OPTIMIZING RING SPINNING VARIABLES AND A PROPOSED PROCEDURE TO DETERMINE THE EGYPTIAN COTTON SPINNING POTENTIAL

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Abstract

In this study, many approaches were examined such as spindle defects and yarn bobbin position along with successively varying spindle speed to select the optimum processing parameters for standard testing of the Egyptian cotton, and hence suggesting a spinning procedure for the CRI 96-spindle-hour spinning test. Giza 80 was used to test the spindle error and yarn bobbin position also, to study the varying spindle speed, while, Giza 80 as well as Giza 86 and Giza 70 were used to reveal the spinning limit technique.

The coefficient of variation in lea count strength product (introduced between the spindles of the ring frame) was considerable, the variance was very small (1.01 %) in extreme cases and could be neglected. The lea count strength product at different positions on the bobbin spun on the ring frame between the pigtail to full bobbin was insignificant. The increase in spindle speed from 1000 to 17500 rpm did not affect single yarn strength, yarn evenness and yarn hairiness. The total imperfections are minimum at 10000 rpm of spindle, and beyond this speed the imperfections increase gradually with the increase in spindle speed.

The proposed procedure of accelerated spinning technique appears promising in indicating the relative level of end breakage and optimum yarn quality parameters for different cotton varieties. A series of 96- spindle-hour spinning tests proved to be reliable in exploring practical spinning limits of any cotton to find out the finest count for a particular cotton taking in consideration ends-down and yarn quality parameters.

INTRODUCTION

As a result of the technological advances in spinning industry, The Cotton Research Institute, in its effort to continuously improve the Egyptian cotton competitiveness in the world markets has modernized the experimental spinning mill. It was established in 1935 and expanded in 1965, and is running according to a system using very small samples of lint (60 grams). A completely new spinning mill working under a semi-industrial condition using a bulk sample of lint (5 Kg minimum) has been added more recently (2006).

A standard testing system is required to make the best use of the new machinery. To define the new system, several spinning variables, especially spindle speed and spindle defects, yarn bobbin position and spinning potential.

The effect of spindle speed on yarn properties was observed by many workers, Anbarasan (1996) reported that the benefit available with the advanced speed system was subsequently extended future with the introduction of variable speed system such as inverter drive system. This system offers the possibility of arranging a selective and continuous speed adjustment for the complete cop build. In this way, optimum conditions of spindle speed can be obtained such that, throughout the cop build, a practically constant spinning tension is available. Chaudhuri (2003) in his work on acrylic spun yarn observed that, increase of spindle speed results in the increase of 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 the 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

The spinning performance of cotton is evaluated mainly by its rate of end breakage per 1000 spindle hours. For a valid evaluation of cotton, experience has shown that a minimum of 25000 spindle-hour mill scale test, the conventional 5000 spindle-hour pilot plant scale test, the SRRL "Southern Regional Research Laboratory" 720 spindle-hour scale spinning performance test and the 84 spindle-hour small laboratory scale spinning performance are needed, (ASTM 1991). These many spindle hours need much material and time, and necessarily limit the extent of the possible evaluations. As a result, research laboratories find it difficult to conduct such types of "spinnability" tests routinely, since experimental samples are generally small and processing equipment is limited, (Louis 1961). In Cotton Research Institute "CRI", increase emphasis are placed on comparing the new promising varieties with commercial ones and evaluate the new hybrid in isolated filed. Thus it appears that there is a real need for a procedure to rapidly evaluate the spinning performance in terms of yarn quality and end breakage rate.

Through several investigations, different studies to determine the spinning potential yarn number or spinning limit by proposed approaches depend on; a) use of accelerated tests by increasing the yarn tension or reducing its twist during the spinning trails; b) measurement of the "spinning end strength", which was defined as the maximum stress sustained by the yarn during the end-breakage sequence; and c) using neural network based on the fiber and machine interaction, (Krifa and Ethridge 2004).

Rouse (1965) proposed an equation for predicting the spinning potential yarn number "SPY".

The equation used to compute the SPY is given as follows:

$$SPY = 2(Na) - (Nn) - 0.2B$$
$$= Na - e - 0.2B$$

Where,

SPY: Spinning potential yarn number (expressed as English yarn count, Ne)

Na: Actual yarn count

Nn: Nominal yarn count

B: Number of spindles with end breakage

e: Nn – Na: error in actual yarn count

The formula was criticized by Zhu and Ethridge (1996) as follows;

1. Neither the formal nor the informal record on development and application of the ring SPY test contains explanation or justification of the term -0.2B in the equation. Since there is no theoretical justification, it must be surmised that it was determined by empirical testing done during the 1950's. Therefore, prudence would demand that its empirical validity be verified on modern ring spinning frames.
2. It is also not explained in the literature why the actual yarn count (Na) is doubled while the nominal yarn count (Nn) is not. The second line of the equation was added to indicate that the formulation results in an adjustment for the failure to always spin the exact yarn count targeted in the test procedure.

It could be added that the range of 4 to 20 end breakages is an absolute number i.e. number of end breakages for coarse counts "up to 24 Ne," were even with the same range of the extra fine counts "up to 160 Ne." in this respect, Ratnam and Chellamani (1999) decided that in ring spinning, the norms for end breaks per 100 spindle hours for a good working are: 25 in 20s and 30s, 16 in 40s, 12 in 60s, 80s and finer counts.

In this study, for a rapid spinning technique, many approaches were examined such as (a) spindle defects and yarn bobbin position; (b) successively varying spindle speed to select of optimum process parameters for standard testing of the Egyptian cotton, and (c) suggesting a spinning procedure for the CRI 96-spindle-hour spinning test.

MATERIALS AND METHODS

Giza 80 was spun at 40s carded yarn to test the spindle error and yarn bobbin position and also, to study the varying spindle speeds, while, Giza 80 as well as Giza 86 and Giza 70, were spun into successive fine carded yarn counts 40, 50 and 60s for

Giza 80, while Giza 86 and Giza 70 were spun into 70, 80, 90 and 100's carded counts to reveal the spinning limit technique. Data on the properties of the cotton varieties are illustrated in Table 1.

Yarn preparation

The new spinning machinery included: Compact Bale Opener "BO-C"; compact Opener "TO-C" with needle beater fitted with Chute feed and "DK-780" carding machine working with short and long term Auto leveler; HSR 1000 draw-frame machine, working with short and long term Auto leveler. Marzoli, High-speed frame "PCX 16-A 36 spindles; Marzoli, RST1 ring and compact spinning" Olfil System" of one frame consisting of 96 spindles, was used sequentially for the preparation of the samples. Six different samples of yarns having nominal linear density of 14.8 tex (40 Ne) with αe 4.0 were prepared by varying spindle speeds from 10 000 rpm to 18 000 rpm.

Table 1. HVI Spectrum fiber data.

Cotton variety	UHM. (mm)	U.I. (%)	Short Fiber Index	Strength (g/tex)	Elongation (%)	Micronaire
Giza 80	31.2	85.2	8.9	38.2	7.9	4.3
Giza 86	33.0	86.0	7.0	45.0	7.0	4.5
Giza 70	35.5	87.0	5.4	45.0	5.4	3.9

End breakage

96 hours runs were made for each yarn count and the number of end breakages was recorded at 30-minute intervals during which all broken ends were pieced up. According to Louis (1961) end breakage data were sorted into two categories, one is based on the initial end breakages and the other is based on the initial and repeated end breakages, thus giving justification for not piecing the end after breakage. Furthermore, another advantage of this method is that it avoids the danger of counting repeated breakages caused by mechanical defects.

Tensile testing

Statimat ME with a testing speed of 5000 mm/min with a test length of 50 cm was used for the testing of tensile properties. An average of 120 tests for breaking load and elongation value was taken for the calculation of tenacity and breaking extension of the samples. Lea product (lea count strength product) was measured by using the Good-Brand Lea Tester.

Evenness, imperfections and hairiness testing

The Uster Evenness Tester (UT-3) was used for testing yarn evenness, number of imperfections and hairiness index with a testing speed of 400 m/min for a period of one minute. Average of three tests was taken for final results.

RESULTS AND DISCUSSION

Spindle defect

In order to study the "spindle defects" i.e. the inherent variability between machine spindles, the ring frame was divided into different six parts of the spindles. Giza 80 samples were spun on each of the 96 spindles for the machine giving 24 lea count strength per spindle/sample as shown in Table 2. The experiment revealed that the coefficient of variation in lea strength (introduced between the spindles of the ring frame) were considerable, and a C.V. % was very small (1.01 %) in extreme cases and could be neglected.

Yarn bobbin position

The first problem was to decide the position at which yarn should be spun and tested on the bobbin. With the aid of a Good-Brand Lea Tester, it was found that the lea count strength product at different positions on the bobbin spun on a frame between the pigtail to full bobbin showed insignificant differences, (Table 2). The concept of continuous development of ring spinning technology, is that the inverter drive controls and provides constancy of the yarn tension along the bobbin by smoothness of transition from the slow speed to the maximum speed at every phase of bobbin build up during start-up and vise versa during the end of the bobbin build. The following speed can be modified during the bobbin build up, according to Marzoli, RST1 report (2001):

(a) Yarn tensioning speed; this speed is only used on restart in the upper position;

(b) First layer speed on restart to take a complete lay:

(c) Core starting speed;

(d) End-of-formation speed:

(e) Fastening speed, and

(f) Stop positioning speed, as shown in figure 1.

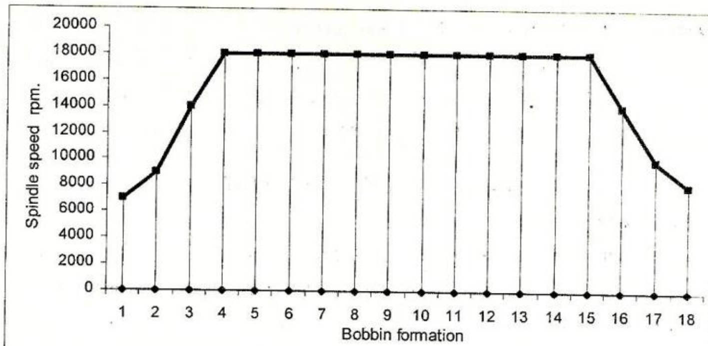

Figure (1): Modified spindle speed

Table 2. Coefficient of variation for spindle error and yarn bobbin position.

Spindle No.	1 - 16	17 - 32	33 - 48	49 - 64	65 - 80	81 - 96	*All machine*
Lea No.							
1-8	1.03	1.21	1.21	1.01	1.05	1.09	*1.01*
9-16	0.60	1.21	1.05	1.02	1.03	1.03	*1.03*
17-24	0.68	1.07	1.03	0.87	1.03	0.70	*1.01*
All bobbins	*0.88*	*1.10*	*1.20*	*1.00*	*1.11*	*1.01*	*1.15*

Effect of spindle speed on end breaks

A major factor which limits the maximum spindle speed is the end breakage rate. An end break occurs whenever the spinning tension exceeds the yarn breaking force. End breakage rates of yarn produced from Giza 80 with various spindle speeds is given in Table 3. The data showed no effect of spindle speed on end breakage of 100 spindle/hour. Considering the above aspects, a clear understanding of the yarn tension condition prevailing during a bobbin build up becomes necessary in any attempt to increase the spindle speed by reducing the end breakage rate.

With inverter motor drives, end breaks are fewer by about 30 percent at the beginning of the doff compared to constant drive motors. End breaks are usually more at the bobbin bottom stage and so, inverter motor drives help in reducing the work load of the tension at the beginning of the doff, (Ratnam and Chellamani 1999).

Table 3. Effect of spindle speed on yarn properties

Yarn count	40 Ne						
Spindle speed "rpm"	10,000	11,500	13,000	14,500	16,000	17,500	L.S.D.
No. of End breakage (96 Spindle/hour)	0	0	0	0	0	0	0
Tenacity (cN/tex)	17.62	17.59	18.02	17.76	17.62	17.69	0.60
Elongation (%)	5.60	5.60	5.50	5.70	5.63	5.62	0.15
Evenness (C.V. %)	17.82	17.89	18.27	18.38	18.62	18.89	1.03
Hairiness (unit)	4.74	4.68	5.04	4.97	5.15	5.14	0.09
Thin places (-50%) /1000m	87	102	172	162	177	182	15.60
Thick places (+50%)/1000m	*522	517	585	627	577	685	28.13
Neps (+200%)/1000m	457	460	495	722	692	855	35.15

Effect of spindle speed on yarn tenacity and elongation

The statistical analysis of variance supporting by least significant difference of the data pertaining to yarn lea strength is given in Table 3. While increasing spindle speeds, all possible care should be taken to ensure that yarn quality is not affected. With the increase in spindle speed, there is no appreciable change in yarn tenacity and elongation. The data show that there is small change of 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. This result is basically due to the constancy of the yarn tension along the bobbin build. This finding is not supported by Chaudhuri (2003), who stated that, at higher spindle speed, packing coefficient is higher resulting higher compactness. Higher the 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 yarn strength rises with the increase in spindle speed of the ring frame.

Effect of spindle speed on yarn unevenness and hairiness index

The mean values pertaining to yarn unevenness under different levels of spindle speed are tabulated in Table 3. There is an appreciable change in unevenness and hairiness index value of the yarns according to the increase in spindle speed. The data show that there is significant increase of yarn unevenness with the increase in of spindle speed, while there is a slight increase in yarn hairiness index. The reason may be due to a high centrifugal force acting on the yarn which gives more outward force of the tail end of the fiber causing formation of more protruding ends and irregularity on the yarn surface Chaudhuri (2003).

Effect of spindle speed on yarn imperfections

The mean values of yarn imperfections are given in Table 3. It is observed that the total imperfections is minimum at 10000 rpm of the ring frame spindle for the cotton variety under study, and beyond this speed the imperfections increases gradually with the increase in spindle speed. This finding was supported by Chaudhuri (2003) who reported that at 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 un-drafted sliver into the nip of the front roller and the subsequent retreat under the action of internal elastic force would cause an increase in the irregularity and imperfections that would offset the randomization effect of the speed.

A proposed spinning procedure for the CRI 96 spindle-hour spinning test

Confidence limits and degree of precision are calculated as follows;

Confidence limit (0.95 significant level = 1.96 X Standard Deviation / $\sqrt{n}$

Degree of precision = confidence limit/ average X100

It could be seen from Table 4, that the degree of precision decreased markedly when total number of spindles were increased from 16 to 96. The differences between the degrees of precision for the same number of spindles are ascribed to the real differences between fiber properties of the cotton varieties "Giza 80, Giza 86 and Giza 70". Figure 2 illustrated the potential spinning of the three cotton varieties using the number of end breakage rates within the control limits of 16 "for Giza 80" to 12 "for Giza 86 and Giza 70".

Table 4. Degree of precision at different level of number of spindles

No. of spindles	16	32	48	64	80	96
Time of running (min)	360	180	120	90	72	60
Degree of precision	0.90	0.88	0.88	0.88	0.86	0.84

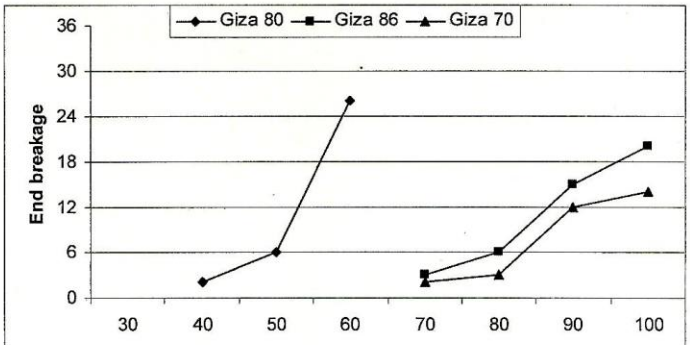

Figure (2): Spinning limit valu

After many experimental trials, the following test procedure was developed starting with 40s for LS Upper Egypt cottons, 50s for LS Delta cottons and 70s for ELS cottons, but it can be easily adapted to evaluate the spinning performance of any cotton and yarn numbers. **value**

1. Frame specification:
   96 spindles with pendulum arm
   45 mm diameter ring
   10,000 – 18,000 rpm spindle speed range
2. Spinning work reported in this investigation was done on 16 spindles. Spinning duration was 6 hours per run.
3. Use about 50 Kg of cotton, based on average 3 Kg per roving bobbin.
4. Select a yarn count that is estimated to be the spinning limit, and set up the spinning frame.
5. Use a constant 14000 spindle speed with appropriate traveler and twist multiplier according to ASTM, D-2811, (1991).
6. For LS Egyptian cotton, the tests were started at initial medium yarn count of 40 Ne, while ELS cotton, started at fine carded yarn count of 70 Ne and 100 Ne for combed yarns.
7. For this test, spin all the 16 bobbins for 6 hours. In this respect, six different cotton varieties in the same cotton category can be spun.
8. After sufficient time of running, size all the 16 bobbins for the actual yarn count and set up the machine for the target yarn count.
9. Use the end breakage rates within the control limits of 25 and 12, according to yarn count, Ratnam and chellamani (1999).
10. Spin the twelve 30- minute intervals and sum up the data, Table 5.
11. The frame should be doffed after each yarn count to test yarn quality parameters, hence each run will start with empty bobbins.

12. After the first yarn count has been run, set up the frame for another yarn count and follow a similar procedure for progressive finer yarn count by increasing yarn count in increments of 5 units.

Table 5. Suggested 16 spindle-hour spinning performance work sheet

Cotton variety ---------------- Yarn count ----------------- Date -------------------------

Spindle speed -------------- T. M. ----------------------- Time start and stop ------

ENDS DOWN

Sp. No.	1	2	3	4	5	6	7	8	9	10	11	12	Sp. No.	1	2	3	4	5	6	7	8	9	10	11	12
1													49												
2													50												
3													51												
48													96												
Total																									

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المتغيرات الغزلية المثلى لماكينة الغزل الحلقى و طريقة مقترحة لتقدير الكفاءة الغزلية للأقطان المصرية

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الهدف من هذه الدراسة هو تحديد متغيرات ماكينة الغزل المثلى لتقييم الأقطان المصرية على مستوى قياسى مثل: دراسة الفروق بين مرادن ماكينة الغزل و الفروق فى موضع بناء الخيوط فى البوبينة الواحدة من حيث صفات جودة الخيوط وكذلك دراسة تأثير سرعة المرادن على خواص الجودة. و أيضا اقتراح طريقة مثلى لتحديد الكفاءة الغزلية للأقطان المصرية.

أستخدم فى هذا البحث صنف القطن جيزة ٨٠ لدراسة الفروق بين المرادن و فى موضع بناء الخيوط فى البوبينة الواحدة و أيضا، فى دراسة الفروق بين سرعات المرادن. كما أستخدمت الأصناف جيزة ٨٠، جيزة ٨٦ وجيزة ٧٠ لتحديد طريقة مثلى لدراسة الكفاءة الغزلية للأقطان المصرية.

وقد أظهرت النتائج أن معامل الاختلاف فى متانة الشلة بين المرادن قليل جدا (١,٠١%) ويمكن إهماله كما أوضحت النتائج أيضا أن معامل الاختلاف فى موضع بناء الخيوط فى البوبينة الواحدة غير معنوى.

أن زيادة سرعة الماردن من ١٠٠٠٠ لفة/دقيقة الى ١٧٥٠٠لفة/دقيقة لم تؤثر فى صفات متانة الخيط المفرد والانتظام والتشعير بشكل كبير بينما زادت العيوب (الآماكن الرفيعة والسميكة والعقد) بزيادة السرعة.

الطريقة المقترحة لتحديد الكفاءة الغزلية تظهر نتائجً مبشرة لتحديد عدد القطوع بجانب صفات الجودة المقبولة حيث يتم تشغيل عدد ١٦ مردن لمدة ٦ ساعات متصلة لتعطى نتيجة موثوق بها لتحديد حد الغزل الأمثل لأى صنف من القطن وكذلك كفاءته لأنتاج خيوط رفيعة.

نتيجة للتقدم التكنولوجى الكبير فى صناعة الغزل، فقد قام معهد بحوث القطن كعادته المستمرة فى المحافظة على تفوق القطن المصرى فى السوق العالمى بتحديث مصنع الغزل التجريبى الذى أنشيء عام ١٩٣٥ الذى كان يعمل بنظام العينات الصغيرة زنة ٦٠ جرام بأحدث خطوط الغزل المتكاملة التى تعمل فى ظروف شبة صناعية على عينات كبيرة الحجم (خمسة كيلو جرامات كحد أدنى وبدون حد أقصى)