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A Study of the Physical Properties of some Commercial South African Cotton Blends and Resultant Carded Yarns

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A STUDY OF THE PHYSICAL PROPERTIES OF SOME COMMERCIAL SOUTH AFRICAN COTTON BLENDS AND RESULTANT CARDED YARNS.

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ABSTRACT

A survey was carried out of the characteristics of 24 cotton blends used and 102 carded yarns spun from these blends by 13 South African mills. The 2,5 per cent span length range of 26,2 mm to 27,8 mm accounted for 67 per cent of the blends, while 79 per cent of the blends had a zero-gauge strength within the range 37,1 to 42,1 gf/tex.

The average strength of the yarns compared very well with the Uster values of similar type carded yarns. The finer yarns (10 – 45 tex) were, however, significantly more irregular and also contained more neps than similar yarns tested by Uster. A Classimat analysis of the yarns showed that the frequencies of the larger and longer size faults were two-and-a-half times that of the Uster median values.

INTRODUCTION

As a consequence of competition within the textile industry the requirements of the weaver and knitter with respect to the quality of yarns are becoming more stringent. Any spinning mill should, therefore, consistantly use all the technological means and quality control techniques at his disposal to improve the quality of his yarns and to maintain it at an acceptable level.

It is indeed very difficult to define an acceptable level of yarn quality, because such a level is amongst many other factors influenced by the desired quality and type of end-product, economical considerations, type of machinery (in spinning, weaving and knitting) and by the quality of the raw material used. The spinner can, therefore, only try to produce the highest quality yarns within his particular organisation. The weaver or knitter of the yarn will always try to bargain for the highest quality yarn spun from the best raw material at the lowest price. In many cases the weaver and knitter (who is the consumer) buys yarn at a negotiated price not knowing what quality of raw material is used. The question, therefore, remains as to what quality of yarn the weaver or knitter can expect and what reasonable minimum quality standards for a particular yarn should be.

There is no straightforward answer to this question. A reasonable solution of this problem is to use average quality standards obtained from the evaluation of a large number of yarns of a particular type and spun under a range of conditions. In the case of cotton yarns such a survey was made by Messrs Zellweger Ltd. (Uster, Switzerland) for yarn irregularity, strength and Classimat grades. The "experience values" quoted are based on an evaluation of yarns collected from all over the world, produced from a wide range of raw materials and spun under widely different conditions. As rightly stated, however,: these values "in no way set binding directives"

It was felt that, since the various Uster experience values have been based mainly on results from tests conducted on overseas yarns, these values may not be entirely applicable to yarns spun under South African conditions. It is known, for instance, that certain yarn faults cannot be ascribed to the raw material but rather to other factors such as operator efficiency, quality of mechanical processing, general quality consciousness, etc. The South African labour force certainly differs from its overseas counterpart in many respects, and the quality of the labour force plays an important role in this respect.

It will be of interest to see how yarns spun under local conditions compare with yarns spun under mainly West European and American (North and South) conditions. The purpose of this investigation was, therefore, to compile information on the physical properties of pure cotton *carded yarns spun in South Africa,* and to compare it, as far as possible, with the Uster experience values.

EXPERIMENTAL

SAMPLING:

During the period March 1973 to May 1975 yarn samples and their corresponding raw cotton samples were collected from 13 South African cotton spinning mills. In this way samples of 24 different cotton blends (mixes), containing mostly only South African cotton, were collected. A total of 102 yarn samples, with a linear density range from 10 tex to 100 tex, were compiled.

The raw cotton samples were drawn at the lap stage. In general approximately 2 or 4 kg of cotton were drawn from 5 or 3 laps each respectively giving a total composite sample of approximately 10 – 12 kg . The *yarn* samples were drawn directly from the ringframes and 15 full cops (in some cases 25) were drawn at random for each linear density (tex) batch. Care was taken to ensure that the samples were as representative as is practically possible under mill conditions.

The yarns were conditioned for at least 48 hours in an atmosphere of 20°C and 65 *per cent* RH before any tests were carried out in the same atmosphere.

IRREGULARITY TESTS:

The irregularity of the yarns was measured on the Uster range of evenness testing equipment. The following settings were used on the different instruments during the tests:

Evenness Tester (Model GGP–B30)

Speed	=	100 m/min.
Range of scale	=	$\pm$ 100%
Test	=	normal

Integrator (Model ITG–Q103)

Evaluating time	=	2,5 min.
Scale	=	$\pm$ 100%

Imperfection Indicator (Model IPI–12–Transistor)

Material	=	cotton
Thin places	=	– 50%
Thick places	=	3
Neps	=	3
Evaluating time	=	2,5 min.

A 2,5 min. test was done on each of 8 bobbins so that a total length of 2 000 m of yarn was tested on each lot. The average of the irregularity (CV %) values obtained on the individual cops was used, whereas the imperfection values were normalised to 1 000 m of yarn.

USTER CLASSIMAT ANALYSES:

All the yarns were evaluated by means of the **Uster Classimat** Fault Classifying Installation[2]. This instrument classifies each yarn fault automatically into one of 16 fault classes (A1 to D4) as listed below:

Length class:

A	:	Faults shorter than 1 cm
B	:	Faults from 1 to 2 cm
C	:	Faults from 2 to 4 cm
D	:	Faults longer than 4 cm

Cross-sectional class:	1 :	+ 100% to + 150%
(in percentage of mean	2 :	+ 150% to + 250%
yarn cross-section)	3 :	+ 250% to + 400%
	4 :	+ 400% and larger

All the yarns spun from each blend (A to Y in Table 1) were combined for the Classimat analysis and the faults in each class normalised to 100 000 metres of yarn. For each of the 24 blends at least 100 000 m of yarn were tested.

TENSILE TESTS:

The single thread breaking strength tests were carried out on an Uster automatic yarn strength tester (constant rate of loading) with 200 tests per lot using 5 cops and 40 tests per cop. The tenacity (gf/tex), extension at break (%) and the coefficient of variation of breaking strength and extension were calculated in the normal manner. A rupture time of 20 $\pm$ 3 s was used throughout the tests (ISO- specification).

The hank strength (lea strength) of the yarns was measured on a James Heal Hank Breaking Tester using hanks of 120 yards with 1,5 yards circumference. The yarn strength is expressed as Count-strength-product (CSP) where the yarn count is the English cotton count and the strength is in pound-force. The average CSP-value of 5 tests (1 test each on 5 cops) is given.

YARN LINEAR DENSITY (Count)

The yarn linear density was obtained from the mass of the 120 yard hanks used for the CSP tests. The average of 5 tests is given throughout.

YARN TWIST:

Twist tests were carried out on a Zweigle Automatic Twist Tester (type D130) employing the double untwist – twist test. The average of 100 tests (20 each from 5 cops) is given.

FIBRE TESTS:

The Micronaire value of the cotton was determined on a Port-Ar instrument, while a Fibrograph Model 330 was used to determine the 2,5 *per cent* span length and uniformity ratio of the cotton. The *uniformity ratio* is the ratio of the 50 *per cent* and 2,5 *per cent* span lengths expressed as a percentage and is a measure of the relative uniformity of fibre length in the samples. Larger values indicate more uniform fibre length distribution. The following descriptions will serve to classify the blends in this investigation according to fibre length uniformity. [3]

Uniformity Ratio (%)	Description
Below 42	Very low
42 – 43	Low
44 – 45	Average
46 – 47	High
Above 47	Very high

Fibre bundle breaking strength tests were carried out according to the ASTM Method D 1445. Fibre immaturity indices were measured on an Arealometer (Model 142) according to ASTM Method D 1449. These indices were converted to percentages maturity according to the imperical relationship of Hertel and Craven. [4]

RESULTS AND DISCUSSION

FIBRE CHARACTERISTICS:

The fibre characteristics of the 24 blends are given in Table 1. Only 6 of the 24 blends had a Micronaire value below 4,0 and none had a value below 3,5

A histogram of the 2,5 *per cent* span lengths of the blends is given in Figure I. Eleven (or 46 *per cent*) of the blends had a 2,5 *per cent* span length between 26,2 and 27,0 mm (1.1/32 inch to 1.1/16 inch) while that of a further 5 (or 21 *per cent*) were between 27,0 and 27,8 mm . The length range 26,2 mm to 27,8 mm (1.1/32 to 1.3/32 inch), therefore, accounted for 16 (or 67 *per cent*) of the 24 blends. The uniformity ratio of 5 of the blends could be described as low to very low, while that of the other 19 ranged from average to very high.

The fibre bundle breaking strength of the blends at zero-gauge and 3,2 mm-gauge are quoted in Table I and a histogram of the zero-gauge strength values are given in Figure 2. Eight (33 *per cent*) of the blends had a zero-gauge strength between 37,1 and 39,6 gf/tex (75 000 and 80 000 p.s.i.) while that of a further 11 (45,8 *per cent*) were between 39,6 and 42,1 gf/tex (80 000 and 85 000 p.s.i.). The zero-gauge strength range of 37,1 to 42,1 gf/tex (75 000 to 85 000 p.s.i.), therefore, accounted for 19 (79 *per cent*) of the 24 blends analysed. Similarly, the 3,2 mm-gauge strength range of 20,0

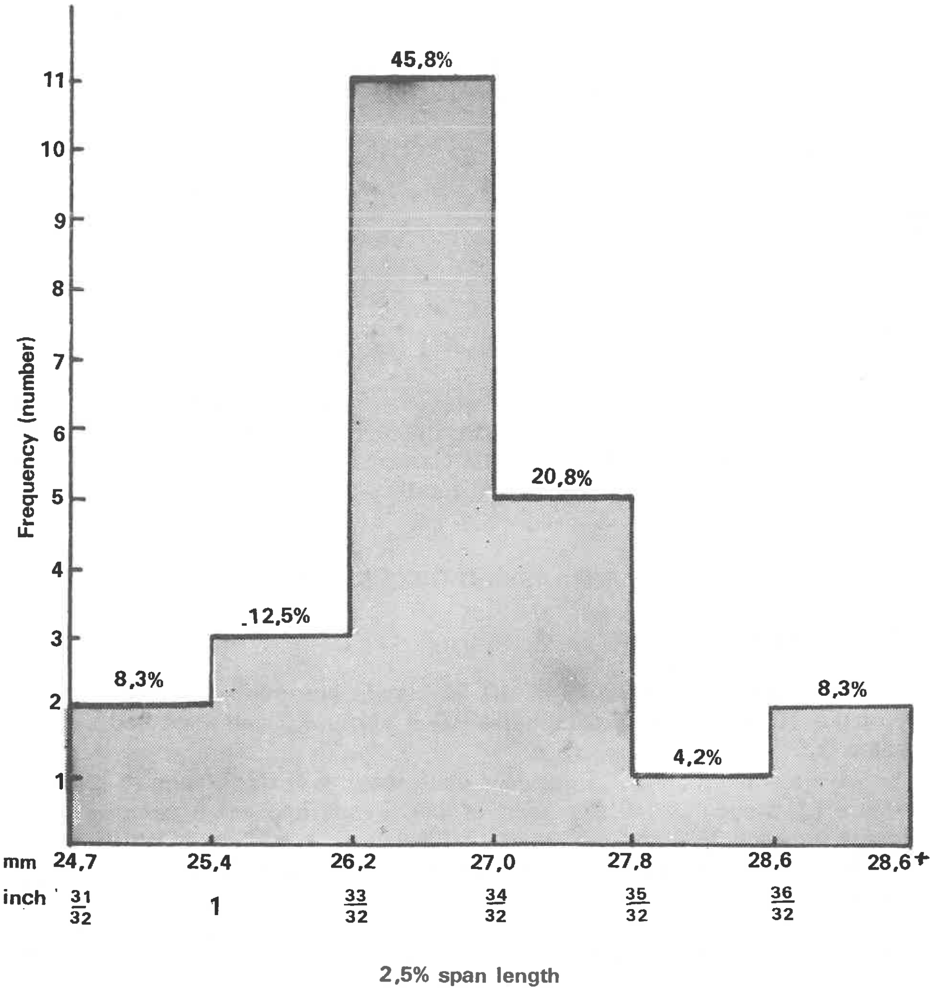

Figure 1 Histogram of the 2,5 per cent span lengths of the Blends investigated.

to 23,9 gf/tex accounted for 17 (72 *per cent*) of the 24 blends.

The total trash content (visible plus invisible) of the raw cotton varied within the range 1,5 to 4,6 *per cent*, although 18 of the blends had a trash content between 1,7 and 3,5 *per cent.*

TABLE I

FIBRE CHARACTERISTICS OF THE 24 BLENDS

Blend	Micronaire	2,5% Span Length (mm)	Uniformity Ratio (%)	3,2mm Gauge Bundle Breaking Strength (gf/tex)	0-Gauge Bundle Breaking Strength (gf/tex)	0-Gauge Bundle Breaking Strength (1000 p.s.i.)	Maturity (%) (Arealometer)	Percentage Trash	
								Visible	Invisible
A	3,7	27,0	43	22,2	40,6	82	75	2,7	0,5
B	4,4	26,9	47	23,4	40,9	83	88	1,8	0,3
C	4,1	26,6	44	23,2	39,8	81	78	2,2	0,6
D	4,1	26,5	45	20,2	37,2	75	79	2,4	0,7
E	3,5	26,0	43	18,9	39,7	80	68	2,1	0,6
F	4,9	28,0	45	21,2	38,8	78	71	2,0	0,8
G	4,2	25,9	44	20,8	40,9	83	77	2,0	0,7
H	3,7	29,4	44	27,4	47,4	96	76	1,6	0,3
I	4,1	27,7	44	21,6	40,0	81	82	3,8	0,7
J	4,1	30,2	47	27,4	44,6	90	76	2,0	0,5
K	4,5	24,7	45	21,7	41,8	84	83	2,7	0,3
L	4,4	27,3	47	23,4	45,0	91	85	1,5	0,2
M	3,7	26,4	44	22,1	35,7	72	70	2,7	0,5
N	4,3	27,2	47	20,0	41,6	84	86	1,4	0,1
O	4,1	26,8	44	22,0	38,7	78	78	2,9	0,6
P	3,9	26,6	44	19,0	39,7	80	70	2,9	1,1
R	3,8	24,9	41	18,5	37,5	76	68	2,5	1,2
S	4,9	27,5	47	22,4	41,5	84	80	1,8	0,4
T	4,3	26,8	45	19,4	38,0	77	66	4,3	0,3
U	4,9	26,1	40	23,2	39,0	79	85	0,9	0,6
V	4,6	26,4	47	21,8	40,0	81	81	1,6	0,4
W	4,2	26,3	43	21,1	40,1	81	80	1,9	0,8
X	4,8	26,9	48	20,7	41,1	83	79	1,7	0,3
Y	4,5	27,2	48	19,5	38,0	77	76	2,1	0,4

The percentage fibre maturity (Arealometer) of five of the blends was below 75 *per cent* and could be considered as slightly immature, while the other blends could be classified as ranging from average maturity to very mature.[5]

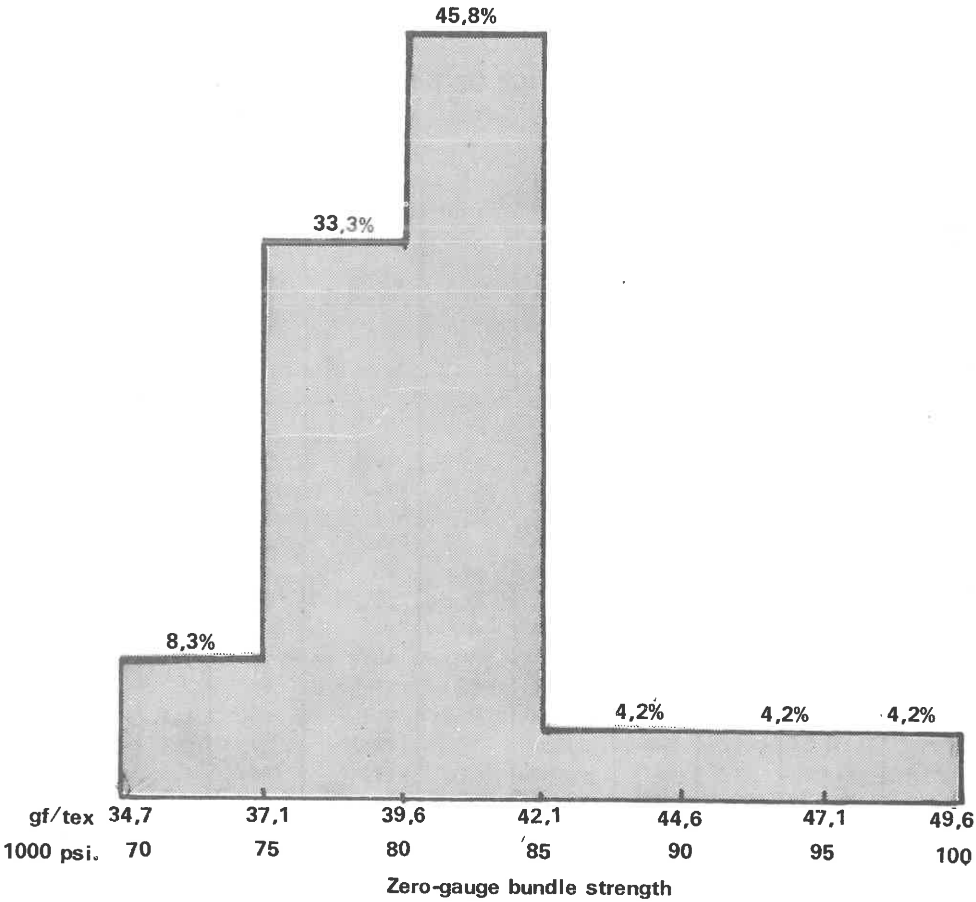

Figure 2 Histogram of the Zero-gauge Bundle Breaking Strength of the Blends investigated.

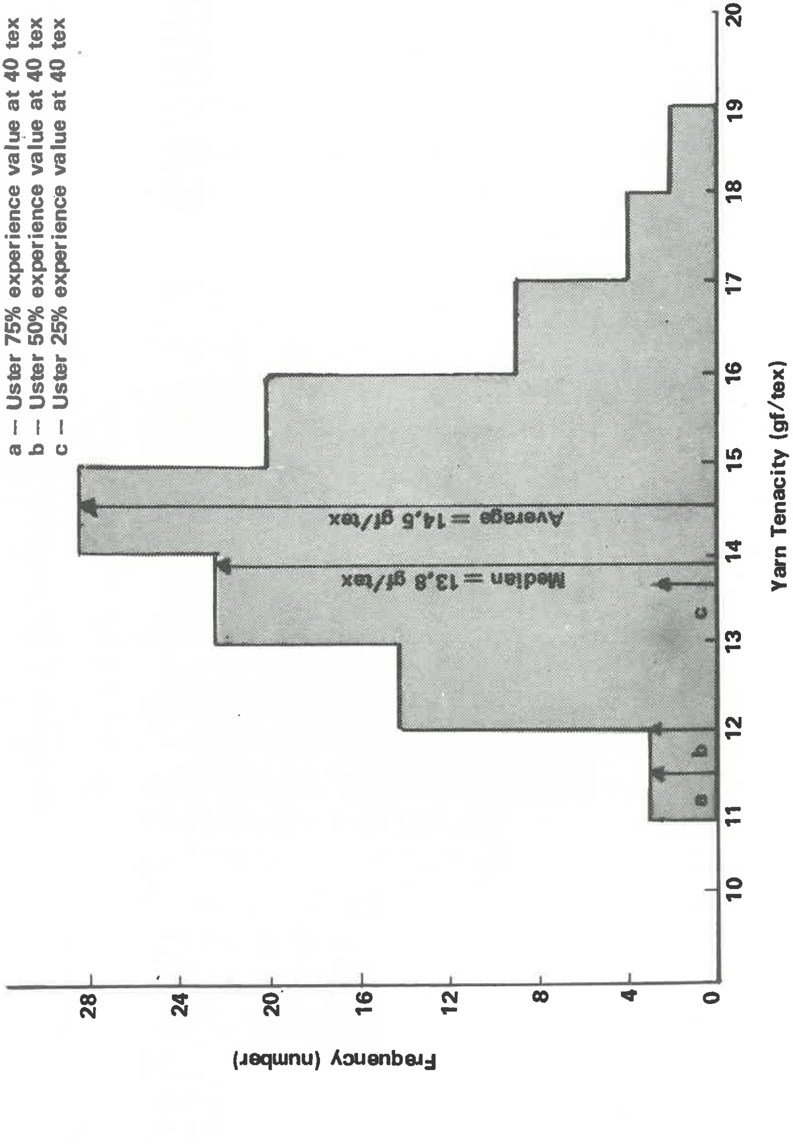

Figure 3 Histogram of yarn tenacity (Class intervals 1 gf/tex)

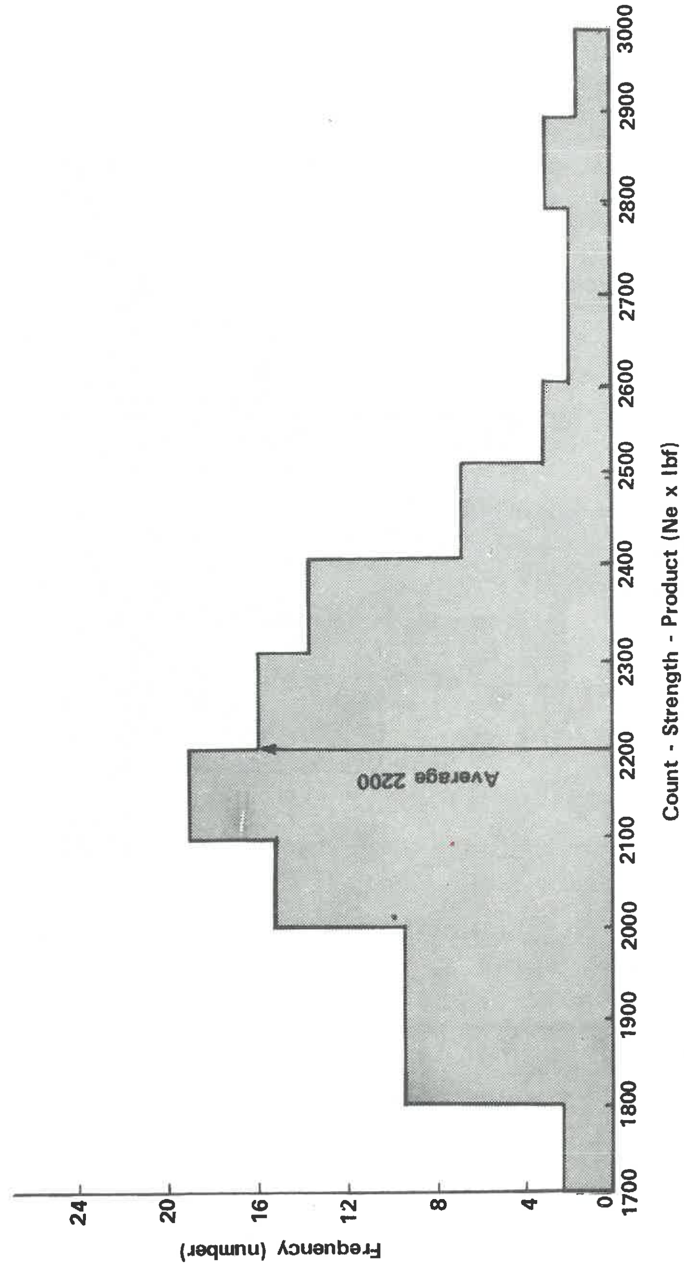

Figure 4 Histogram of CSP-values (Class intervals 100 units)

YARN CHARACTERISTICS:

Tensile properties:

The measured metric twist multiplier* of all the yarns were within the range 32 to 45 (3,3 to 4,5 English twist factor**) while 75 *per cent* of the yarns had a metric twist multiplier between 35 and 40. For a particular cotton of medium staple length one could expect an increase in yarn strength of 7 to 9 *per cent* [7] for an increase in twist multiplier from 35 to 40. Such a relative small increase in tenacity could easily be obscured by other variables present in industrial samples. A statistical analysis of these 102 yarn samples did in fact show that there was no significant correlation between single thread tenacity and twist multiplier for the above twist multiplier range. Similarly no significant correlation was found between single thread tenacity and yarn tex.

In analysing the strength results of the 102 yarns the effect of twist and tex was, therefore, ignored and histograms of the single thread tenacities (gf/tex) and the CSP-values are given in Figures 3 and 4. The average single thread tenacity was 14,5 gf/tex, which is 2,5 gf/tex (20 *per cent*) stronger than the 50 *per cent* (median) Uster experience value.[6] The average CSP-value was 2200, with approximately 20 *per cent* of the yarns having CSP-values less than 2000.

From a total of 556 yarns tested by Messrs. Zellweger Limited, approximately 25 *per cent* had tenacities better than 13,5 gf/tex at 40 tex (indicated by (c) in Figure 3). Using this value as a criterion it was found that approximately 72 *per cent* of the South African yarns tested were stronger.

Messrs. Zellweger limited also quotes experience values [7] of single thread tenacities at different twist levels for different cottons. The tenacities of carded yarns at a twist multiplier of 38 (English twist factor = 4,0) spun from cottons in the staple length range 24,6 mm to 28,6 mm (31/32 inch to 1.1/8 inch) were selected and are, for purposes of comparison, quoted in Table 2. All the cottons with a staple length longer than 25,4 mm (one inch) had yarn tenacities in the range 13,0 to 15,1 gf/tex which are all covered by the lower half of the histogram in Figure 3.

The coefficient of variation of single thread strength (CVs) is plotted against yarn tex in Figure 5. Also shown is the 50 *per cent* (median) Uster

* Metric twist multiplier = t.p. cm X $\sqrt{\text{tex}}$

** English twist factor = t.p.i. $/\sqrt{\text{Ne}}$

Metric twist multiplier = 9,57 X (English twist factor)

TABLE II

USTER EXPERIENCE VALUES [7] FOR SINGLE THREAD TENACITY OF CARDED COTTON YARNS SPUN FROM VARIOUS COTTONS (TWIST MULTIPLIER = 38)

Origin and/or Cultivar (Staple Length in inches)	Yarn tex	Single thread tenacity (gf/tex)	Breaking Elongation (%)
Ashmouni $(1\frac{1}{16})$	22	14,5	8,3
Turkey $(\frac{31}{32} - 1\frac{1}{32})$	40	13,4	8,5
Russia $(1\frac{1}{32})$	30	15,1	8,0
Brazil $(\frac{31}{32} - 1\frac{1}{32})$	40	13,7	8,6
Nicaraqua $(1 - 1\frac{1}{32})$	40	13,8	8,7
Mexico $(1\frac{1}{32} - 1\frac{3}{32})$	30	14,6	8,5
California $(1\frac{1}{16} - 1\frac{1}{8})$	40	14,5	7,9
Louisiana $(1\frac{1}{32} - 1\frac{1}{16})$	30	14,1	7,7
Orleans/Texas $(1\frac{1}{16})$	30	15,1	8,4
Orleans/Texas $(1\frac{1}{32})$	40	13,0	9,0
Orleans/Texas $(\frac{31}{32} - 1)$	40	12,5	8,7

experience curve. [6] The South African yarns have, in general, a lower CVs-value than the corresponding 50 *per cent* Uster value (except for 13 of the 102 yarns of which the CVs-values are higher). Judged by their tensile properties, all the South African yarns tested could be classified as "good" or "very good" according to Rozicki's [10] classification of American cotton yarns.

With the exception of only 10 yarns, all the South African yarns had a higher breaking elongation than the 50 *per cent* Uster experience values (see Figure 6).

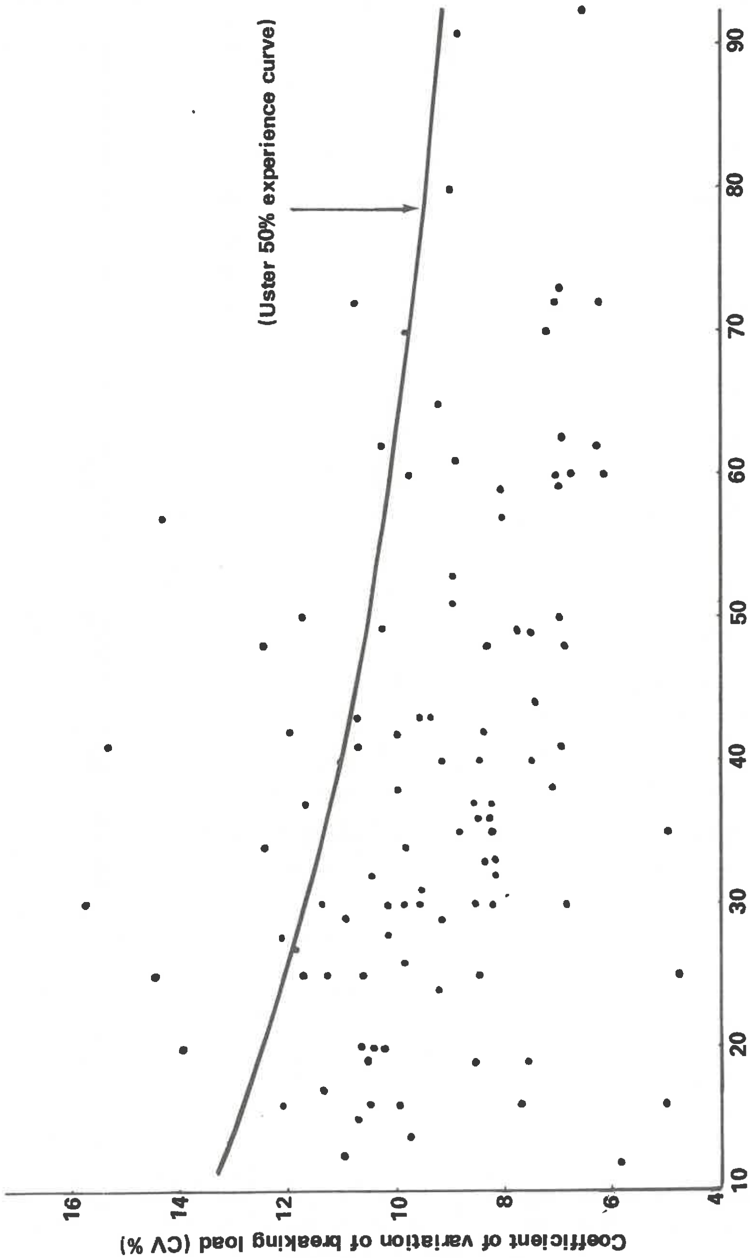

Figure 5 Coefficient of variation of single thread strength versus tex

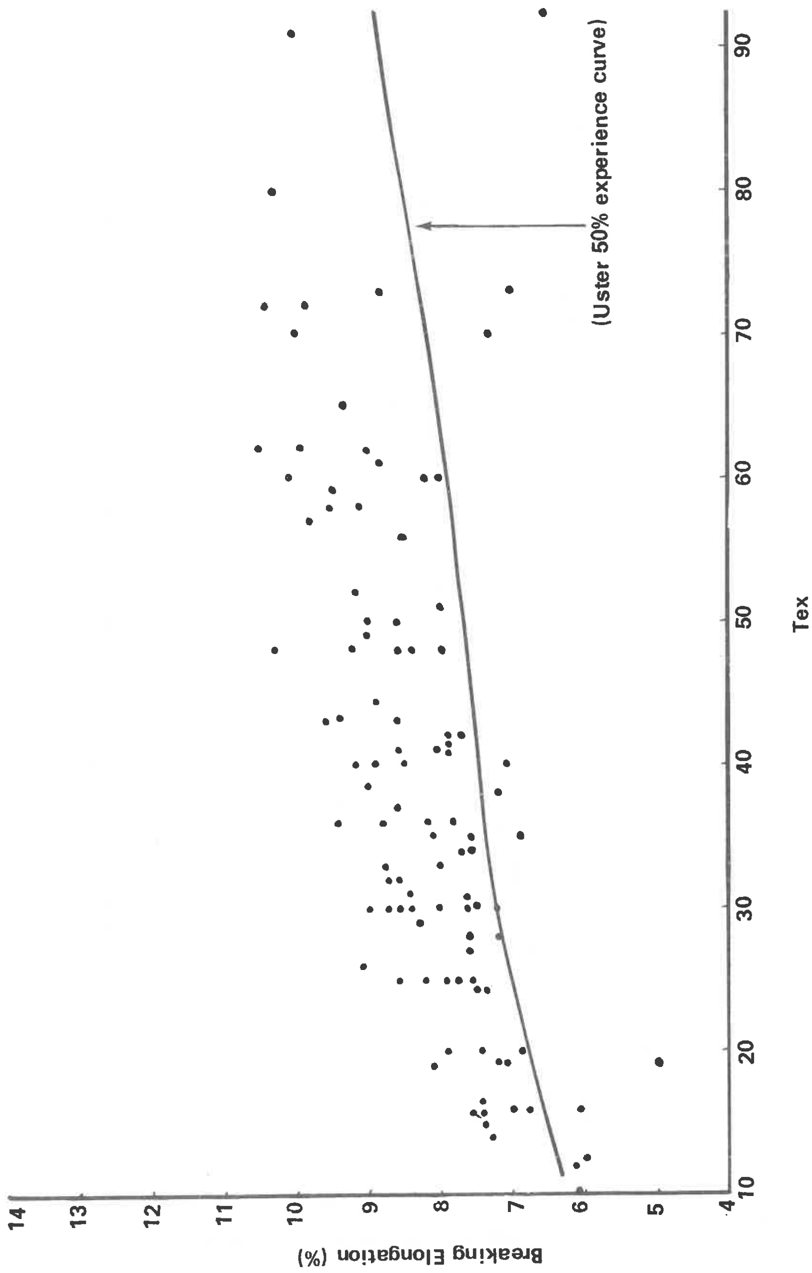

Figure 6 Yarn breaking elongation versus tex.

YARN IRREGULARITY:

The irregularity (CV *per cent*) of the yarns is plotted against tex in Figure 7. Also shown in Figure 7 are three curves (bold lines) numbered 1, 2 and 3, which have the following interpretation:

(i) Curve 1 represents the 50 *per cent* (median) Uster experience value at the different tex values. Fifty *per cent* of the yarns tested by Uster had a higher irregularity than curve 1 and 50 *per cent* had a lower irregularity.

(ii) Curve 2 represents the 75 *per cent* Uster experience values, which means that 25 *per cent* of the yarns tested by Uster had a higher irregularity than curve 2 and 75 *per cent* had a lower irregularity.

(iii) Curve 3 represents the median value of the irregularities of the South African yarns tested. (50 *per cent* had a higher irregularity than curve 3 and 50 *per cent* had a lower irregularity).

In the range of 55 tex and coarser, curve 3 compares well with curve 1, but in the range 10 tex to 55 tex curve 3 is significantly different from curve 1, indicating that the South African yarns were more irregular in this range. This tendency is further illustrated by using curve 2 (the 75 *per cent* Uster curve) as a reference curve. Within the range 10 to 45 tex, 37 *per cent* of the yarns in that range had an irregularity higher than that given by the Uster 75 *per cent* experience curve (curve 2). Furthermore, within the range 10 to 25 tex, 68 *per cent* of the yarns in that range had irregularities higher than the Uster 75 *per cent* experience curve. In the range 60 to 100 tex all the South African yarns tested (15) were well below the Uster 75 *per cent* curve.

In the report "Relationship between test values of yarn irregularity and the appearance of finished fabrics" [8] it is concluded that irregularity whether expressed in terms of U% or CV% can give some indication as to the appearance of the finished fabric as long as no periodic faults are present. Keeping in mind that factors other than irregularity, such as neppiness and hairiness, can also influence fabric appearance, it may be concluded that yarn irregularity values lying above the 75 *per cent* Uster experience curve would be considered not acceptable from the point of view of fabric appearance.

The relationship between the number of neps and the yarn linear density (tex) is shown in Figure 8. The median level of the South African yarns as indicated by curve 2 (Figure 8) tends to deviate progressively from curve

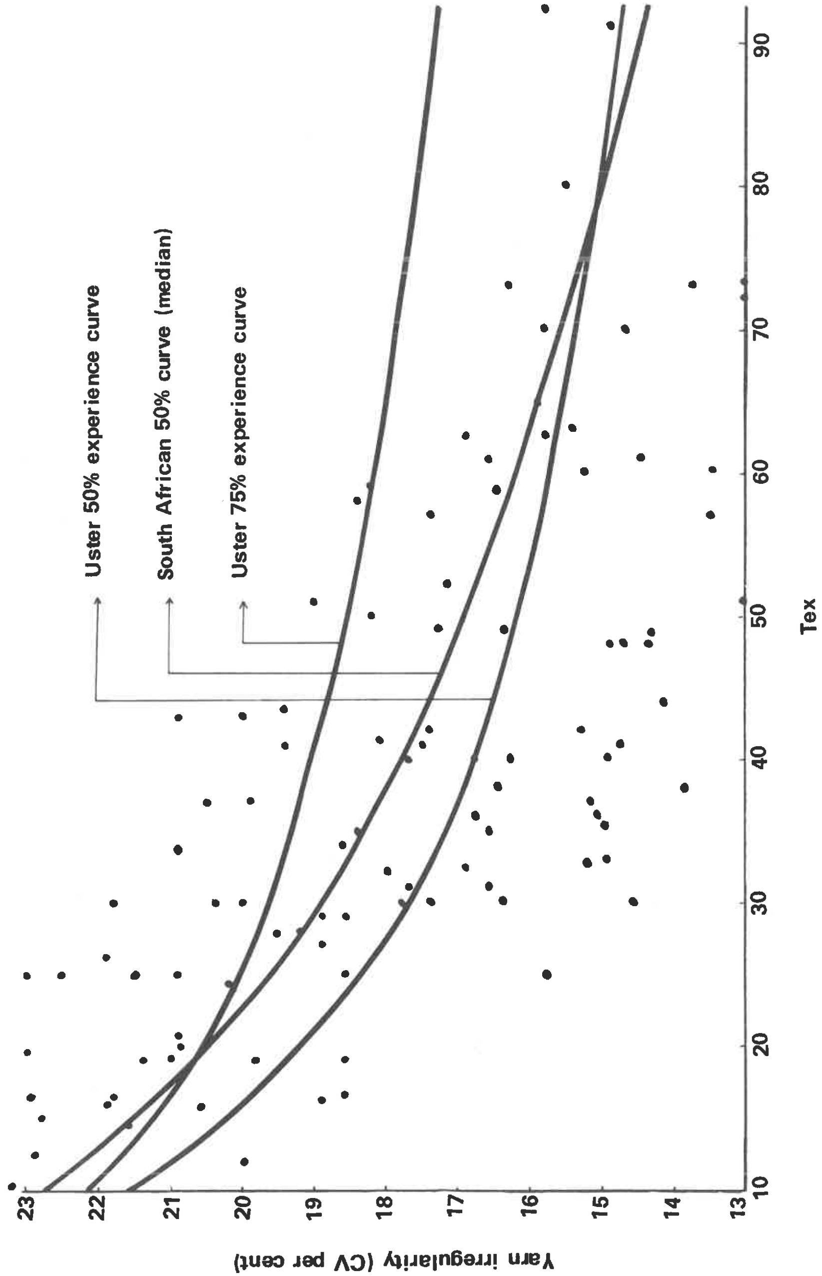

Figure 7 Yarn irregularity versus tex.

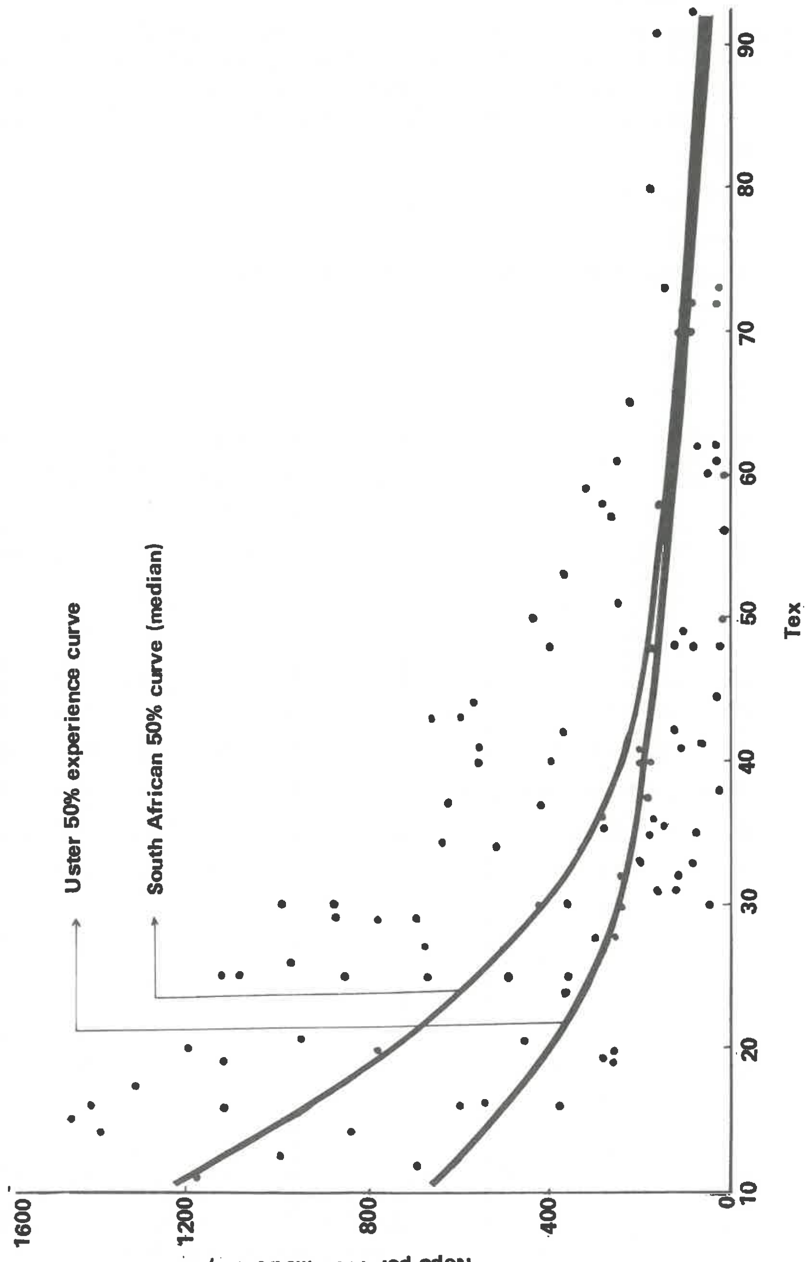

Figure 8 Number of Neps per 1000 metres of yarn versus tex.

1 with decreasing yarn tex. In the fine count range (below 25 tex) almost all the South African yarns had a nep count above the Uster 50 *per cent* experience curve. In the range 50 to 100 tex the nep content of the South African yarns compares well with the level indicated by the 50 *per cent* Uster line (curve 1).

TABLE III

CLASSIMAT ANALYSES OF YARNS (24 LOTS TESTED)

Classimat Fault Class	Minimum Value Recorded	Maximum Value Recorded	Average	Median	Uster 50% Experience Value	Percentage of lots containing more faults than Uster 50% value
A 1	100	9341	2543	1000	900	45
A 2	33	2093	483	222	100	63
A 3	7	221	59	26	11	79
A 4	3	47	11	8	2	100
B 1	12	480	159	80	90	54
B 2	12	186	72	47	40	50
B 3	5	60	24	24	10	75
B 4	3	24	9	8	4	75
C 1	11	64	34	24	20	67
C 2	5	43	22	19	11	83
C 3	3	23	13	14	6	79
C 4	2	14	8	9	3	79
D 1	5	24	11	10	8	54
D 2	2	17	9	8	4	79
D 3	2	15	7	7	3	79
D 4	2	10	5	4	2	88

The median values of the *thin* and *thick* places of the South African yarns for all practical purposes, coincide with the 50 *per cent* Uster values.

CLASSIMAT ANALYSIS OF THE YARNS:

Each linear density was analysed on the *Uster Classimat* Yarn Fault Classifying Installation. The *Classimat* analyses of the different linear densities spun from each of the 24 blends listed in Table I were combined and treated as a lot, thus producing 24 lots of yarn. A summary of the results of the 24 lots is given in Table 3.

The minimum and maximum values recorded for the 24 lots are quoted in columns 2 and 3 (Table 3) respectively and can be used as an indication of the range of values between the lots. The maximum value is on the average more than 20 times higher than the minimum value, showing that there was a vast difference in the number of faults in the lots from different mills.

The percentage of the lots which had more faults than the Uster 50 *per cent* values are given in the last column of Table 3. In the case of the longer and larger faults (A4, B3, B4, C3, C4, D2, D3 and D4) 75 *per cent* and more of the lots had more faults than would be expected from the Uster 50 *per cent* values.

If the Classimat Test sheet is divided into halves (diagonally from top left to bottom right) then the faults are subdivided according to their source in an approximate manner [9]. The shorter and smaller size faults (lower half) are due to the raw material, the opening and the carding processes; the longer and larger faults (upper half) are introduced during drawing and spinning.

For the purpose of this investigation the Classimat Test sheet was divided as shown in Table 4. For purposes of comparison the total number of faults (A1 + B1 + C1 + D1), and the number of faults in the upper and lower halves of the Table 4 are summarised in Table 5.

The total number of faults as well as the number of faults in the lower half of Table 4 for South African yarns correspond closely with the Uster 50 *per cent* experience value. This seems to indicate that the type of raw material and the opening and carding quality was generally similar to that of the yarns used in the Uster analysis. The median number of faults in the upper half of Table 4 (which are often also objectionable type of faults) are, however, 2,5 times that of the Uster 50 *per cent* experience values for the corresponding fault classes. According to Hättenschwiler *et al* [9] these are the type of faults which are introduced in the drawing processes prior to spinning and during spinning itself. It is these faults which the spinner should try to remove during winding. One could therefore rightly expect the efficiency of the winding process to be detrimentally affected by this relatively high frequency of faults in the abovementioned classes.

TABLE IV

CLASSIMATE TEST SHEET

Fault length class	A	B	C	D	Cross-sectional size class
South African Median value	8	8	9	4	4
Uster 50 *per cent* experience value	2	4	3	2	4
South African Median value	26	24	14	7	3
Uster 50 *per cent* experience value	11	10	6	3	3
South African Median value	222	47	19	8	2
Uster 50 *per cent* experience value	100	40	11	4	2
South African Median value	1000	80	24	10	1
Uster 50 *per cent* experience value	900	90	20	8	1

TABLE V

APPROXIMATE CLASSIFICATION OF FAULTS ACCORDING TO THEIR SOURCE[9]

Type of fault	Number of faults for South African yarns. (Median values)	Number of faults from Uster 50% experience values (Median values)
Total number of faults (A 1 + B 1 + C 1 + D 1)	1114	1018
Shorter and smaller size faults* (Lower half of test sheet - Table 4)	1060	996
Longer and larger size faults** (Upper half of test sheet - Table 4)	54	22

* Due to raw material, opening and carding.

** Often considered as objectionable faults introduced during drawing processes and spinning.

SUMMARY AND CONCLUSIONS

Twenty-four cotton blends from which 102 yarns (linear densities ranging from 10 to 100 tex) were produced by 13 South African Mills, were analysed for fibre and yarn characteristics. The yarn characteristics were, where possible, compared with the corresponding Uster experience values.

Sixteen of the blends had a 2,5 *per cent* span length between 26,2 and 27,8 mm (1.1/32 to 1.3/32 inch), and 19 had a zero-gauge bundle breaking strength between 37,1 and 42,1 gf/tex (75 000 to 85 000 p.s.i.)

The average yarn strength was 14,5 gf/tex which is 20 *per cent* stronger than the Uster 50 *per cent* experience value for carded yarns of similar linear densities. Only 3 of the yarns tested were weaker than the Uster 50 *per cent* value. The strength of the yarns also compared well with that of yarns spun from other cottons of similar staple length but unknown fibre strength.

Within the range 50 to 100 tex the irregulairty of the South African yarns compared well with the Uster experience values, but in the range 10 to 45 tex the South African yarns were significantly more irregular than the Uster experience values. A similar trend was observed for the number of neps per 1 000 metres of yarn.

The number of faults with a cross-section of + 100 *per cent* to + 150 *per cent* of the mean yarn cross-section compared favourably with the corresponding Uster experience values. The number of faults with a cross-section of + 150 *per cent* and more (irrespective of fault length) were on the average about two-and-a-half times the number to be expected from the Uster experience values. These latter faults usually originate during the drawing and spinning processes and are not considered as being the result of unfavourable raw material characteristics.

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THE USE OF PROPRIETARY NAMES

The fact that instruments with proprietary names have been mentioned in this report does not in any way imply that SAWTRI recommends them or that there are not other instruments which may be equal or better.

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