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# THE EFFECT OF GAUGE LENGTH AND RATE OF LOADING ON THE TENSILE PROPERTIES PART 2: COMBED COTTON YARNS

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ABSTRACT

Seven combed yarns (6-16 tex) under different operating condition from Giza 75 with 15% percentage combing were produced. The tensile properties of these yarns (Strength & Elongation) were determined under different testing conditions of rate of loading or time of break and specimen length. Two different experimental designs for testing conditions were applied. The specimen length was carried in the study as a control factor concerning the regressions abilities. Different regression equations were attained from experimental data. The Quadratic relation for the strength and elongation give the most representative regression for the obtained results. Rate of loading have a -ve effect on yarn strength and +ve effect on percentage elongation. The decrease of breaking time from 442 to 0.33 second tend to decrease the mean yarn strength by about 28% and increase the mean percent elongation by about 19%, depending on the equilibrium of realigned fibers & the percentage of the ruptured fibers.

## NOMENCLATURE

$X_1$ = Rate of loading cm/min
$X_2$ = Gauge length in cm
$X_3$ = Time of break in seconds
$W_i$ = Transformation of $X_i$ factors
$A_0$, $A_i$, $A_{ij}$ = Parameters of the regression equations
$B_0$, $B_{11}$, $B_{22}$ = Coefficients of the conical equations
= Parameter of the transferred coordinate axis
$Z_1$, $Z_2$ = The center of the response surface

## INTRODUCTION

The yarn tensile properties, strength, elongation and their variabilities are considered as the most important characteristic influencing the successive textile applications and processes. The number of tests needed for detecting the tensile properties at a higher precision are time consuming, therefore there are always a tendency of carrying a lower number of tests which can lead to untrue conclusions. For increasing the accuracy of strength determination a new trend which consists of increasing the number of experimentations from 50 readings to 150 with the decrease of breaking time from 20 seconds ± 2 sec. to 1/3 - 5 seconds. The effect of rate of loading on cotton yarns have been studied by many investigators [1-7], while no unique conclusion have been attained in these works.

It was decided that the breaking load is inversely proportional to the logarithm of the time to break the yarn [1-4], so that at higher speed of loading a higher maximum force can be attained. While [6,7] determined that for higher speed of loading, a lower force can be attained in most tested condition and the relation is not in a logarithm form. The effect of Gauge length on tensile strength is adequately explained by the weak link theory proposed by Pierce [6] and the strength of yarn is inversely proportional to the Gauge length. Early all the work concerning the effect of rate of loading on yarn strength were carried out using the carded cotton yarns. It is important to carry such work on spun combed cotton yarn, this will permit the application of the results especially when comparing the results or studying different technological features also when introducing standards for yarn mechanical properties or Mill Quality Control levels.

The aim of this work consists of studying the effect of rate of loading & gauge length on yarn strength & elongation of Egyptian combed yarns. Also the determination of most suitable regression which can represent the experimental data. For that, seven yarns ranging from (6-16 tex) were produced in two testing experimental designs were applied on the Instron 1151, with rate of loading ranging from 1 cm/min to 900 cm/min while gauge length changes from 10 cm to 90 cm. Different factor transformations were applied for determining the most suitable regression relation.

## EXPERIMENTAL PROCEDURE

Combed cotton yarns, processed through normal cotton fibre spinning system, combed at 15%, were obtained. Different yarn count were obtained ranging from 6.0 to 16 tex, with twist factor equal to 3.77 ± 0.07 depending on the allowed gear train. The cotton fibre was Giza 75 with the physical properties shown in table (1). The dimensional properties of yarn are shown in table (2).

TABLE (1)

COTTON FIBER PROPERTIES

| Cotton Grade | Length | | | | Fineness | | Strength | |
|---|---|---|---|---|---|---|---|---|
| | Staple length | 2.5% mm | 50% mm | Uniform. ratio % | Micronaire reading | millitex | Tenacity g/tex | El. % |
| G/FG | 32.3 | 29.5 | 14.6 | 48.3 | 4.6 | 163 | 30.2 | 6.1 |

TABLE (2)

DIMENSIONAL PROPERTIES OF YARNS

| Property | Yarn No. 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Count tex | 15.84 | 11.05 | 9.23 | 8.42 | 7.54 | 6.57 | 5.95 |
| C.V.Count % | 2.9 | 2.2 | 2.1 | 2.6 | 2.9 | 2.7 | 2.5 |
| Twist T/mt | 905.5 | 1074.8 | 1165.4 | 1240.2 | 1342.5 | 1381.9 | 1452.8 |
| C.V.Twist % | 2.75 | 3.1 | 3.1 | 3.8 | 2.9 | 3.3 | 4.1 |
| T.F. | 3.77 | 3.74 | 3.7 | 3.76 | 3.84 | 3.7 | 3.7 |

The yarn strength and elongation were determined on the Instron 1151. Two experimental designs for the two factors under study (rate of loading, Gauge length) were applied, which is shown in table (3).

TABLE (3)

DIFFERENT EXPERIMENTAL DESIGNS USED IN THE STUDY

| SET | | Exp. No. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | TEX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | x1 | 90 | 70 | 50 | 40 | 90 | 50 | 30 | 10 | 50 | 50 | 10 | 90 | 20 | 10 | -- | -- | -- | 15.84 |
| | | | | | | | | | | | | | | | | | | | 11.05 |
| | x2 | 900 | 900 | 900 | 430 | 30 | 30 | 300 | 30 | 9 | 4 | 4 | 1 | 1 | 1 | -- | -- | -- | 7.54 |
| II | x1 | 10 | 10 | 10 | 10 | 10 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | |
| | | | | | | | | | | | | | 10 | 700 | -- | -- | -- | -- | 5.95 |
| | x2 | 80 | 10 | 50 | 3 | 1 | 70 | 30 | 20 | 5 | 3 | 1 | 10 | 200 | 500 | -- | -- | -- | 8.42 |
| | | | | | | | | | | | | | 15 | 200 | 100 | 50 | 17 | 7 | 9.23 |
| | | | | | | | | | | | | | 15 | 200 | 100 | 50 | 17 | 7 | 6.57 |

## RESULTS & DISCUSSION

The mean value of strength, percentage elongation & time to break the yarn are shown in table (4). Two regressions of the following forms were proposed for the obtained data.

TABLE (4)

EXPERIMENTAL RESULTS FOR DIFFERENT YARNS

| FIRST EXPERIMENTAL DESIGN | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T E X ***> | | | 5.95 | | | | 9.23 | | | | 8.4 | | | | 6.5 | | | |
| Sp. cm/m. | L. cm | No. Ob. | Time Sec | Str. RKM | % El. | Work Done | Time Sec | Str. RKM | % El. | Work Done | Time Sec | Str. RKM | % El. | Work Done | Time Sec | Str. RKM | % El. | Work Done |
| 80 | 10 | 50 | 1 | 14.96 | 8.45 | 63.20 | 0.33 | 22.18 | 8.08 | 89.60 | 0.6 | 14.96 | 7.5 | 56.12 | 0.66 | 21.61 | 7.8 | 84.29 |
| 10 | 10 | 50 | 4.3 | 19.45 | 5.93 | 57.66 | 4 | 27.38 | 6.84 | 93.63 | 3.3 | 20.78 | 5.8 | 60.27 | 3 | 21.26 | 5.6 | 59.54 |
| 5 | 10 | 50 | 6.3 | 19.55 | 5.52 | 53.95 | 7.6 | 25.35 | 6.57 | 83.28 | 7 | 20.90 | 5.9 | 61.66 | 7.3 | 21.14 | 5.6 | 59.20 |
| 3 | 10 | 50 | 4.6 | 20.24 | 5.43 | 54.94 | 12.3 | 24.99 | 6.8 | 84.98 | 10.3 | 18.41 | 5.5 | 50.62 | 4.3 | 21.17 | 5.5 | 58.22 |
| 1 | 10 | 50 | 35 | 19.93 | 5.86 | 58.40 | 34.7 | 24.49 | 5.88 | 71.99 | 32 | 16.98 | 5.5 | 46.70 | 35.7 | 20.85 | 5.6 | 58.39 |
| 700 | 50 | 50 | 1 | 14.12 | 6.33 | 44.68 | | | | | | | | | | | | |
| 70 | 50 | 50 | 2 | 17.09 | 4.86 | 41.53 | 2.3 | 19.75 | 5.77 | 56.98 | 2 | 17.54 | 5.1 | 44.73 | 2 | 19.54 | 4.7 | 45.93 |
| 30 | 50 | 50 | 4.7 | 18.32 | 4.71 | 43.14 | 5 | 21.39 | 5.41 | 57.85 | 4.6 | 19.88 | 5.1 | 50.70 | 5 | 20.70 | 4.8 | 49.68 |
| 20 | 50 | 50 | 6.6 | 17.92 | 4.13 | 37.00 | 7.3 | 21.74 | 5.41 | 58.82 | 7.6 | 20.26 | 5 | 50.65 | 6.6 | 19.70 | 4.6 | 45.30 |
| 10 | 50 | 50 | 12.6 | 18.91 | 4.31 | 40.75 | 15.7 | 21.71 | 5.11 | 55.47 | 17.3 | 21.41 | 5.1 | 54.60 | 13.6 | 18.68 | 4.6 | 42.95 |
| 5 | 50 | 50 | 25.6 | 18.72 | 4.52 | 42.31 | 27.5 | 21.09 | 5.23 | 55.16 | 33.3 | 22.21 | 5.2 | 57.74 | 29 | 17.91 | 4.7 | 42.10 |
| 3 | 50 | 50 | 41 | 17.82 | 4.38 | 39.02 | 48.3 | 21.12 | 4.81 | 50.78 | 57.3 | 21.66 | 5.2 | 56.32 | 46.3 | 17.00 | 4.5 | 38.25 |
| 1 | 50 | 20 | 129 | 14.62 | 4.05 | 29.61 | 145 | 20.41 | 5.12 | 52.25 | 164.7 | 20.82 | 5 | 52.05 | 137 | 16.65 | 4.4 | 36.63 |
| 200 | 50 | 50 | | | | | 0.66 | 18.31 | 5.88 | 53.83 | 1 | 15.43 | 5.4 | 41.65 | 1 | 18.78 | 5.5 | 51.65 |
| 100 | 50 | 50 | | | | | 1.7 | 19.14 | 5.6 | 53.60 | | | | | 1.6 | 19.44 | 5 | 48.59 |
| 50 | 50 | 50 | | | | | 3 | 20.52 | 5.34 | 54.79 | | | | | 3.3 | 20.24 | 4.9 | 49.60 |
| 15 | 50 | 50 | | | | | 9.3 | 21.96 | 5.33 | 58.53 | | | | | 9.6 | 19.03 | 4.9 | 46.61 |
| 7 | 50 | 50 | | | | | 23.3 | 21.31 | 5.28 | 56.26 | | | | | 20 | 18.26 | 4.5 | 41.10 |
| 500 | 50 | 50 | | | | | | | | | | | | | | | | |
| MEAN | | | 21.1 | 17.82 | 5.27 | 46.63 | 20.47 | 21.93 | 5.79 | 63.99 | 26.23 | 19.33 | 5.5 | 52.60 | 19.17 | 19.53 | 5.1 | 50.47 |
| S.D. | | | 33.7 | 1.98 | 1.17 | 9.58 | 33.77 | 2.29 | 0.81 | 14.09 | 43.10 | 2.32 | 0.6 | 5.72 | 32.20 | 1.47 | 0.8 | 10.98 |

TABLE (4) cont.

EXPERIMENTAL RESULTS FOR DIFFERENT YARNS

| SECOND EXPERIMENTAL DESIGN | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T E X ***> | | | 15.8 | | | | 7.54 | | | | 11.0 | | | |
| Sp. cm/m. | L. cm | No. Ob. | Time Sec | Str. RKM | % El. | Work Done | Time Sec | Str. RKM | % El. | Work Done | Time Sec | Str. RKM | % El. | Work Done |
| 900 | 70 | 50 | 0.67 | 16.36 | 9.8 | 80.15 | 0.67 | 11.29 | 9.6 | 54.18 | 0.33 | 11.18 | 5.5 | 30.74 |
| 900 | 50 | 50 | 0.33 | 16.63 | 10.9 | 90.63 | 0.33 | 12.57 | 10.3 | 64.75 | 0.33 | 13.03 | 10.3 | 67.11 |
| 900 | 90 | 50 | 0.67 | 15.67 | 9.1 | 71.29 | 0.67 | 10.78 | 8.3 | 44.75 | 0.33 | 10.45 | 7.6 | 39.72 |
| 430 | 40 | 50 | 0.67 | 16.82 | 9.2 | 77.36 | 1.00 | 13.53 | 8.3 | 56.14 | 0.66 | 14.27 | 7.7 | 54.95 |
| 30 | 10 | 50 | 2 | 27.58 | 9.9 | 136.50 | 1.66 | 22.63 | 6.8 | 76.93 | 0.66 | 20.50 | 7.6 | 77.89 |
| 30 | 30 | 50 | 6.33 | 26.81 | 8.9 | 119.31 | 3.20 | 22.23 | 5.6 | 62.24 | 4 | 22.25 | 6.4 | 71.21 |
| 30 | 50 | 50 | 8.33 | 23.73 | 8.2 | 97.30 | 5.30 | 21.39 | 5.5 | 58.83 | 6.33 | 21.16 | 6.5 | 68.76 |
| 30 | 90 | 50 | 14.33 | 23.45 | 8.0 | 93.81 | 9.30 | 20.72 | 5.2 | 53.86 | 7.66 | 19.45 | 6.3 | 61.26 |
| 9 | 50 | 50 | 27.3 | 23.04 | 7.6 | 87.56 | 16.70 | 20.61 | 5.3 | 54.62 | 17.7 | 21.39 | 5.5 | 58.83 |
| 4 | 10 | 50 | 14 | 26.42 | 9.1 | 120.21 | 7.00 | 21.96 | 6.2 | 68.08 | 12 | 24.25 | 7.1 | 86.10 |
| 4 | 50 | 50 | 64 | 22.14 | 7.6 | 84.13 | 28.30 | 20.34 | 5 | 50.86 | 43.7 | 21.11 | 5.6 | 59.12 |
| 1 | 10 | 50 | 58 | 27.39 | 9.8 | 134.19 | 36.70 | 23.32 | 6.2 | 72.28 | 44.7 | 24.43 | 7.2 | 87.96 |
| 1 | 20 | 20 | 107.7 | 23.40 | 8.8 | 102.97 | 70.30 | 20.21 | 5.1 | 51.54 | 79.3 | 21.90 | 6.5 | 71.18 |
| 1 | 90 | 50 | 442 | 22.94 | 7.8 | 89.45 | 253.30 | 17.07 | 4.8 | 40.97 | 325 | 17.53 | 5.2 | 45.58 |
| MEAN | | | 53.31 | 22.31 | 8.91 | 98.92 | 31.03 | 18.47 | 6.59 | 57.86 | 38.76 | 18.78 | 6.79 | 62.89 |
| S.D. | | | 112.1 | 4.12 | 0.95 | 20.10 | 64.49 | 4.34 | 1.75 | 9.76 | 82.53 | 4.53 | 1.27 | 15.92 |

a- Straight line:

$$y = A_0 + \sum_{i=1}^{2} A_i x_i \qquad (1)$$

b- Quadratic relation:

$$y = A_0 + \sum_{i=1}^{2} A_i x_i + \sum_{i=1}^{2} \sum_{j \geq i}^{2} A_{ij} x_i x_j \qquad (2)$$

## 1. The effect of Gauge length and Rate of loading:

The effect of the Gauge length and rate of loading on the results obtained for the seven yarns were studied. The following are the results obtained:

### 1.1. Time of break:

The regression equations for the seven response surfaces are shown in table (5). It can be decided that the proposed regressions fail to describe the phenomena since $R^2$ are within the range of (0.22-0.52), DATA I, which are non-significant. This can be due to the fact that the error in time determination is about 0.33 second which is considerably high for low breaking time. For that, results for time lesser than 4 minutes are eliminated and the coefficients of regression are obtained, DATA II,which is 90% significant for the first set of experiment and 99% for the second set. DATA III represents the regressions for the first experimental design with gauge length 50 cm. No defined conclusion can be decided.

### 1.2 Yarn Strength:

Four different transformations of $x_i$ were applied and are shown in table (6).

TABLE (5)
REGRESSION EQUATIONS CONCERNING DIFFERENT RESPONSE SURFACES
CHARACTERIZING THE DEPENDENCE OF BREAKING TIME ON
GAUGE LENGTH & RATE OF LOADING

| TYPE OF REG. | DATA | EXP. SET | TEX | COEFFICIENTS OF REGRESSION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A0 | A1 | A2 | A12 | A11 | A22 | R^2 | Mean R | SSE |
| QUADRATIC | I | I | 9.2 | 18 | -3.2 | 11 | -0.23 | 0.05 | | 0.52 | | 31 |
| | | | 8.4 | 14 | -2.9 | 12 | 0.18 | 0.008 | | 0.44 | 0.59 | 43 |
| | | | 6.7 | 32 | -6.4 | 4.8 | -0.43 | 0.33 | | 0.23 | | 34 |
| | | | 6 | 8.9 | -0.16 | 7.1 | -0.14 | 0.001 | | 0.27 | | 36 |
| | | II | 15.8 | 68 | -0.11 | -30 | -0.06 | 0.0004 | 4.9 | 0.45 | | 110 |
| | | | 11 | 52 | -0.07 | -23 | -0.04 | 0.0003 | 4.1 | 0.44 | 0.67 | 61 |
| | | | 7.5 | 43 | -0.07 | -19 | -0.03 | 0.0003 | 3.3 | 0.45 | 0.62 | 64 |
| | II | I | 9.2 | 23 | -7.7 | 17 | -0.66 | 0.3 | | 0.7 | | 29 |
| | | | 8.4 | 9.1 | -4.9 | 24 | -2 | 0.37 | | 0.75 | 0.84 | 33 |
| | | | 6.7 | 28 | -9.4 | 15 | -1.4 | 0.61 | | 0.57 | | 32 |
| | | | 6 | 24 | -9.5 | 20 | -2.2 | 0.74 | | 0.85 | | 26 |
| | | II | 15.8 | 74 | -19 | 3.9 | -1.9 | 0.71 | 4.4 | 0.98 | | 34 |
| | | | 11 | 62 | -14 | -0.8 | -1.4 | 0.53 | 3.4 | 0.98 | 0.89 | 27 |
| | | | 7.5 | 52 | -12 | -0.8 | -1.1 | 0.43 | 2.6 | 0.96 | 0.8 | 25 |
| | III | I | 9.2 | 110 | -12 | | | 0.3 | | 0.68 | | 32 |
| | | | 8.4 | 130 | -15 | | | 0.37 | | 0.71 | 0.78 | 42 |
| | | | 6.7 | 100 | -17 | | | 0.66 | | 0.51 | | 34 |
| | | | 6 | 100 | -18 | | | 0.69 | | 0.54 | | 41 |
| STRAIGHT | II | I | 9.2 | 17 | -3 | 11 | | | | 0.43 | | 34 |
| | | | 8.4 | 15 | -3.5 | 15 | | | | 0.53 | 0.46 | 38 |
| | | | 6.7 | 21 | -3.8 | 8.6 | | | | 0.35 | | 34 |
| | | | 6 | 19 | -4.6 | 12 | | | | 0.54 | | 33 |
| | | II | 15.8 | 28 | -7 | 31 | | | | 0.65 | | 96 |
| | | | 11 | 79 | -28 | 23 | | | | 0.79 | 0.68 | 60 |
| | | | 7.5 | 18 | -4 | 18 | | | | 0.62 | 0.58 | 57 |

Two regressions were proposed for these transformations.
Straight line

$$y = A_0 + \sum_{i=1}^{2} A_i W_i \qquad (3)$$

Quadratic relation

$$y = A_0 + \sum_{i=1}^{2} A_i W_i + \sum_{i=1}^{2} \sum_{j \geq i}^{2} A_{ij} W_i W_j \qquad (4)$$

TABLE (6)

DIFFERENT FACTOR TRANSFORMATIONS

| Transformed factor | TYPE I | II | III | IV |
|---|---|---|---|---|
| $W_1$ | $x_1$ | $\ln x_1$ | $x_3$ | $\ln x_3$ |
| $W_2$ | $x_2$ | $\ln x_2$ | $x_2$ | $\ln x_2$ |

The conical equation for the Quadratic relation were obtained which is in the following form :

$$y = B_0 + B_{11} W_{11} + B_{22} W_{22} \qquad (5)$$

The new coordinates are: $W_2 - \lambda W_1 = 0$, $\lambda W_2 + W_1 = 0$
(6)

Regression results are shown in table (7), from which it can be decided:

1- The straight line relation failed to attain a significant regression in 21% of the proposed relation.

TABLE (7)

REGRESSION EQUATIONS FOR DIFFERENT RESPONSE SURFACES CONCERNING THE DEPENDENCE OF YARN TENSILE PROPERTIES ON
a- GAUGE LENGTH & RATE OF LOADING

| FACTOR | FT | PROP | TEX | QUADRATIC RELATION COEFFICIENTS OF REGRESSION | | | | | | | | COEFFICIENTS OF CONICAL EQUATION | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A0 | A1 | A2 | A12 | A11 | A22 | R^2 | SSE | Z1 | Z2 | B0 | B11 | B22 | λ |
| LOADING RATE & GAUGE LENGTH | WITHOUT | STR | 15.8 | 453 | -0.35 | -25.20 | -0.0035 | -0.0003 | 1.80 | 0.92 | 24.0 | -676.4 | 6.3 | 490.0 | -0.0003 | 1.80 | 0.001 |
| | | | 11.0 | 173 | -0.27 | -9.16 | 0.0000 | 0.0002 | 0.18 | 0.98 | 10.3 | 742.3 | 25.2 | -41.4 | 0.0002 | 0.18 | 0.000 |
| | | | 7.5 | 173 | -0.18 | -2.92 | 0.0006 | 0.0001 | -0.02 | 0.93 | 11.2 | 917.6 | -52.3 | 167.6 | 0.0001 | -0.02 | 0.012 |
| | | | 9.2 | 247 | -0.45 | -9.74 | 0.0519 | 0.0002 | | 0.90 | 8.2 | 187.7 | 7.4 | 169.0 | | | |
| | | | 8.4 | 160 | -0.50 | 4.06 | 0.0319 | 0.0003 | | 0.88 | 11.5 | -127.3 | 18.4 | 229.3 | | | |
| | | | 6.7 | 143 | 0.14 | -5.12 | 0.0374 | -0.0015 | | 0.78 | 5.4 | 136.9 | 7.4 | 133.4 | | | |
| | | | 6.0 | 123 | -0.48 | -3.71 | 0.0987 | -0.0001 | | 0.76 | 7.6 | 37.6 | 4.9 | 105.0 | | | |
| | | ELO | 15.8 | 10 | 0.004 | -0.80 | -0.0005 | 0.00000 | 0.06 | 0.94 | 0.3 | -146.6 | 6.2 | 7.6 | 0.0000 | 0.06 | 0.004 |
| | | | 11.0 | 8 | 0.01 | 0.79 | 0.0008 | 0.00000 | 0.06 | 0.64 | 1.0 | 553.2 | -10.0 | 6.2 | 0.0000 | 0.06 | 153.4 |
| | | | 7.5 | 7 | 0.00 | -0.42 | -0.0005 | 0.00001 | 0.03 | 0.96 | 0.4 | 354.9 | 11.0 | 3.8 | 0.0000 | 0.03 | 0.009 |
| | | | 9.2 | 7 | 0.03 | -0.33 | -0.0035 | -0.00003 | | 0.94 | 0.2 | -92.1 | 9.1 | 4.0 | | | |
| | | | 8.4 | 6 | 0.03 | -0.11 | -0.0064 | 0.00002 | | 0.99 | 0.1 | -16.4 | 4.4 | 5.2 | | | |
| | | | 6.7 | 6 | 0.04 | -0.22 | -0.0062 | 0.00000 | | 0.98 | 0.1 | -34.8 | 5.8 | 4.4 | | | |
| | | | 6.0 | 6 | 0.04 | -0.32 | -0.0069 | -0.00001 | | 0.98 | 0.2 | -45.8 | 6.5 | 3.8 | | | |
| | LOGARITHM | STR | 15.8 | 416 | 25.60 | -70.90 | -0.2250 | -5.8300 | 19.10 | 0.92 | 24.2 | 2.2 | 1.9 | 377.4 | -5.8305 | 19.10 | 0.005 |
| | | | 11.0 | 263 | 16.90 | -27.20 | 2.2400 | -4.8100 | -39 | 0.99 | 7.4 | 1.7 | -0.3 | 281.3 | -4.7734 | -39.0 | 0.033 |
| | | | 7.5 | 166 | 13.80 | -14.90 | 2.7900 | -3.8300 | -1.02 | 0.96 | 8.2 | -1.7 | -9.6 | 226.0 | -0.4451 | -4.40 | 2.426 |
| | | | 9.2 | 272 | 12.60 | -27.50 | 2.3600 | -3.7400 | | 0.94 | 6.3 | 11.7 | 31.6 | -89.0 | | | |
| | | | 8.4 | 150 | 16.40 | 13.50 | -0.8960 | -4.5600 | | 0.94 | 8.0 | 15.1 | -135 | -638 | | | |
| | | | 6.7 | 135 | 6.31 | -17.00 | 2.3800 | -1.1400 | | 0.88 | 3.9 | 7.1 | 4.2 | 121.9 | | | |
| | | | 6.0 | 119 | 2.83 | -17.30 | 6.2100 | -2.1800 | | 0.94 | 3.8 | 2.8 | 1.5 | 110.0 | | | |
| | | ELO | 15.8 | 10 | -0.21 | -1.13 | -0.0785 | 0.0936 | 0.16 | 0.88 | 0.4 | 3.0 | 4.4 | 6.7 | 0.0745 | 0.17 | 0.487 |
| | | | 11.0 | 7 | 0.03 | -0.61 | -0.1080 | 0.0732 | -0.04 | 0.53 | 1.1 | -2.9 | -3.7 | 8.0 | -0.0611 | 0.09 | 2.487 |
| | | | 7.5 | 6 | -0.36 | -1.66 | 0.0571 | 0.1230 | 0.64 | 0.75 | 1.1 | 1.2 | 1.3 | 5.1 | 0.1214 | 0.64 | 17.99 |
| | | | 9.2 | 6 | 0.36 | -0.62 | -0.2040 | 0.0242 | | 0.97 | 0.2 | -3.1 | 1.0 | 5.1 | | | |
| | | | 8:4 | 6 | -0.44 | -0.12 | -0.2340 | 0.2000 | | 0.76 | 0.7 | -0.5 | -2.7 | 6.0 | | | |
| | | | 6.7 | 5 | 0.20 | -0.34 | -0.2670 | 0.0741 | | 0.92 | 0.3 | -1.3 | 0.0 | 5.1 | | | |
| | | | 6.0 | 5 | 0.22 | -0.52 | -0.3290 | 0.0945 | | 0.93 | 0.4 | -1.0 | 0.1 | 5.2 | | | |

TABLE (7) CONT.

REGRESSION EQUATIONS FOR DIFFERENT RESPONSE SURFACES CONCERNING THE DEPENDENCE OF YARN TENSILE PROPERTIES ON

b- GAUGE LENGTH & TIME OF BREAK

| FACTOR | F.T | PROP | TEX | QUADRATIC RELATION — COEFFICIENTS OF REGRESSION | | | | | | | | COEFFICIENTS OF CONICAL EQUATION | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A0 | A1 | A2 | A12 | A11 | A22 | R^2 | SSE | Z1 | Z2 | B0 | B11 | B22 | λ |
| TIME & GAUGE LENGTH | WITHOUT | STR | 7.5 | 194 | 0.29 | -24.50 | 0.5430 | -0.0199 | 1.45 | 0.73 | 22.7 | 34.4 | 2.0 | 174.4 | 1.4985 | -0.07 | 5.593 |
| | | | 11.0 | 307 | 0.23 | -40.00 | 0.5810 | -0.0178 | 2.30 | 0.80 | 31.0 | 48.4 | 2.6 | 260.9 | 2.3359 | -0.05 | 8.102 |
| | | | 6.7 | 144 | -0.14 | -2.56 | -7.9300 | 0.0028 | | 0.91 | 3.4 | -0.3 | 0.0 | 144.0 | | | |
| | | ELO | 7.5 | 6 | -0.04 | 0.50 | -0.0258 | 0.0010 | -0.02 | 0.52 | 1.6 | 19.0 | 0.1 | 5.6 | -0.0290 | 0.01 | 2.329 |
| | | | 11.0 | 8 | -0.02 | 0.02 | -0.0102 | 0.0004 | -0.01 | 0.39 | 1.3 | 4.2 | -1.6 | 7.5 | -0.0086 | 0.00 | 1.760 |
| | | | 6.7 | 7 | -0.04 | -0.35 | 0.0042 | 0.0001 | | 0.65 | 0.6 | 83.5 | 5.3 | 4.2 | | | |
| | LOGARITHM | STR | 15.8 | 200 | 79.00 | -160 | 16.4000 | -6.6000 | 6.29 | 0.93 | 23.3 | 8.3 | 1.9 | 378.4 | 10.2747 | -10.6 | 2.058 |
| | | | 11.0 | 22 | 77.40 | -80.10 | 9.5900 | -5.8400 | -9.26 | 0.95 | 15.2 | 5.4 | -1.6 | 291.0 | -2.4592 | -12.6 | 0.705 |
| | | | 7.5 | -37 | 64.50 | -48.60 | 5.4700 | -4.8200 | -1.32 | 0.91 | 13.3 | 21.4 | 25.9 | 23.1 | 0.1770 | -6.32 | 1.827 |
| | | | 9.2 | 95 | 45.10 | -55.60 | 4.6400 | -3.5400 | | 0.94 | 6.1 | 9.8 | 5.3 | 169.6 | | | |
| | | | 8.4 | 23 | 41.00 | -42.20 | 7.1500 | -3.0400 | | 0.64 | 19.9 | 6.0 | -0.6 | 159.4 | | | |
| | | | 6.7 | 104 | 13.40 | -4.39 | -0.6850 | -1.1900 | | 0.88 | 4.0 | -6.4 | 41.8 | -30.8 | | | |
| | | | 6.0 | -113 | 64.20 | 1.20 | -0.4750 | -4.3600 | | 0.98 | 2.2 | 2.5 | 88.8 | 21.4 | | | |
| | | ELO | 15.8 | 15 | -1.61 | -0.59 | -0.0707 | 0.1010 | 0.15 | 0.90 | 0.4 | 9.4 | 4.2 | 6.3 | 0.0823 | 0.17 | 0.530 |
| | | | 11.0 | 15 | -2.26 | 0.21 | -0.1310 | 0.1500 | -0.03 | 0.69 | 0.9 | 4.6 | -6.7 | 9.5 | -0.0508 | 0.17 | 3.065 |
| | | | 7.5 | 16 | -2.96 | 0.86 | -0.3480 | 0.2120 | 0.57 | 0.83 | 0.9 | 8.5 | 1.8 | 4.5 | 0.1411 | 0.64 | 0.408 |
| | | | 9.2 | 10 | -0.64 | -1.79 | 0.1470 | 0.0172 | | 0.97 | 0.2 | 21.7 | -0.7 | 3.8 | | | |
| | | | 8.4 | 11 | -1.07 | -0.84 | 0.0952 | 0.0467 | | 0.31 | 1.2 | 8.8 | 2.6 | 5.0 | | | |
| | | | 6.7 | 13 | -1.64 | -1.62 | 0.1420 | 0.0869 | | 0.89 | 0.3 | 11.4 | -2.4 | 5.3 | | | |
| | | | 6.0 | 21 | -3.66 | -0.66 | 0.0407 | 0.2220 | | 0.88 | 0.5 | 16.1 | -85.6 | 19.3 | | | |

F.T. = FACTOR TRANSFORMATION

2- The minimum value of coefficient of correlation is obtained in type III transformation.

3- The standard error of estimation was lesser in case of Quadratic relation than that in Straight line. The ratio between them is minimum (1.06) in type I transformation.

4- The strength of yarn decreased with the increase of gauge length which coincide with the Weak Point Theory. While the yarn strength decreased with the increase of rate of loading or the decrease of breaking time.

5- The type I, II transformations attained better results in Quadratic relation while type I was superior in Straight line regression.

6- The experimental values and expected tenacity for different regressions are shown in figure (1), the Chi-Square test showed no significant difference between type I, II & IV transformations (calculated value = 0.17).

7- The response surfaces and contours concerning the tenacity of two yarns (6 & 11 tex) are shown in figure (2). The X-axis consists of the rate of loading, while the Y-axis represents the gauge length. The yarn tenacity (R.K.M.) is represented by the Z-axis. From figure (2) it is clearly shown that the regression depends on the experimental points, since the tenacity of yarn increased with the increase of rate of loading for 50 cm gauge length till 350 cm/min rate of loading, an approximately constant value to the 500 cm/min rate of loading is followed by a significant decrease in the tenacity to the 900 cm/min rate of loading. The same condition is obtained for 10 and 90 cm gauge length with a significant in the rate of variation.

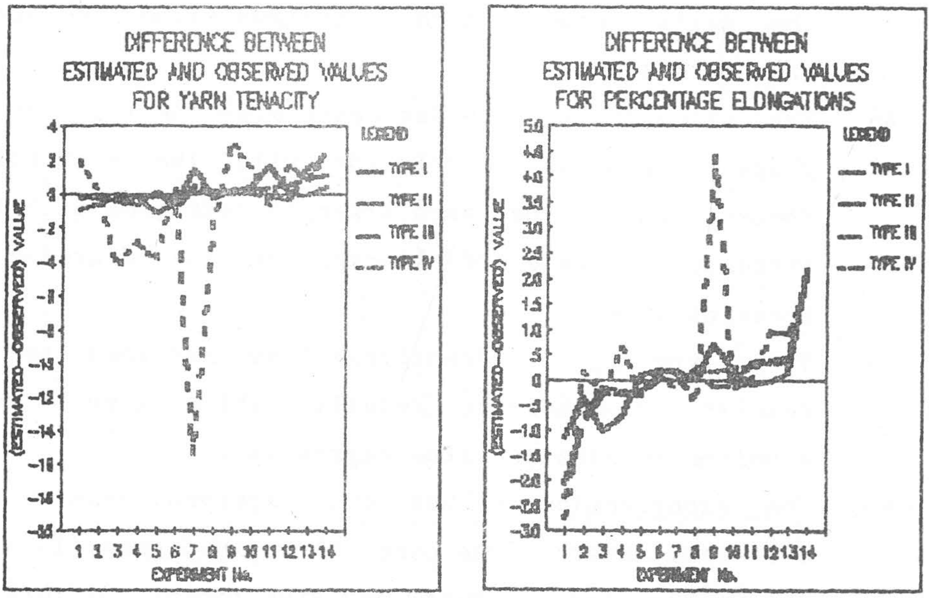


Figure (1)

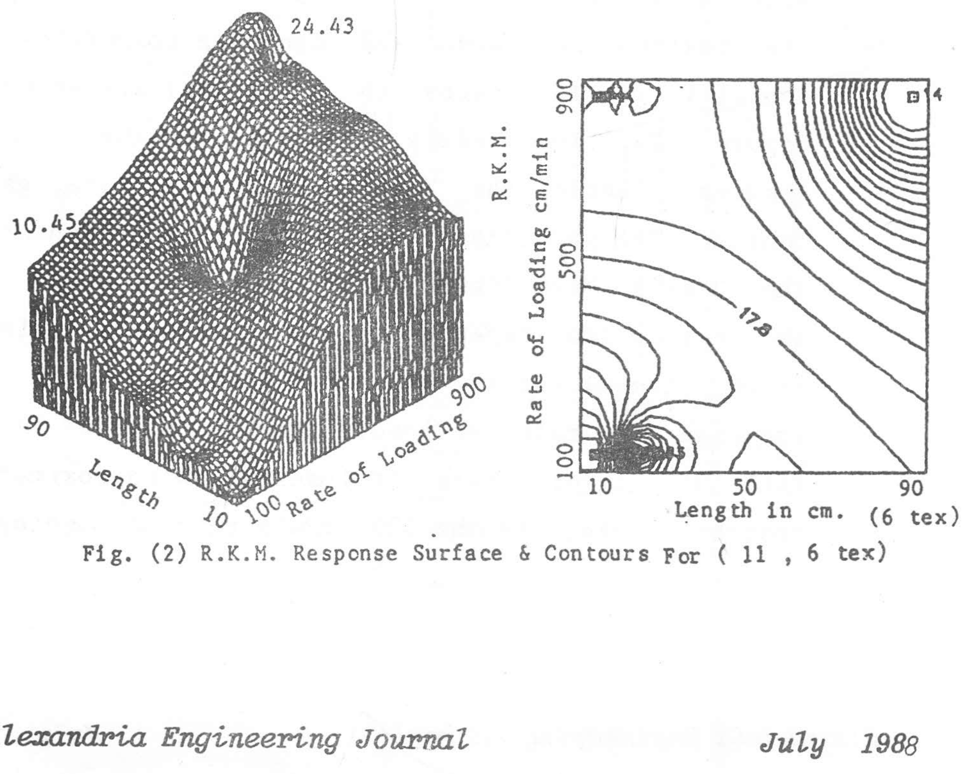


Fig. (2) R.K.M. Response Surface & Contours For ( 11 , 6 tex)

### 1.3 Yarn Elongation

The different regression coefficients are shown in table (7) from which we can point up the following :

1- The Straight line relation failed to attain significant regressions in 33% of the proposed transformations while the Quadratic relation failed in 16.6% only.

2- The type I & II transformations attained a better regression relations with the type I to be superior in Straight line relation.

3- The percent elongation increased with the decrease of gauge length, the increase of rate of loading and the decrease of time to break.

4- The decrease in strength in high rate of loading was accompanied with an increase with the percentage elongation, which maintained an approximately constant work of rupture.

5- Figure (1) shows the observed and expected values values of the percentage elongation which are non-significant for type I, II & IV transformations when tested by the Chi-Square test (calculated value = 0.29).

6- From the response surfaces and contours shown in figure (3) the percent elongation at length 50 cm decrease firstly till 100 cm/min followed a sudden increase specially at 900 cm/min.

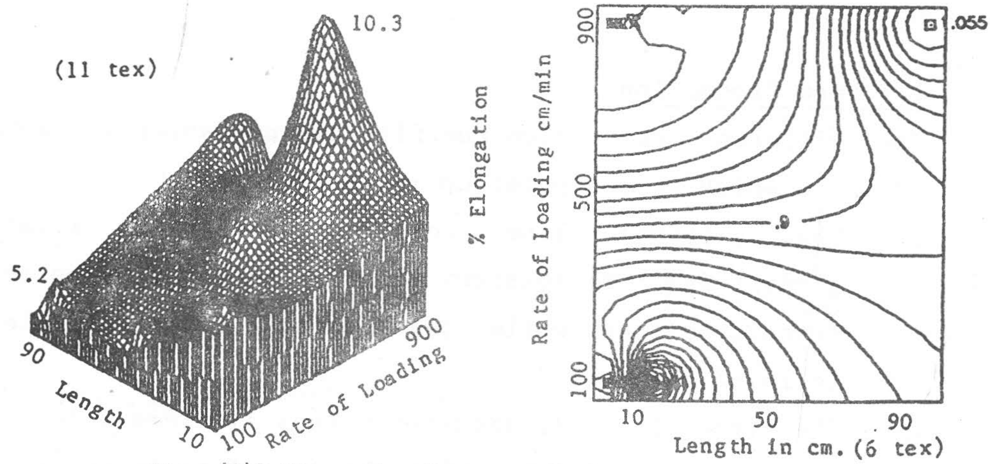


Fig. (3)% Elongation Response Surface & Contours
For ( 11 , 6 tex )

## CONCLUSIONS

1 - The rate of loading has the same effect on yarn strength as the Gauge length.

2 - The straight line relation describe to some extent the effect of rate of loading on yarn strength.

3 - The percentage elongation decrease with the increase of Gauge length while it increases when increasing the rate of loading.

4 - The tenacity of yarn decreases with the increase of the rate of loading, a result which is contrary to many other investigators [1-4] which can be explained by the equilibrium between the fiber realignment which is maximum at low rate of loading and the percentage of ruptured fibers which is maximum at higher rate loading [8].

5 - The error in the breaking time determination has a great influence on the significance of the proposed regression.

6 - The significance of the proposed regression is highly influenced by the design of experiment applied.

7 - The data are highly representative for the following conditions: rate of loading and Gauge length, logarithm (rate of loading and Gauge length) and logarithm (time and Gauge length).

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