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Tensile Properties of Cotton Yarn as Affected by Different Yarn Singeing Machine Variables

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Abstract. The present study endeavours to optimise the yarn quality in respect of its tensile properties by choosing the best combination of the yarn singeing machine variables for excellent manufacture results. This research study revealed that different values of winding speed, gas pressure and air pressure of yarn singeing machine put significant effect upon the tensile properties of cotton yarn after singeing.

Keywords: air pressure, gas pressure, tensile properties, winding speed, yarn singeing

Introduction

Yarn singeing process (known as gassing) is one of the latest methods to remove the hairiness from the yarn surface so that a smoother surface of yarn could be available for the fabrication, causing less fabric hairiness and ultimately, affecting positively the fabric properties especially the pilling. The singeing of yarn is accomplished by passing it over a gas flame at a speed sufficient to burn away the protruding material without scorching or burning the yarn. Different yarn singeing machine variables like winding speed, gas pressure and air pressure may affect different properties of the yarn, such as appearance, fineness, evenness and especially its tensile properties.

Singeing is the burning of loose fibres sticking out of textile goods. It is a part of the pretreatment processes carried out in textile processing, and is usually the first step carried out after weaving. Textiles materials are most commonly singed in woven or knitted fabric form or in yarn form. Singeing of a fabric is done in order to obtain a clean fabric surface which allows the structure of the fabric to be clearly seen. The risk of pilling, especially with synthetics and their blends, is reduced in case of singed fabrics. Singed fabrics allow printing of fine intricate patterns with high clarity and detail. The risk of skitter dyeing with singed articles dyed in dark shades is considerably reduced, as randomly protruding fibres are removed in singeing which could cause diffused reflection of light (Hussain, 2010).

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Ring spun yarn is one of the most widely applied yarns in textile industry. However, microscopic analysis had shown that some fibres protrude from the stem of the yarn and these fibres, so-called hairiness, make no contribution to the yarn strength (Cheng and Yu, 2003). Hairiness is undesirable property of yarn; it may lead to surface fraction and geometric roughness, uneven dyeing and colour effect, interlocking of warp yarns during sizing and weaving, and a higher propensity to pill formation in the finished fabric (Wang and Chang, 1999). Hairiness increases more than twice during the normal winding process in spinning process. Thus, singeing treatment of yarn is widely applied in the winding process. Singeing treatment removes a large amount of hairiness from the yarn, which may affect different properties of the yarn, such as appearance, fineness, evenness and tensile properties (Xia *et al.,* 2009). Singeing is often carried out on cotton fabrics, or fabrics with cotton blends and results in increased wettability, a smoother surface (better clarity in printing), improved visibility of the fabric structure, less pilling. During the yarn singeing process, the yarn has to pass through a burner, which burns the protruding fibres on the yarn surface, removing them from the yarn surface creating smoothness in the yarn. The improper setting of winding speed, gas pressure and air pressure of singeing machine may affect the burning intensity and result in a negative effect upon the tensile properties of the yarn. Thus keeping this in view, the present research study was planned to evaluate the effect of winding speed (S), gas pressure (G), air pressure (A) of the yarn singeing machine on the tensile properties of cotton yarn.

Materials and Methods

The present research work was initiated in the Department of Fibre and Textile Technology, University of Agriculture, Faisalabad, Pakistan. The yarn preparation was conducted in the Koh-e-Noor Spinning Mills Chakwal, Pakistan. The detail of materials and methods used to achieve data for various quality characters are briefly described here under.

Winding speed (S)	Gas pressure (G)	Air pressure (A)
S_1 = 400 m/min	$G_1 = 12_m$bar	$A_1 = 8_m$bar
S_2 = 500 m/min	$G_2 = 14_m$bar	$A_2 = 9_m$bar
S_3 = 600 m/min	$G_3 = 16_m$bar	$A_3 = 10_m$bar

Yarn singeing. The samples of 20^s combed hosiery yarn were collected from the running stock of the mills and further processed on the yarn singeing machine with following variable.

Yarn characteristics. After making the singed yarn samples according to the above cited machine setting they were tested for evaluation of their tensile properties adopting the standards of ASTM 2008 as given below.

Tensile properties of yarn. Tensile properties i.e., single yarn strength, elongation and rupture per kilometer were observed with Uster Tensorapid-3, which works on the principle of constant rate of extension (CRE). The principle describes the fact that the moving clamps are displaced at constant velocity as a result of which the specimen caught in between the stationary and moving clamps, extended by a constant rate. The breaking tenacity was measured from the maximum force, which was applied anywhere, between the beginning of the test and the final rupture of the specimen. The breaking elongation of yarn was measured from the clamp displacement at the point of peak force. The yarn rupture per kilometer (RKM) can also be derived from the following formula:

RKM = single yarn strength (g) × yarn count × 0.001693

Analysis of data. Factorial design was applied in the analysis of variance of data for testing the differences among various quality characteristics as suggested by Montgomery (2009), using statistical programme for social sciences (SPSS) microcomputer statistical programme.

Results and Discussion

Yarn single end strength (SES) (g). The analysis of variance of the data regarding SES is given in Table 1. Highly significant effects of the winding speed (S), gas pressure (G), and air pressure(A) were found on SES, while the effect of all possible interactions remained non-significant.

The statistical comparison of individual treatment means with regards to yarn SES is presented in Table 1a. Duncan's multiple range test for the comparison of individual treatment means of winding speed showed that the maximum SES was recorded for S_3 (winding speed) with the mean value 425.50 g followed by S_2 and S_1 with their mean values as 420.72 and 417.88 g, respectively. The results showed that with the increase of the winding speed on the yarn singeing machine, the SES of the yarn was also increased. The study gets support from the findings of Rasool (2000), who reported that the yarn SES increased with the increase of winding speed.

Table 1. Analysis of variance for SES

SOV	DF	SS	MS	F. value	Prob.
S	2	267.049	133.524	5400.99	0.0000**
G	2	200.167	100.083	4048.31	0.0000**
A	2	19.016	9.508	384.58	0.0000**
S×G	4	0.218	0.054	2.16	N.S
S×A	4	0.202	0.051	2.04	N.S
G×A	4	0.071	0.018	0.72	N.S
S×G×A	8	0.075	0.009	0.36	N.S
Error	81	0.198	0.025	-	-
Total	107	486.996	-	-	-

** = highly significant; N.S. = non significant; CV% = 0.04.

Table 1a. Comparison of individual mean values for SES (g)

Winding speed	Gas pressure	Air pressure
$S_1 = 417.88^c$	$G_1 = 424.64^a$	$A_1 = 422.40^a$
$S_2 = 420.72^b$	$G_2 = 421.48^b$	$A_2 = 421.36^b$
$S_3 = 425.50^a$	$G_3 = 417.98^c$	$A_3 = 420.34^c$

Mean values having different letters, differ significantly at 0.05 level of probability.

Duncan's multiple range test and the comparison of individual treatment means regarding gas pressure under investigation showed that the maximum SES was recorded for G_1 (gas pressure) with the mean value 424.64 g followed by G_2 and G_3 with their mean values as 421.48 and 417.98 g, respectively. The results showed that with the increase of the gas pressure of the yarn singeing machine, the SES of the yarn decreased. These findings correlate with the observation of Sardag *et al.* (2007), who concluded that the increase of temperature from

90 °C to 110 °C caused a decrease in the strength values of the yarns.

Duncan's multiple range test and the comparison of individual treatment means regarding air pressure under investigation showed that the maximum SES was recorded for A_1 (air pressure) with the mean value of 422.40 g followed by A_2 and A_3 with their mean values as 421.36 and 420.34 g, respectively. The results showed that with the increase of the air pressure of the yarn singeing machine, the SES of the yarn was decreased. The study gets support from the findings of Sardag *et al.* (2007), who concluded that the increase of temperature from 90 °C to 110 °C caused a decrease in the strength values of the yarns.

Yarn elongation (%). The analysis of variance of the data regarding elongation is given in Table 2. Highly significant effects of the winding speed (S) and significant effect of gas pressure (G), air pressure (A) were found on elongation, while the effect of all possible interactions remained nonsignificant.

The statistical comparison of individual treatment means with regards to elongation is presented in Table 2a. Duncan's multiple range test for the comparison of individual treatment means of winding speed showed that the maximum elongation was recorded for S_3 (winding speed) with the mean value 5.6744 % followed by S_2 and S_1 with their mean values as 5.6100 and 5.5733 %, respectively. The results showed that with the increase of the winding speed on the yarn singeing machine, the elongation of the yarn was also increased. The study gets support from the findings of Saeed (1993), who depicted that with the increase of winding speed and with the application of wax, the yarn elongation was increased.

Table 2. Analysis of variance for elongation (%)

SOV	DF	SS	MS	F. value	Prob.
S	2	0.04716	0.02358	1157.64	0.0000**
G	2	0.03650	0.01825	895.82	0.0000**
A	2	0.00347	0.00174	85.27	0.0000**
S×G	4	0.00092	0.00023	2.27	N.S
S×A	4	0.00001	0.00002	0.18	N.S
G×A	4	0.00008	0.000002	1.00	N.S
S×G×A	8	0.00006	0.00002	0.36	N.S
Error	81	0.00165	0.00041	-	-
Total	107	0.08985	-	-	-

** = highly significant; N.S = nonsignificant; CV% = 0.08.

Table 2a. Comparison of individual mean values for elongation (%)

Winding speed	Gas pressure	Air pressure
$S_1 = 5.5733^c$	$G_1 = 5.6633^a$	$A_1 = 5.6333^a$
$S_2 = 5.6100^b$	$G_2 = 5.6211^b$	$A_2 = 5.6189^b$
$S_3 = 5.6744^a$	$G_3 = 5.5733^c$	$A_3 = 5.6056^c$

Mean values having different letters, differ significantly at 0.05 level of probability.

Duncan's multiple range test and the comparison of individual treatment means regarding gas pressure under investigation showed that the maximum elongation was recorded for G_1 (gas pressure) with the mean value 5.6633 % followed by G_2 and G_3 with their mean values as 5.6211 and 5.5733 %, respectively. The results showed that with the increase of the gas pressure on the yarn singeing machine, the elongation of the yarn was decreased. These results correlate with the findings of Xia *et al.* (2009), who concluded that after singeing treatment, the elongation was decreased.

Duncan's multiple range test and the comparison of individual treatment means regarding air pressure under investigation showed that the maximum elongation was recorded for A_1 (gas pressure) with the mean value 5.6333 % followed by A_2 and A_3 with their mean values as 5.6189 and 5.6056 %, respectively. The results showed that with the increase of the air pressure on the yarn singeing machine, the elongation of the yarn was decreased. These results are in line with the findings of Xia *et al.* (2009), who concluded that after singeing treatment, the elongation was decreased.

Yarn rupture per kilometer (RKM) (g/tex). The analysis of variance of the data regarding RKM is given in Table 3. Highly significant effects of the winding speed (S) and significant effect of gas pressure (G), and air pressure (A) were found on RKM, while the effect of all possible interactions remained nonsignificant.

The statistical comparison of individual treatment means with regards to yarn RKM is presented in Table 3a. Duncan's multiple range test for the comparison of individual treatment means of winding speed showed that the maximum RKM was recorded for S_3 (winding speed) with the mean value 14.412 (g/tex) followed by S_2 and S_1 with their mean values as 14.250 and 14.153 (g/tex), respectively. The results showed that with the increase of the winding speed on the yarn singeing machine, the RKM of the yarn was also increased. The study gets support from the findings of Azam (2001)

narrated that, the yarn RKM increased with the increase of winding speed.

Duncan's multiple range test and the comparison of individual treatment means regarding gas pressure under investigation showed that the maximum RKM was

Table 3. Analysis of variance for yarn RKM

SOV	DF	SS	MS	F. value	Prob.
S	2	0.30634	0.15317	5401.02	0.0000**
G	2	0.22962	0.11481	4048.34	0.0000**
A	2	0.02181	0.01091	384.59	0.0000**
S×G	4	0.00021	0.00005	2.36	N.S
S×A	4	0.00020	0.00005	2.04	N.S
G×A	4	0.00008	0.00002	0.72	N.S
S×G×A	8	0.00032	0.00004	1.82	N.S
Error	81	0.00023	0.00002	-	-
Total	107	0.55881	-	-	-

** = highly significant; N.S = nonsignificant; CV% = 0.04.

Table 3a. Comparison of individual mean values for yarn RKM (g/tex)

Winding speed	Gas pressure	Air pressure
$S_1 = 14.153^c$	$G_1 = 14.383^a$	$A_1 = 14.307^a$
$S_2 = 14.250^b$	$G_2 = 14.275^b$	$A_2 = 14.271^b$
$S_3 = 14.412^a$	$G_3 = 14.157^c$	$A_3 = 14.237^c$

Mean values having different letters, differ significantly at 0.05 level of probability.

recorded for G_1 (gas pressure) with the mean value 14.383 (g/tex) followed by G_2 and G_3 with their mean values as 14.275 and 14.157 (g/tex), respectively. The results showed that with the increase of the gas pressure of the yarn singeing machine, the RKM of the yarn decreased. These results correlate with the findings of Xia *et al.* (2009), who concluded that tenacity of the yarn decreased after singeing treatment.

Duncan's multiple range test and the comparison of individual treatment means regarding air pressure under investigation showed that the maximum RKM was recorded for A_1 (air pressure) with the mean value 14.307 (g/tex) followed by A_2 and A_3 with their mean values as 14.271 and 14.237 (g/tex), respectively. The results showed that with the increase of the air pressure of the yarn singeing machine, the RKM of the yarn decreased. These results are in line with the findings of Xia *et al.* (2009).

Conclusion

The study revealed that with the increase in winding speed, gas and air pressure, the single end strength, elongation and RKM of cotton yarn decreased. It is also concluded that the increase in heat intensity of yarn singeing machine, in order to remove more and more hairiness from yarn surface, negatively influences the tensile properties of yarn.

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