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Blending of Two Cottons Differing Widely in Fibre Properties

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ABSTRACT

Two cottons differing by 4,2 mm in their 2,5 per cent span lengths (30,9 and 26,7 mm) and by 6,1 cN/tex in their zero-gauge bundle tenacities were blended and the resultant yarn and fabric properties measured. Yarn tenacities and irregularities were within ± 5 per cent of the weighted mean values calculated from the yarn properties of the two unblended cottons. Correlation coefficients of 0,995 and 0,973 were found between the blend composition, and the average warp/weft strength and bursting strength respectively.

INTRODUCTION

The blending of cotton with man-made fibres (especially with polyester) has been accepted practice for many years. Lately the blending of cotton with other natural fibres, such as wool, has also received more attention. The blending of two cottons differing widely in fibre properties, however, is generally not seen as a sound practice. It is textbook knowledge that when blending different cottons the individual components should not differ greatly in staple length, while too big a difference in fibre fineness and maturity also is not desirable. Blending of cottons differing in staple length up to 1,5 mm (1/16 inch), however, is often carried out. It is routine to blend cotton with a staple length of 32 mm with polyester fibre of 38 mm staple length. Such a difference in staple length, however, will never be tolerated when blending two cottons.

The main criticisms usually expressed against the blending of cottons differing widely in staple length are the concern for floating fibres, and drafting waves at drawing. Whether these criticisms are still completely valid today by the use of modern drafting systems, is a debatable question.

Waters and Phillips[1] investigated the effect of blending cottons, which differ widely in fibre properties, on spinning performance and reported that blending of such cottons did not have a large effect on spinnability, but had a significant effect on yarn strength. Leitgeb and Wakeham[2] found that lower Micronaire values resulted in increased yarn strength and lower end-breakage rates, while it has been reported that an extremely low Micronaire value of 2,9 tended to increase[3] the end-breakage rate in spinning.

The blending of extremely fine and coarse cottons was also investigated[4 5] as a possible way of economically using these discount cottons in blended form. The processing behaviour of a 60/40 blend of a fine (3,0 Micronaire value) and a coarse (6,0 Micronaire value) cotton giving an average Micronaire value of 4,0 was compared with an unblended control cotton having the same Micronaire value. The other fibre properties of the blended cottons and the control cotton were very much the same. The tensile properties of the sheeting type fabrics produced, showed no significant differences between the blended and control cottons. Colour evaluations showed small differences and it was felt that only small modifications in the dyeing procedure would be required. These results showed that extremely low and high Micronaire value cottons, in most instances, could be tolerated in bleached fabrics, but only to a limited extent in dyed fabrics due to neppiness.

Parthasarathy[6] observed that all the physical properties of the fibres played an important part in determining the spinning quality of a blend of Indian, African and American types. He also reported that when two cottons are blended the yarn strength of the blend tended to be higher than the weighted average strength of an equivalent yarn calculated from the yarn strength of the individual components.

Ganatra *et al*[7] reported that, other fibre properties remaining equal, the fibre tenacity of cotton is directly related to single yarn tenacity. Cotton yarns of desired tenacity can, therefore, be produced by blending two or more cottons of different fibre tenacities. They also reported that the potential of fine cottons to form neps can be reduced by blending with coarser cottons.

Using an open-end spinning system the Textile Research Centre[8] has produced and evaluated yarns made from blends of two cottons, which differ widely in fibre properties. Blends of Upland cotton (2,5 *per cent* span length = 26,4 mm, O-gauge tenacity = 50,4 cN/tex) and Pima cotton (2,5 *per cent* span length = 33mm, O-gauge tenacity = 40,4 cN/tex) were made and yarns of 42 tex produced. The addition of 40 *per cent* of the Pima cotton to the Upland cotton increased the yarn tenacity from 12,5 cN/tex to 13,1 cN/tex.

Up to 20 *per cent* of the South African cotton crop is in certain seasons graded as "below standard grade" (BSG). When a particular lot is graded as BSG it generally has one or more of the following "defects":

1. Bundle tenacity (O-gauge) below 36,2 cN/tex (37 gf/tex);
2. Staple length shorter than 25 mm (1 inch);
3. Too neppy, yellow, stained, etc.;
4. Trash content too high;
5. Micronaire value 3,0 and below.

These cottons are normally processed locally as it is difficult, if not impossible, to find an export market for them. Most of them are too inferior to process on their own and it was felt that it would be of interest to see how they would perform in blends with a high quality cotton.

EXPERIMENTAL

Raw Materials:

Two South African cottons were used, namely an Acala 1517/70 (Dirk grade) and a Deltapine 5826 (BSG grade), which will be referred to as the Acala and BSG cotton respectively. The fibre characteristics of the cottons are given in Table I. The high (Acala) and low (BSG) quality component were processed on their own and in three different blends with each other. Yarn and fabric properties were determined for all five lots and related to the blend composition.

Five experiments (A to E) were carried out. Experiments A and E were 100 *per cent* Acala and BSG cotton respectively, while B, C and D were 80/20, 60/40 and 20/80 Acala/BSG blends.

Mechanical Processing:

In each case the individual components were carefully blended by hand, using the sandwich technique, before it was processed through the blowroom. Fifty kg of the blend was processed in each case. Only three cleaning points (a porcupine beater, two-bladed beater and Kirschner beater) were used for Experiments A and B. An ERM cleaner was added when Experiments C, D and E were carried out. The reason for this was the very high trash content of the BSG cotton when compared with that of the Acala cotton.

The production rate of the card was 6 kg/hr and it was not equipped with crush rollers. The licker-in waste and flat-strip waste were combined to give the total percentage card waste. The normal processing sequence of two draw frame passages and a speedframe passage was used to prepare a 420 tex roving for spinning. The yarns (15, 25 and 30 tex) were spun on a 48-spindle ring spinning frame equipped with 50 mm (2-inch) rings and an SKF/PK 225 drafting system. Approximately 20 kg of the 25 tex yarn was spun in each case for the weaving trials. All the yarns were spun to a metric twist multiplier of 38 (4,0 English twist factor).

Mechanical processing was carried out under atmospheric conditions of 22° C and 50 *per cent* RH.

Weaving:

The 25 tex yarns were autoclave-steamed at 100° C for 10 minutes under a vacuum of 660 mm Hg and subsequently allowed to condition in an atmosphere of 65 *per cent* RH and 20° C before further processing. After steaming the yarns were electronically cleared by means of an Uster Classimat, with the clearing levels set at B4 C3 D2.

The warps were prepared on a Hergeth Sample Warper and sized under identical sizing conditions using Solvitose XI (Scholten Foxhol). The size pick-up was 11 *per cent*. The fabrics were of a 2/2 twill construction with a nominal mass per unit area of 140 g/m². The same yarns were used for both warp and weft.

Scouring and Bleaching:

The loomstate fabric was scoured in a Longclose winch containing a 0,2 g/ℓ Lissapol NX and 5 *per cent* sodium carbonate solution. The fabric entered the winch at 40° C, the temperature was then raised to the boil and maintained for 1 hour before rinsing twice.

Bleaching was also carried out on the above winch which contained the following solution:

2,8 ml/ℓ hydrogen peroxide
2,0 g/ℓ Prestogen PC (BASF)
0,6 g/ℓ sodium hydroxide

The fabric entered the winch at 40° C, the temperature was then raised to 95° C and maintained for 1,5 hours. The fabric was subsequently rinsed and treated with 0,5 g/ℓ sodium hydrosulphite at 60° C for 20 minutes.

The fabric was hydroextracted, stenter-dried and subsequently allowed to condition for 48 hours in an atmosphere of 65 *per cent* RH and 20° C before testing.

Testing:

All fibre and yarn tests were carried out under standard atmospheric conditions (20 ± 2° C and 65 ± 2% relative humidity). The samples were kept under these conditions for at least 48 hours before any tests were carried out.

The maturity ratio, fibre fineness and Micronaire value were determined using the IIC/Shirley Fineness Maturity Tester. The samples used on the IIC/Shirley tester were, in accordance with the instructions of the manufacturers, prepared on a Shirley Analyser. The classification given in Table II may be used to interpret the maturity ratios of American Upland type cottons[1].

A Fibrograph (Model 330) was used to determine the 2,5 *per cent* and 50 *per cent* span length. A Stelometer was used for the determination of fibre bundle tenacity at both zero-gauge and 1/8-gauge. Trash content was determined using a Shirley Analyser.

Yarn tensile properties (breaking strength, extension at break as well as the CV of breaking strength) were determined on a Uster automatic yarn strength tester. Yarn hairiness was measured on a Shirley Hairiness Meter according to the standard test in which the number of hairs per metre protruding more than about 3 mm from the yarn core is determined.

RESULTS AND DISCUSSION

The fibre characteristics of the two unblended cottons (Acala 1517/70 and Deltapine 5826 (BSG)) used as well as those of the three blends are given in Table I. The two unblended cottons (Experiments A and E) differed greatly in most of their fibre characteristics. The Acala cotton was 4,2 mm (approximately 3/16 inch) longer than the BSG cotton and its O-gauge and 1/8-gauge tenacities were respectively 15 *per cent* and 50 *per cent* higher than those of the BSG cotton. The BSG cotton could be considered as immature, while the Acala cotton could be considered as mature.

The visible trash content (see Table II) of the BSG cotton was 10,3 *per*

TABLE I
FIBRE CHARACTERISTICS

EXPERIMENT	BLEND COMPOSITION (%)	2,5% SPAN LENGTH (mm)	UNIFORMITY RATIO (%)	MICRONAIRE VALUE	MATURITY RATIO	FIBRE FINENESS (decitex)	0-GAUGE TENACITY (cN/tex)*	1/8-GAUGE TENACITY (cN/tex)*
A	100% Acala	30,9	47,5	4,3	0,93	1,75	45,9	30,4
B	80% Acala 20% BSG	30,0	47,3	4,2	0,90	1,73	44,2	—
C	60% Acala 40% BSG	29,9	45,2	4,1	0,87	1,70	42,2	—
D	20% Acala 80% BSG	27,9	43,0	3,9	0,83	1,66	41,0	—
E	100% BSG	26,7	43,5	3,7	0,79	1,63	39,8	20,0

* 1 cN/tex = 1,02 gf/tex

TABLE II
PROCESSING PERFORMANCE

EXPERIMENT	TRASH CONTENT OF RAW COTTON (%)		TRASH CONTENT OF LAP (%)		TRASH CONTENT OF CARD SLIVER (%)	TOTAL BLOWROOM WASTE (%)	TOTAL CARD WASTE (%)	IRREGULARITY	
	Visible	In-visible	Visible	In-visible				2nd Draw Frame Sliver** (CV %)	Roving*** (CV %)
A 100% Acala	1,6	2,0	0,9	1,5	0,22	0,9	1,6	2,8	5,4
B 80% Acala	—	—	2,0	2,0	0,35	1,3	2,4	3,2	6,0
C 60% Acala	—	—	2,4	2,2	0,41	3,7*	3,1	4,2	6,6
D 20% Acala	—	—	3,5	2,7	0,87	5,8*	4,8	4,1	7,0
E 100% BSG	10,3	5,2	4,5	3,7	0,94	7,1*	5,6	4,3	7,8

* ERM cleaner used in blowroom
** 50% Uster Experience value for cotton sliver of similar ktex = 4,6% (CV).
*** 50% Uster Experience value for cotton roving of similar tex = 8,2% (CV).

cent, while the Acala had a visible trash content of only 1,6 *per cent*. The large increase in blowroom waste (from 0,9 *per cent* to 7,1 *per cent*) is due to the fact that an ERM cleaner was used in Experiments C, D and E but not in Experiments A and B. The total card waste increased from 1,6 *per cent* for the Acala cotton to 5,6 *per cent* for the BSG cotton. The visible trash content of the card sliver increased from 0,22 *per cent* to 0,9 *per cent* for Experiments A and E respectively.

The irregularity of both the second draw frame sliver and the roving increased steadily as more BSG cotton was added to the blend (see Table II). The highest irregularities (those of the sliver and roving from the BSG cotton), however, were still lower than the 50 *per cent* Uster experience values for similar slivers and rovings[9].

The characteristics of the 15, 25 and 30 tex yarns are given in Table III. The weighted mean values for the yarn tenacity, irregularity and neps per 1 000 metres for the three blends (Experiments B, C & D) were calculated from the corresponding characteristics of the yarns spun from the two unblended cottons (Experiments A & E). The ratio of the measured yarn property to the calculated weighted mean value are given in Table IV. In the case of the yarn tenacity and irregularity the above ratios were all within the range 0,95 to 1,05. It is possible, therefore, once the yarn characteristics of the two unblended cottons (Experiments A and E) are known, to predict the yarn tenacity and irregularity of the three blends (B, C and D) to within 5 *per cent* of the measured value.

For the nep content of the yarn the corresponding ratios varied from 0,86 to 1,25, which is a much wider range than that found for yarn tenacity and irregularity, although the overall average ratio was still close to unity. This may be due to the relatively large variation (or error) inherent in the determination of nep frequency.

Also given in Table IV is the percentage change in yarn tenacity, irregularity and nep content for increasing percentages BSG in the blend (positive signs indicate an increase and negative signs a decrease). When, for example, 20 *per cent* of the BSG cotton was added to the Acala cotton the decrease in yarn tenacity was on the average only 7 *per cent* and the increase in irregularity only 3 *per cent*. Although the percentage increase in nep content was very high, in this particular case it was not serious because all the nep contents were well below the 50 *per cent* Uster experience values (see Table III).

The variation in yarn strength (CV %), yarn extension and yarn hairiness showed no clear tendencies and, therefore, it is not possible to draw any conclusions.

The results of the Classimat analysis of the 25 tex yarns are summarised in Table V. No definite trend could be observed as far as the number of objectionable type faults was concerned. The total number of registered faults,

TABLE III

CHARACTERISTICS OF THE 15, 25 AND 30 TEX YARNS

EXPERIMENT	YARN TEX	COUNT-STRENGTH PRODUCT	SINGLE THREAD TENACITY (cN/tex)	STRENGTH VARIATION (CV %)	YARN EXTENSION (%)	YARN IRREGULARITY (CV %)	NEPS PER 1 000 m YARN	YARN HAIRINESS (Hairs per metre)
15 Tex:	50% Uster Experience value					20,0	500	
A	14,3	2711	17,6	10,7	6,6	19,0	103	9,3
B	15,8	2759	15,8	9,0	5,9	20,0	197	7,5
C	15,4	2367	14,3	10,1	5,7	20,9	244	6,2
D	15,3	2188	13,2	11,0	6,0	21,6	338	6,2
E	15,1	1837	11,3	8,8	5,4	23,3	373	6,5
25 Tex:	50% Uster Experience value					18,6	300	
A	25,2	2945	18,0	8,0	7,1	17,9	61	9,3
B	25,0	2745	16,5	8,7	6,9	18,4	101	11,1
C	24,9	2552	15,2	8,6	6,9	19,6	137	12,8
D	24,8	2389	14,0	9,2	6,6	20,9	213	19,1
E	24,6	2039	12,2	9,6	6,8	21,7	236	17,1
30 Tex:	50% Uster Experience value					17,8	250	
A	30,1	3069	18,4	7,4	5,8	14,1	52	9,6
B	30,6	2926	17,6	7,5	6,2	14,4	81	9,3
C	29,3	2676	15,8	6,7	6,1	15,3	92	6,3
D	30,3	2332	14,2	8,1	6,1	16,2	138	8,3
E	30,0	2058	12,6	8,8	6,0	17,2	188	8,7

TABLE IV

RATIO OF MEASURED YARN PROPERTY TO WEIGHTED MEAN VALUE

EXPERIMENT	PERCENTAGE* DECREASE IN YARN TENACITY AND INCREASE IN YARN IRREGULARITY AND NEP CONTENT	RATIO OF MEASURED YARN PROPERTY TO WEIGHTED MEAN VALUE CALCULATED FROM EXPERIMENT A AND E			
		15 tex	25 tex	30 tex	Average Ratio
YARN TENACITY					
A	0	—	—	—	—
B	-7	0,97	0,98	0,99	
C	-16	0,95	0,97	0,98	0,97
D	-23	1,05	1,04	1,03	1,04
E	-33	—	—	—	—
IRREGULARITY					
A	0	—	—	—	—
B	+3	1,01	0,98	0,98	0,99
C	+10	1,01	1,01	1,00	1,01
D	+15	0,96	1,00	0,98	0,98
E	+22	—	—	—	—
NEPS					
A	0	—	—	—	—
B	+71	1,25	1,05	1,03	1,11
C	+113	1,17	1,05	0,87	1,03
D	+214	1,06	1,06	0,86	0,99
E	+270	—	—	—	—

*Average for 15, 25 and 30 tex

however, increased drastically with increasing percentages of the BSG cotton in the blend. This is due mainly to the increase in nep content and the increase in trash particle content. This is interesting since Uster[10] maintains that the total number of faults (of which the overwhelming proportion are the small faults) is a property of the raw material while the faults defined as objectionable are a function of processing. This is, therefore, supported by the findings here.

The properties of the five bleached fabrics are given in Table VI.

The air permeability showed a tendency to decrease slightly with an increasing percentage of the BSG cotton in the blend. The yarn from the longer staple Acala cotton might have been less voluminous than the yarn from the shorter staple BSG cotton, resulting in a bigger airflow between the yarns of the Acala fabric (Experiment A). The smaller fibre linear density and the consequent increase in specific surface area of the BSG cotton may also have contributed to the decrease in air permeability with an increased percentage BSG cotton in the blend.

The abrasion resistance showed a tendency to decrease with an increasing percentage of the BSG cotton. The decrease was small, however, and the resistance of the pure BSG cotton is still considered as good.

The warp and weft breaking strength of the fabrics were averaged and correlated with the blend composition. The following linear regression equation was obtained:

$$y = -1{,}21\ x + 536{,}2$$

where y = fabric strength (Newton)
x = percentage of the BSG cotton in the blend.

TABLE V

CLASSIMAT ANALYSIS OF 25 TEX YARNS

EXPERIMENT	COMPOSITION (Acala/BSG)	TOTAL NUMBER OF FAULTS PER 100 000 METRE	NUMBER OF FAULTS IN CLASSES A4 B3, C3, D2*
A	100/0	2 210	65
B	80/20	3 461	56
C	60/40	4 446	57
D	20/80	8 328	64
E	0/100	12 434	75

*Considered to be objectionable type faults

The correlation coefficient was found to be -0,995 (significant at the 99,9 *per cent* level of confidence).

The linear regression equation for the bursting strength against blend composition was:

$$y = -2{,}38\,x + 1244$$

where y = bursting strength (kN/m^2)

x = percentage of the BSG cotton in the blend.

The correlation coefficient was -0,973 (significant at the 99,9 *per cent* level of confidence).

These very high correlation coefficients indicate that there is almost a perfect linear relationship between blend composition and fabric strength.

The regression equations were used to calculate the predicted strength values, which are also given in Table VI. The addition of (for example) 20 *per cent* of the BSG cotton to the Acala 1517/70 cotton resulted in a reduction of only 4,5 *per cent* in the warp/weft breaking strength and only 3,8 *per cent* in the bursting strength. If, however, 20 *per cent* of the Acala cotton is added to the BSG cotton the fabric strength is increased by only 5,8 *per cent* and the bursting strength by only 4,8 *per cent*. From the point of utilization of the low quality (BSG) cotton it seems, therefore, more advantageous to add, for example, 20 *per cent* of this to a high quality cotton, which will result in a small decrease in fabric strength, than to try to upgrade the low quality cotton by adding 20 *per cent* of the high grade cotton to it. This latter method will result in only a small increase in fabric strength which may in many cases still not be enough to give the fabric the required strength. The decision whether to add a relatively small percentage of low quality cotton to a high quality cotton or vice versa, will depend to a large extent on the type of end-product and its characteristics.

TABLE VI
BLEACHED FABRIC CHARACTERISTICS

FABRIC CHARACTERISTICS	A (Acala)	B	C	D	E (BSG)
Composition (%)	100A	80A/20E	60A/40E	20A/80E	100E
Mass per unit area (g/m²)	138	135	140	136	139
Sett (Ends/Picks per cm)	28/27	28/26	29/26	28/26	28/26
Air Permeability at 1 cm water pressure (cm³/sec/cm²/cm)	90	90	73	67	59
Abrasion Resistance (Mass loss at 10 000 cycles)	5,4	5,9	6,1	6,0	7,1
Warp Extension at Break (%)	13,0	12,0	12,4	12,5	13,5
Weft Extension at Break (%)	12,6	13,4	13,3	13,2	13,1
Bursting Strength (kN/m²) (Measured)	1236	1177	1187	1059	991
Predicted Bursting Strength (kN/m²)	1244	1196	1148	1054	1006
Average Measured Warp and Weft Breaking Strength (N)	538	507	489	446	410
Predicted Average Warp and Weft Breaking Strength (N)	536	512	488	439	415

SUMMARY AND CONCLUSIONS

A Deltapine 5826, BSG-grade, cotton was used to blend with an Acala 1517/70 cotton. The two cottons differed widely in fibre properties. The two cottons differed in their 2,5 *per cent* span length by 4,2 mm, in their zero-gauge bundle tenacity by 6,1 cN/tex (15 000 p.s.i.). Other fibre properties also differed greatly. Three blends (20/80, 40/60 and 80/20 BSG/Acala) as well as the two unblended cottons were converted into fabric of 140 g/m². Fibre, yarn and fabric properties were measured in all the cases.

The strength of the 25 tex yarn spun from the Acala 1517/70 cotton was 48 *per cent* higher than that of the BSG cotton. The weighted mean yarn strength of the blends calculated from the yarn strength of the two unblended cottons was always within 5 *per cent* of the measured yarn strength of the blends. The ratio of measured yarn strength to weighted mean yarn strength ranged from 0,95 to 1,05. The above ratio for yarn irregularity and number of neps per 1 000 metres ranged from 0,96 to 1,01 and 0,86 to 1,25 respectively. The differences between the number of objectionable type faults in the yarns from the different lots were small and no tendency could be found. It can, therefore, be concluded that the measured yarn properties agreed very well with those predicted from the weighted mean values of the individual components.

Linear regression analyses of the warp/weft breaking strength and bursting strength respectively against the percentage of the BSG cotton in the blend gave correlation coefficients of -0,995 and -0,973 respectively. Almost perfect linear relationships were found between blend composition, and warp/weft fabric strength and bursting strength.

In this particular investigation the addition of 20 *per cent* of the low quality BSG cotton to the high quality Acala 1517/70 cotton reduced the fabric breaking strength by only 4,5 *per cent*, and the bursting strength by only 3,8 *per cent*.

In summarising, therefore, it can be stated that the results of this investigation show that if two cotton types differing widely in their fibre properties are blended, the properties of the blends (both yarn and fabric) are very close to those predicted from the weighted mean values of the individual components.

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THE USE OF PROPRIETARY NAMES

The fact that equipment and substances 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 substitutes which may be of equal value or even better.

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