RELATIVE IMPORTANCE OF FIBER PROPERTIES AFFECTING YARN HAIRINESS IN SOME EGYPTIAN COTTON VARIETIES

Hussein¹, Kh.M.M.; M.H. Mahmoud⁴ and A.A. Hassan¹
1- Cotton Research Institute, Agricultural Research Center, Giza, Egypt

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ABSTRACT

Yarn hairiness can be both desirable and undesirable, depending on the application for which the yarn is being used. Hairy yarns provide good heat retention and a softer hand (feel) for finished fabrics, and except for a few special cases, when it is an excessive degree of hairiness, yarn hairiness is an undesirable property in yarn and can cause serious problems in both yarn production and in subsequent textile processes.

This search was carried out to investigate the most important fiber properties i.e. short fiber content (SFC w %), maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex) which correlated with yarn hairiness and also their relative contributions in yarn hairiness under study by using four Egyptian cotton varieties during season 2008, namely; Giza88, Giza86, Giza80 and Giza90 spun into carded ring and compact yarns at twist multiplier 3.6 and two into counts according to the following:

ring yarns were processed to carded yarns Ne 50 and 60. Compact yarns were also processed to carded yarns at the same counts.

The most important results were:
1- Yarns manufactured by the carded ring spinning frame are characterized by higher hairiness mean values in all studied varieties in comparison with those of carded compact frame.
2- The correlation coefficients have positive signs and are very high between hairiness in yarns and short fiber content (SFC w %), on the contrary the correlation coefficients have negative signs being high or very high between maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex) and yarn hairiness in all varieties.

3- Stepwise regression procedure was employed to determine the most effective independent variables which make the maximum contributions to the coefficient of determination (R²).
4- The rate of improvement in yarn hairiness index due to decrease short fiber content (the larger the share of fibers in the shorter length the higher is the hairiness index), increase fiber strength (more mature fiber) and increasing fiber length (the larger the share of the fibers in longer length the lower is the hairiness index).

INTRODUCTION

Hairiness of staple yarns is due to the protrusion of fiber ends and loops from the yarn core. Yarn hairiness is a quite complex parameter of yarn quality that is affected by various parameters (fiber quality and the mechanical processing). It can be defined as the total number or total length of the fibers which leave from the unit yarn's surface, it is formed by surface fiber edges which leave the yarn center and spoil its appearance, the downside to yarn hairiness is that hairs tend to increase the amount of lint generated in processing and can affect processing at warping, slashing, weaving, and knitting by contaminating the process with loose lint (Altaş and Kadoglu, 2006).

Hequet, (1999) used upland cotton and focused on short fiber and length distribution how affect ring spun yarns regularity. He found that yarn hairiness appears to be highly related to the fiber length distribution and the shortest fibers apparently tend to cause hairy protrusions from the ring spun yarns.

The percentages of both the shortest and the longest fibers have an important impact on yarn quality, the shortest fibers increase hairiness and the longest fibers decrease hairiness. Short fibers shorter than 1/4 inch are important contributors
toward increased yarn hairiness. The fibers longer than two inches which measure very long are important contributors toward decreased yarn hairiness. The shortest and the longest fibers are highly correlated with the hairiness for all the types of yarns. (Hequet and Ethridge, 2000).

Yarn Formation

The most important feature in obtaining high-quality yarns is the quality of raw material because the raw material costs constitute over 50% of the unit cost of cotton yarn, and the yarn properties have changed with regard to raw material properties.

One of the most important fiber parameters that affect hairiness is the amount of trash, and yarn count during spinning processes is an important parameter that affects the physical properties of yarns such as hairiness. (Karapinar and Erdem, 2003).

Yarn hairiness, in ring spinning process is greatly influenced by various fiber properties, among which the most commonly cited are length (length distribution) and fineness. (Krifa and Ethridge, 2006).

The acceptable spinning performance will differ by the raw fiber properties and by the technology for transforming these fibers into yarn, and both factors depending on the technology used. Krifa and Ethridge, (2003) found that, 50 Ne Compact spinning carded yarn having-on the conventional frame- significantly yarn hairiness levels lower for a great majority of the compact spun yarns.

Compact or condensed spinning is a new concept of yarn forming. It represents a fundamental modification of the conventional ring-spinning system that aims at producing a better surface integrity of spun yarns that can largely be determined by yarn hairiness. The idea stems from the necessity of controlling the dimensions of the spinning triangle to reduce yarn hairiness (El-Mogahzy, 2000).

Artzt, (2000) presented a figure of yarn formation (shown above) shows how the compact sliver is twisted in a very small spinning triangle, thereby eliminating peripheral fibers. He added that, compact spinning produces yarns which represent a superior ring yarn because compact spinning forms fibers into a narrow sliver by drafting in a virtually tension-free process within a compacting zone to produce a novel yarns better strength with reduced hairiness therefore compact yarn provides a completely new approach to the problem of hairiness with carded yarn.

**MATERIALS AND METHODS**

The materials used in this study included the 4 commercial Egyptian cotton varieties Giza88, Giza 86, Giza 80 and Giza 90. All of these varieties belong to the Long Staple category except Giza 88 which belongs to the Extra- Long Staple category according to the local practise in Egypt. The previously mentioned varieties were taken from the 2008 season.

All fiber and yarn tests were carried out at the laboratories of the Cotton Research Institute, Giza, under controlled atmospheric conditions of 20 ± 1.1C° temperature and 65 ± 2% relative humidity.

Means were calculated from the 12 repetitions for each variety to compute the correlation coefficients and stepwise multiple regression analysis which was carried with a regression equation of the following form: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 +...+\beta_p X_p$ Where Y is the dependent variable “yarn hairiness index”, $\beta_0$ is the constant, $X_1,X_2...to X_p$ are the independent variables “short fiber content (SFC w %), maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex)” and $\beta_1, \beta_2...to \beta_p$ are the regression coefficients according to Draper and Smith, (1966). And using SAS software, SAS Institute, (1997), to evaluate the relative contribution by determining the most effective independent variables, (short fiber content (SFC w %), maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex)) which make the maximum contributions to the coefficient of deter-
Fiber properties affecting cotton yarn hairiness

Mean, minimum and maximum values for hairiness index in carded yarns produced at count (Ne) 50 and 60 by using spinning processes ring and compact within each of variety under study Giza88, Giza86, Giza80 and Giza90 are presented in Table (1).

It could be noticed that values of hairiness index occurred in yarns manufactured by the carded ring spinning frame were higher in comparison with yarns manufactured by the carded compact frame at the same count (Ne) in all studied varieties. i.e., mean values for hairiness index for variety Giza88 was (4.07) in carded ring yarn while was (3.52) in carded compact yarn at count Ne 50. With regard to variety Giza86, mean values for hairiness in yarn were 3.75 and 3.48 at Ne 50 and 60 respectively, this trend was obtained in all varieties under study and assured that carded compact yarns at Ne 60 have smaller hairiness in comparison to carded compact yarns at Ne 50 in the same variety. The compact yarns are characterized by quality parameters such as lower hairiness which are better than those of ring yarns and can be accepted as the number of fibers in the yarn cross-section increases and thus presents yarns of high quality. El-Mogahzy, (2000); Krifa & Ethridge, (2003); Krifa & Ethridge, (2006) and Strumillo, et al (2007).

Generally the comparison of mean values for yarn hairiness index due to machines effects indicated that, the less mean value of hairiness index (3.24) was obtained from fiber of Giza88 that manufactured to yarn by carded compact spinning frame at Ne 60, the highest mean value of hairiness index (5.24) was obtained from fiber of Giza90 that manufactured to yarn by ring spinning frame and count Ne 60.

The highest mean value of yarn hairiness are obtained from ring spinning machine at Ne 50 and 60 of all varieties under study, this means that ring machine produces more hairy yarn than compact spinning machine. These results are supported by Sheikh, (2000), who reported that the compact yarns are much better in quality as compared to conventional ring spun yarns and possess little hairiness.

Correlation coefficients between yarn hairiness index and fiber properties

Correlation coefficients were computed within each variety (Giza88, Giza 86, Giza 80 and Giza 90) between fiber properties i.e. short fiber content (SFC w %), maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex) and UT3 hairiness index as a
measure for hairs exceeded from carded ring and compact yarns which produced at Ne 50 and 60 are shown in Table (2).
The results indicated that, hairiness in yarns at Ne 50 in ring spinning system correlated positively and highly significant with short fiber content (SFC w %) in all varieties under study, whereas, maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex) were correlated negatively and significantly with hairiness index in yarn. Similar correlation was observed with hairiness in carded ring yarns which produced at Ne 60.

With regard to carded compact yarns at Ne 50, the correlation coefficients have positive signs and are very high between hairiness index in yarns at Ne 50 and short fiber content (SFC w %), on the contrary the correlation coefficients have negative signs, high and are very high between maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex) and yarn hairiness in all varieties. Same trends were obtained from carded compact yarns at Ne 60.

The data shown in Table (2) clearly indicate that there was a downward trend as for the short fiber content (SFC w %) with increasing of hairiness in Ne 50, 60 carded ring and compact yarns at the same count, this positive relationship between short fiber content (SFC w %) and yarn hairiness was confirmed by the highly significant correlation coefficients obtained, conversely, correlation coefficients for fiber strength (g/tex) are also high but with negative signs. On the other hand, there was a consistent pattern of increase in hairiness index in all types of yarns with the diminish of maturity ratio, micronaire value, uniformity index (UI %) and fiber length (UHM). Hence, correlation coefficients between hairiness in all types of yarns and the previously properties were significantly negative in all the varieties involved in the study.

In this respect, it is rather interesting to note that in all types of yarns and all studied varieties, the increase of short fiber content (SFC w %) and decrease fiber strength (g/tex) are important contributors toward increased yarn hairiness index. Conversely, correlation coefficients for fiber length (UHM) are also high but with negative signs; therefore, these fibers which measure very long (UHM) are important contributors toward decreased yarn hairiness index. These finding are in the same line with Zurek et al (1996); Hequet & Ethridge, (2000) and Zhang et al (2003).
Table 2. Coefficient of correlation between fiber properties and hairiness in carded ring and compact yarns at twist multiplier 3.6, Ne 50 and 60 in four Egyptian cotton varieties

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Carded Ring Spinning</th>
<th>Carded Compact Spinning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ne 60</td>
<td>Ne 60</td>
</tr>
<tr>
<td></td>
<td>Giza88</td>
<td>Giza86</td>
</tr>
<tr>
<td>Short fiber content</td>
<td>0.84**</td>
<td>0.91**</td>
</tr>
<tr>
<td>Maturity ratio</td>
<td>-0.95**</td>
<td>-0.80**</td>
</tr>
<tr>
<td>Micronaire value</td>
<td>-0.89**</td>
<td>-0.59</td>
</tr>
<tr>
<td>Uniformity index</td>
<td>-0.26</td>
<td>-0.63**</td>
</tr>
<tr>
<td>Fiber length</td>
<td>-0.48*</td>
<td>-0.64**</td>
</tr>
<tr>
<td>Fiber strength</td>
<td>-0.91**</td>
<td>-0.72**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Carded Ring Spinning</th>
<th>Carded Compact Spinning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ne 60</td>
<td>Ne 60</td>
</tr>
<tr>
<td></td>
<td>Giza88</td>
<td>Giza86</td>
</tr>
<tr>
<td>Short fiber content</td>
<td>0.94**</td>
<td>0.83**</td>
</tr>
<tr>
<td>Maturity ratio</td>
<td>-0.95**</td>
<td>-0.71**</td>
</tr>
<tr>
<td>Micronaire value</td>
<td>-0.82**</td>
<td>-0.44*</td>
</tr>
<tr>
<td>Uniformity index</td>
<td>-0.38*</td>
<td>-0.56</td>
</tr>
<tr>
<td>Fiber length</td>
<td>-0.61*</td>
<td>-0.72**</td>
</tr>
<tr>
<td>Fiber strength</td>
<td>-0.97**</td>
<td>-0.74**</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.
Fiber properties affecting cotton yarn hairiness

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Contribution of cotton fiber properties to yarn hairiness index

Stepwise regression procedure has been applied to determine the most effective independent variables which make the maximum contributions to the coefficient of determination \( R^2 \), Draper and Smith, (1966).

The prediction equations and coefficients of determination \( R^2 \) of the best model and rank of contributors (best 1-variable, the best 2-variables and 3-variables) to yarn hairiness index obtained from fiber of Giza88, Giza86, Giza80 and Giza90 that manufactured to carded yarn by using ring and compact spinning frame at count (Ne) 50, 60 and their six fiber parameters (short fiber content (SFC w %), maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex) (independent variables) within each of variety Giza88, Giza86, Giza80 and Giza90. It can be noticed that with regard to variety Giza88, the best contributor to hairiness index in carded compact yarn at Ne50 maturity ratio with an \( R^2 = 0.92*** \) and maximum contributors were maturity ratio, short fiber content and fiber length, while was short fiber content the best contributor to hairiness index in carded compact yarn at Ne50 and the maximum contributors were short fiber content, maturity ratio and fiber length. Within each of variety Giza86, Giza80 and Giza90, the most important contributor to hairiness index in carded compact yarn at Ne50 and Ne60 respectively were short fiber content and fiber strength.

With respect to spinning processes, the most important contributors in Tables (3 and 4) to hairiness index differs from Extra long Staple (Giza88) to Long Staple (Giza86, Giza80 and Giza90) according to the change of varieties under study. The most important contributors to yarn hairiness index were in Giza88 (maturity ratio, short fiber content and fiber strength), in Giza86 (short fiber content), in Giza80 (short fiber content and fiber strength), and in Giza90 (short fiber content and fiber length).

Generally, From the previously finding it can be noticed that the most effective fiber properties for predicting yarn hairiness index were short fiber content, fiber strength, maturity ratio and fiber length. Therefore the rate of improvement in yarn hairiness index due to decrease short fiber content (the larger the share of fibers in the shorter length the higher is the hairiness index), increase fiber strength (more mature fiber) and increasing fiber length as yarn gets coarser (the larger the share of the fibers in longer length the lower is the hairiness index). Zurek et al 1996. Zhang et al 2003 and Altas and Kadoğlu, 2006 came to similar conclusions.

REFERENCES


