EFFECT OF SPINDLE SPEED ON THE QUALITY OF COMPACT EGYPTIAN COTTON SPUN YARNS

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Abstract

It is well known that yarn produced using the compact spinning technique, which has been introduced as one of the best spinning innovations by the end of last century"1999", has superior yarn structure and quality, especially in terms of strength, evenness and hairiness.

This paper deals with the effect of four different spindle speeds "11000,13000, 15000 and 17000/rpm" on end breakage rate and yarn quality for four Long-Staple cotton varieties, G85, G86 and G89 and two promising crosses, i.e., G.89X S6 and G.89XG.86 spun on 30s, 40s and 50s count carded yarns at a constant twist multiplier (4.0 TM). Results showed that Giza 85 and Giza 86 were less sensitive in yarn quality properties to increasing the spindle speed from 11000 to 17000 rpm. With increase in spindle speed from 11000 rpm to 17000 rpm, there is no effect on end breakage rates, but with the increase in spindle speed there is an increasing trend of yarn tenacity, but strength C.V.%, yarn unevenness C.V.% and yarn hairiness showed a tendency to increase. An increase in spindle speed brings many advantages in the spinning mills which together lead to a reduction in manufacturing cost with optimizing yarn quality properties.

INTRODUCTION

The ultimate goal of spinning technologists is focused on higher productivity, combined with adequate quality. With the passage of time, the production cost of spun yarn is becoming higher and higher. Reduction in production cost is the only solution, which is possible through increasing the production per spinning position but in the same time, optimizing yarn quality. There have been a lot of developments in ring spinning in the past, but the development of compact spinning has changed all aspects of advancement. This is the development, whose advantages are not limited to the extent of quality and productivity elevation; rather it is multidirectional and also covers the sphere of subsequent processes of weaving, knitting and dyeing with tremendous and significant increase in productivity, (Mahmood et al. 2004). Compact spinning which is simply the modification of ring spinning system at drafting zone set up, that aims at producing a better surface integrity of spun yarns and maximizing the fiber contribution to yarn strength, this was asserted by numerous workers. Spindle speed is the most important parameter deciding the ring frame production per spindle though, an increase in spindle speed leads to a reduction of costs per unit production on the one hand, and increased profit margin from higher sales volume on the other. While increasing spindle speeds, all possible care should be taken to ensure that yarn quality is not affected the two key factors which determine spindle speeds are the technological capability of ring frame and end breakage rate. Research previously conducted by many authors, Artzt, (2003), Momir et al. (2003), Çelik and Kadoğlu (2004), Jackowski et al. (2004) and El-Sayed and Souzan, Sanad (2007) have demonstrated that the compact yarn shows higher strength, reduced hairiness, and improved evenness. Krifa et al. (2002), study on a broad range of short-to-medium-staple cottons, treating the qualitative aspects of the compact-spun yarn. the improvements in yarn strength appear to be greater for shorter stapled cottons than for the longer staple lengths and greatly reduced the hairiness of yarns with the shorter stapled fibers. Chaudhuri (2003) in his work on acrylic spun yarn observed that, increase of spindle speed results in an increase in yarn tenacity, initial modulus, work of rupture, packing coefficient and total imperfections up to spindle speed of 18000 rpm, whereas mass irregularity remains unchanged. Hairiness Index does not show any relationship with the increase in spindle speed. Nasir et al. (2004) and Shamuganandam et al. (2005) indicated that spindle speed is the most important parameter deciding the ring frame production per spindle. From quality point of view, it was observed that lower spindle speed was better for yarn quality parameters viz. yarn count, yarn lea strength. From production point of view higher spindle speed was the best but it deteriorates yarn quality. The three key factors which determine spindle speeds are the technological capability of ring frame, end breakage rate and yarn quality. El-Sayed (2009) reported that there is small change of cotton yarn tenacity and elongation with the change of spindle speed from 10000 up to 17500 rpm., meaning that the differences in yarn tenacity and elongation are marginal and there is appreciable change in unevenness and hairiness index value of the yarns according to the increase in spindle speed. Beyond 10000 rpm of the ring frame spindle speed the imperfections increases gradually with the increase in spindle speed. Ramesh (2007) stated that at increase spindle speeds, yarn quality attributes like strength, evenness and thick places do not gèt highly affected. Thin places, strength C.V.% and hairiness show a tendency to increase with increase in spindle speed.

The aim of this investigation is to examine the effect of spindle speed on the quality of the compact spun yarns of Egyptian cotton.

MATERIALS AND METHODS

Four Long-Staple cotton varieties and two promising crosses grown in Delta and Upper Egypt were selected to produce 30s, 40s and 50s count yarns spun at a constant twist multiplier "4.0 Tm". The yarns were produced in compact spinning with four different spindle speed 11000, 13000, 15000 and 17000 rpm for each count, keeping the end breaks rate to a minimum level.

compact carded yarns processed under comparable technological conditions on the RST1 Marzoli ring and compact spinning fitted with "Olfil System" on one frame in the experimental cotton spinning mill, Cotton Research Institute. After the spinning trials, the physical properties of each yarn sample were measured according to ASTM (1991). Yarn evenness (C.V.%), and hairiness values were measured on Uster Tester 3 (the measurement length was 400 m/bobbin). Yarn tenacity (cN/Tex) and elongation at break (%) were measured on a Statimat ME with 120 breaks per sample. The HVI raw fiber data, along with the Micromat measurements were carried out on carded finisher sliver and presented in Table 1. For the statistical analyses, the trials were designed as analysis of variance experiment as factorial analysis with six replications, (Draper and Smith 1966).

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

RESULTS AND DISCUSSION

While increasing spindle speed, all possible care should be taken to ensure that yarn quality is not affected. Spindle speed is the most important parameter deciding the ring frame production per spindle. The two key factors which determine spindle speeds are the technological capability of ring frame and end breakage rate. Generally, an increase in spindle speed from 11000 rpm to 17000 rpm did not affect end breakage rates (per 100 spindle/hour) of yarn produced from the four Long Staple cotton varieties and two promising crosses Considering the above aspects, a clear understanding of the yarn tension condition prevailing during a bobbin build becomes necessary in any attempt to increase the spindle speed and reducing the end breakage rate, (El-sayed, 2009).

Effect of spindle speed on yarn tenacity and elongation

With the increase in spindle speed there is an increasing trend of yarn tenacity as shown in Table 2 and figure 1. As the spindle speed increases, the randomization of the fibers in the yarn gradually increases which causes better parallelization of fibers along the axis in the yarn and hence increases the yarn strength. At higher spindle speed, strength coefficient of variation (C.V.%) is higher. Higher compactness of the yarn structure better is the fiber migration within the yarn and hence higher is the interlocking structure of fibers within the yarn. As a result the yarn strength rises with the increase in spindle speed of the ring frame. On the other hand, an increase in the spindle speed leads to fiber protrusion on the surface of the yarn, thus yarn hairiness increases. There is a decreasing trend of yarn elongation with the increase in spindle speed. Yarn produced at higher spindle speed bears higher tenacity and much compact cause's low elongation of the yarn. Strength C.V.% showed a tendency to increase with increasing spindle speed. In this respect, Chaudhuri (2003) reported that increasing the spindle speed causes a rise in yarn tension and in the centrifugal force.

Effect of spindle speed on unevenness and hairiness

Table 2 and figure 1, show that the yarn unevenness (C.V %) increases with the increase of spindle speed from 11 000 rpm to 17 000 rpm. In this respect, Chaudhuri (2003) reported that at the higher spindle speed, the drafting force becomes higher. So, at the higher drafting force the average fiber tension at the front roller will cause an increase in the dragging out of the sliver into the front roller-nip. This dragging out of undrafted sliver into the nip of the front roller and if subsequent retreat under the action of internal elastic force would cause an increase in the irregularity that would offset the randomization effect of the speed. There is small change of hairiness index with the change of spindle speed though the difference of increasing hairiness index is marginal which is not established appreciably the reason may be due to high centrifugal force acted on the yarn which gives more outward force of the tail end of the fiber causes formation of more protruding ends on the yarn surface. However yarn unevenness "C.V.%", showed a tendency to increase with spindle speed. The more the yarn tension increase, the more the yarn twist backs onto the roller nip; therefore it is natural to expect better binding of the fibers, and consequently, a decrease in yarn hairiness.

Generally, at low spindle speeds, the effect of yarn tension is greater than the effect of the centrifugal force, therefore hairiness is expected to decrease; but at higher spindle speeds the force involved in raising fibers from the yarn surface is greater than those which tend to incorporate them within the body of the yarn;

increases in forces due to the speed of the yarn liners are proportional to the spindle speed, whereas forces due to centrifugal acceleration are not proportional and consequently yarn hairiness increases.

Effect of cotton varieties and spindle speed on yarn quality properties

The results shown in Tables 3 and 4, and illustrated in Figures 2 and 3 to 6 were compiled by averaging the data for yarn spun of different cotton varieties and promising crosses under compact spinning system. When cottons are compact-spun into the same yarn count under identical spinning conditions, the resultant yarn strength varies quite widely. It could be realized that the Egyptian cotton promising cross Giza 89 x Giza 86 and the commercial cotton varieties Giza 86 and Giza 85 exhibited higher single yarn strength and evenness and lower yarn strength coefficient of variation than the respective cottons under study due to their superior fiber quality (fiber length, fiber strength and micronaire reading). Evidently, the promising cross Giza 89 x Giza 86 showed the highest yarn quality properties among the Egyptian cottons under study. Yarns from promising cross Giza 89 X S6, Giza 89 and Giza 80 cotton varieties were of similar yarn quality properties. From another point of view, Table 4 showed the effect of cotton varieties and spindle speed on yarn quality properties. The results showed that Giza 85 and Giza 86 were less sensitive for yarn quality properties as increasing the spindle speed from 11000 to 17000 rpm. These results corroborate those described in the fiber properties components shown in Table 1.

Effect of yarn count and spindle speed on yarn quality properties

The results shown in Tables 2 and 5 were compiled by averaging the data for yarn spun at different yarn counts under five spindle speeds. The general trends revealed that yarn strength decreased with increasing yarn count, while yarn strength increased with increasing spindle speed from 11000 to 17000 rpm. Regarding yarn count, it was intended to spin each of six yarns from the same cotton variety at three yarn counts of about 30s, 40s, and 50s. The factorial analysis of variance revealed that each of yarn count and spindle speed, individually, had a significant effect on yarn properties of the six cotton varieties under study. Results obtained emphasized the consistent trends revealed that the yarn strength decreased with increasing yarn count as shown in Table 5.

Table1. Fiber parameters for Long Staple cotton varieties.

Material / Test results	G.80	G.85	G.89	G.86	G.89X S6	G.89XG.86
HVI measurement						
UHM. (mm)	31.3	30.5	32.1	33.1	31.1	33.2
UI (%)	85.0	87.0	86.5	87.0	86.3	87.4
Strength (g/tex)	37.0	39.5	40.0	45.0	40.0	45.0
Elongation (%)	7.5	6.6	6.5	6.5	7.3	7.0
Reflectance Rd%	64.0	75.5	77.0	76.0	74.5	73.8
Yellowness +b	12.7	8.4	8.0	8.7	8.8	8.7
Micronaire	4.2	3.9	4.1	4.6	4.3	4.1
Micromat measurement						
Maturity ratio	0.93	0.93	0.94	0.98	0.95	0.96
Fineness (mtex)	169	144	162	168	160	155

Table 2. Effect spindle speed on yarn quality properties.

Spindle Speed (rpm)	End Breaks	Yarn properties				
		Strength (cN\tex)	Strength (C.V.%)	Elongation (%)	Evenness (CV%)	Hairiness Index
11000	0	18.25	6.65	5.39	17.86	3.81
13000	0	18.34	6.93	5.14	17.94	4.00
15000	0	18.45	7.13	4.57	18.11	4.16
17000	0	18.75	7.33	4.63	18.39	4.32
L.S.D at 0.05 level	–	0.12	0.266	0.114	0.17	0.031

Table 3. Effect of cotton varieties and promising crosses on yarn quality properties.

Varieties	Yarn properties				
	Strength (cN\tex)	Strength (C.V.%)	Elongation (%)	Evenness (%)	Hairiness Index
G80	17.05	7.42	5.12	19.16	3.87
G85	19.29	6.12	5.11	17.52	3.92
G86	19.62	6.29	4.29	18.05	4.25
G89	16.79	7.75	4.76	18.27	4.71
G.89XG.86	20.54	6.91	5.53	16.86	3.66
G.89XS6	17.38	7.57	4.80	18.55	4.02
L.S.D at 0.05 level	0.15	0.326	0.139	0.20	0.076

Table 4. Effect of cotton varieties and promising crosses and spindle speed on yarn quality properties.

Varieties	Spindle Speed (rpm)	Yarn properties				
		Strength (cN\tex)	Strength (C.V.%)	Elongation (%)	Evenness (%)	Hairiness Index
G. 80	11000	16.85	6.45	5.63	18.85	3.72
	13000	16.97	7.39	5.18	19.02	3.83
	15000	17.13	7.78	4.71	19.17	4.02
	17000	17.27	8.04	4.97	19.62	4.25
G. 85	11000	19.05	5.84	5.59	17.35	3.73
	13000	19.14	5.91	5.37	17.45	3.83
	15000	19.41	6.12	4.63	17.54	3.95
	17000	19.59	6.62	4.87	17.77	4.08
G. 86	11000	19.47	5.49	4.86	17.68	3.98
	13000	19.49	6.40	4.58	17.86	4.19
	15000	19.56	6.49	3.89	18.15	4.32
	17000	19.96	6.76	3.84	18.55	4.51
G. 89	11000	16.58	7.23	5.04	18.07	4.27
	13000	16.75	7.38	4.93	18.23	4.66
	15000	16.85	8.12	4.44	18.30	4.83
	17000	17.00	8.24	4.60	18.50	5.09
G.89XG.86	11000	20.23	6.59	5.96	16.72	3.45
	13000	20.32	6.62	5.81	16.70	3.59
	15000	20.63	6.94	5.22	16.97	3.70
	17000	20.99	7.45	5.13	17.07	3.91
G.89XS6	11000	17.08	6.80	5.29	18.32	3.68
	13000	17.28	7.50	5.00	18.55	3.93
	15000	17.47	7.88	4.54	18.52	4.16
	17000	17.69	8.10	4.37	18.82	4.32
L.S.D at 0.05 level		0.30	0.652	0.279	0.418	0.076

Table 5. Effect of yarn count and spindle speed on yarn quality properties.

Count	Spindle Speed (rpm)	Yarn properties				
		Strength (cN\tex)	Strength (C.V.%)	Elongation (%)	Evenness (%)	Hairiness Index
30s	11000	20.14	5.73	6.29	15.44	4.14
	13000	20.19	6.22	5.91	15.51	4.29
	15000	20.27	6.30	5.45	15.78	4.42
	17000	20.57	7.47	4.86	16.38	4.48
40s	11000	17.85	6.58	5.44	17.95	3.81
	13000	18.02	6.89	5.12	18.00	4.02
	15000	18.00	6.92	4.58	18.23	4.16
	17000	18.33	7.79	4.45	18.46	4.40
50s	11000	16.73	7.36	4.45	20.18	3.47
	13000	16.78	7.56	4.41	20.31	3.71
	15000	17.16	7.62	4.28	20.32	3.91
	17000	17.35	7.63	3.99	20.32	4.08
L.S.D at 0.05 level		0.21	0.461	0.191	0.295	0.054

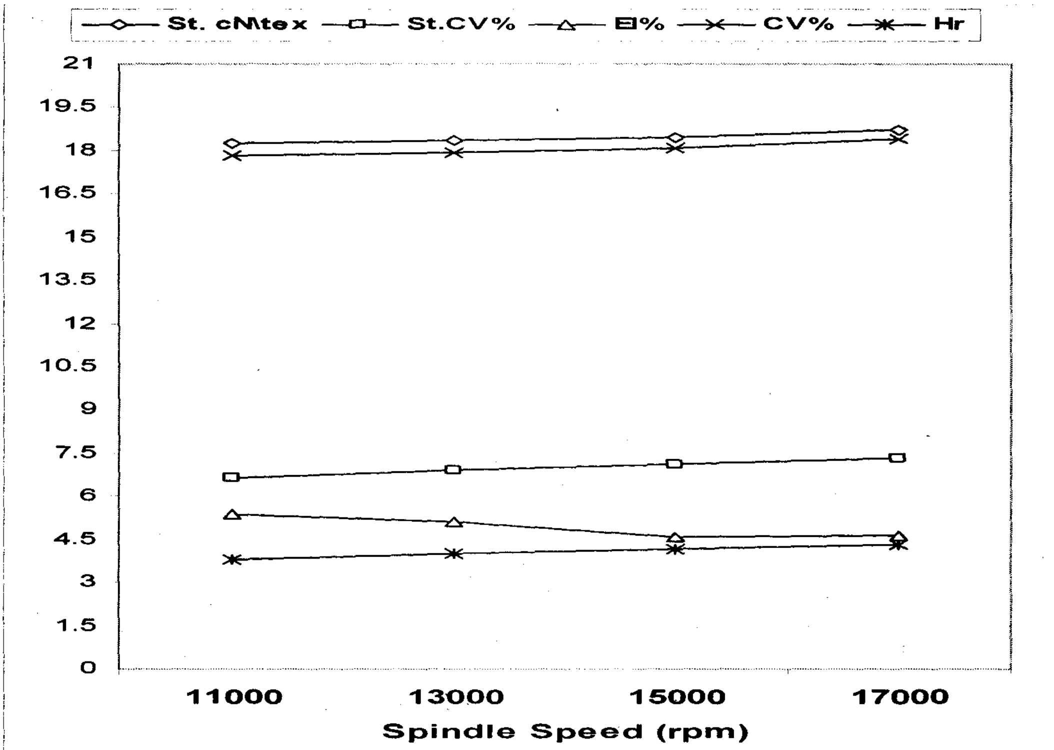

Figure1. Effect of spindle speed on yarn quality properties.

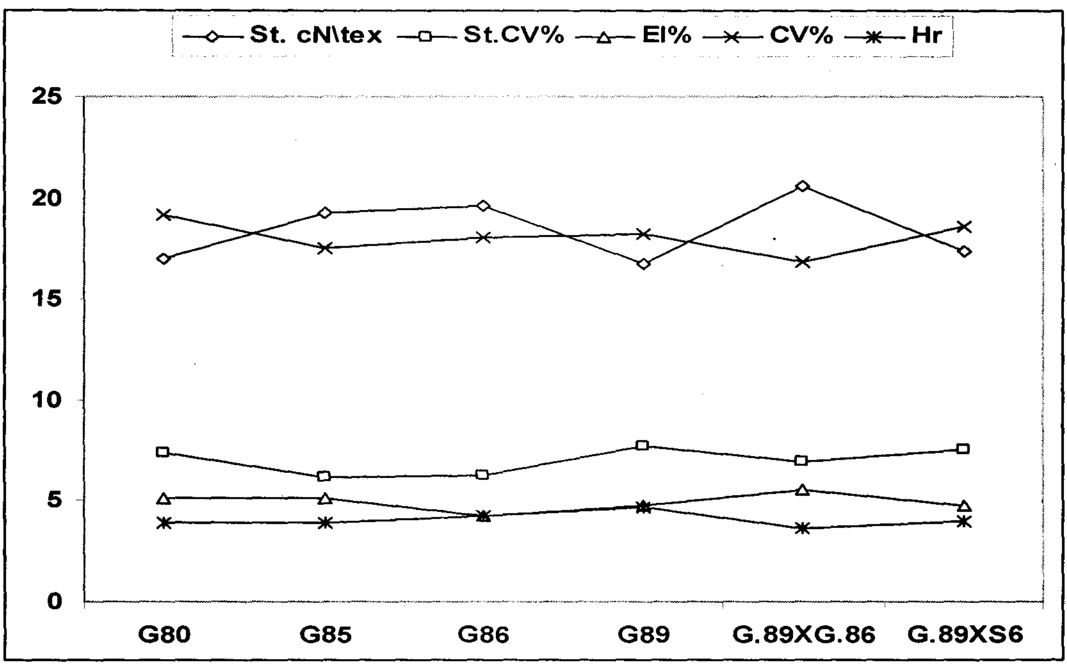

Figure 2. Effect of cotton varieties on yarn quality properties.

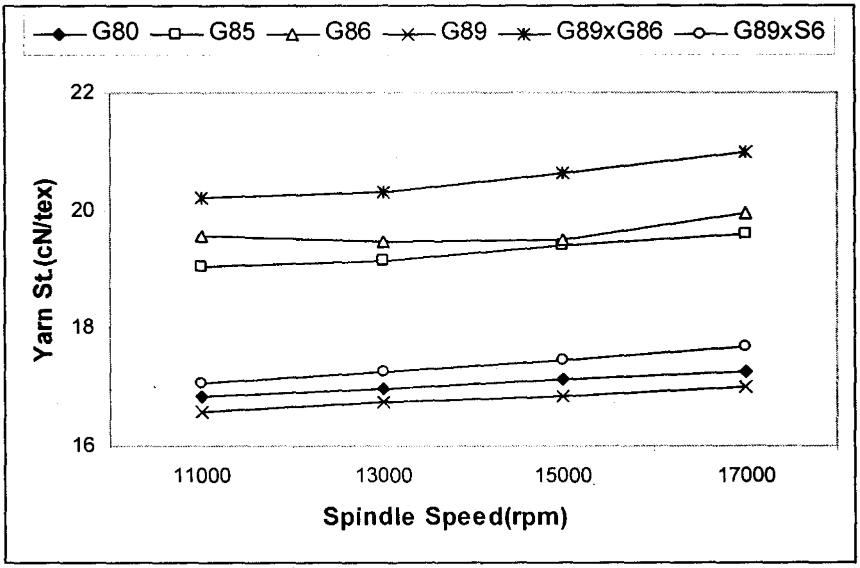

Figure 3. Effect of spindle speed and cotton varieties on single yarn strength.

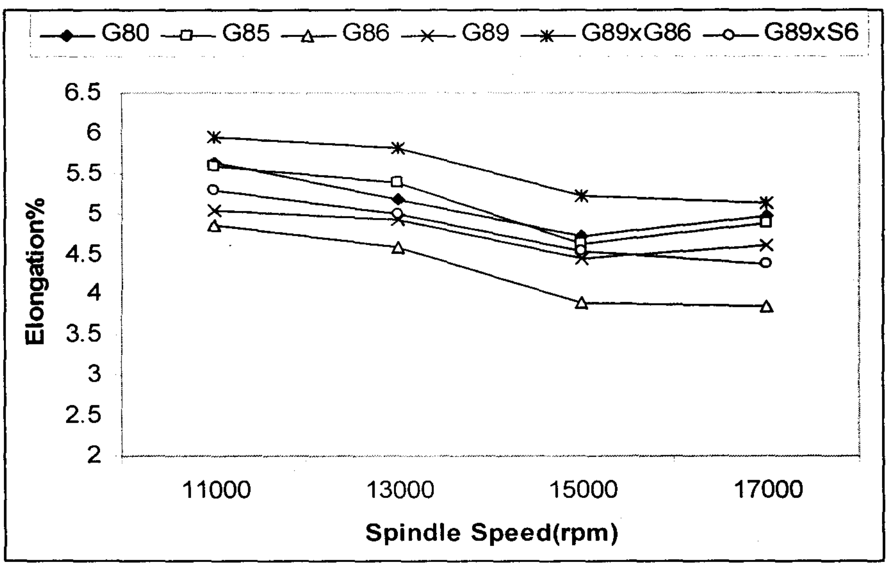

Figure 4. Effect of spindle speed and cotton varieties on yarn elongation.

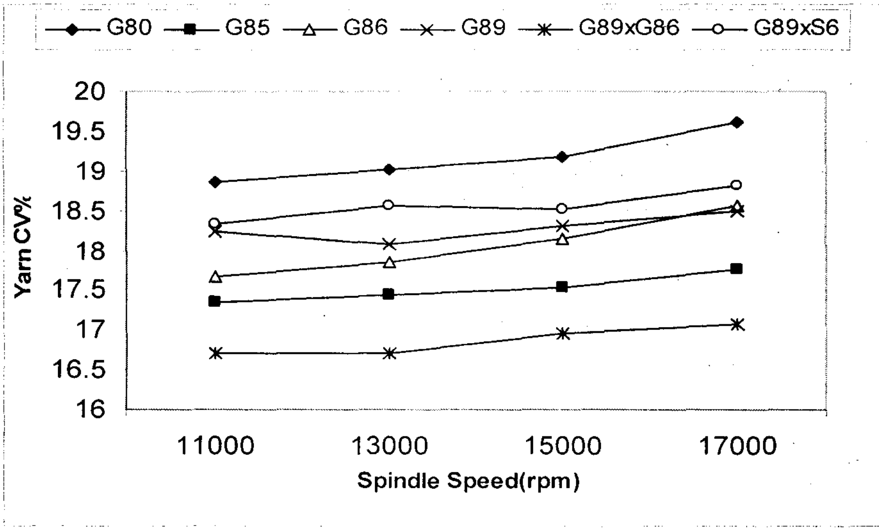

Figure 5. Effect of spindle speed and cotton varieties on yarn evenness.

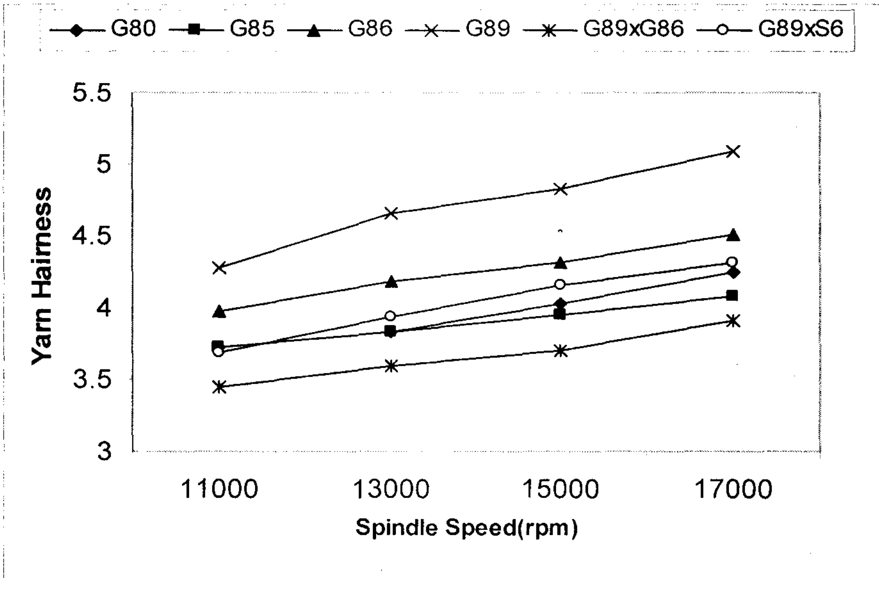

Figure 6. Effect of spindle speed and cotton varieties on yarn hairiness.

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تأثير زيادة سرعة المردن على صفات جودة الخيوط المغزولة من الأقطان المصرية طويلة التيلة على نظام الغزل المدمج

سوزان حسينى سند

معهد بحوث القطن- مركز البحوث الزراعية - الجيزة

من المعروف أن انتاج خيوط الغزل المنتجة بإستخدام تكنولوجيا الغزل المدمج، الذى ظهر كتطور تكنولوجى جديد فى القرن الحالى، والذى يتميز بخواص تركيبية وجودة مميزة وبخاصة فى صفات المتانة و الانتظام و التشعير. هذا البحث يدرس مدى تأثير زيادة سرعة المردن على صفات جودة الخيط وبخاصة المتانة ومعامل انتظام المتانة والانتظام و التشعير لبعض أصناف القطن المصرى طويلة التيلة وهى جيزة ٨٠ ، جيزة ٨٥، جيزة ٨٦، جيزة ٨٩ والهجن المبشرة وهى (جيزة ٨٩×جيزة ٨٦) و (جيزة ٨٩ × س٦) والمغزولة على نظام الغزل المدمج، بزيادة سرعة المردن من ١١٠٠٠، ١٣٠٠٠، ١٥٠٠٠ و ١٧٠٠٠ لفة/دقيقة على نمر ٣٠، ٤٠ و٥٠ مسرح بمعامل برم ثابت (٤,٠).

اظهرت النتائج أن الهجين المبشر جيزة ٨٩ × جيزة ٨٦ و الصنفين جيزة ٨٥ وجيزة ٨٦ هما أقل الأصناف تأثرا من حيث الصفات الغزلية المدروسة بزيادة سرعة المردن من ١١٠٠٠ إلى ١٧٠٠٠ لفة/دقيقة، كما اوضحت النتائج أنه بزيادة السرعة لم تتأثر صفة معدل القطوع كما وجد أن هناك إتجاه ملحوظ فى زيادة المتانة وزيادة معامل اختلاف المتانة والانتظام وصفة التشعير بزيادة سرعة المردن حتى ١٧٠٠٠ لفة/دقيقة. ووجد ايضا إن زيادة سرعة المرادن تضيف العديد من المزايا لمصنع الغزل ومنها خفض تكاليف التشغيل وزيادة الانتاجية مع المحافظة على مستوى جودة مقبول من صفات الغزل الناتج.