STUDY OF SOME TEST VARIABLES ON ZWICK 1511 YARN STRENGTH TESTER

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Abstract

This study was carried out to determine some test variables on Zwick 1511 yarn strength tester. To determine the suitable number of breaks for any sample, the suitable test speed for different yarn counts for the standard time to break (20±3Sc.) and the effect of pre-feeding actual or nominal yarn count on yarn strength values.

Giza 88 Egyptian Extra-Long Staple cotton variety was used to spin six combed yarn counts; 30s, 40s, 60s, 80s, 100s, and 120s, at twist constant of (3.6). It was found that the test sample size of 40 breaks is more acceptable and optimum from the stand-point of degree of precision and also saving testing time. It was found that speed (70) is acceptable speed for fine counts (60s – 120s) and speeds (80-90) for medium counts (30s-40s). Considering the differences between the actual and nominal yarn counts to input information to Zwick 1511 single yarn strength tester, it was found important to input the actual yarn count.

INTRODUCTION

Single yarn tensile properties are, undoubtedly, the most important factors in determining yarn quality and consequently cotton quality. The lea count strength product is the traditional method of assessing yarn strength correlated to yarn count. It is still standard method of the Cotton Research Institute. In addition, the single thread testing, which is usually based on testing a 50cm sample of a yarn, is usually done at either the principle of a constant rate of loading or a constant rate of extension. Booth (1968) explained the two principles in the following: consider two identical specimens A and B in figure (1); specimen A is gripped in a fixed-top jaw J1 and in a bottom jaw J2 which is movable. A force F, initially zero but increasing at a constant rate, is applied to the specimen in a direction shown. The effect of applying this force is to extend the specimen until it eventually breaks. The loading has thus caused the elongation, that is C.R.L. conditions. Specimen B is gripped in the fixed-top jaw J3 and in the bottom jaw J4 which can be moved downwards at a constant velocity by means of a screw mechanism. Initially, the tension in B is zero but when the bottom jaw J4 moves downward the specimen is extended and an increasing tension is developed until the specimen finally breaks. In this case the cause and effect are the other way round, extension causes loading that is C.R.E. conditions. Zwick 1511, depends on constant rate of extension (C.R.E.).

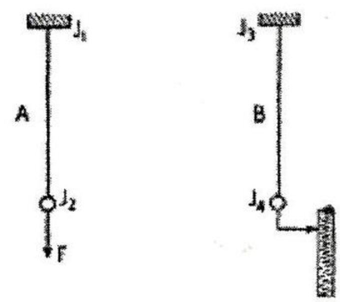


figure 1. C.R.L. and C.R.E. principles

Abou Sehly *et al.* (1973) studying the determination of the required number of breaks and confidence limits for single thread tensile parameters measured on the "Uster Automatic yarn strength tester", found that the number of breaks decreases markedly when the confidence limits are increased from 0.01 to 0.02 or 0.03 of average. The range of individual values becomes much narrower as the number of breaks is increased and also the coefficient of variation for the individual values decreases steadily. Balasubramanian and Salhotra (1985) investigated the influence of rate of loading on the tensile behavior of rotor spun yarns. They found that the tenacity reaches a peak value around a strain rate of 20 cms/min and thereafter declines gradually. Nomeir *et al.* (1987) studying the differences in yarn tensile mechanical properties of Giza 75, Dandara and Giza 80 cotton yarns, due to changing test speed, i.e., breaking time (3,20 and 40sec./test). They reported that changing test speeds caused significant differences in yarn mechanical properties. Decreasing test speed resulted in a general trend of decrease in yarn strength, toughness and stiffness, as well as yarn breaking load and elongation which decreased significantly for the slower test speeds than for the faster ones. Nafisa, Ahmed *et al.* (1987) found that the best test sample length and test loading rates were 50 cm. and 30 sec., respectively, on the Statimat Automatic Tensile Tester. Kaushik *et al.* (1989) observed that maximum yarn tenacity occurs at a strain rate of 20 cm/min for a gauge length of 10 cm and at a strain rate of 100 cm/min for a gauge length of 50 cm. De Luca and Thibodeaux (1992) compared yarn tenacity data from three different machines i.e., the Tensorapid at 5000 mm/min, the Dynamat 11 at 20 seconds to break, and the Scott skein tester at 305 mm/min. At a constant rate of extension, the data from each machine shows that the effects of the time-to-break on tenacity and the percent extension of the 49.2 tex and 16.4 tex differed slightly (0.35% to 3.68%) for each yarn. Parker (1993) reported that in a constant rate of loading tester, the time to break is held approximately constant by adjusting the rate of loading. Therefore, the rate of extension and the percent extension per minute are variable, however, in a constant rate of extension tester, the time to break is variable. At a fixed rate of extension, the percent extension per minute is constant. Lee *et al.* (1997) reported that there were significant differences in tenacity measured by different machines (USTER Tensorapid 3, USTER Tensojet and Constant Tension Transport).The effect of testing speed on measured tenacity showed the expected trend, i.e., as testing rate increased, the force required to break the yarn, also increased.

The Cotton Research Institute, in its effort to continuously improve the Egyptian cotton competitiveness in world markets, and because of the single thread tensile properties are undoubtedly, the most important factors in determining yarn quality and consequently cotton quality, therefore installed a new tensile testing machine that is Zwick 1511. This is one of the high speed yarn tensile testing machines, which use the testing principle of constant rate of extension (CRE), it has multi-tests variables (input parameters) :

1. number of tests per reel
2. number of reels
3. yarn count (tex)
4. test speed (mm/min)

The main purpose of this current research is to determine the best test speed for different counts at the same time to break (20±3 sc.). The other purpose of the research is the determination of the required number of breaks for a specified test sample and specified degree of precision. Third objective is to find out the effect of using actual and nominal yarn count on the yarn tensile strength and elongation obtained measurements.

MATERIALS AND METHODS

Introduced in 1998, Zwick 1511 (Figure 2), is used for testing the tensile strength. It is a constant rate of extension (CRE) tester and it is claimed to be suitable for testing single yarns, woven strips and lea strength. It consists of four units which are the tester (yarn length is 50 cm), the creel, the processor and the printer. Input parameters are : number of tests per reel, number of reels, yarn count (tex) and test speed (mm/min). Output parameters results are :

single yarn strength (f-max) .... cN/tex
breaking load (f-max) .... N
work to break .... cN/tex
test time .... seconds
Extension at break .... %
Stress strain curve

Statistics parameters : (number of tests, standard deviation and the coefficient of variation).

The present study was carried out at Cotton Spinning. Res. Div., Cotton Research Institute The samples were obtained from commercial crop of 2002 season. Giza 88 Egyptian extra long staple cotton was used as experimental material (34.2 mm fiber length 2.5% Span Length, 48.7 UR %, 33 g/tex fiber strength, 6.5% elongation and 3.6 micronaire reading). Six combed yarn counts 30s, 40s, 60s, 80s, 100s, and 120s, were produced at twist multiplier constant (3.6). The actual count was determined before testing on Zwick 1511 for all counts. The actual 40s and 60s ring and 40s open-end yarn counts were tested on the Zwick 1511 automatic tensile tester taking 20, 40, 60 and 80 breaks to determine the suitable number of breaks. Also, the difference between nominal and actual 60s and 80s yarns to input the correct data were determined. Moreover, single yarn tensile strength (cN/Tex), elongation %, work of rupture %, were measured on various test speeds as shown in Table 1, as well as constant test loading rate (breaking time) 20± 3 seconds.

Table 1. Processing test speeds for different yarn counts.

Yarn count	Test speed mm/min.			
30s	70	80	90	100
40s	70	80	90	100
60s	70	80	90	
80s	60	70	80	
100s	60	70	80	
120s	50	60	70	

Fiber and yarn properties were determined according to ASTM method. Fiber length was measured by Fibrograph 630 (A.S.T.M., D-1440-67), and (A.S.T.M., D-1445-75, 1984) for the fiber strength by Stelometer and micronaire reading was measured by Micronaire (A.S.T.M., D-1448-59, 1984) The single yarn tenacity and breaking extension were determined on Zwick 1511 Automatic Tensile Tester (ASTM, D-2256-84). Statistical analysis was used for the confidence limit (C.L) according to Senedecor and Cochran (1976):

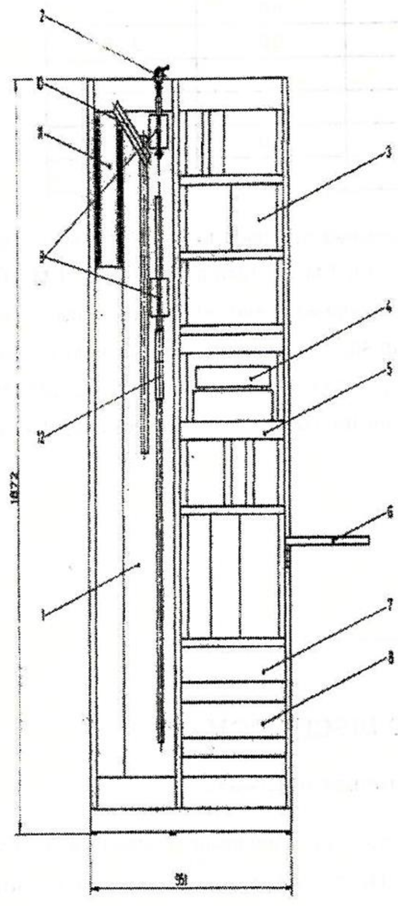
$$\text{Confidence limit (C.L)} = \frac{1.96 \text{ X S.D}}{\sqrt{n}}$$

$$\text{Degree of precision (E)\%} = \frac{\text{C.L}}{\text{average } (\bar{x})} \text{ X } 100$$

RESULTS AND DISCUSSION

1. Determination of the suitable number of breaks

Because of the high capital and running costs of the tester and the limited number of tests which could be carried out per day, it is of paramount importance to carry out the minimum number of breaks from each test sample and at the same time maintaining the degree of accuracy at a suitable level. Therefore, this investigation was carried out for the purpose of the determination of the required number of breaks for a specified test sample at a specified degree of precision. The actual 40s and 60s ring and 40s open-end yarn counts were tested on the Zwick 1511 automatic tensile tester taking 20, 40, 60 and 80 breaks to determine the most suitable number of breaks. The abnormal breaks or bias results of yarn strength within the predetermined number of



1. reaction unit
2. load cell
3. measurement and control cabinet
4. printer with paper holder
5. pull-out drawer
6. swiveling table plate
7. drawer for accessories
8. drawer for fiber remnants
9. specimen holder
10. clamping arm
11. changing device
12. cover

Figure 2. the Zwick 1511 tester.

breaks were discarded and the results were recalculated according to the statistical analysis of Zwick-1511.

Table (2) shows the confidence limits and degrees of precision for number of breaks according to different spinning systems and yarn counts after recalculating the average value of yarn strength C.V. It is important to mention that increasing the number of breaks improves the degree of precision, and it was found that 40 breaks sample size was more acceptable number of tests and optimum for degree of precision since the change form 40 breaks to 60 breaks was lower than the change from 20 to 40 breaks, and also for saving time of test.

Table 2. The degree of precision for number of breaks according to different spinning systems and yarn counts.

No. of	40s R.S				40s O.E				60s R.S			
breaks	St. cN/tex	C.V (%)	C.L cN/tex	E (%)	St. cN/tex	C.V (%)	C.L cN/tex	E (%)	St. cN/tex	C.V (%)	C.L cN/tex	E (%)
20	21.3	9.27	0.86	4.06	14.03	11.00	0.68	4.84	19.46	10.60	0.83	4.25
40	21.9	9.01	0.61	2.88	15.59	9.56	0.36	2.32	20.03	8.83	0.52	2.59
60	22.4	8.61	0.49	2.29	15.11	7.48	0.29	1.89	20.08	8.19	0.49	2.43
80	22.7	8.42	0.42	1.97	14.62	7.47	0.24	1.61	20.86	7.90	0.45	2.16

St = strength cN/tex

CL = Confidence limit

E = Degree of precision

2. Determination of the most suitable test speed for different yarn counts

According to ASTM (D-2256-84) the tensile test speed should be within (20±3) second. Table (3) and figure (3) showed significant differences between yarn count due to changing in test speeds. Decreasing test speed (increasing breaking time) caused a general trend of decrease in single yarn strength, elongation and toughness also the magnitudes of differences in yarn strength due to increasing breaking time were more sizable than those differences in yarn elongation.

According to these results, it was found that speed (70 mm/min) is the suitable speed for fine counts (60 - 120) and speeds (80-90 mm/min) for medium counts (30-

40) these results are clearly shown in fig.(3) and also are in agreement with ASTM (D-2256-84).

Table 3. Relationship between test speed and time at break for different counts.

Yarn Count	Speed mm/min	Time sec.	Strength cN/tex	Elongation %	Toughness cN/tex
120s	50	23.5	16.20	3.94	0.32
	60	21.9	18.40	4.23	0.39
	70	21.5	18.75	4.33	0.41
100s	60	21.5	17.45	4.30	0.38
	70	19.3	18.15	4.35	0.39
	80	16.4	18.20	4.48	0.41
80s	60	24.3	20.60	4.67	0.48
	70	20.00	20.80	4.73	0.49
	80	17.00	21.00	4.86	0.51
60s	70	20.70	20.20	4.84	0.49
	80	18.60	21.70	4.92	0.53
	90	16.43	22.91	4.96	0.54
40s	70	23.80	21.50	5.51	0.59
	80	20.80	21.80	5.57	0.61
	90	19.00	22.30	5.64	0.63
	100	17.00	22.60	5.67	0.64
30s	70	24.00	22.20	5.51	0.61
	80	22.40	23.50	6.04	0.71
	90	20.40	24.10	6.08	0.73
	100	18.10	24.50	6.21	0.76

3. The effect of actual and nominal yarn counts

According to operating system of (Zwick-1511 instrument) the nominal yarn count is input, which means that the required load to break depends on the nominal yarn count not the actual one. If the yarn count variation is within ±3%, there is slight difference. On the other hand, if the variation is more than 10%, the results show significant differences. The results in table (4) showed the differences between the actual and nominal yarn counts and their effects on the single yarn strength and elongation results.

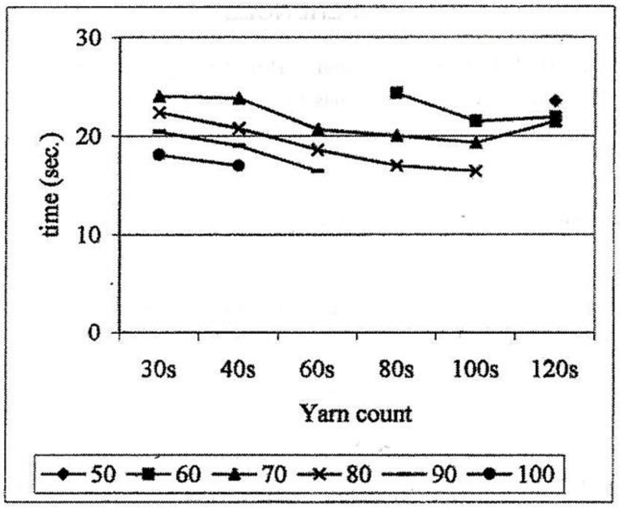


Figure 3. Test speeds and time to break for different yarn counts.

Table 4. Single yarn strength and elongation as affected by using nominal and actual yarn count as yarn count inputs.

	Count	Strength cN/tex	Elongation %	F -max N.	Time Sec.
Nominal (-16%)	25s	18.79	6.41	2.6	21.4
Nominal (-5%)	28.5	20.88	6.39	2.5	21.4
Actual	30s	21.22	6.22	2.4	20.8
Nominal (+5%)	31.5	21.79	6.30	2.5	21.4
Nominal (+16%)	35s	24.79	6.30	2.6	21.2

It is also clear from table (4) that the strength results based on nominal count input deviate substantially from strength values when actual count is used, according to the yarn count variation. Under the actual conditions of spinning testing procedure of small samples (60 gram spinning technique) substantial variation in yarn count are usually encountered. Therefore, determination of the actual yarn count is necessary. Therefore it is concluded that it is important to determine the actual count before testing yarns on Zwick 1511.

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دراسة بعض المتغيرات الاختبارية على جهاز ZWICK-1511 لقياس متانة الخيوط

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أجريت هذه الدراسة بهدف تحديد المتغيرات الاختبارية لقياس المتانة على جهاز ZWICK-1511 وهى تحديد عدد القطعات اللازمة لاختبار العينة وتحديد سرعة الاختبار المناسبة للنمر المختلفة وكذلك دراسة تأثير النمرة الفعلية والاسمية على المتانة. وقد استخدم لهذه الدراسة صنف القطن الفائق الطول جيزة ٨٨ وتم غزله إلى ٦ نمر ممشطة مختلفة وهى (٣٠،٤٠،٦٠،٨٠،١٠٠-١٢٠) بمعامل برم ٣,٦ . تم تحديد النمرة الفعلية لجميع الخيوط قبل اختبارها على الجهاز .

أظهرت نتائج الدراسة أن عدد قطعات ٤٠ يعطى درجة دقة مناسبة وكذلك يوفر الوقت وذلك بالنسبة للنمر المختلفة ونظم الغزل المختلفة .وقد وجد أيضا أن السرعة ٧٠ تناسب النمر الرفيعة من (٦٠-١٢٠) بينما السرعة (٨٠-٩٠) تناسب النمر المتوسطة (٣٠-٤٠) وأظهرت النتائج أيضا انه لابد من تحديد النمرة الفعلية للخيوط قبل اختبارها على الجهاز نظرا لاختلاف النتائج تبعا لتغير النمرة الفعلية عن النمرة الاسمية.