise.

Research leading to the granting of this patent was funded by Cotton Incorporated and the Texas Food and Fibers Commission.

ITC TRAVEL

- **Dean Ethridge to Vietnam as a leader in a project (Pilot Program to Enhance U.S. Cotton Exports to Vietnam) funded by USDA Emerging Markets grant, March 13-28, 2003.**
- **Eric Hequet to Mulhouse, France to visit with personnel from the University of Mulhouse, March 24-27, 2003.**
- **Eric Hequet to Zurich, Switzerland to attend the International Textile Manufacturers Federation, March 28, 2003.**

COMPACT RING SPUN YARNS: AN EXAMINATION OF SOME PRODUCTIVITY ISSUES

Mourad Krifa
Dean Ethridge

The Texas Food and Fiber Commission funded the research reported here.

INTRODUCTION

For a given cotton, the range of possible end products is dictated by the raw fiber properties and by the technology for transforming these fibers into yarn. Both factors interact. Indeed, depending on the technology used, the fiber properties required for acceptable spinning performance will differ.

Innovations in the field of textile spinning technologies have always altered processing practices, end products manufactured from cotton, and mixes of fiber properties used.

In recent decades, several new spinning technologies have been introduced to compete with conventional ring spinning (Artzt, 1998). Two of these, air-jet spinning and friction spinning, have found limited application in specific markets. The open-end rotor system, on the other hand, has been very successful and now has a considerable share of the short-stapled cotton spinning market. This was possible as a result of the shortening of the process (elimination of roving and winding) and the tremendous increase in the production rate (up to 10:1 vs. the ring spinning systems). However, issues of efficiency and yarn quality limited the commercial application rotor yarns to the coarser counts (Egbers, 1999). Among all technologies, conventional ring spinning remains the uncontested quality standard (Stalder, 2000), and continues to dominate the high-value-added yarn markets.

The latest advance in spinning technology is an innovation in ring spinning called compact spinning. It has been shown to effectively improve yarn quality and enhance its performance during the downstream processing phases. This was asserted by numerous authors (Artzt *et al.*, 1995; Artzt, 2000; Olbrich, 2000; Stahlecker, 2000; Stalder, 2000; Stalder and Rusch, 2002), and is now an undisputed accomplishment. On the other hand, little work was conducted on productivity issues relevant to this technology.

In a previous issue of the Textile Topics (Krifa *et al.*, 2002), results were provided from an extensive study on a broad range of short-to-medium-staple cottons, treating the qualitative aspects of the compact-spun yarn. In order to properly exploit compact spinning, however, it is crucial to combine both profitability and quality considerations, in order to identify the proper approach to exploiting this new technology.

Reported here are preliminary results of two different exploratory approaches adopted to achieve this objective.

- The first approach is based on the possibility of twist reduction while maintaining yarn performance, which results in significantly higher production rates on the spinning frame. Though very few results were shown to support it, this approach was mentioned in the literature (Thum, 2000; Clapp, 2001), and will only be treated briefly in the present paper.
- The second approach, which appears quite promising, is to radically revise the yarn manufacturing operations and to identify opportunities for shortening the process by taking advantage of the enhanced compact yarn structure. This important potential has been raised (Artzt, 2002), but remains largely unexplored. The preliminary results presented here treat the potential offered by the compact spinning for shortening the combed-yarn production process.

MATERIALS AND METHODS

Twenty-three cotton bales, with a staple length ranging from 1.10 to 1.23", were used to produce a 50/1 Ne, 3.8 TM yarn (12 tex, $alpha_m$ = 115). The main criterion for the selection of these bales was the Short Fiber Content (SFC), which is the main concern when dealing with combed cotton. The HVI raw fiber data, along with the AFIS Short Fiber Content by number (SFCn%) measured on carded finisher drawing sliver of the 23 samples, is presented in **Table 1**. The samples are sorted by ascending SFCn(%).

Two different processing sequences were tested to produce the targeted yarn:

- RS combed: Combed 50/1 Ne 3.8 TM yarn, conventioal spinning (Suessen Fiomax 1000).
- Compact Carded: carded 50/1 Ne 3.8 TM yarn, compact spinning (Suessen EliTe® system).

The yarn samples were tested for evenness (Zellweger UT3, 4000 m), and for single-end tensile properties on the Uster Tensorapid, with 200 individual breaks per sample.

In order to treat the twist reduction potential on the compact spinning frame, a subset of the carded samples was also spun on the conventional frame with a 3.8 TM, and on the compact frame with a 3.2 TM ($alpha_m$ = 97).

Table 1: HVI data and Short Fiber Content by number (SFCn%) of the 23 samples (sorted by ascending SFCn).

ID	Mic.	Length (")	Uniformity (%)	Strength (g/tex)	Elongation (%)	Rd %	+b	SFCn (%)
1	4.3	1.17	83.4	34.9	4.9	78.9	8.0	12.3
2	4.9	1.15	84.4	35.4	5.1	78.0	8.3	14
3	4.7	1.17	84.1	33.2	6.5	79.3	8.3	14
4	4.6	1.19	84.6	34.6	5.8	79.9	8.1	14
5	4.1	1.18	84.6	32.7	6.5	78.6	8.5	15.6
6	4.4	1.14	83.5	32.5	6.5	79.7	8.2	16.4
7	4.1	1.13	83.9	30.3	6.7	80.1	8.3	17.1
8	4.3	1.18	84.8	32.8	6.0	79.4	8.2	17.1
9	4.1	1.13	83.5	34.2	5.1	78.7	8.5	17.1
10	4.1	1.18	83.8	33.0	5.5	79.6	8.3	17.2
11	4.5	1.19	83.3	34.2	5.5	78.7	8.4	17.3
12	4.2	1.23	83.4	31.6	5.4	76.7	8.6	17.9
13	4.0	1.16	84.6	32.7	5.0	79.6	8.3	18
14	4.5	1.20	83.5	34.7	6.2	76.7	8.8	18.5
15	4.1	1.17	84.0	32.1	4.8	79.2	8.2	18.8
16	4.5	1.22	83.4	33.1	5.6	77.3	8.4	18.8
17	3.7	1.16	84.3	31.5	7.6	78.6	8.8	21
18	3.9	1.10	82.5	30.5	6.5	80.6	8.4	21.1
19	3.5	1.16	83.6	31.9	7.5	78.4	8.5	21.1
20	3.9	1.16	84.0	31.7	5.3	79.0	8.1	21.2
21	3.8	1.15	83.0	33.3	5.2	79.8	8.4	21.4
22	4.7	1.19	84.5	34.7	5.9	79.4	8.2	23.2
23	3.6	1.22	82.5	32.4	5.4	79.1	8.6	29.8

RESULTS AND DISCUSSION

Twist reduction

Table 2 compares the results of yarn strength obtained on the low-twist compact yarns versus the regular-twist conventional yarns. The difference of yarn strength is statistically non-significant. The reduction of the twist multiplier resulted in a 19% increase of the production rate; therefore, the compact technology permits higher spinning productivity while maintaining the yarn strength. These results corroborate those described in the literature, where a 21% increase in the spinning frame production rate was reported (Clapp, 2001).

Note: All subsequent results reported here pertain to yarns that were spun at the same twist level.

Yarn hairiness

Figure 1 shows that the carded compact yarns in this study exhibited significantly lower hairiness indexes than did the combed conventional yarns. Most of the pair-wise differences in the hairiness indexes are statistically significant.

Yarn strength

In contrast to the yarn hairiness results, yarn tensile properties appeared similar for both processes. A paired t-test was conducted on the yarn strength and elongation data. The results are shown in **Table 3**. The difference observed between the two processes regarding yarn strength and elongation was found to be non-significant.

Thus, compact spinning made it possible to produce a 50 Ne carded yarn having tensile properties comparable to those of a combed yarn spun on the conventional frame. Furthermore, yarn hairiness levels were significantly lower for a great majority of the compact-spun yarns.

Table 2: Yarn strength, compact yarn with reduced twist vs. conventional yarn (paired t-test).

	Mean	Std. Dev.	N	Diff.	Std. Dev.	T	df	Prob.
Conventional (high twist)	16.28	1.15						
Compact (low twist)	16.11	0.67	6	0.172	0.74	0.57	5	0.59 ns

TEXTILE TOPICS
A research bulletin on fiber and textile industries.
Spring 2003 - Vol 2003-2

Published quarterly
Texas Tech University
International Textile Center
P.O. Box 45019
Lubbock, TX 79409-5019

Figure 1: Yarn hairiness, Conventional combed RS yarn vs. compact carded yarn.

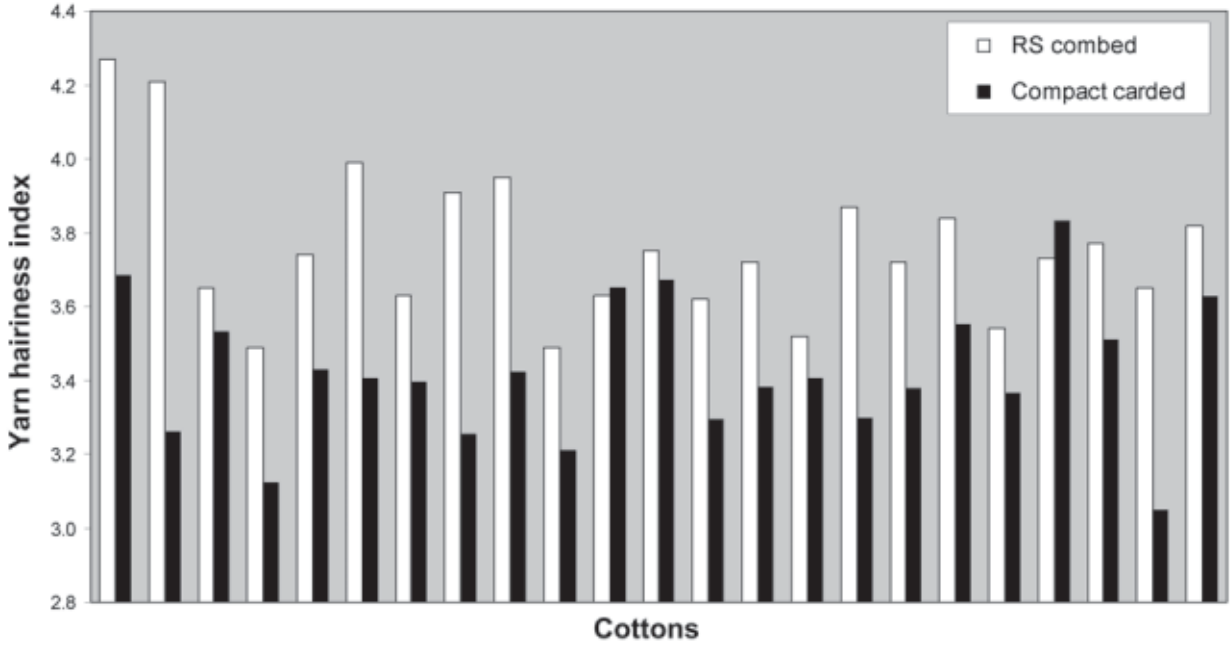


Table 3: Paired t-test on yarn tensile properties, combed conventional vs. carded compact.

		Mean	Std. Dev.	N	Diff.	Std. Dev.	T	df.	Prob.
Strength	Conventional combed	18.00	0.96						
	Compact carded	17.78	0.94	23	0.22	0.68	1.57	22	0.13 ns
Elongation	Conventional combed	5.61	0.46						
	Compact carded	5.56	0.45	23	0.05	0.33	0.74	22	0.46 ns

A useful presentation of the yarn tensile strength data is given in **Figure 2**. The samples are sorted by ascendant SFC values, as measured by AFIS on the carded finisher drawing sliver.

In addition to the values of strength obtained for each sample spun with the two different processing sequences (left axis), **Figure 2** depicts the absolute differences in the levels of this property between the compact carded yarn and the conventional combed yarn (right axis).

Figure 2 shows that, for several of the cottons with lower SFC values, yarn strength was higher for carded compact yarns. On the other hand, several samples of the cottons with higher SFC values gave the opposite result. Thus, it appears that the ability of compact spinning to compensate for the beneficial effect of combing tends to diminish as the SFC increases.

The foregoing result – strength gains with compact spinning when SFC is low and losses when SFC is high – is intuitively obvious. However, **Figure 2** also contains some exceptions to this general conclusion. This is likely to be due to impacts by (interactions with) fiber properties other than SFC.

When dealing with yarn strength data, one should pay special interest to the intra-sample distribution and to the dispersion of the individual-strand tenacity values. We have examined the strength distribution of all the yarn samples included in this study. This revealed distinct patterns, depending on the cottons, in the differences between the two processing sequences. Among the samples showing a carded compact yarns with equivalent or higher strength levels than the combed conventional ones:

- Some exhibited higher variances. An example is shown in **Figure 3**, where the higher-strength mean value of the carded compact yarn was accompanied by a "flatter" strength distribution. This carded, compact-spun yarn might be inferior to its combed, conventional-spun counterpart.

- Some of the yarn pairs exhibited comparable variances. **Figure 4** shows an example where the two yarns have equal strength variances, but with a higher mean value for the carded compact yarn. This carded, compact-spun yarn should be superior to its combed, conventional-spun counterpart.

Figure 2: Yarn strength depending on the processing sequence.

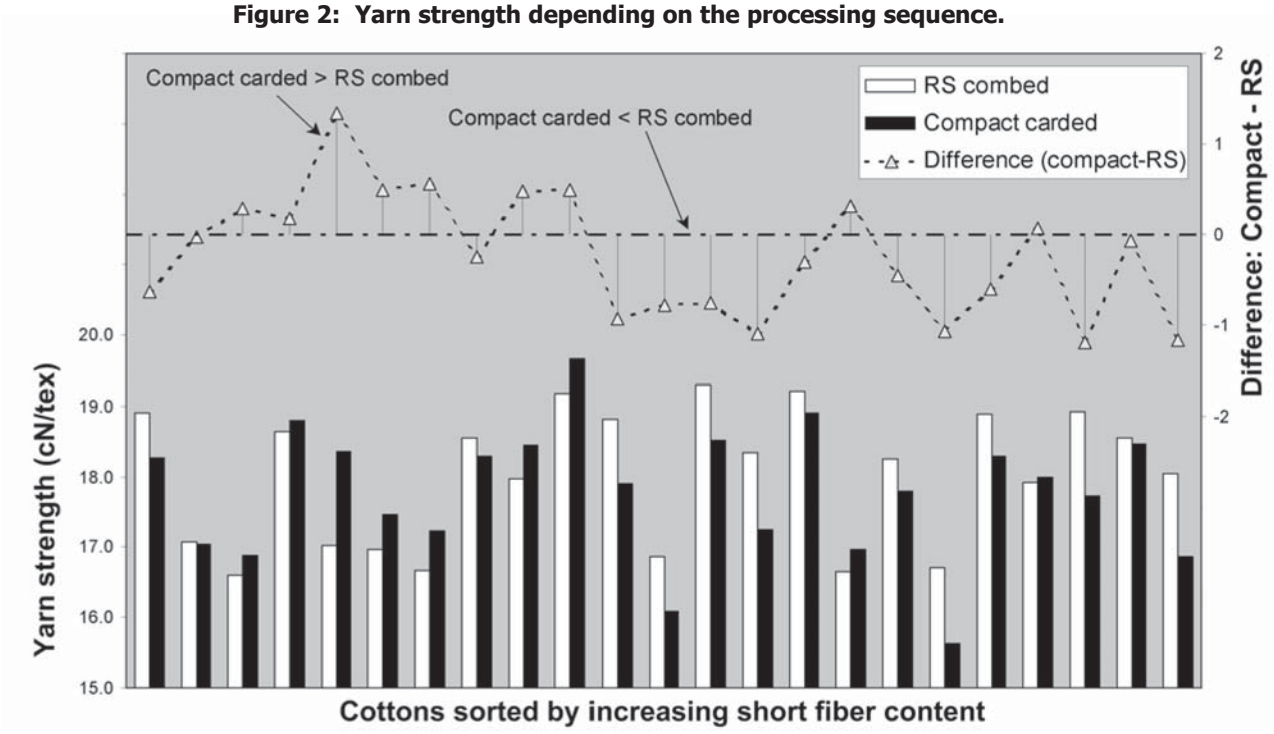


Figure 3: An example of yarn strength distribution dependence on the cotton processing sequence: carded compact with high variance.

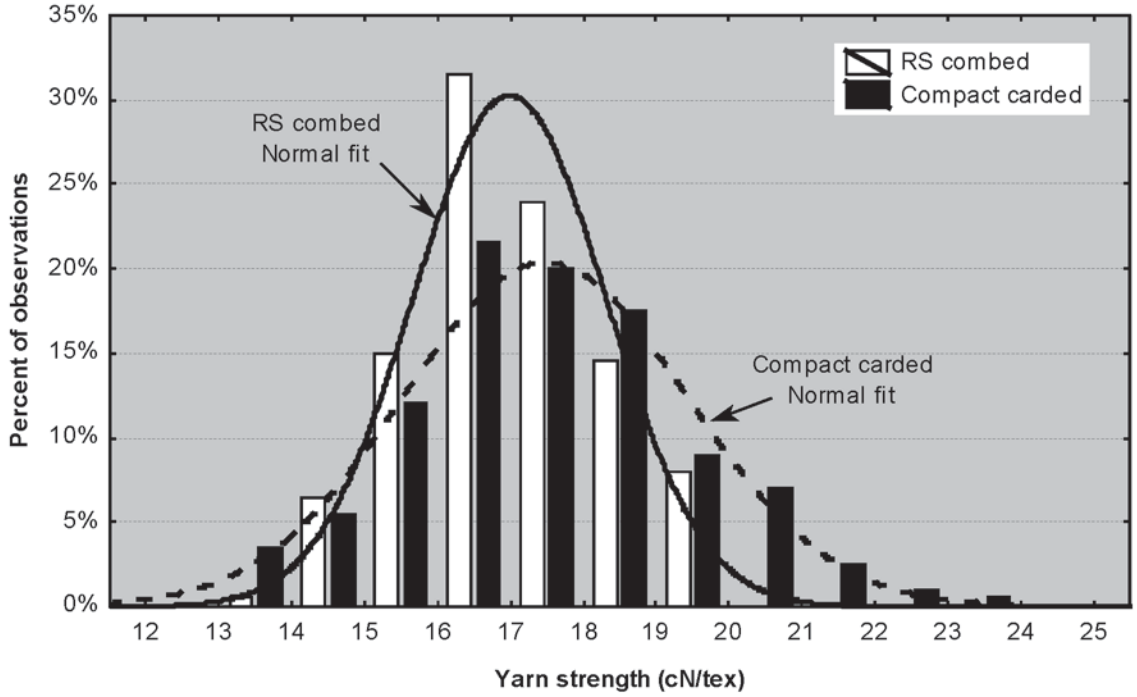
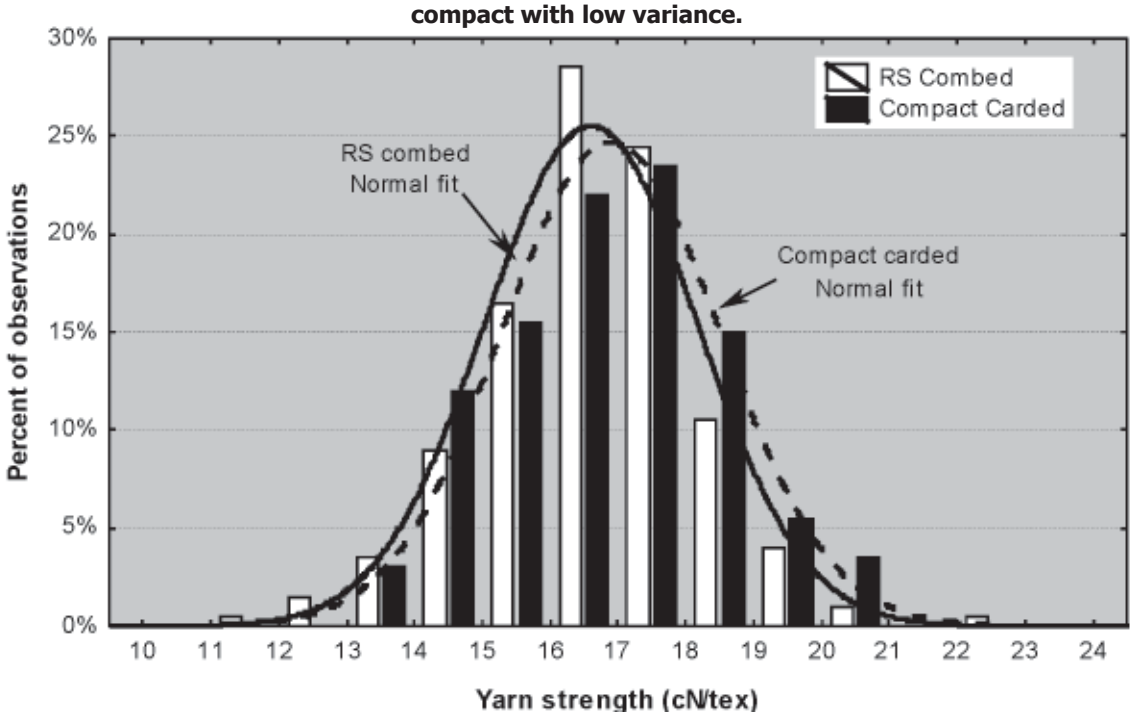


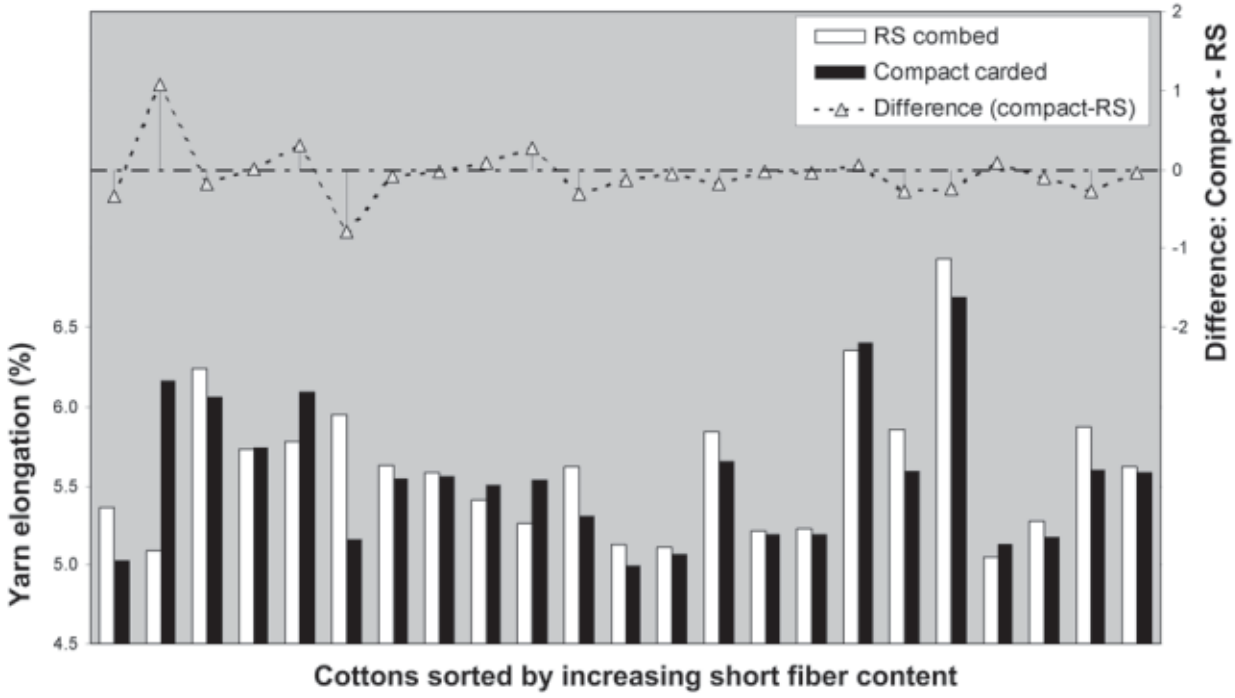
Figure 4: An example of yarn strength distribution dependence on the cotton processing sequence: carded compact with low variance.



Yarn elongation

The results concerning the yarn elongation at break are reported on **Figure 5** in an analogous way as done in **Figure 2**. Only two samples showed statistically significant differences between the two spinning technologies. Clearly, the rest of the differences were quite small. It will only be noted here that somewhat different distributional patterns were also observed for elongation, as was the case for yarn strength.

Figure 5: Yarn elongation depending on the processing sequence.



Yarn evenness

In addition to removing short fibers, the combing operation eliminates many impurities remaining in the fiber after the carding process. Some of these, namely fiber neps and seed-coat fragments (SCFs), are known to significantly deteriorate yarn evenness and increase its defects (Krifa *et al.*, 1999; 2000). Without combing, these particles remain problematic, and the compact spinning is not likely to overcome them.

It is not surprising, then, that the carded compact yarns did not compare favorably to the combed conventional yarn when considering the evenness aspect. As shown in **Figure 6**, differences among the yarn mass variation (CV%) are highly significant. **Figure 6** also shows a slight tendency toward lower CV% differences when SFC is low.

These evenness results would limit the application of carded compact yarns in traditionally combed yarn markets. However, there are ways to alleviate the evenness problem. Examples include:

- A raw fiber selection process that minimizes short fibers and impurities such as neps and SCFs.
- Opening and carding processes that are adapted and optimized for reducing the impact of short fibers and impurities.

CONCLUSIONS / PERSPECTIVES

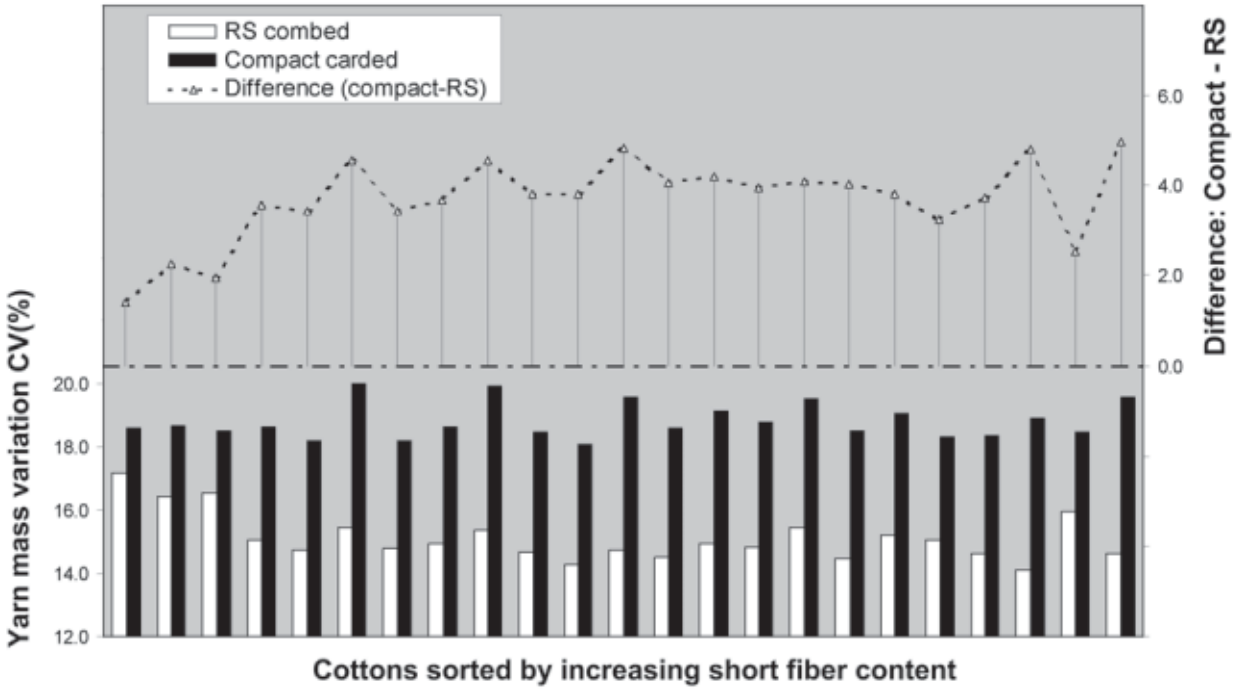
Compact spinning technology has potential for improving both the quality and profitability aspects of cotton yarn manufacturing. Depending on the objectives of the textile manufacturer, different approaches are available. One approach could be to reduce the cost of the raw fiber while maintaining yarn quality. Another could be reducing twist while using the same raw fiber. Yet another – as emphasized in this report – is to eliminate some or all of the combing while still producing acceptable yarn quality.

According to expert estimates (Egbers, 1999), the combing operations account for nearly 9 % of the total production cost of a 30 Ne combed cotton yarn. This represents approximately 21 % of the processing cost.

While the compact technology is promising, there are still major questions to be answered. These include the following:

- In order to produce a carded compact yarn with comparable performance to the combed conventional one, what type of raw cotton fiber should be used?

Figure 6: Yarn mass CV% depending on the processing sequence.



- Do the fiber quality requirements vary depending on the yarn production sequence? If so, what are the fiber properties that are most crucial for the alternative process?
- Is it possible to overcome yarn evenness problems by optimizing the preparation (especially carding) or by selecting raw fiber with specific parameters?
- Given the new, enhanced structure of compact yarns, are these evenness defects as critical as they were for the conventional yarns?
- What are the properties of the end products achievable with the alternative spinning sequence(s)?

Further investigation of the structural traits of compact yarns is needed to treat these issues.

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