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Influence of Cotton Waste Fibre Properties, Twist Multiplier and Yarn Linear Density on Open-End Yarn Quality.

Rizk El-Bealy
Assistant Professor, Textile Engineering Department, Faculty of Engineering, Mansoura University, Mansoura, Egypt., rizk@mans.edu.eg

INFLUENCE OF COTTON WASTE FIBRE PROPERTIES, TWIST MULTIPLIER AND YARN LINEAR DENSITY ON OPEN-END YARN QUALITY.

دراسة تأثير خواص الشعيرات فى مخاليط القطن بالعوادم ، معامل اس البرم ونمر الخيوط المنتجه على خواص خيوط الغـزل ذات الطرف المفتـوح .

R.A. El-Bealy

Textile Dept., Faculty of Engineering, Mansoura Univeity.

الخلاصـه : أظهرت كثير من التجارب أهمية عوادم مصانع غزل القطن من حيث امكانية أعادة تشغيلها على ماكينة الغزل ذات الطرف المفتوح وبالتالى يمكن انتاج خيوط بتكلفه أقل دون أن تسبب مشاكل وصعوبات أثناء عملية التشغيل . والبحث الحالى يهدف الى دراسة العلاقة بين خواص الشـعيرات فى مخاليط القطن الخام بالعوادم المختلفة وخواص خيوط الغزل ذات الطرف المفتوح . وقداستخدم التحليل الاحصائى لدراسة مدى الارتباط بين طول الشعيرات ، نسـة الشعيرات القصـيرة ، متانة الشعيرات ودقتها وكل من متانة الخيوط ودرجة انتظامها ، كذلك دراسة تأثير كل من نمر الخيوط المنتجه حتى نمره ٣٤ ترى وتغير معامل اس البرم من ١١٥ الى ١٤٠ ترى على درجة جـوده الخيوط المغزولة من العوادم .

ABSTRACT: The aim of this work is to study the influence of the following-parameters: waste fibre properties, twist multiplier and yarn linear density on open end yarn characteristics. Cotton waste fibres which extracted from Giza 70, raw cotton "Giza 31" and their blends were the subject of the experiments. A wide range of yarn count Nm 14 to Nm 34 and twist multiplier α m 115 to α m 140 was used. The results declared that, there is a significant correlation between fibre paremeters and open-end yarn properties. The increase in twist multiplier and as yarn becomes finer does affect the open-end yarn quality.

1. INTRODUCTION:

The quality of open-end yarn is determined by many parameters, the interactions of which decides whether the final yarn produced will meet the requirements in the subsequent processing stages. The different parameters may be listed as follow:

i) Properties of the raw material, such as: fibre length strength, fineness, microdust, overlength fibres snd fibre fragments.

ii) Quality grade of sliver, such as: Sliver uniformity and cleanlines.

iii) The performance of the spinning instruments "i.e machine parameters" such as: Type and r.p.m. of opening roller, diameter, r.p.m. and shapa of rotor; twist inserted and winding tension, and;

iv) Environmental effects such as: Temperature and relative humidity.

The new generation of rotor spinning machines[1] has the capability of processing wide variety of raw materials such as:

i- Raw cotton-blending with different types, cotton comber waste 100%, blend of cotton waste with raw cotton, cotton waste from blowing room , carding and draw frame.

ii- Blends of man-made fibres with cotton such as cotton/polyester, Rayon/cotton and Acrylic/cotton blend.

iii- 100% man-msde fibres such as: Viscose, Polyester and Acrylic fibres.

In terms of how the influence of raw material properties reflect on the ysrn quality and on the runing properties: Many studies have been carried out for prediction open end yarn strength from fibre properties.[2,3,4] RAMEY, LAWSON and WORLY[4] have studied the relationship between most fibre properties and open-end and ring spun yarn tenacity and they formulated different equations for yarn strength.
Also, Several Research Workers[5,6,7] have studied the effect of twist factor on the quality of cotton O.E yarn and compared the results with that obtained for ring spun yarn from the same cotton fibres. Ibrahim[8] have studied the influence of Linear density and twist factor on O.E and ring spun ysrn characteristics. Other Study[9] showed that the influence of cotton/waste blend ratio and machine aggregation on O.E yarn properties.

The present work is concerned with the use of waste fibres in the production of O.E yarn on BD 200 Rotor Spinning "in Dakhalia Spinning Mill". The study tends to show that how this waste fibres could successfully be reprocessed to produce a yarn count up to Nm 34 with twist Multiplier up to α m 140 compared with that which could be spun from raw cotton fibres. The investigation was carried out considering the following parameters:

i) The effect of waste fibre properties Fibre Strength, fineness and fibre length (Length at 2.5%, mean length and short fibre %).

ii) The influence of twist multiplier and yarn count on open-end yarn quality.

iii) Relationship between the incorporation percentage of waste fibres in blends and O.E yarn quality index (YQI).

2. EXPERIMENTAL:

The experiments were constructed for studying the characteristics of open-end yarn dueto:

i) Waste fibre properties:

To investigate the effect of waste fibre properties and blend ratio on O.E yarn quality, the process is designed to use different types of cotton waste which extracted from Egyptian cotton "Giza 70". While Giza 31 "Oandara" was selected for blends with cotton waste fibres. Three types of cotton waste "Comber noil, penumafil and carded sliver" were blended with 100% cotton fibre at five level of blends. The Construction details of material used is shown in Table(1).

Table (1)
Fibre Material used

Raw cotton Giza 31	Cotton Waste			Blend level	Designation
	Comber noil	Penu-mafil	Carded sliver		
100	-	-	-	100_{c}	I
50	50	-	-	$50_{c}/50_{w1}$	II
35	45	20	-	$35_{c}/65_{w2}$	III
20	35	45	-	$20_{c}/80_{w3}$	IV
0	20	50	30	$_{c}100_{w4}$	V

The main fibre properties of individual component, cotton waste and blends were examined according to ASTM standard. Fibre length characteristics using Digital Fibrograph, Fibre Tensile properties on pressely flat bundle tester and Stelometer. Fibre fineness in terms of ug/inch using Sheffield micronaire and fibre cleanlines were measured by Shirely Analyser.

ii) Twist Multiplier and Yarn Linear Density:-

To investigate the effect of twist multiplier and blend composition on open-end yarn properties 25 samples were produced, all for the same yarn count Nm 24, and twist multiplier varies between m 115 and m 140. Also, the yarn produced from variety of cotton-waste blends (100_c, $50_c/50_{w1}$, $35_c/65_{w2}$, $20_c/80_{w3}$ and 100% w_4) while the other machine parameters were kept constant (rotor speed = 36000 r.p.m. and Combing roller 7500 r.p.m) as given in Table (2).

Table (2)

O.E yarn count Nm	Twist Factor (α m)	Fibre Material Used					Designation
		I	II	III	IV	V	
24(42tex)	115	X	X	X	X	X	i(1-5)
	121	X	X	X	X	X	ii(1-5)
	127	X	X	X	X	X	iii(1-5)
	123	X	X	X	X	X	iv(1-5)
	139	X	X	X	X	X	v(1-5)

To investigate the effect of open-end yarn linear density on the final yarn characteristics, 25 samples were produced. All for the same twist multiplier α m 127. The yarn count varies between 14 Nm and 34Nm, each produced from five level of cotton-waste blends, while the other psrameters were kept constant as illustrated in Table (3).

The blends were processed through blowing room (bale-opener, step cleaner, XL Rando, chut feeding), tandem carding machine, Zinser drawing frame (Model 720), and finally open-end machine (BD 200 R_c). For all cotton-waste blends the machine parameters were kept constant through the production of yarns.

All of open-end yarns listed above, in Tables (2) and (3), were examined according to ASTM standard to determine the following parameters:
Tensile properties on USTER TENSOMAT tester, yarn irregularity and imperfections by USTER Evenness tester, twist on Zweigle twist meter and yarn count on USTER Autosorter.

3. RESULTS AND DISCUSSIONS:

3.1. Effect of Waste Fibre Properties on O.E. Spun yarn Quality:

The characteristics of various components; raw cotton fibre "Giza 31" and cotton waste "comber noil, penumafil and card sliver" which extracted from Giza 70 are shown in Table (4). Also, the main properties for material used ($50_c/50_{w2}$, $20_c/80_{w3}$ and 100_{w4}) are given in Table (4).

Table (3)

O.E yarn count (Nm)	Twist Factor (α_m)	Fibre Material Used					Desig-nation
		I	II	III	IV	V	
14(72 tex)		X	X	X	X	X	i(1-5)
20(50 tex)		X	X	X	X	X	ii(1-5)
24(42 tex)	127	X	X	X	X	X	iii(1-5)
27(37 tex)		X	X	X	X	X	iv(1-5)
34(30 tex)		X	X	X	X	X	v(1-5)

The curves, in Fig.(1.1), shows the influence of subsequent process; blowing room, carding machine and drawing frame on the mean fibre length. It can be observed that, mean fibre length (mm) for all blends increases due to the ection of processing from raw materal until drawing Sliver. On the other hand, the curves in figure (1.2) shows Shirley non-lint content (%) for all material used. The sample were examined picked up from raw material (RM), tufts from chut feed (II), Carded Sliver (CS) and drawing sliver (DS). It is obvious that, the trash content is gradually decreases from raw material to drawing sliver. Also, it can be noted that, a little amount of trashes with cotton waste and blends compared with 100% cotton fibre.

Teble (4' Fibre properties

Fibre property	Fibre Material used							
	Cotton Waste			Raw cotton "G31"	Cotton-Waste blends*			
	Comber noil	Penu-mafil	Card sliver		50_C 50_{W1}	35_C 65_{W2}	20_C 80_{W3}	0 100_{W4}
1) Fibre length:								
Length at 2.5%	24.5	32.5	35.5	31.5	30.00	30.50	31.50	33.50
at 50%	9.9	18.2	19.3	14.5	13.95	14.50	15.00	16.75
Uniformity ratiu	40.4	55.8	54.3	46.0	46.50	47.46	47.60	50.00
Mean Length(mm)	16.0	28.7	32.3	25.2	24.10	25.20	26.20	29.70
Short fibre < ½"	25.7	6.9	2.5	13.7	14.20	12.39	11.35	5.90
2) Fibre Strength:								
Pressely Index	8.64	10.65	9.97	8.63	9.27	9.05	10.20	10.44
Fibre tenacity(g/tex)	21.50	32.70	31.20	26.00	24.60	27.70	31.70	31.50
Elongation E%	6.50	5.70	5.90	7.50	6.70	6.10	5.50	5.70
3) Fibre Fineness $\frac{\mu g}{inch}$	3.45	3.90	3.65	3.75	3.55	3.45	3.85	3.75
4) Fibre cleanliness								
Good Fibre %	98.40	99.80	99.50	96.4	96.60	98.00	98.80	98.90
non-lint %	1.60	0.20	0.50	3.6	3.40	1.95	1.20	1.10
Dust %	1.00	0.18	0.15	1.8	2.00	1.23	0.89	0.33
Invisible Waste %	0.60	0.02	0.35	1.8	1.40	0.72	0.31	0.77

* tufts picked up befor feeding to carding m/C.

Correlation analysis between fibre properties and open-end spun yarn characteristics:-

To explain the relationship between waste fibre properties and the final yarn properties, the analysis of correlstion is applied to the results of experiments in groups based on twinty five observations. The statistical analysis was done by computer Apple II to form a multiple regression analysis for a dependent variables "yarn tenacity (g / tex) and yarn irregularity (C.V%)" and two sets of independent variables. The first group of fibre parameters include X_2 (fibre strengtb), X_3 (mean length), X_4(short fibre) and X_5(fibre fineness) as shown in Table (5). While the second group of parameters is concerned with fibre length characteristics, X_2: Length at 2.5%, X_3: mean fibre length and X_3: Short fibre % as given in Table (6).

Table (5) Correlation analysis between Waste fibre properties and O.E yarn quality.

Fibre properties	O.E Spun yarn Characteristics	
	Yarn tenacity (g /tex)	Yarn regularity (C.V%)
(i) Simple correlation coefficients		
Fibre Strength (g /tex): (r_{12})	0.826	0.717
Fibre length in mm : (r_{13})	0.816	0.731
Short fibre % : (r_{14})	-0.742	-0.657
Fibre Fineness(µg/inch) : (r_{15})	0.648	0.479
(ii) Partial correlation coefficients (1st order)		
Fibre Strength at short fibre = Const. ($r_{12.4}$)	0.556	0.384
at micronaire = Const. ($r_{12.5}$)	0.673	0.623
Fibre length at short fibre = Const. ($r_{13.4}$)	0.592	0.513
at micronaire = Const. ($r_{13.5}$)	0.677	0.629
Short fibre at micronaire = Const. ($r_{14.5}$)	-0.621	-0.543
Micronaire at short fibre = Const. ($r_{15.4}$)	0.455	0.212
(2nd order)		
Fibre Strength at short fibres and micronaire const ($r_{12.45}$)	0.425	0.558
Fibre length at short fibres and micronaire const ($r_{13.45}$)	0.425	0.558
(iii) Multiple correlation coefficients		
Fibre Strength, fibre length and Short fibres ($R_{1.234}$)	0.778	0.791
Fibre Length, short fibres and micronaire ($R_{1.345}$)	0.777	0.791

Fibre Strength: The analysis was made as shown in Table (5) indicate the effect of waste fibre tenacity (gf/tex.) on Open-end yarn Strength. In general the correlation coefficients shows a direct ralation between fibre strength and the resultant yarn strength (R.K.M) in a cotton-waste blended yarn Nm 24, with twist multiplier (αm) of 115 and 127.

The simple correlation between yarn strength and X_1: fibre tenacity is equal to r_{12} = 0.83 which is highly significant. Also, the partial correlation $r_{12.4}$ at X_4 (Short fibres % = Const), $r_{12.5}$ at X_5 (micronaire const) are equal to 0.556 and 0.673 while the second order coefficients are low = 0.43 and not significant.

Fibre fineness: The results show the correlation coefficients between fibre fineness and O.E spun yarn irregularity (0.5) and 0.65 for yarn tenacity. The influence of fibre fineness in terms of number of fibres per cross-section on yarn quality is shown in figure (1.5). The improvement in yarn strength or the reduction in yarn irregularity is determined by the number of individual fibres in the yarn cross-section. The curves show for the same fibre fineness and constant twist multiplier imparted to the yarn,as the yarn becomes fiber the O.E yarn tenacity falls and the irregularity rises.

Table (6) Correlation analysis between fibre length characteristics and O.C spun yarn quality.

Fibre length characteristics	O.E spun yarn characteristics	
	Yarn Tenacity (g/tex)	Yarn irregularity (C.V%)
(i) Simple correlation coefficients		
Length at 2.5% : (r_{12})	0.671	0.775
Mean Length (mm): (r_{13})	0.641	0.745
Short fibre % : (r_{14})	-0.595	-0.697
(ii) Partial correlation coefficients (1st order)		
Length at 2.5% and Mean length = Const. ($r_{12.3}$)	0.283	0.341
and Short fibre = Const. ($r_{12.4}$)	0.399	0.484
Mean length at Short fibre = Const: ($r_{13.4}$)	0.397	0.482
(iii) Multiple correlation coefficients		
Length at 2.5%, Mean length and short fibre($R_{1.234}$)	0.676	0.777

Fibre length: The influence of mean fibre length on yarn tenacity at different twist multiplier (αm) is shown in Figure (1.3). Also, the analysis of correlation is summerized in Tables (5) and (6). From which itispossible to discuss the influence of mean length,length at 2.5% and short fibre % on Open-end yarn tenacity and irregularity.

The correlation between yarn strength and mean fibre length, r_{13}, $r_{13.4}$ at X_4 = Conat. and $r_{13.5}$st X_5 = Const. are significant at 99% level.

The Same trend has been observed with yarn irregularity, in which the correlation varies between 0.5 and 0.73. Length at 2.5% has a significant effect on uster C.V% and strength. On the other hand, the results indicate the effect of short fibre % in cotton-waste blends on open-end yarn quality. The increase of short fibres % in Sliver fed to O.E Spinning machine resulted in e lower yarn Strength, as shown in Figure (1.4), and increases yarn irregularity.

3.2. Effect of Twist Multiplier on Open-End yarn quality:

The relationship between twist multiplier with Varying cotton-Waste blends and open-end spun yarn characteristics are shown in Figures (2.1), (2.2) and (2.3). Figure (2.1) show the effect of twist multiplier on O.E yarn tenacity. The curves indicate that, the increase of twist from α m 115 to α m 140 lead to an increase of yarn strength. For mix $20_c/80_{w3}$ and 100% w_4 a higher strength or closer to those for 100% cotton, while a lower strength has been observed for mix $50_c/50_{w1}$ and $35_c/65_{w2}$.

The influence of twist on O.E yarn elongation is shown in Figure (2.2). The curves indicate that an increase in yarn elongation due to the increase in twist level. Also, it can be noted thet, the higher extension is particularly prominent with cotton yarn than those for blends.

From Figure (2.3), it is evident that from the experimental results, there is no influence on the Uster C.V% when the twist varied between α m 115 and α m 140.

3.3. Effect of Yarn Linear Deneity on O.E yarn Properties:

The effect of yarn count and type of material used on the tensile properties of O.E spun yarn is given in figures (3.1) and (3.2). From Fig. (3.1), open-end yarn tenacity varies from one group to annther. Ahigher strength values has been observed in case of 100% cotton yarn and gradually decreases as the proportion of waste fibres increases in blends ($50_c/50_{w1}$ and $35_c/65_{w2}$). On the other hand $20_c/80_{w3}$ and 100_{w4} resulted in acloser or highef value than for 100% cotton. Also within each group a substantial decrease in yarn tensacity as yarn becomes finer.

It is evident that from the experimental values illustrated in Figure (3.2), the yarn count, when varied between Nm14 and Nm 34 has a significant effect on open-end yarn extension. Also, the curves shows ahigher extension values for 100% cottnn yarn than with all cotton-waste blends.

Figure (3.3) shows the effect of yarn count with varying the cotton-waste blends on irregularity of open-end yarns. As would be expected better yarn regularity occurs with 100% cotton yarn than with all cotton-waste blends. At the same time within each group the irregularity increases as yarn becomes finer.

3.4. Effect of Waste Composition on Open-End Yarn Quelity Index (YQI):

The experimental results obtained for yarn tenacity, breaking extension and yarn irregulqrity, in the previuus sections, were used for calculation the yarn-quality index;

$$YQI = \frac{\text{Yarn tenacity (g /tex) . breaking elongation (\%)}}{\text{Yarn irregularity (C.V\%)}}$$

The curves for open-end yarn-quality index are illustrated in figures (4.1) and (4.2). It can be seen that, the yarn-quality index decreases with the increase in yarn count from Nm 14 to Nm 34. This is in agreement with the earlier Studies[10]. At the same time, for the same yarn count, the incresse in twist multiplier bring about change in YQI, which is lower than that obtained for yarn count.

The curves indicate clearly the effect of blend levels on yarn quality index. It can be seen that, a better O.E yarn-quality index, ranged between 4 and 12, occours with blend levels between 100% cotton and 35 /65 . At the same time, the yarn quality index for 100% cotton is higher than those for all cotton-waste blends.

4. CONCLUSIONS:

The experimental results of production open-end yarn from cotton-waste blends demonstrate clearly that;

1) The fibre properties fibre strength, fibre fineness, fibre length and Short fibre %" influences significantly on open-end yarn characteristics:

- Alonger mean fibre length for waste fibres resulted in a lower rate of irregularity and higher strengthes of open-end yarn.
- The presence of higher percentage of short fibres tends to reduce yarn strength and increases oster C.V% of open-end yarn.
- A lower micronaire value of blend compnents tends to improve the yarn regularity and gives a better yarn tensile properties.
- The results shows a direct relation between fibre tenacity and the resultent yarn strength in cotton-waste blends.

2) The relationships established by multiple correlation analysis between open-end yarn characteristics and fibre parameters have shown that the fibre properties "length, % short fibres, strength end micronaire" have a strong effect on open-end yarn tenacity and yarn irregularity. The multiple correlation coefficient for yarn tenacity 0.77 and 0.8 for yarn irregularity.

3) twist multiplier values from α_m 115 to α_m 140 has a considerable effect on open-end yarn tenacity and yarn extension. While the increase in twist level does not show markedly variation with yarn irregularity.

4) For all cotton-waste blends, a significant reduction in open-end yarn tenacity and elongation has been found when yarn becomes finer. While an increese in Open-end yarn irregularity is proportional to tbe increase of yarn count from Nm 14 to Nm 34.

5) In terms of open-end yarn-quality index, the results indicate that:

- Cotton-waste fibre blends can be spun satisfactory on BD 200 Rc and producing yarn count up to Nm 34.
- Blends containing waste fibre ratio higher than 65% Waste show a lower yarn quality index.
- A lower ratio of waste fibres is recommended for blend with cotton fibres to achieve a better O.E yarn quality index.

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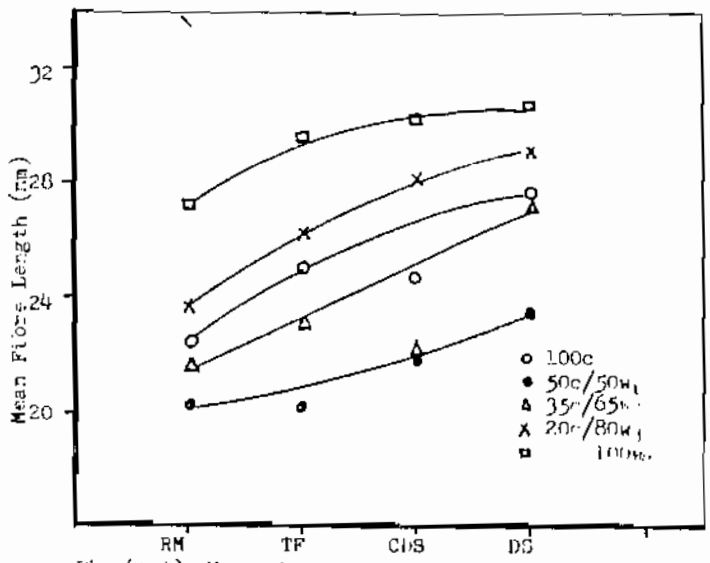
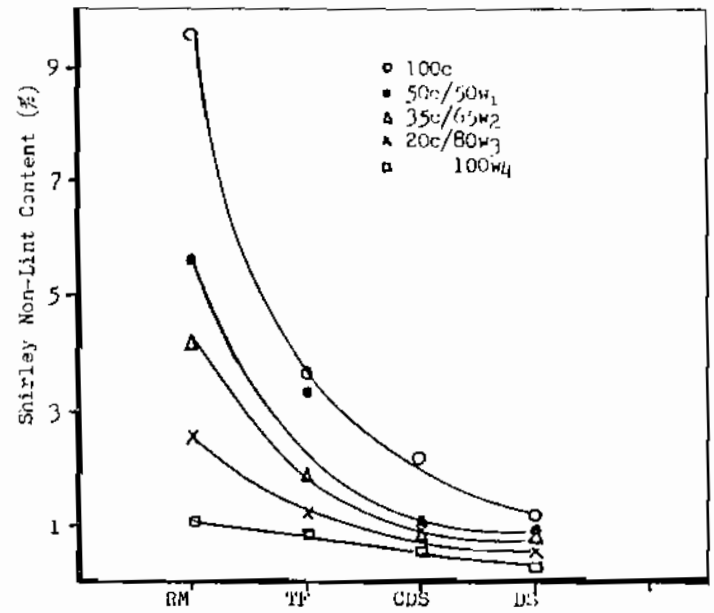


Fig.(1.1) Mean fibre length in material used
(Raw material, Tufts, Carded and Drawing sliver)



Fig(1.2) Shirley non-lint content in material used
(Raw material, Tufts, Carded and Drawing sliver)

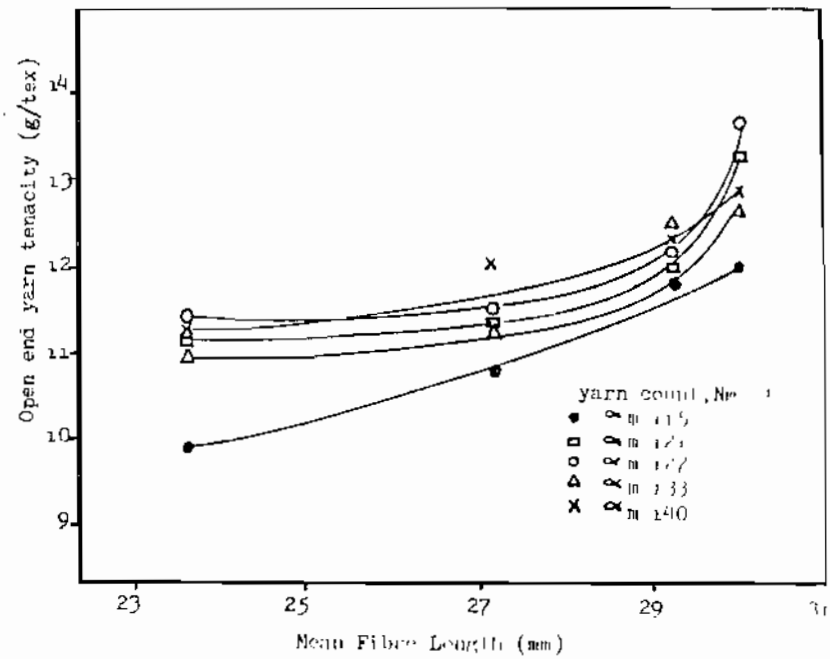


Fig.(1.7) Effect of fibre length on O.E yarn tenacity

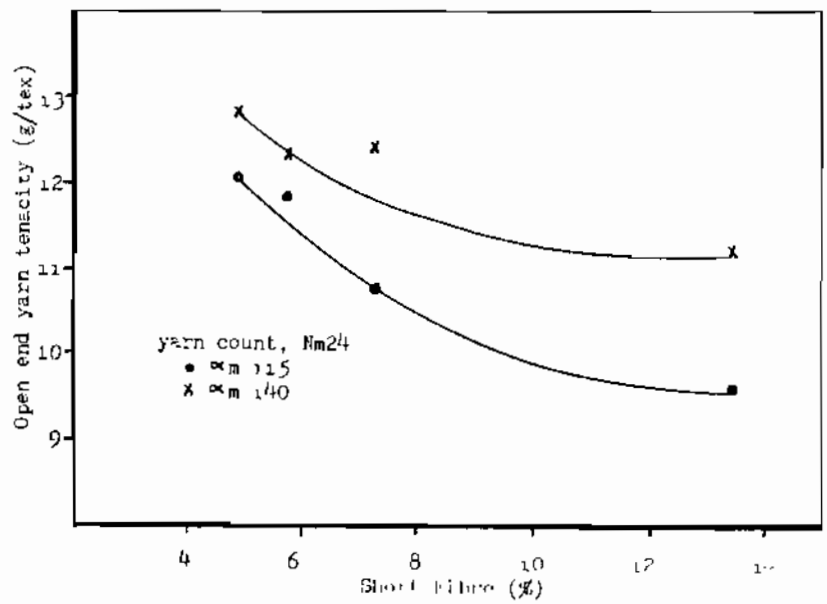
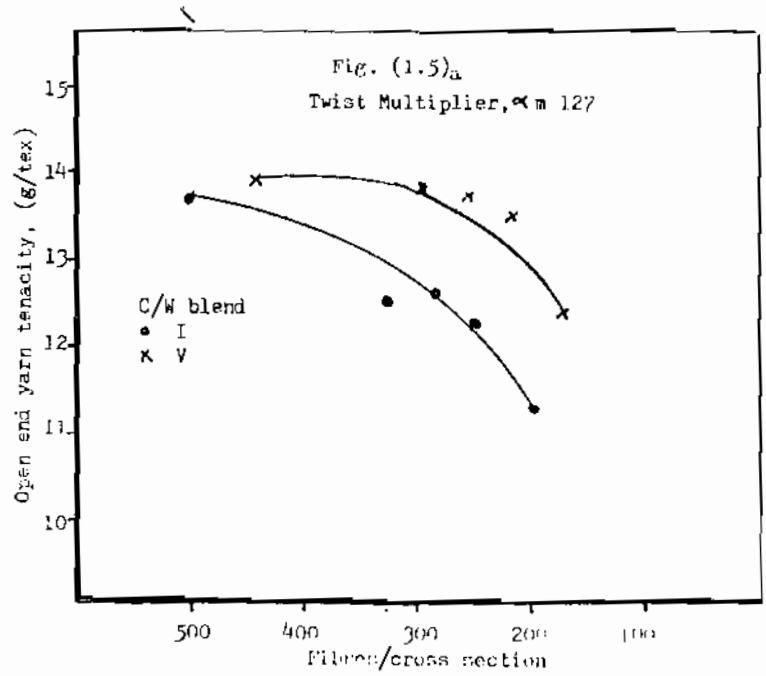


Fig.(1.8) Effect of short fibre (%) on O.E yarn tenacity



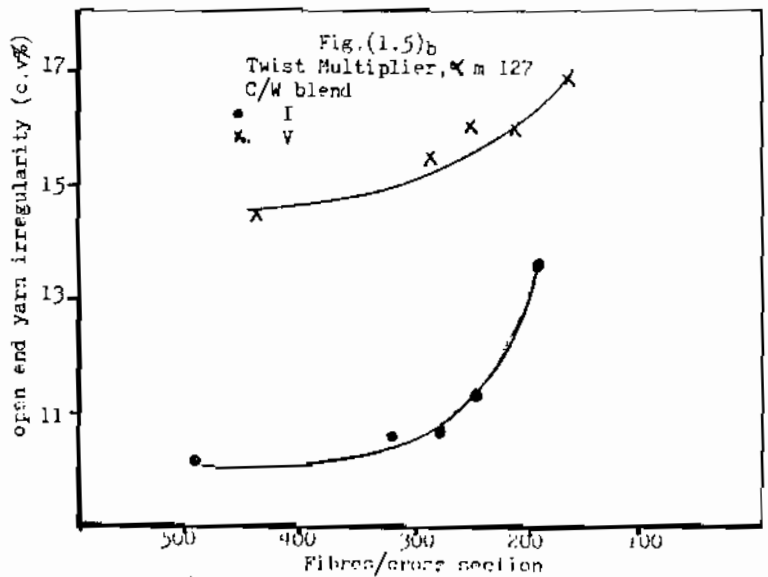


Fig.(1.5) Open end yarn tenacity and irregularity in relation to No. of fibres/cross section

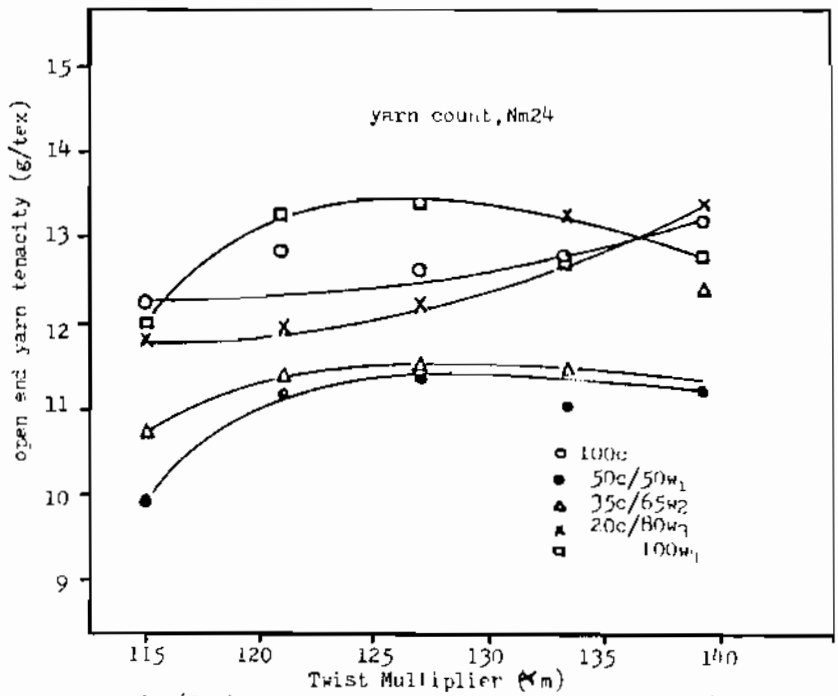


Fig.(2.1) Effect of twist multiplier and cotton/waste blend level on O.E yarn characteristics (tenacity g/tex)

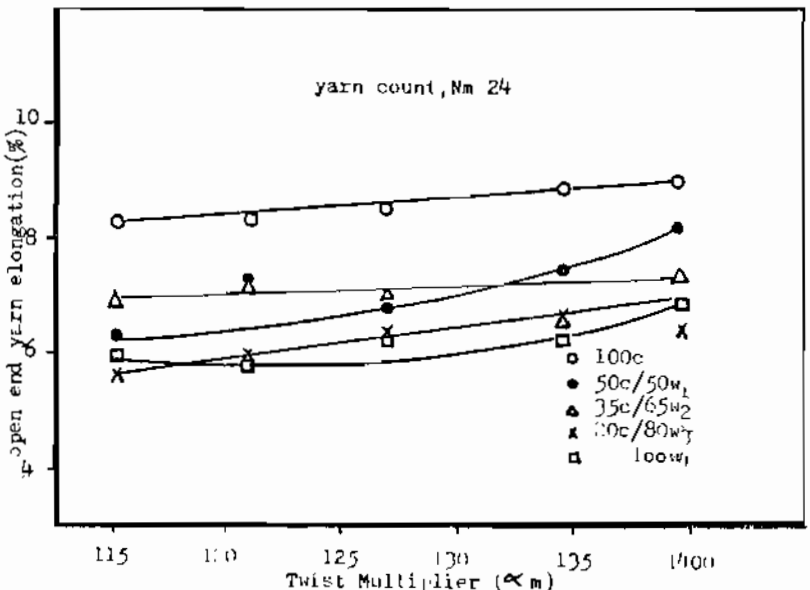


Fig.(2.2) Effect of twist multiplier and cotton/waste blend level on open end yarn elongation(%)

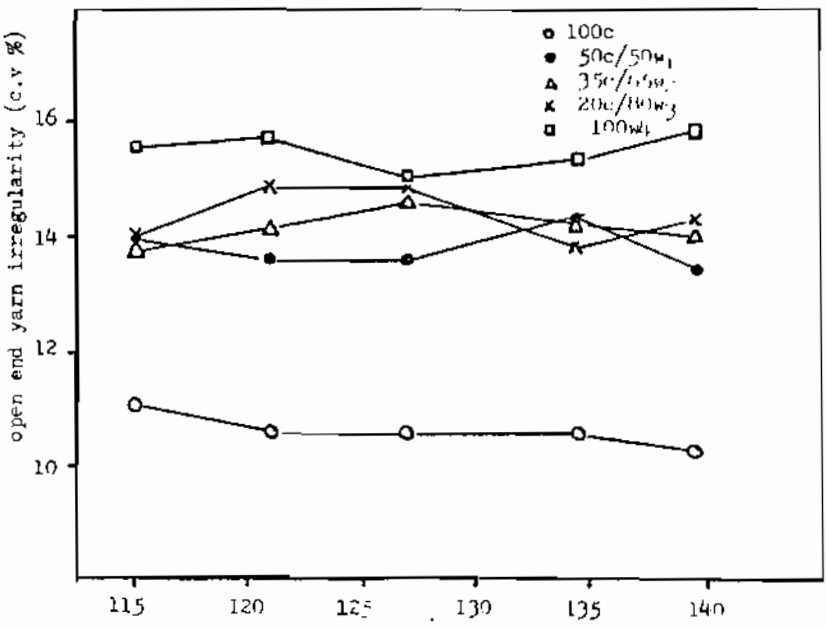


Fig.(3.3) Effect of twist multiplier and cotton/waste blend level on open end yarn irregularity

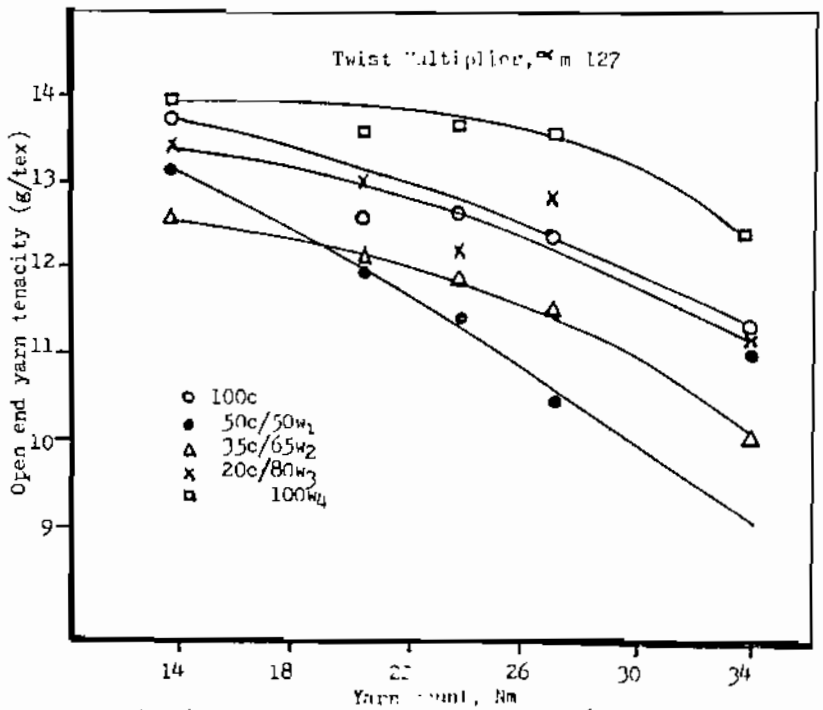


Fig.(3.4) Effect of yarn count and cotton/waste blend level on open end yarn tenacity (g/tex)

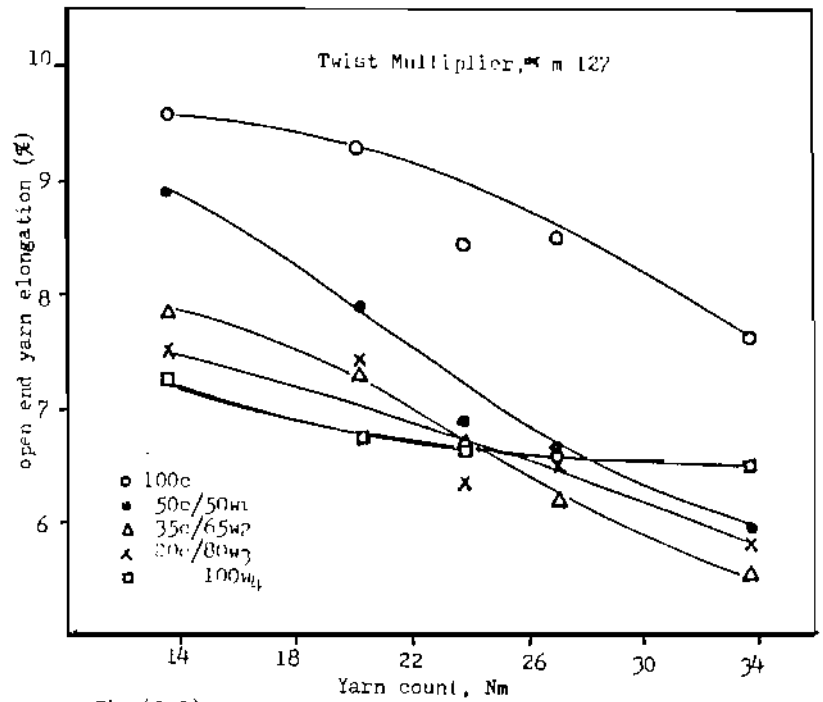


Fig.(3.2) Effect of yarn count and cotton/waste blend level on open end yarn elongation (%)

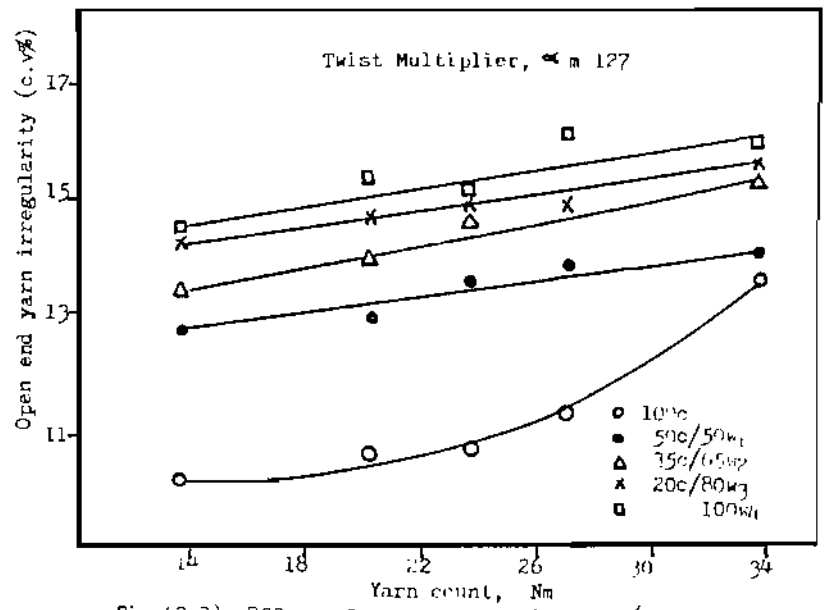
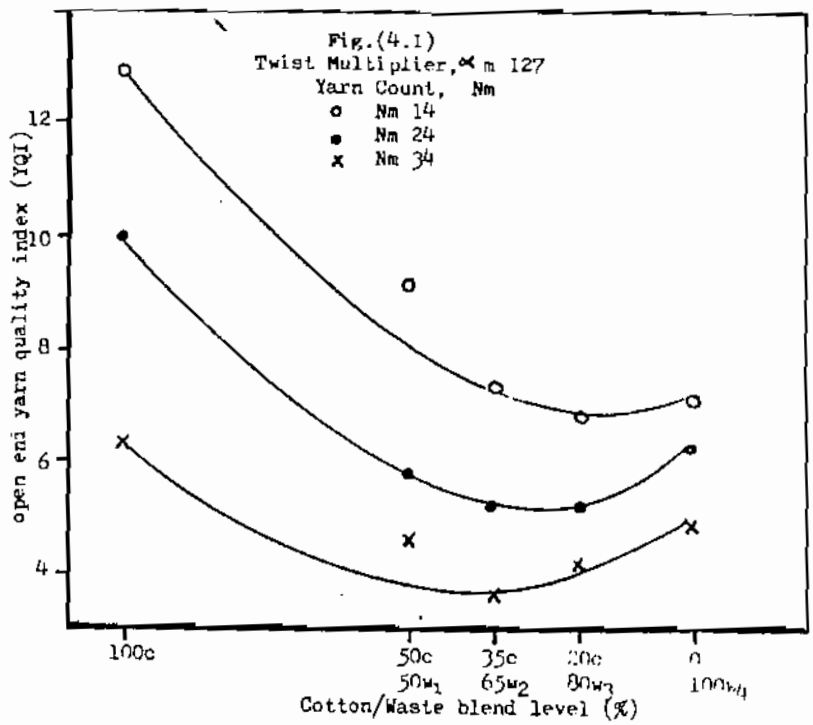


Fig.(3.3) Effect of yarn count and cotton/waste blend level on open end yarn irregularity(c.v%)



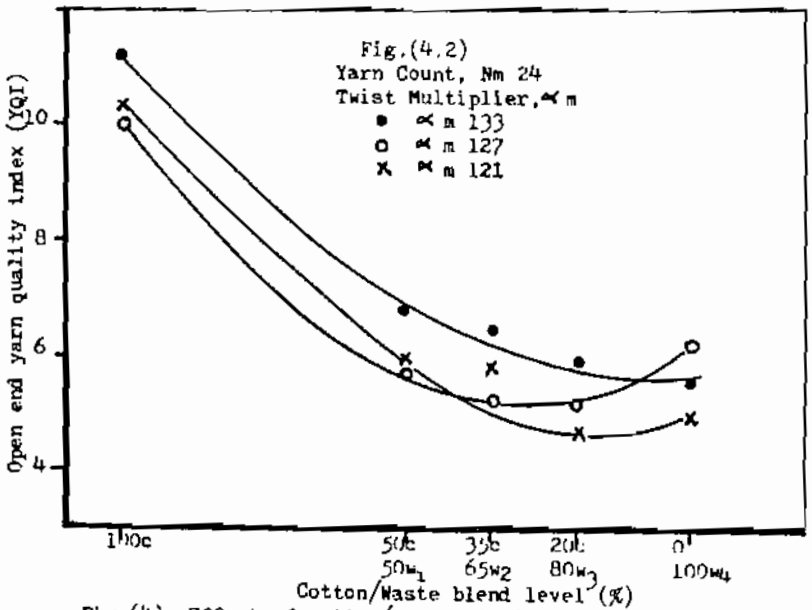


Fig.(4) Effect of cotton/waste blend level at different yarn count and twist multiplier on Open end yarn quality index (YQI)