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STUDIES ON BLENDING OF COTTON WITH POLYESTER

Part II. Utilization of Chemcally Treated Cotton in Blending with Polyester For better Properties.

BY

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1. INTRODUCTION:

Over the last 20 years, blending of cotton with polyester has came to occupy a very important position in the textile industry allover the world. Recently, much efforts were and still are being paid in A.R.E. to achieve the best properties of polyester/cotton blend. One way of improving the strength properties of the blend is to increase the extension value of cotton as much as possible to make it nearer to the extension value of polyester. In a previous study /1/, it was disclosed that slack mercerization or partial carboxymethylation of cotton fibres improves significantly the extension of cotton without serfously affecting other strength properties.

The present work is undertaken with a view of studying: (a) blending of slack mercerized cotton and partially carboxymethylated cottons with polyester at different ratios, (b) relation between fibre properties in the individual components and in the blends; (c) spinning performance of the blended fibres into yarns having the same count (Ne = 50 = 11.83 tex) under similar processing conditions and, (d) characteristics of blended yarns made from the chemically treated cottons and polyester.

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2. EXPERIMENTAL:

2.1. Materials:

2.1.1. Raw Cotton (RC):

Egyptian cotton fibres (Giza 70) were selected for this study due to their long length and high fineness which would probably outweigh the shortening of fibre length and coarseness of fibre brought about by the chemical treatement.

2.1.2. Alkali treated cotton (AC):

Alkali treated cotton (AC) was prepared by slack mercerization of the cotton fibres as described elsewhere/1/.

2.1.3. Partially carboxymethylated cotton with low degree of substitution (LC).

2.1.4. Partially carboxymethylated cotton with medium degree of substitution (MC).

2.1.5. Partially carboxymethylated cotton with high degree of substitution (HC).

These partially carboxymethylated cottons were prepared according to conditions described in details in a previous communication /1/.

2.1.6. Polyester staple fibres (P) having 1.5 denier, 1.5 inch (38 mm) were used throughout this investigation. Each of the above cotton substrates was blended with the polyester to produce three yarns as per the blend ratios given below:

Cotton	100%	70%	50%
Polyester	0%	30%	50%

Regardless of the substrate or the blend ratios used, the fibers were processed so as to yield yarns having the same count and twist multiplier (Ne = 50 and α_e = 3.6).

2.2. Blending Technique:

Blending of cotton with polyester fibres was carried-out on the carding machine, owing to the ability of this machine to breakdown the material into the individual-fibre state and the complete ramdomization of fibres as they are transferred to and from the main carding surfaces /2/.

Blending by weight was carried-out, by placing the two sheets of fibre, which were primarily distributed by hand, in the sandwich form on the feed plate. The sliver produced from this machine was wound around a small beam, then cut parallel to the beam axis and fed into the second carding machine in the sheet form. It may be argued that, these two carding passages are probably too intensive, but inspection of the chemically treated fibres would reveal that these fibres were adhered together most probably because of wax removal during caustic soda treatments.

The processing parameters are summarized in Table (1). Systems used and machinary employed were described elsewhere /3/.

Table (1) Spin Plan

Operation	Input count Ne_i	Draft V	Doubling D	Output count Ne_o
Card (First)	0.0022	100	-	0.22
Card (Second)	0.22	100	100	0.22
Drawing 1st pass	0.22	8	8	0.22
Drawing 2nd pass	0.22	8	8	0.22
Roving (slubber)	0.22	5	1	1.08
Roving(Intermediate)	1.08	5	2	2.71
Roving (Finisher)	2.71	5	2	6.77
Ring Spinning	6.77	14.78	2	50

2.3. Testing:

2.3.1. Fibres:

The properties of the fibres alone or on conjuction with the polyester were measured according to procedures described in A.S.T.M. Main fibre properties examined were: Fibre length, Fibre Fineness as well as fibre strength and extension.

2.3.2. Yarns:

Properties of the yarns were also measured according to A.S.T.M. procedures. The main yarn properties examined were; yarn count and count variation, yarn twist, yarn strength and elongation, skien strength, yarn eveness, wear resistance, uending ratio and yarn diameter.

3. RESULTS AND DISCUSSION:

3.1. Fibre Bundle strength and strain:

The Fibre bundle strength and strain of the five cotton substrates (RC, LC, MC, HC and AC) alone and in their blends with polyester were measured and shown in Tables (2 and 3), and represented graphically in the Figures 1-5.

The experimental results obtained were compared with the theoritical values obtained by applying these equations:

$$R_{1} = B_1R_1 + B_2R_2 \qquad \ldots\ldots(1)$$

and

$$R_{2} = B_2R_2 \qquad \ldots\ldots(2)$$

where:

R_1 : Breaking strength of the first component.

R_2 : Breaking " " " second "

B_1, B_2 : Proportion by mass of the first and second components.

$_{1}$, $_{2}$: Breaking strain in %.

R : Breaking strength in the blend.

The above two equations were described elswhere /4,5/, when relations between the main fibre properties in the blend and its individual components were derived.

Based on the relations between blending ratio and fibre bundle strength and strain, it is clear that when the strain of raw cotton fibres (Ca.6.5%) is Foirly lower than that of polyester fibres (Ca. 17.5%), the fibre bundle strength in the blends is substantially lower than the weighted average strength. On the other hand, when the strain of modified cotton fibres is increased (to 14% for HC) and becomes nearer to the strain of polyester fibres, the fibre bundle strength in the blends become nearer to the weighted average strength.

By blending raw cotton with polyester as shown in Fig. 1, the fibre bundle strength decreases theoretically from Ca-389-wt/tex for 100% RC to the minimum of 29 g-wt/tex at the critical blending ratio, B^{*} = 48% C/52% P following the values of the first rupture point, where B^{*}, C and P represent blend, cotton and plyester respectively. As the percentage of polyester increases more B_{p}^{*} = 52%, the strength increases following the values of the second rupture point. At the blending ratio 33% C /67% P, the fibre strength in the blend reaches again the same strength of 100% raw cotton.

By blending modified cotton with polyester as shown in Figures 2-5, the fibre bundle strength in the blends does not decrease, as in the case of raw cotton, but increases up to the critical blending ratios, which are B_{p}^{*} = 59.3%, 67.3%, 75.7% and 60% for LC, MC, HC and AC respectively.

The strain of blended fibre bundle increases as the percentage of polyester increases. It equals the strain of the weaker component (Cotton) provided that the blended fibre bundle strength is following the values of the first rupture point, and equals the strain of the stronger component(plyester) when the blended fibre bundle strength is following the values of the second rupture point.

3.2. Properties of Modified Cotton/Polyester Blended Yarns:

Strength and strain of blended yarns from the different substrates at different blending ratios were measured and shown in Tables 4-6. These results were represented graphically in figures 6-10 and compared with the theoritical values obtained from the following equations:

$$P_{1} = B_1P_1 + B_2P_2 \qquad ......(3)$$

and $$P_{2} = B_2P_2 \qquad ......(4)$$

These equations were derived by Hamburger /6/ and discussed as relations that can be applied to predict theoretically the strength of blended yarn composed of two components at any blending ratio.

3.2.1. Blended yarn strength and strain characterstics:

The single-end strength and strain and skein strength, are illustrated in Tables 4-6 and represented graphically in figures 6-10.

From the studies carried-out on the effect of different levels of blends on the properties of modified cotton/polyester blended yarns, It is evident that, the tenacity of RC/P blended yarn decreases following the values of the first rupture point. However, the percentage of polyester increases. The maximum tenacity of 100% RC yarn of (Ne 50) and $_e$ = 3.6 at critical blending ratio 53.5 C/46.5 P amounts 14.32 g-wt/tex, and the minimum tenacity amounts to Ca- 12 g-wt/tex. After this critical blending ratio, the tenacity of RC/P yarns tends to increase following the values of the second rupture point as the percentage of polyester increases more than B_P = 54%, the tenacity of RC/P yarns starts to more than that of 100% RC yarn.

Similarly as concluded for the fibre bundle strength of RC/P blends, when there is a great difference between the strains of raw cotton and polyester, the tenacity of RC/P blended yarns is reasonably lower than the weighted average tenacity. The tenacity of modified cotton/polyester yarns shows the be closer to the weighted average tenacity.

The critical blending ratio of modified cottons/Polyester blended yarns (expressed as B_p^*) is 41.28%, 50.2% , 57.25% and 64.83% for LC, AC, MC and HC respectively.

Fig.(11) shows the relation between the critical blending ratio of blended fibres and that of blended yarns. This relation seems linear: $B_{py}^* = 0.89\ B_{pf}^* - 3.9$ with correlation coefficient r = 0.87.

The strain of blended yarns follows the same trend as discussed previously for the strain of blended fibres. Figures 12 and 13 show the relations between yarn strength skein strength and blending ratio. It is clear that the tenacity and skein strength (CSP) of 100% RC yarn is higher than that of all 100% modified cotton yarns. In case of cotton/polyester blended yarns, the tenacity and skein strength (CSP) of modified cottons/polyester blends are higher than that of RC/polyester blended yarns. In other words, the tenacity of 50% HC/50%P increases by 75% of its value for 50% RC/50%P yarns, and the CSP of 50% HC/50%P increases by 90% of its value for 50% RC/50% P and by 60% of its value for 50% AC/50% P yarns.

The strain of 100% RC yarn is 5.64%; a value which is lower than that for all 100% modified cotton yarns (ranging from 6.2% for LC to 7.4% for HC). The strain of 50% RC/50% P yarn is 6%, which is lower than that of all 100% modified cottons, and their blends with polyester. The strain of 50% C/50% P blended yarns for modified cottons ranges from 8% for LC to 8.8 for HC, as shown in Fig.(14).

3.2.2. Specific Work of Rupture:

Although the chemical modification of cotton fibres has a reasonable effect on the strain of 100% cotton yarns, it does not show any significant difference between the specific work of rupture of all 100% cotton yarns spun from the different substrates (ranging from 31 to 36 g-wt 10^{-2}/tex.), except for 100% LC yarn, which shows a lower specific work of rupture (Ca-21.5 g-wt 10^{-2}/tex.) as shown in Table (7) and Fig.(15). In cases of 50% C/50% P, this modification does show a strong effect on the specific work of rupture of the yarns.

The value for 50% HC/50% P is 160% greater than for 50% RC/50% P. On the other hand, the specific work of rupture of 50% AC/50% P is 80% greater than 50% RC/50% P.

3.2.3. The Wear Resistance:

The wear resistance of yarns were tested using "wear tester for yarns and sewing threads". The wear resistance of 100% HC yarn decreases by 75% of its value for 100% RC and also decreases by 85% for 100% AC yarn. The wear resistance of 50% HC/50% P yarns increases by Ca-160% of its value for 50% RC/50% P and also increases by Ca-45% for 50% AC/50% P yarns, as shown in Table (7) and Fig.(16).

CONCLUSIONS:

From the previous discussions and investigations the following conclusions may be drawn:

1- As the strain of cotton fibres (weaker component) increases and becomes nearer to the strain of polyester fibres, the fibre bundle strength in the blends becomes nearer to the weighted average strength.

2- The strain of blended fibre bundle increases as the percentage of polyester increases.

3- The tenacity of cotton/polyester blended yarns is reasonably lower than the weighted average tenacity when there is a great difference between the strains of cotton and polyester.
4- The tenacity of modified cotton/polyester yarns are closer to the weighted average tenacity.
5- The relation between the critical blending ratio of blended fibres and that of blended yarns seems to be linear.
6- The breaking strain of blended yarns follows the same trends as concluded previously for the strain of blended fibres.
7- The tenacity and skein strength (CSP) of modified cotton/polyester blends are higher than that of RC/polyester blended yarns.
8- The breaking strain of 100% RC yarn is lower than that for all 100% modified cotton yarns, and the breaking strain of blended yarns increased as the percentage of polyester increases, specially in modified cotton/polyester blended yarns.
9- Although the wear resistance of cotton yarns decreases according to the modification effect, yet the modified cotton/polyester yarns acquire higher wear resistance than 100% cotton yarn and RC/polyester blended yarns.
10- The better properties found with the modified cotton/polyester compared to nonmodified cotton/polyester yarns calls for industrial trials. Besides the improvement in the physico-mechanical properties, the modified cotton/polyester yarns require higher moisture regain and would not require to be mercerized.

ACKNOWLEDGEMENT:

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REFERENCES:

1. A. Barghash, A. Hebeish, B.D. Farah and E.M. Rakha.
"Studies on Blending of cotton with Polyester" Part I. , Faculty of Engineering Bulletin, Mansoura University, 1981.

2. W.Nutter.
"Yarn production and properties" Textile progress Vol. 3, No. 2, 1971.

3. E.M.M. Rakha.
"Studies of optimum Blending of Modified cotton with polyester in cotton spinning system", M.Sc. Mansoura University, 1980.

4. Farah, B.D.
"Contribution to the optimization of Blowroom Processes" Dissertation, TH Karl-Marx-stadt (1973).

5. Simon, L.; B.D. Farah.
(Linear optimization in textile Engineering), Deutsche Textil technik, 23 (1973) 11, P. 685.

6. Hamburger, W.J.
"Industrial Application of the stress-strain relationship" J. Textile Inst. (Proc) 40, 700=720 (1949).

Table (2): Theoretical Relations for Calculating the Theoretical values of fibre Bundle Strength ($\bar{R}_{\varepsilon_r}$) in the Blends.

Cotton Substrate	First rupture point $\bar{R}\varepsilon_1 = B_1.R_1 + \frac{\varepsilon_1}{\varepsilon_2} B_2R_2$..(1)	Second rupture point $\bar{R}\varepsilon_2 = B_2R_2$..(2)
RC	$\bar{R}\varepsilon_o = 17.15\ BC + 20.79$	$\bar{R}\varepsilon_p = 56-56\ BC$
LC	$\bar{R}\varepsilon_o = 34.66 - 3.55\ BC$	$\bar{R}\varepsilon_p = 56-56\ BC$
MC	$\bar{R}\varepsilon_o = 39.29 - 4.96\ BC$	$\bar{R}\varepsilon_p = 56-56\ BC$
HC	$\bar{R}\varepsilon_c = 45.05 - 10.9\ BC$	$\bar{R}\varepsilon_p = 56-56\ BC$
AC	$R\varepsilon_c = 35.4 - 4.48\ BC$	$\bar{R}\varepsilon_p = 56-56\ BC$

Table (3): Theoretical and Experimental Values of Fibre Bundle Strength $\bar{R}_{\varepsilon_f}$ and Strain $\varepsilon_f\%$ in the Blends.

Cotton substrate	Property		100% C	70% C/ 30% P	50% C/ 50% P	25% C/ 75% P	100% P
RC	$\bar{R}_f$	Theor	37.94	32.80	29.37	42.0	56.0
		Exp.	37.94	38.24	40.18	40.52	56.0
	$\varepsilon_f\%$	Theor.	6.46	6.46	6.46	17.4	17.4
		Exp.	6.46	6.98	16.2	15.6	17.4
LC	$\bar{R}_f$	Theor.	31.11	32.18	32.89	42.0	56.0
		Exp.	31.11	33.67	44.02	46.6	56.0
	$\varepsilon_f\%$	Theor.	10.77	10.77	10.77	17.4	17.4
		Exp.	10.77	11.85	15.9	17.65	17.4
MC	$\bar{R}_f$	Theor.	34.33	35.82	36.81	42.0	56.0
		Exp.	34.33	37.1	43.56	49.47	56.0
	$\varepsilon_f\%$	Theor.	12.21	12.21	12.21	17.4	17.4
		Exp.	12.21	12.64	13.5	16.8	17.4
HC	$\bar{R}_f$	Theor.	34.15	37.42	39.6	42.0	56.0
		Exp.	34.15	39.44	49.81	49.47	56.0
	$\varepsilon_f\%$	Theor.	14.0	14.0	14.0	14.0	17.4
		Exp.	14.0	15.0	15.8	16.9	17.4
AC	$\bar{R}_f$	Theor.	30.92	32.26	33.16	42.0	56.0
		Exp.	30.92	32.93	41.2	47.45	56.0
	$\varepsilon_f\%$	Theor.	11.0	11.0	11.0	17.4	17.4
		Exp.	11.0	11.85	12.5	17.4	17.4

Table (4): Theoretical Relations for Calculating Blended yarn Strength $\bar{P}$.

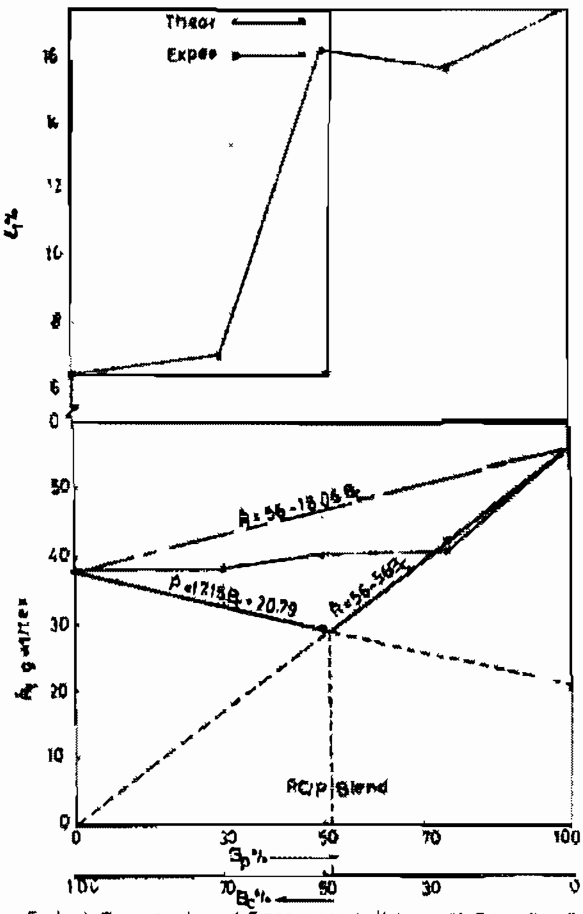
Cotton Substrate	First rupture point $\bar{P}_{\mathcal{E}_1} = B_1 P_1 + B_2 P_2 (\frac{\mathcal{E}_1}{\mathcal{E}_2}) \ldots (3)$	Second rupture point $\bar{P}_{\mathcal{E}_2} = B_2 P_2 \ldots (4)$
RC	$\bar{P}_{\mathcal{E}_c} = 4.6\ BC + 9.72$	$\bar{P}_{\mathcal{E}_p} = 26.17 - 26.17\ BC$
LC	$\bar{P}_{\mathcal{E}_c} = 16.2 - 9.19\ BC$	$\bar{P}_{\mathcal{E}_p} = 26.17 - 26.17\ BC$
MC	$\bar{P}_{\mathcal{E}_c} = 18.36 - 7.91\ BC$	$\bar{P}_{\mathcal{E}_p} = 26.17 - 26.17\ BC$
HC	$\bar{P}_{\mathcal{E}_c} = 21.06 - 11.64\ BC$	$\bar{P}_{\mathcal{E}_p} = 26.17 - 26.17\ BC$
AC	$\bar{P}_{\mathcal{E}_c} = 16.54 - 6.99\ BC$	$\bar{P}_{\mathcal{E}_p} = 26.17 - 26.17\ BC$

Table (5): Theoretical and Experimental Values of yarn Strength $\bar{P}$ and strain % in the Blends.

Cotton Substrate			100% Cotton	70% C/ 30% P	50%C/ 50% P	100% P	Theoretical critical Blend ratio B^*	Diag.
RC	$\bar{P}$	Theor.	14.32	12.94	12.02	26.17	B_p^* = 46.54	Fig.(6)
		Exp.	14.32	11.81	11.44	26.17		
	ε %	Theor.	5.64	5.64	11.8	11.8	B_c^* = 53.46	
		Exp.	5.64	5.55	6.05	11.8		
LC	$\bar{P}$	Theor.	7.01	9.77	11.61	26.17	B_p^* = 41.28	Fig.(7)
		Exp.	7.01	8.77	10.92	26.17		
	ε %	Theor.	6.2	6.20	11.8	11.8	B_c^* = 58.72	
		Exp.	6.2	7.19	8.0	11.8		
MC	$\bar{P}$	Theor.	10.45	12.82	14.41	26.17	B_p^* = 57.23	Fig.(8)
		ExP.	10.45	11.59	19.18	26.17		
	ε %	Theor.	6.64	6.64	6.64	11.8	B_p^* = 42.77	
		Exp.	6.64	7.28	8.61	11.8		
HC	$\bar{P}$	Theor.	9.42	12.91	15.24	26.17	B_p^* = 64.83	Fig.(9)
		Exp.	9.42	14.2	20.26	26.17		
	ε %	Theor.	7.4	7.4	7.4	11.8	B_p^* = 35.17	
		Exp.	7.4	7.81	8.8	11.8		
AC	$\bar{P}$	Theor.	9.55	11.65	13.05	26.17	B_p^* = 50.21	Fig.(10)
		Exp.	9.55	10.86	13.1	26.17		
	ε %	Theor.	6.29	6.29	6.29	11.8	B_p^* = 49.79	
		Exp.	6.29	8.26	8.78	11.8		

Table (6): Experimental values of skein strength (CSP), Specific work of rupture and wear resistance.

Yarn Type	CSP (Ne. lb)	Specific W. of Rupture (gwt./tex)x 10^{-2}	Wear Resistance incycles
100% RC	2018	34.41	3464
70% RC/30% P	1829	28.54	4768
50% RC/50% P	1542	32.87	11557
100% LC	729.4	21.41	271
70% LC/30% P	1324	32.74	6173
50% LC/50% P	1505	46.38	15692
100% MC	1059	36.26	487
70% MC/30% P	1770	41.96	8035
50% MC/50% P	2477	75.60	29650
100% HC	1054	35.65	774
70% HC/30% P	2203	56.81	12205
50% HC/50% P	2879	85.81	30870
100 AC	1342	30.85	4894
70% AC/30% P	1583	47.60	4962
50% AC/50% P	1788	59.23	16765



Fig(1) Theoretical and Experimental Values of Fibre Bundle Strength R_f and Strain ϵ_f% in the Blend

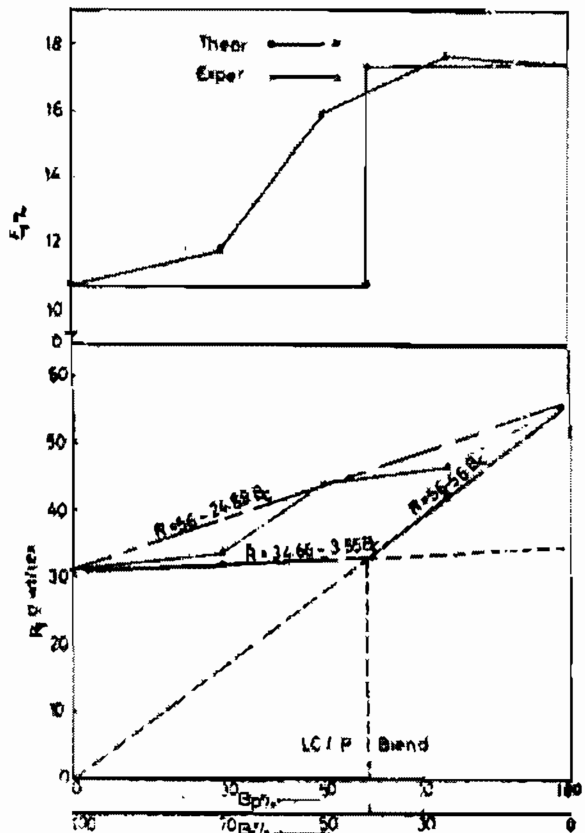
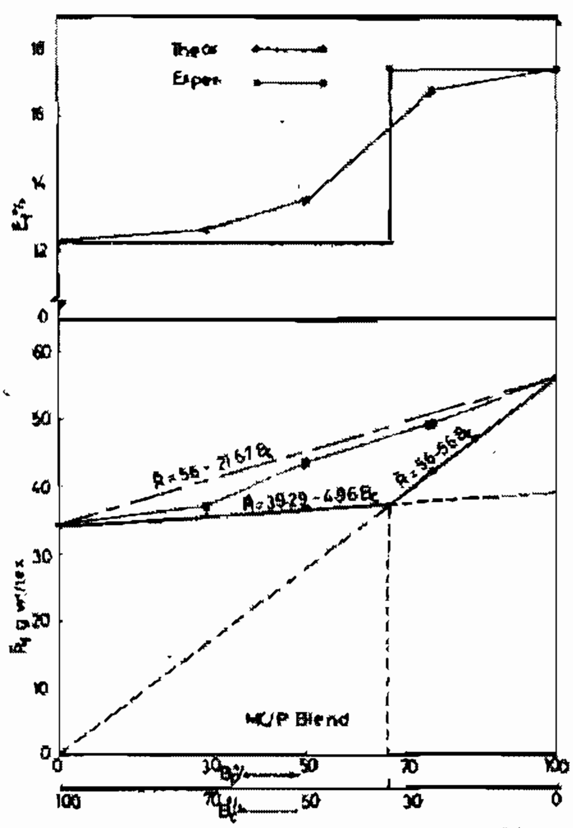


Fig (2) Theoretical and Experimental Values of Fibre Bundle Strength R_f and Strain ϵ_f% in the Blend



Fig(3) Theoretical and Experimental Values of Fibre Bundle Strength R and Strain ϵ_f % in the Blend

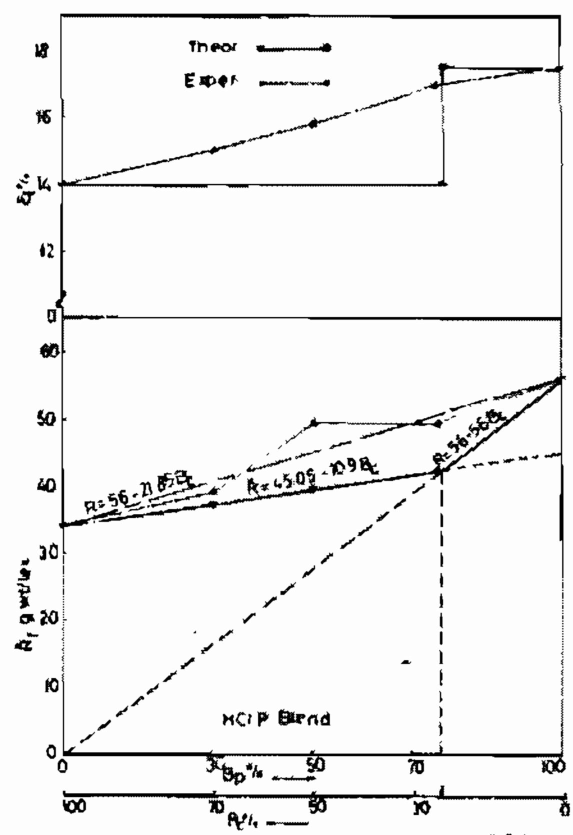


Fig.(4) Theoretical and Experimental Values of Fibre Bundle Strength R_f and Strain ϵ_f% in the Blend

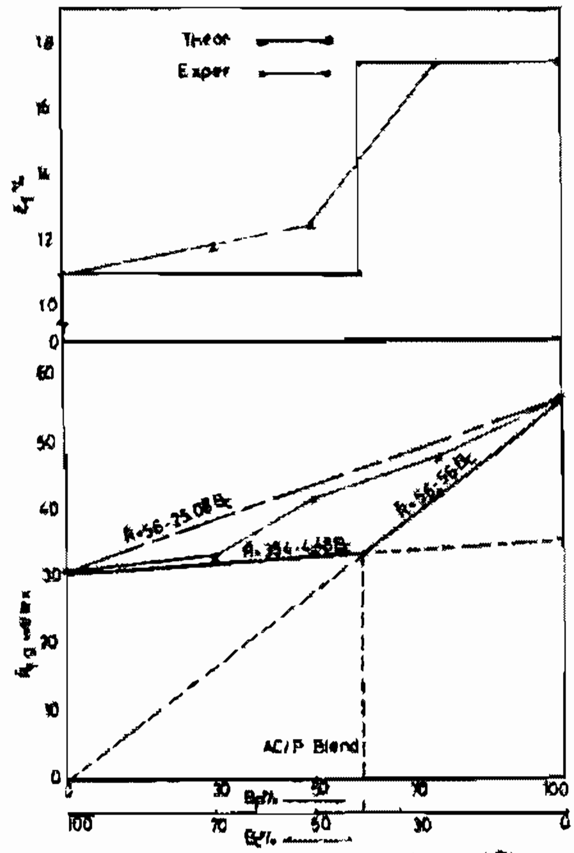


Fig (5) Theoretical and Experimental Values of Fibre Bundle Strength $\bar{P}_1$ and Strain ε_1% in the Blend

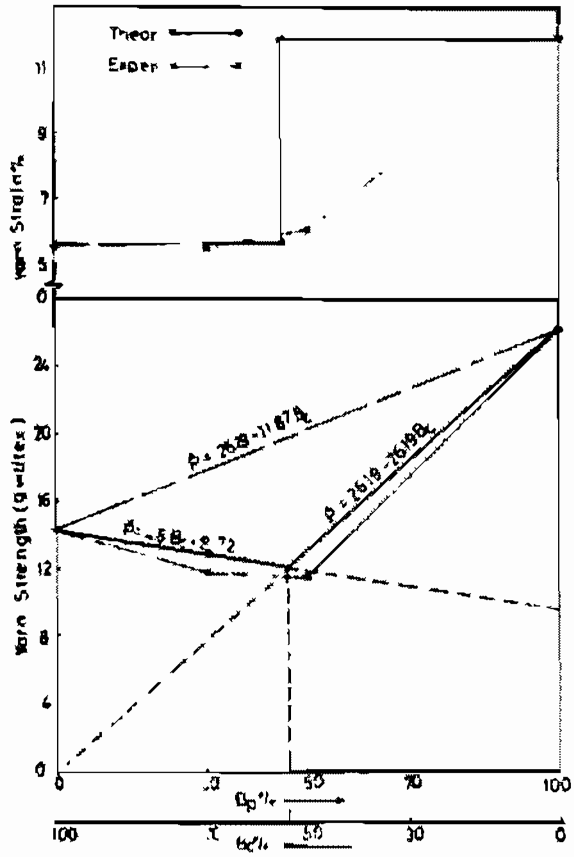


Fig (6) Theoretical and Experimental Values of RC/P Blended Yarns Strength and Strain

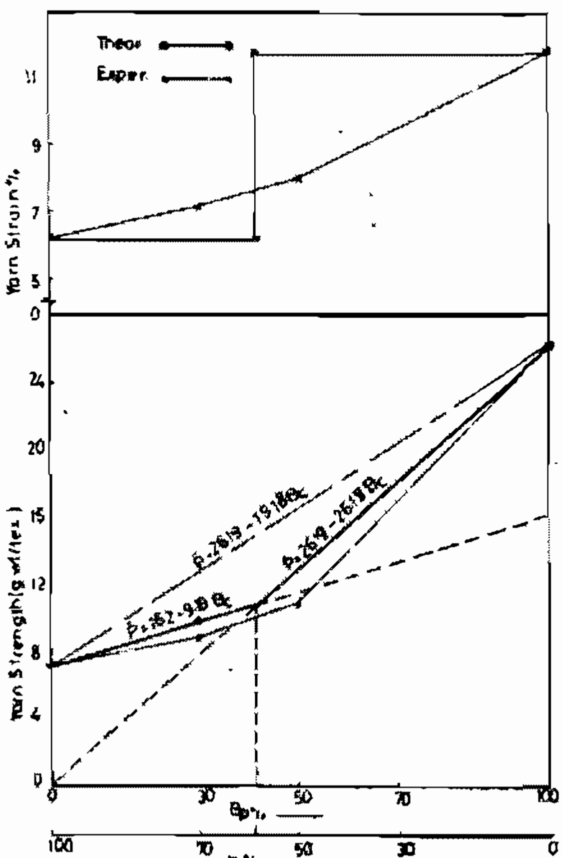


Fig (7) Theoretical and Experimental Values of LC/P Blended Yarns Strength and Strain.

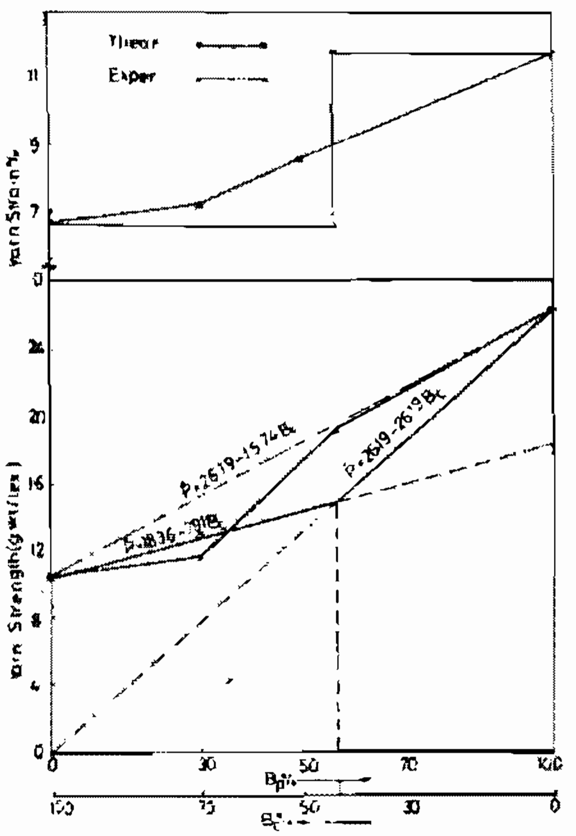


Fig (8) Theoretical and Experimental Values of MC/P Blended Yarns Strength and Strain

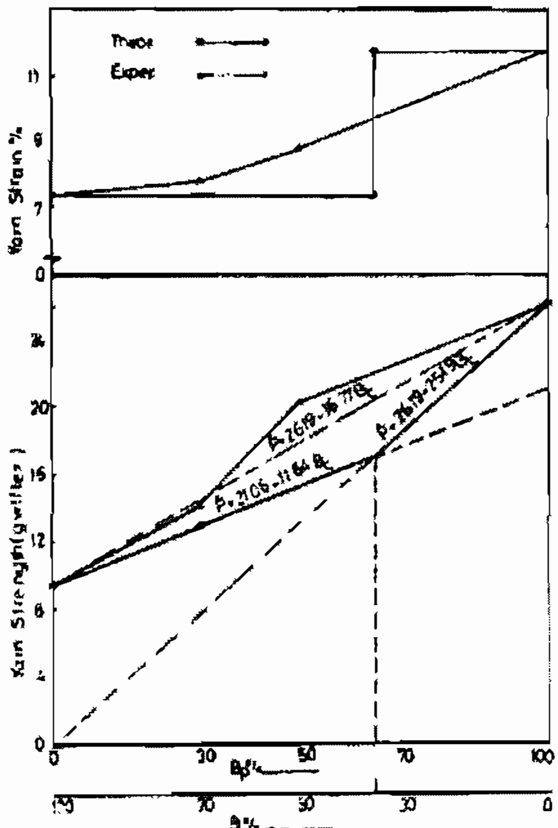


Fig (9) Theoretical and Experimental Values of HC/P Blended Yarns Strength and Strain

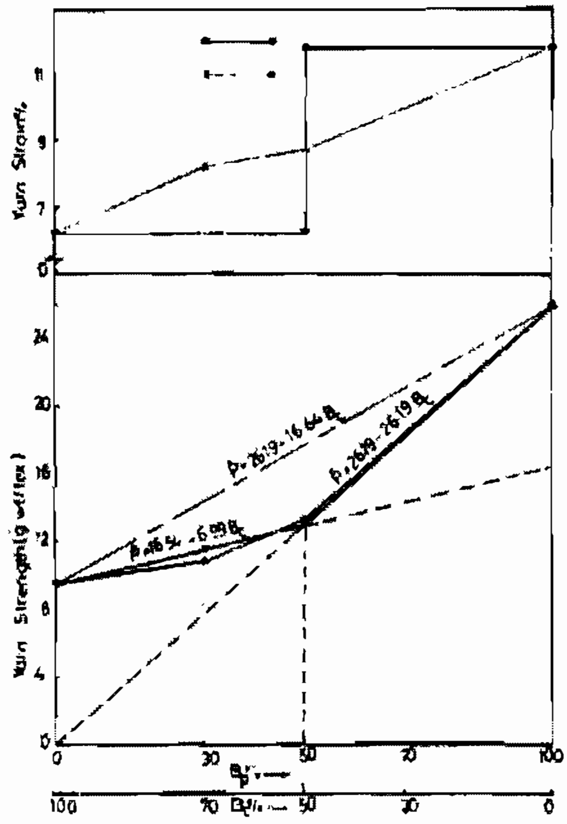


Fig (10) Theoretical and Experimental Values of AC/P Blended Yarns Strength and Strain

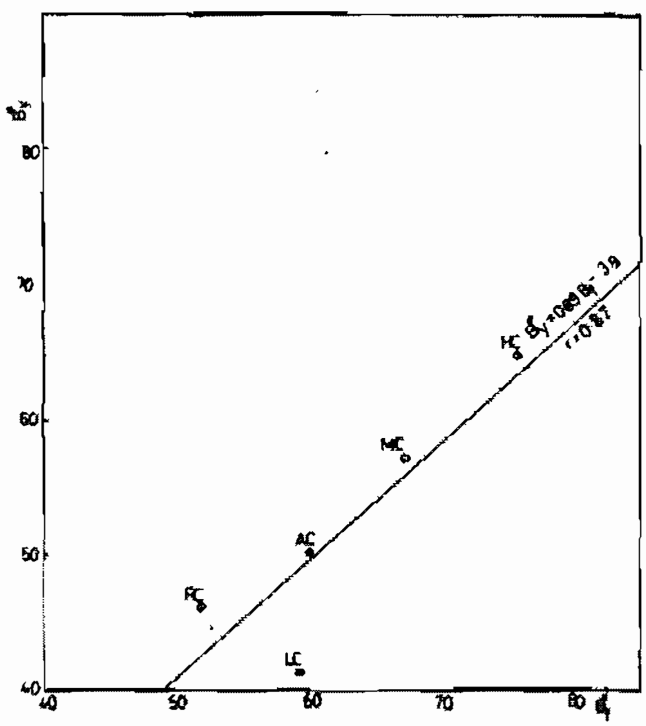


Fig (11) Linear Relation between Critical Blending Ratio in Yarns B_y and Fibres B_f

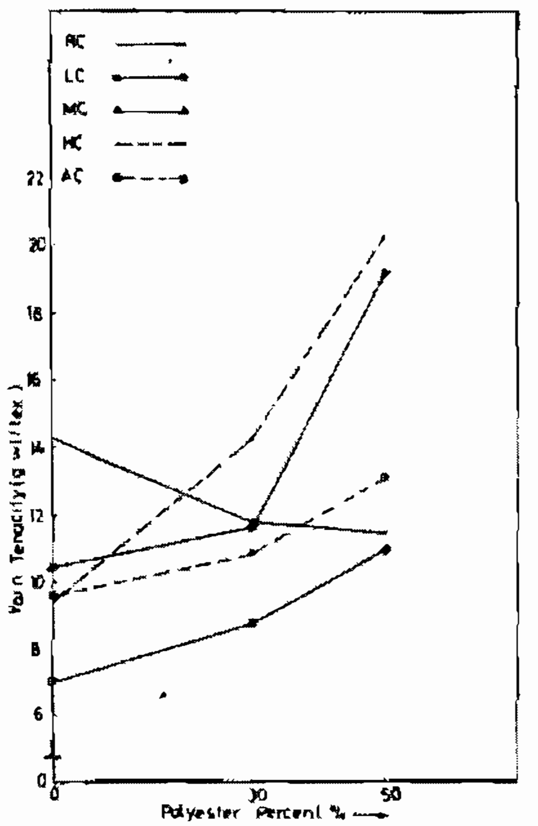


Fig (12) Yarn Strength of Cotton Substrates / P Blends

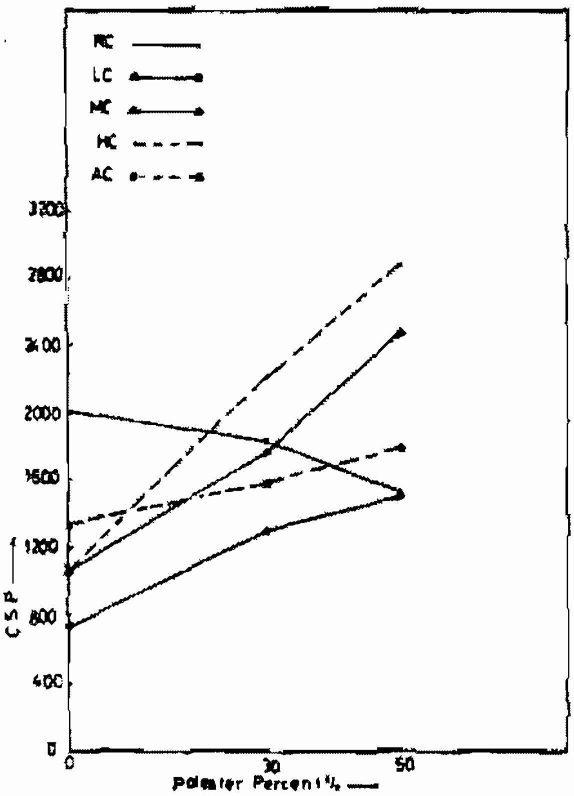


Fig (13) Relation between Skein Strength (CSP) and Blending Ratio.

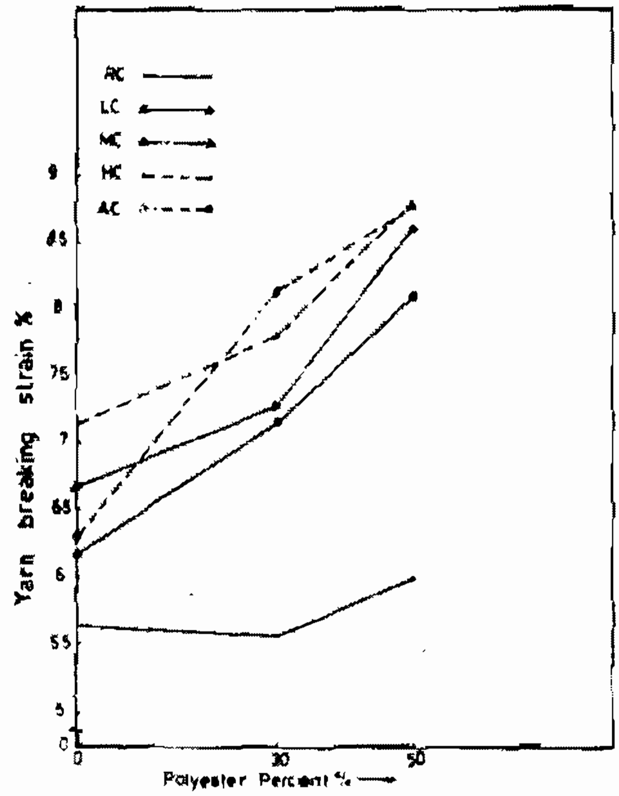


Fig (14) Relation between Yarn Strain% and Blending Ratio.

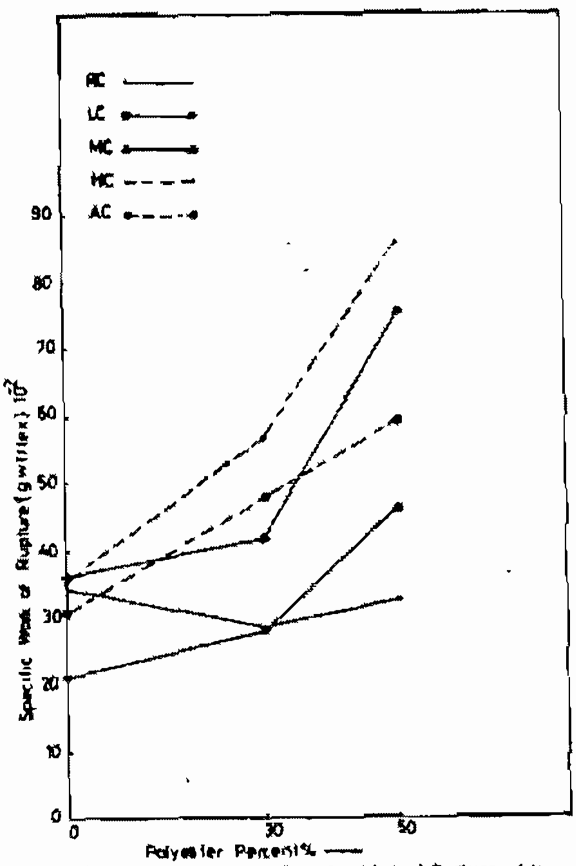


Fig (15) Relation between Specific Work of Rupture of Yarn and Blending Ratio

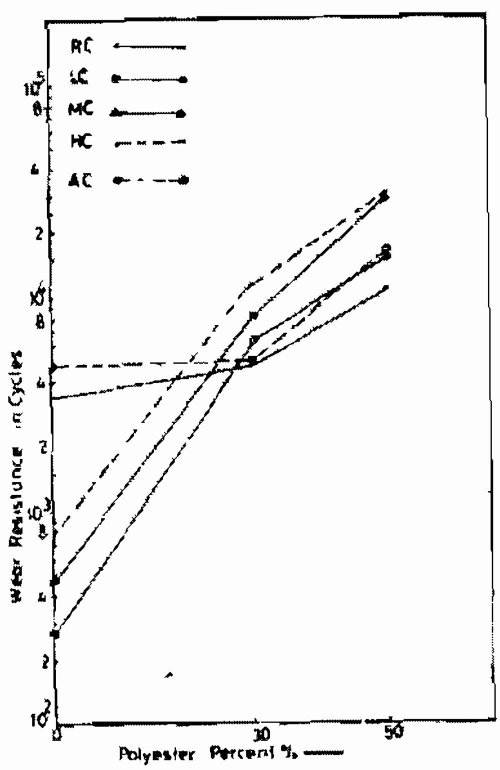


Fig (16) Relation between Wear Resistance of Yarn and Blending Ratio.