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Arab Univ.
J. Agric. Sci.,
Ain Shams Univ.,
Cairo, 17(2), 323-332, 2009

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

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Keywords: Cotton fiber properties - Yarn hairiness - Correlation and stepwise analysis

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 (R^2).
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

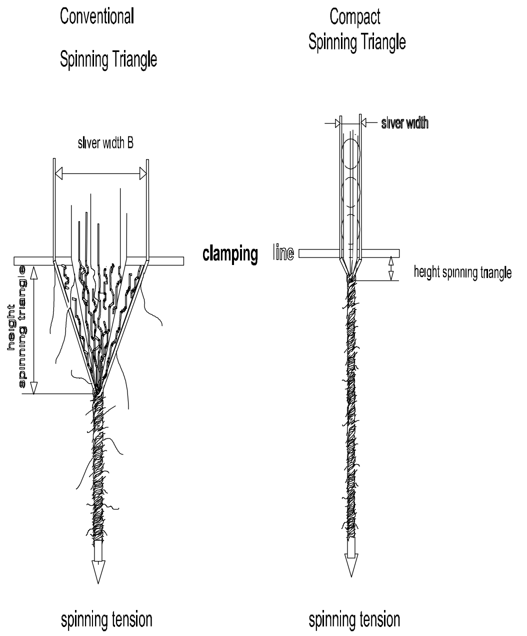
Hairiness of staple yarns is due to the protrusion of fiber ends and loops from the yarn core. Yarn hairiness is a quite complex parameter of yarn quality that is affected by various parameters (fiber quality and the mechanical processing). It can be defined as the total number or total length of the 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 Kadoğlu, 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

(Received April 11, 2009)
(Accepted May 14, 2009)

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: $Y = \beta o + \beta 1\ X1 + \beta 2\ X2 + \ldots + \beta \rho\ X\rho$ Where Y is the dependent variable "yarn hairiness index", βo is the constant, X1,X2...to Xρ 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 β1, β2 ...to βρ 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 determination (R^2) "stepwise" regression affecting yarn hairiness.

The methods of testing were used for determining the fiber parameters on samples as follows:-

1- By using the array methods, the Suter-Webb comb sorter was used according to the **ASTM (D- 1440- 65) (1998),** to estimate the short fiber content % by weight (SFC w %), fibers shorter than ½ inch.

2-Spinlap 900 B (HVI) Instrument System was used according to **ASTM (D- 4603-86)** to determine Upper Half Mean Length (UHM) by mm., Uniformity Index (UI %), Micronaire value (MIC) and fiber strength (g/tex).

3- Determining maturity ratio by using Micromat Tester **(SDL 089)**, **1994.**

Fiber of the 4 commercial Egyptian cotton varieties Giza88, Giza 86, Giza 80 and Giza 90 spun to produce carded ring and compact yarns at twist multiplier 3.6.with two counts (Ne) 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.

Yarn hairiness measurement was measured by a computerized type of Uster Evenness Tester (Uster Tester 3) (UT3) according to the standard methods of testing textile materials **(ASTM -D-1425-98) (1998),** for evenness and hairiness where hairiness parameter: H is expressed as the total hair length per yarn centimeter, and hence unitless, (H -UT3 hairiness index).

RESULTS AND DISCUSSION

For the selection of a suitable raw material for high spun yarn quality, spinners are interested in knowing the effect of fiber properties on yarn hairiness. Therefore, we have devoted our attention to the correlation and contributor of fiber parameters i.e. short fiber content (SFC w %), maturity ratio, micronaire value, uniformity index (UI %), fiber length (UHM) and fiber strength (g/tex) to yarn hairiness. The results sometimes differ because of the nature of different measuring principles. It is generally accepted that a certain level of hairiness in yarn is unavoidable, owing to the practical limitations of mechanical processing machines. As previously stated, measuring yarn hairiness was by using method: the Uster® Tester (UT3). The instrument provides a hairiness parameter: H (expressed as the total hair length per yarn centimeter, and hence unitless).

Summary of yarn hairiness index in carded ring and compact yarns within each variety

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 Strumiłło, *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 betters in quality as compared to conventional ring spun yarns and posses 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).**

Table 1. Summary of hairiness in carded yarns for four Egyptian cotton varieties manufactured by ring and compact spinning process at counts (Ne) 50 and 60

H = Hiariness index in yarn						
Varieties	Ring spinning process			Compact spinning process		
	Carded Ne 50		Carded Ne 60	Carded Ne 50		Carded Ne 60
Giza88	Mean	4.07	3.87	Mean	3.52	3.24
	Min	3.78	3.53	Min	3.23	3.03
	Max	4.38	4.30	Max	3.74	3.40
Giza86	Mean	3.86	3.98	Mean	3.75	3.48
	Min	3.72	3.80	Min	3.58	3.35
	Max	4.01	4.10	Max	3.87	3.59
Giza80	Mean	4.01	3.98	Mean	3.81	3.69
	Min	3.86	3.99	Min	3.71	3.62
	Max	4.15	4.15	Max	3.89	3.75
Giza90	Mean	4.74	5.24	Mean	4.73	4.23
	Min	4.63	5.15	Min	4.67	4.26
	Max	4.82	5.35	Max	4.82	4.40
H -UT3 hairiness index = unitless						

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 verities 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

Fiber Properties	Carded Ring Spinning Ne 60				Carded Compact Spinning Ne 60			
	Giza88	Giza86	Giza80	Giza90	Giza88	Giza86	Giza80	Giza90
Short fiber content	0.84**	0.91**	0.95**	0.91**	0.90**	0.86**	0.91**	0.89**
Maturity ratio	-0.95**	-0.80**	-0.84**	-0.68**	-0.96**	-0.74**	-0.89**	-0.51*
Micronaire value	-0.89**	-0.59*	-0.88**	-0.80**	-0.91**	-0.48*	-0.85**	-0.78**
Uniformity index	-0.26	-0.63**	-0.40*	-0.59*	-0.30-	-0.56*	-0.45*	-0.59*
Fiber length	-0.48*	-0.64**	-0.63**	-0.84**	-0.52*	-0.67**	-0.66**	-0.79**
Fiber strength	-0.91**	-0.72**	-0.92**	-0.89**	-0.93**	-0.72**	-0.94**	-0.84**
Fiber Properties	**Carded Ring Spinning Ne 60**				**Carded Compact Spinning Ne 60**			
	Giza88	Giza86	Giza80	Giza90	Giza88	Giza86	Giza80	Giza90
Short fiber content	0.94**	0.83**	0.93**	0.93**	0.88**	0.87**	0.85**	0.92**
Maturity ratio	-0.95**	-0.71**	-0.88**	-0.69**	-0.93**	-0.80**	-0.79**	-0.48*
Micronaire value	-0.82**	-0.44*	-0.88**	-0.89**	-0.90**	-0.58*	-0.78**	-0.74**
Uniformity index	-0.38*	-0.56*	-0.41*	-0.72**	-0.26	-0.72**	-0.47*	-0.65**
Fiber length	-0.61*	-0.72**	-0.64**	-0.93**	-0.45**	-0.73**	-0.52*	-0.74**
Fiber strength	-0.97**	-0.74**	-0.95**	-0.92**	-0.91**	-0.75**	-0.88**	-0.84**

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

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)) are presented in **Tables (3 and 4).** It can be seen that as the variety is changed, the order and amount of fiber parameters to yarn hairiness index differed from one variety to another. Moreover, in the same variety, the order and amount of contribution of six fiber parameters differed according to processes of yarn.

Table (3) shows the rank of the best contributors and regression equations that defines relationship between hairiness index in carded ring yarns at Ne 50, 60 and six fiber variables of interest within each of variety Giza 88, Giza 86, Giza 80 and Giza 90. The best contributor to hairiness index in carded ring yarn at Ne50 was maturity ratio with an R^2 = 0.91***, and the maximum contributors were maturity ratio, short fiber content (SFC w %) and uniformity index, while was fiber strength the best contributor to hairiness index in carded ring yarns at Ne60 with an R^2= 0.94***, and the maximum contributors were fiber strength, maturity ratio and micronaire value in Giza88 Extra Long variety. Regarding Long varieties Giza86, Giza80 and Giza90 in **Table (3)** it could be noticed that, the best contributor to hairiness index in carded ring yarns at Ne50 was short fiber content (SFC w %), while the best contributor to yarn hairiness index at Ne60 was short fiber content (SFC w %), fiber strength and fiber length with an R^2 = 0.68**, 0.90***, 0.87*** in Giza86, Giza80 and Giza90 respectively.

Table (4) shows regression equations and rank of contributors (best 1-variable, the best 2-variables and 3-variables) between yarn hairiness index (dependent variable) in carded compact yarns at 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 with an R^2= 0.92*** in carded compact yarn at Ne60 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 Altaş and Kadoğlu, 2006** came to similar conclusions.

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