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Effect of Egyptian Cotton Fibre Length Distribution on Yarn Properties.

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EFFECT OF EGYPTIAN COTTON FIBRE LENGTH DISTRIBUTION ON YARN PROPERTIES

تأثير توزيع طول الشعيرات للأقطان المصرية على خواص الخيوط

By
Fawkia F. El-Habiby

ملخص البحث

يهدف هذا البحث إلى دراسة تأثير توزيع أطوال الشعيرات المقاس بواسطة جهاز AFIS (بالوزن والعدد) على خواص الخيوط المنتجة. حيث تم اختبار عدد من الأقطان المصرية المختلفة النوع والرتبة بواسطة جهاز AFIS، ثم تم تشغيلها لإنتاج خيوط ممشطه (نسبة تمشيط ١٨%) بنمر تتراوح من ١٦ إلى ١٠٠ نمره إنجليزي. تم تحليل النتائج بحساب معامل الارتباط بين خواص الخيوط الاساسية " المتانة، الانتظامية، عدد المناطق السميكة والرفيعة والنبس" ومتغيرات الطول للشعيرات. وتم أيضا حساب معامل الارتباط بين خواص الخيوط ونسبة الشعيرات في فئات الطول المختلفة والتي تبدأ من الفئة (٠- ٦) مم حتى الفئة (٥٤-٦٠) مم. كما تم حساب معادلة الانحدار لخواص الخيوط كمتغير تابع ونسب الشعيرات في فئات الطول المختلفة بالإضافة إلى دقة الشعيرات ونسبة الشعيرات الغير ناضجة كمتغير مستقل. كما تم حساب مقدار مساهمة نسب الشعيرات عند الأطوال المختلفة للتوزيع، نسبة الشعيرات الغير ناضجة والنعومة، (ونحافة الشعيرات فى حالة النبس) إلى جانب نمرة الخيط فى خواص الخيوط. وقد أوضحت النتائج أن متغيرات الطول ونسب الشعيرات في الفئات القصيرة والطويلة لها تأثير كبير على خواص الخيوط المنتجة.

Abstract

In this work studying the effect of AFIS fibre length distribution by weight and by number on combed ring spun yarn properties is carried out. Where Egyptian cotton fibres of different types and grades were processed for producing combed ring spun yarns with counts ranged from 16Ne to 100 Ne. Correlation coefficients between yarn properties and fibre length parameters (and slenderness of fibres for yarn neps) were calculated. Also correlation coefficients between yarn properties and percentages of fibres in the different length categories, by weight and by number, were calculated. The prediction of yarn properties based on percentages of fibres in different length categories, fibre fineness and immature fibre content was carried out through linear multiple regression analysis. The contribution of the percentages of fibres in different length categories, immature fibre content (IFC), fibre fineness and yarn count in yarn properties was calculated. The results showed that fibre length parameters and the percentages of both the shortest and longest fibres have a great influence on yarn properties. Therefore fibre length distribution data available by AFIS contains information that is useful to spinners

1. Introduction

Raw material is the most important factor influencing yarn quality. To a great extent it can determine weather a product is good and it also responsible for cost factor. The quality of final yarn is largely influenced (up to 80%) by the characteristics of raw cotton [1]. The cost share of the raw material is 50% to 70% of the total yarn manufacturing cost depending on spinning system and yarn count [1]. Spinning performance is considerably influenced by raw material quality. Longer staple is required for the manufacture of fine, strong yarns. These fibres also increase spinning efficiency. Therefore fibre length is an essential part of

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the economical operation of a spinning mill and essential for maintaining yarn quality

The parameters of raw material significantly influence the basic quality parameters of the yarns. El Mogahzy [2] listed fibre parameters in ring spinning according to the order of their importance as, strength variation and elongation followed by fibre length and length uniformity, short fibre content, fibre fineness, stickiness and trash content. Numerous studies [3, 4, and 10] have shown that the quality of ring-spun yarns is influenced primarily by length, strength and fineness of fibres.

Fibre length is an important attribute in determining the quality of cotton and is the most important single parameter determining yarn quality for ring spinning. Cotton fiber length data products strongly correlate with spinning process costs and with yarn and fabric qualities [5, 6, 7, 8]. Fibre length is also critical for optimization of machinery settings in each department. However, 'length' in a cotton sample is a variable parameter and it needs to be defined which length is most important -the length of the longest fibre or the length of the shortest fibre or the length of a majority of fibres and so on. The length of a cotton sample can only be fully described by its fibre length distribution [8, 9].

The AFIS (Advanced Fibre Information System) measures single fibre length and obtains the entire length distribution as weight-length distribution and number-length distribution.

Zeidman et al [11] stated that that one can calculate probability density function of fibre length by number from that by weight and probability density function of fibre length by weight from that by number. Cui and Calimari [8] statistically analyzed weather fibre length by weight and by number have the same rank order when comparing cotton fibre length distribution. They showed that mean length by weight is always greater than mean length by number with the assumption that fibre length and linear density are statistically independent. However SFC and UQL length by number and by weight may give opposite rank orders.

Eric H. [12] studied the effect of fibre length distribution, represented by AFIS short fibre content by weight, on yarn strength and uniformity. Eric H. and DeanE. [13] studied the impact of AFIS fibre length distribution by weight on rotor- and ring-spun yarn properties.

2.Experimental work

2.1.Material

Eleven Egyptian cotton verities including ELS (Extra long staple), LS_n (Long staple-north) and LS_s (Long staple-south) were processed (on industrial scale) for producing combed ring spun yarns (18% combing ratio) with different counts according to the following:

- ELS cottons were processed to combed varns Ne 50, 60, 80 and 100.
- LSn cottons were processed to combed yarns Ne 30, 40, 50 and 60.
- LSs cottons were processed to combed yarns Ne 16, 20, 24, and 30.

2.2.Measurements

2.2.1.Fibre Tests

For the different cotton varieties fibre properties were measured by Uster AFIS. Where fibre length parameters can be obtained from the lengths and the weights of the fibre groups.

-The weight fraction of each length group plotted against the length of the group gives weight-length distribution or fibre length distribution by weight (a weight-based distribution), Fibre length characteristics calculated from such a distribution are characteristics by weight or weight-based.

- If, however the number of tibres in each length group is determined by counting , and then the number fraction of each length group plotted against the length , a number-length distribution is obtained or fibre length distribution by number (a number-based distribution), Fibre length characteristics calculated from such a distribution are characteristics by number or number-based.

For the different cotton varieties fibre properties were measured by Uster AFIS with 5 replications and 3000 fibre per each, for a total of 15000 fibre measurements. Weight- and number-based distributions were considered.

For fibre length distribution. A histogram of 30 length categories from 0 to 60 mm with increment of 2mm and frequency (%).

To study the effect of different fibre length categories on yarn properties number of length categories was reduced from 30 to 10 by aggregating each 3 categories together. Therefore increment of length categories became 6 mm instead of 2mm. A sample of fibre length distributions is shown in Fig. (1 to 3). Where fibre length distribution by weight and by number for only three different cottons are shown. First one representing the cotton of the maximum fibre length (ELS), the second one is in the middle (LS_n) and the third representing the cotton of the minimum fibre length (LS_s).

Summary fibre length properties and percentages of fibres in different length categories are shown in Table (1) and (2).

2.2.2. Yarn Tests

The produced yarns were tested for:

-Strength and elongation (Uster Tensojet with 1000 breaks per bobbin and 10 bobbins).

-Yarn irregularity and imperfections (thin, thick places and neps)/1000m (Uster Evenness Tester "UT4" with 400m per bobbin and 10 bobbins). Summary of yarn properties are shown in Table (3)

2.3. Statistical Analysis

The following statistical analysis were carried out for the yarns Ne 30, Ne 50 and Ne 60

-Correlation coefficients between yarn properties and fibre length parameters by weight and by number were calculated. Taking into consideration Slenderness of fibres in the case of yarn nep count, where slenderness of fibres "S" is the proportion of fibre length to linear density:

$$S = \frac{L}{dtex_f}$$

L – fibre length in mm

$dtex_f$ – linear density of fibre in decitex

-Correlation coefficients between percentages of fibres in different length categories, by weight and by number, and yarn properties, including tenacity, irregularity and yarn imperfections/ 1000m were calqulated and presented in Table (5) to Table (9).

-Linear multiple regression analysis was carried with a regression equation of the following form:

$$Y = \beta o + \beta 1 X1 + \beta 2 X2 + ... + \beta p Xp + \varepsilon$$

Where Y is the dependent variable "yarn properties", βo is the constant $X1, X2$...to Xp are the independent variables "percentage of fibres in the different length categories, IFC and fibre fineness ", $\beta 1, \beta 2$...to βp are the regression coefficients and ε is the residual error.

- In order to determine the most effective independent variables, which make the maximum contributions to the coefficient of determination (R^2) "stepwise" regression procedure was applied.

- Contribution of percentages of fibres in the different length categories in yarn properties was calculated from Standardized Coefficients (β) and regression coefficient of determination (R^2) and is shown in Fig. (15) and Fig. (16).

3. Results and Discussion

3.1. Fibre length distribution

Fig. (1, 2 and 3) Show fibre length distribution for ELS cotton (G88), LS_n (G86) and LS_s (G90) as samples of the eleven processed cottons. As shown in fibre length distributions "by weight and by number". ELS cotton has the higher percentages of the longest fibres and the lower percentages of the shortest fibres. While LS_s cotton has the higher percentages of the shortest fibres and the lower percentages of the longest fibres. For the three cottons fibre length distribution by number exhibits a larger portion of shorter fibres and a lower portion of longer fibres as compared with fibre length distribution by weight. Summary of fibre length parameters in Table (1) shows that mean fibre length is higher by weight than by number, while coefficient of length variation and SFC% by number are higher than those by weight.

3.2. Effect of fibre length parameters on yarn properties

3.2.1. Yarn Tenacity

Table (4) shows the correlation coefficients between yarn properties and fibre length parameters by weight and by number. The relationship between yarn tenacity and mean fibre length is shown in Fig. (4).Yarn tenacity is positively correlated with mean fibre length. For mean fibre length by weight the correlation is highly significant than that by number.

Fig. (5) shows the relationship between yarn tenacity and SFC%. Yarn tenacity is negatively correlated with SFC%. The correlation coefficient is higher for the yarn Ne30 than that for the yarns Ne 50 and 60.

Yarn tenacity is significantly (at 99% confidence level) correlated with Upper quartile length (by weight), 5% span length and 2.5% span length (by number)

Table (5) Shows the coefficient of correlation between yarn tenacity and percentages of fibres at different length categories by weight and by number. For the yarn Ne30 percentages of fibres shorter than the length category [24-30 mm] are negatively and significantly correlated with yarn tenacity. The percentage of fibres in the length category [12-18mm] is the most significantly (at 99%) correlated with yarn tenacity. Therefore the larger the share of short fibre fibres the lower the yarn tenacity.

The percentages of fibres in the length category [42-48mm] has the highest positive correlation with yarn tenacity.

Table (10) shows regression equations between yarn properties (dependent variables) and fibre length parameters, immature fibre content (IFC) and fibre fineness (independent variables). Stepwise regression procedure has been applied to determine the most effective independent variables i.e., which make the maximum contributions to the coefficient of determination (R^2). Therefore the regression equations for the dependent variable yarn tenacity show the most important fibre length categories and fibre parameters for predicting the yarn tenacity. It can be noticed that the percentage of fibres in the length category [42-48mm] is the most effective for predicting yarn tenacity.

3.2.2. Yarn Irregularity

Correlation coefficients between yarn irregularity (CV %) and fibre length parameters are shown in Table (4). Relationship between yarn irregularity (CV %) and both mean fibre length and SFC% is represented in Fig. (6) and Fig. (7). It can be noticed that yarn irregularity (CV %) increases as yarn gets finer. This is due to decreased number of fibres in the cross section as yarn gets coarser. Also yarn irregularity (CV %) decreases as fibre length gets longer. Therefore the higher the mean fibre length the higher is the yarn regularity. The rate of improvement in yarn regularity due to increasing fibre length increases as yarn gets coarser. Yarn irregularity (CV %) increases as SFC% increases as shown in Fig. (7). Yarn irregularity (CV %) is highly and negatively correlated with UQL (by weight), 5% SL and 2.5% SL (by number) as shown in Table (3).

Table (6) shows the coefficient of correlation between yarn irregularity (C.V %) and percentages of fibres at different length categories by weight and by number. For the yarn Ne30 irregularity is positively correlated with the percentages of fibres in the length categories shorter than the category [12-18mm], and negatively correlated with the percentages of fibres in the length categories loner than the category [18-24mm]. Therefore for the Ne30 yarn, the larger the share of fibres shorter than the category [12-18mm] the higher is the yarn irregularity (CV %) and the larger the share of the fibres longer than the length category [18-24mm] the lower is the yarn irregularity (CV %). for finer yarns the significant negative correlation was found for the longer length categories.

Regression equations between yarn irregularity and fibre parameters are shown in Table (10). The regression equations for the dependent variable yarn irregularity show the most important fibre length categories and fibre parameters sharing the yarn irregularity. As shown from the equations the contribution of the dependent variables is increasing or decreasing the yarn irregularity. Where for the yarn Ne30 the percentages of fibres in the length category [6-12mm] by weight is the most significant for predicting yarn irregularity (CV%), while for Ne60 the percentages of fibres in the length category [42-48mm] is the most effective for predicting its irregularity (CV%).

3.2.3. Yarn Imperfections

Fig. (8) and (9) show the relationship between yarn thin places/1000m and both mean fibre length and short fibre content (SFC %). It can be noticed that number of thin places increases as yarn gets finer and is negatively correlated with mean fibre length and positively correlated with short fibre content (SFC%). The same behavior was found for number of thick places as shown in Fig. (10) and (11). It can be noticed also that the increment in number of thick places due to SFC% is the higher for the finer yarn.

Table (4) shows the correlation coefficients between yarn imperfections/ 1000m fibre length parameters by weight and by number. It can be noticed that thin and thick places/1000m are negatively correlated with UQL (by weight), 5% and 2.5% span length (by number) and positively correlated with coefficient of length variation. Therefore the higher the mean fibre length the lower are the thin and thick places and the higher the SFC% the higher is the number of thin and thick places.

Tables (7) and (8) show the coefficient of correlation between thin and thick places/ 1000m and percentages of fibres at different length categories by weight and by number respectively. The behavior of percentages of fibres in the different length categories with number of thin and thick places are quite similar to their behavior with yarn irregularity (CV %). Therefore the larger the share of fibres in the shorter length the higher is the number of thin and thick places and the larger the share of the fibres in longer length categories the lower is the number of thin and thick places.

For the yarn Ne30 for the number of thin places the highest correlation (-ve) was found with percentage of fibres in the length category [48-54 mm], and for the number of thick place the highest correlation (+ve) was found with percentage of fibres in the categories shorter than [12-18mm].

Regression equations for the dependent variable number of thin or thick places and fibre parameters as independent variables are given in Table (10).

Table (4) shows the correlation coefficients between nep count per 1000m and fibre length parameters by weight and by number. Fig. (12) and (13) show the relationship between yarn nep count and man fibre length and SFC%. It can be noticed that yarn nep count increases as yarn gets finer. The relationship between yarn neps and mean fibre length is not clear, where it is positively correlated with mean fibre the yarn Ne50 and Ne60 and negatively correlated for the yarn Ne 30.

Fig. (14) shows the relationship between yarn nep count and slenderness of fibres (slenderness ratio = fibre length /fibre fineness). It can be noticed that yarn nep count is positively and significantly correlated with slenderness of fibre The correlation coefficient is 0.91 and 0.81 for the yarns Ne 50 and 60 respectively. Therefore as slenderness of fibres increases yarn nep counts increases. Where as slenderness of fibres increases, for the same fibre substance, fibre stiffness increases and fibres which are not stiff enough have too little springiness. They do not return to shape after deformation. They have no longitudinal resistance. This leads to the formation of neps.

Table (9) shows the coefficient of correlation between yarn neps/1000m and percentages of fibres at the different length categories by weight and by number.

Regression equations for predicting yarn neps from fibre parameters are given in Table (10).

3.3. Contribution of fibre length parameters in yarn properties

Contribution of fibre length parameters in yarn irregularity and imperfections is shown in Fig. (15) and Fig. (16). For yarn irregularity (Fig. 15-1) it can be noticed that the percentages of fibres in different length categories contribute about 66% of yarn irregularity, followed by yarn count by about 16% , and by about 13% for fibre fineness and immature fibre content (IFC).

The contribution of the percentages of fibre in different length categories in yarn irregularity shown in Fig. (15-2) indicates that the maximum contribution was found for the length category [48-54mm]; it contributes by about 27% of yarn irregularity. The different length categories longer than [24-30mm] sharing by about 50% of yarn irregularity and the contribution of the shortest categories s about 17%.

Contribution of fibre and fibre length parameters in yarn imperfections is shown in Fig. (16). As shown in Fig. (16-1) and Fig. (16-2) for thin and thick places it can be noticed that the percentages of fibres in different length categories contribute by more than 50% of thin and thick places, while fibre fineness and immature fibre content (IFC) are sharing by about18%. Regarding to the percentages of fibres in the length categories, the highest contribution was found for the percentage of fibres in the category [6-12mm] which is sharing by about 44% and 35% of number of thin and thick places respectively. The percentage of fibres in the categories shorter than 18mm are contributing by >50% of number of thin and thick places.

As shown in Fig. (16-3) percentages of fibres in the length categories are sharing by about 47% of yarn nep count, while slenderness of fibres is sharing by about 25% and fibre fineness by about 9%.

4. Conclusion

From the experimental work and discussion of results the following conclusions can be drawn:

- Fibre length distribution by number exhibits a larger portion of shorter fibres and a lower portion of longer fibres as compared with fibre length distribution by weight.
- Mean fibre length by weight is higher than mean fibre length by number. While short fibre content (<12.7mm) and CVl% by number are higher than those by weight.
- Yarn tenacity is positively and significantly correlated with mean fibre length, UQL, (by weight) 5% and 2.5% span length (by number). For mean fibre length by weight the correlation is highly significant than that for mean length by number.
- Yarn irregularity (CV%) is highly and negatively correlated with mean fibre length, UQL (by weight), 5% and 2.5% SL (by number). Short fibre content (<12.7mm) is positively correlated with yarn irregularity (C.V%).
- Percentages of fibre in the different length categories are sharing by more than 66% of yarn irregularity. While yarn count and fibre fineness are sharing by about 27% in yarn irregularity.
- Regarding to the length categories the highest contribution is for the percentage of fibres in the category [48-54mm] followed by those in the category [0-6mm].
- Number of thin and thick places increases as yarn gets finer
- Number of thin and thick places are negatively correlated with mean fibre length and positively correlated with coefficient of length variation and SFC% (<12.7mm) .
- Percentages of fibre in the different length categories are sharing by more than 50% in yarn thin and thick places/1000m, while fibre fineness and immature fibre content are sharing by about 18%.
- The percentages of fibres in the length category [6-12mm] are sharing by about 44% and 35% in thin and thick places respectively .
- yarn nep count is positively and significantly correlated with slenderness of fibres.
- Slenderness of fibre is sharing by about 25% of yarn nep count.
- Regression equations showed that percentages of both the shortest and longest fibres have a great influence in predicting yarn properties.

References

1. *Uster News Bulletin, Measurement of the quality characteristics of cotton fibres, 38,(23-31), 1991.*
2. *El Mogahzy, Y., "How EFS System Can Help in Producing Optimum Yarn Quality", 11th EFS Conference, 1998.*
3. *Jackowski, T., and Frydrych I., "What I Learned in Fibre Quality: Practical Experience" Technical Seminar at the 58th Plenary Meeting of the International Cotton Advisory Committee. Charleston, USA, October 1999.*

4. *Jackowski T., and Chylewska B., Spinning technology and structure of yarns. Wyd. PL., Lodz, Poland.*
5. *Zhang, Y., Kyle Shofner, C., and Shofner, F. M., "True Short Fiber Content: Complete Fiber Length Distributions From Tapered Beards", BeltWide Cotton Conferences, NashvillTennessee, 9 January 2003.*
6. *Charles K.ragg, TRL., Vol63, No3, " Applied direct measurement of short fibre content", (171-176), 1993.*
7. *Lloyed M.O.,, TRJ., Vol. 68, No 4, "Breeding cottons with high tenacity", (302-307), 1998.*
8. *Xioliang Cui, and Timothy A. Calamari. JR., TRJ., 68, No 7, (467-472), 1998.*
9. *Zurek, W., Grenta, M.,Frydrych, I., and Balcar,G. The use of AFIS for estimation of cotton fibre length changes in the spinning process , 23rd International Cotton Conference, Bremen, Germany 1996.*
10. *Frey M., "Influence of fibre parameters and values of their variation on the spinning process", 4th International GCA Conference, Gydnia, Poland, 1995.*
11. *Zeidman, M. L., Batra, S. K., and Sassèr P. E., "Determination short fibre content in cotton" Part 1 "Some theoretical fundamentals " TRJ., 61, (21-30) 1991.*
12. *Eric, H., " Applications of the AFIS multi data" Proceedings Beltwide Cotton conference (666-670), 1999*
13. *Eric, H., " Impacts on yarn quality of AFIS measurements of cotton fibre length distributions" , Proceedings Beltwide Cotton conference, 2000.*

Table (1) Summary of cotton fibre length properties

Fibre properties	Unit	ELS cottons			LS_n cottons			LS_s cottons		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
By weight										
Mean length	mm	30.98	30.1	32.6	28.83	27.6	30.2	25.23	23.2	27.1
Length variation (CV_L)	%	35.8	33.1	38.5	35.73	31.8	39.1	39.68	36.5	45.8
Short fibre content	%	7.1	5.2	8.6	7.53	4.6	9.8	12.08	9.5	17.8
Upper quartile length	mm	38.5	37.3	39.9	35.3	24.4	36.2	31.63	30.4	33.7
By number										
Mean length	mm	22.08	20.6	24.8	21.07	19	24	17.03	13.6	19
Length variation (CV_L)	%	63.95	56.2	68	61.1	50.7	67.4	70.23	65.8	84
Short fibre content	%	31.38	24.4	34.9	30.43	20.5	36.7	40.98	34.1	54
5% span length	mm	43.35	41.8	45.1	39.73	38.9	41.4	35.43	33.7	37.4
2.5% span length	mm	46.68	44.8	48.4	43.53	42.7	44.8	38.63	37	40.4

Table (2) Summary of percentages of fibres in the different length categories

Length category (mm)	ELS cottons			LS_n cottons			LS_s cottons		
	Mean (%)	Min (%)	Max (%)	Mean (%)	Min (%)	Max (%)	Mean (%)	Min (%)	Max (%)
Weight-length distribution									
L[0-6]	2.95	1.83	3.97	2.96	1.83	3.95	4.56	3.41	7.18
L[6-12]	4.09	3.1	4.88	4.099	2.69	5.33	6.48	5.41	9.2
L[12-18]	6.49	5.51	7.66	7.77	6.53	9.47	11.01	9.07	13.41
L[18-24]	11.22	9.96	12.2	14.12	12.58	15.6	19.02	15.61	22.39
L[24-30]	17.75	16.63	19.01	22.84	22.77	22.94	24.77	22.51	28.18
L[30-36]	22.06	19.62	23.91	24.86	23.62	27.28	20.27	16.48	24.98
L[36-42]	19.81	18.37	21.1	14.67	12.04	17	8.69	6.51	12.29
L[42-48]	10.00	7.64	12	4.92	3.75	5.64	2.70	1.99	3.51
L[48-54]	3.84	2.35	4.64	2.33	2.17	2.53	1.68	1.46	1.92
L[54-60]	1.78	0.97	2.46	1.43	1.18	1.63	0.82	0.57	0.98
Number-length distribution									
L[0-6]	20.13	13.66	23.89	19.58	12.36	24.15	26.68	21.96	37.72
L[6-12]	8.81	7.84	10.78	9.16	7.45	10.56	11.88	10.27	13.72
L[12-18]	9.37	8.34	10.59	10.13	9.34	11.47	13.00	10.97	15.07
L[18-24]	11.77	11.32	12.08	13.94	13.7	14.25	15.38	13.15	18.82
L[24-30]	13.99	13.39	14.72	17.94	15.996	20.47	15.63	11.8	18.92
L[30-36]	14.93	12.83	16.78	15.96	14.19	19.34	10.48	6.81	13.91
L[36-42]	12.10	10.59	15.31	8.22	6.03	10.57	4.10	2.88	6.34
L[42-48]	5.77	4.23	8.34	2.83	1.91	3.49	1.51	0.95	2.46
L[48-54]	2.10	1.41	3.03	1.40	1	1.79	0.71	0.57	0.86
L[54-60]	1.03	0.56	1.65	0.83	0.8	0.85	0.64	0.38	0.85

Table (3) Summary of yarn properties

Yarn properties	Units	Ne 30			Ne 50			Ne 60		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Tenacity	(cN/tex)	25.41	22.02	29.82	27.55	22.13	30.49	26.41	22.4	29.19
Strength variation	%	7.685	7.32	8.6	9.715	9.33	10.59	10.9	9.13	12.59
Elongation	%	4.92	4.64	5.21	4.6	4.2	5.34	4.49	3.73	5.1
CV%	%	12	11.39	13.03	13.6	12.7	14.67	14.42	13.87	14.93
Thin places	cnt/1000m	1.14	0	3	9.54	0.8	25	15.54	5	31
Thick places	cnt/1000m	17.04	9	42	65.5	56.5	86	108.5	79	151
Neps	cnt/1000m	32.17	18	57	184.1	112	229	270.5	117	371

Table (4) Correlation coefficients between yarn properties and fibre length parameters

fibre length parameters	Tenacity (cN/tex)			Strength variation (%)			Irregularity (CV%)		
	Ne 30	Ne 50	Ne 60	Ne 30	Ne 50	Ne 60	Ne 30	Ne 50	Ne 60
By weight									
Mean length	0.889**	0.878**	0.899**	-0.398	-0.76*	-0.477	-0.769*	-0.90**	-0.749
CV_l (w)%	-0.706	-0.424	-0.283	0.701	0.031	-0.515	0.757*	0.442	0.263
SFC%	-0.758*	-0.561	-0.44	0.689	0.25	-0.332	0.827*	0.595	0.42
UQL	0.872*	0.896**	0.981**	-0.232	-0.829*	-0.80*	-0.674	-0.92**	-0.845*
By number									
Mean length	0.819*	0.69	0.591	-0.518	-0.453	0.089**	-0.788*	-0.748	-0.558
CV_l (n)%	-0.657	-0.333	-0.150	-0.127	0.114	-0.473	0.768*	0.401	0.231
SFC%	-0.72	-0.454	-0.29	0.633	0.219	-0.379	0.79*	0.519	0.34
5% span length	0.895**	0.91**	0.973**	-0.305	-0.847*	-0.741	-0.77*	-0.95**	-0.864*
2.5% spanlength	0.89**	0.899**	0.961**	-0.278	-0.86**	-0.728	-0.78*	-0.90**	-0.856*
Fibre fineness (mtex)	0.432	-0.355	-0.573	-0.777*	0.512	0.917**	-0.536	0.394	0.473
	Thin places			**Thick places**			**Neps**		
	Ne 30	Ne 50	Ne 60	Ne 30	Ne 50	Ne 60	Ne 30	Ne 50	Ne 60
By weight									
Mean length	-0.663	-0.863*	-0.820*	-0.77*	-0.88**	-0.73	-0.76*	0.865*	0.597
CV_l (w)%	0.629	0.463	0.327	0.865*	0.235	0.662	0.898	-0.260	0.067
SFC%	0.70	0.61	0.45	0.91**	0.36	0.77*	0.87	-0.398	0.025
UQL	-0.58	-0.877*	-0.90**	-0.654	-0.95**	-0.65	-0.63	0.940**	0.745
By number									
Mean length	-0.665	-0.69	-0.55	-0.82*	-0.56	-0.78*	-0.82*	0.504	0.124
CV_l (n)%	0.629	0.355	0.150	0.841*	0.101	0.625	0.832*	-0.44	0.342
SFC%	0.661	0.489	0.284	0.85*	0.23	0.709	0.838*	-0.198	0.203
5% span length	-0.679	-0.89**	-0.89**	-0.71	-0.93**	-0.71	-0.68	0.913**	0.672
2.5% spanlength	-0.702	-0.88**	-0.85*	-0.70	-0.92**	-0.69	-0.64	0.888**	0.641
Fibre fineness(mtex)	-0.394	0.333	0.487	-0.724	0.603	-0.043	-0.814*	-0.768*	-0.699

** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level

Table (5)Coefficient of correlation between yarn tenacity and percentage of fibres in the different length categories

Length category(mm)	Weight-length distribution			Numbre-length distribution		
	Ne30	Ne50	Ne60	Ne30	Ne50	Ne60
L[0-6]	-0.6993	-0.63657	-0.4362	-0.6702	-0.4940	-0.3380
L[6-12]	-0.7951*	-0.5267	-0.3574	-0.8147*	-0.4065	-0.3177
L[12-18]	-0.8846**	-0.7324	-0.6954	-0.7827*	-0.4675	-0.4513
L[18-24]	-0.7841*	-0.8807**	-0.9197**	-0.2705	-0.6651	-0.8380*
L[24-30]	-0.3661	-0.74997	-0.9099**	0.6374	-0.3764	-0.6098
L[30-36]	0.6996	-0.3974	-0.5275	0.8064*	-0.0672	-0.3448
L[36-42]	0.8847**	0.8631*	0.9271**	0.8885**	0.8593*	0.8859**
L[42-48]	0.9467**	0.8839**	0.9640**	0.8931**	0.8371*	0.8917**
L[48-54]	0.87887**	0.8339*	0.8772**	0.9132**	0.8492*	0.8319*
L[54-60]	0.8947**	0.6313	0.5442	0.7013	0.3824	0.4021

** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level

Table (6)Coefficient of correlation between yarn irregularity and percentage of fibres in the different length categories

Length category(mm)	Weight length distribution			Numbre length distribution		
	Ne30	Ne50	Ne60	Ne30	Ne50	Ne60
L[0-6]	0.7821*	0 5442	0.4190	0 7745*	0.5818	0.4251
L[6-12]	0.8450*	0.4911	0.3255	0.905**	0.3796	0.11631
L[12-18]	0.7453	0.6510	0.5379	0.2458	0.4661	0.3669
L[18-24]	0.4965	0.8423*	0 6965	-0.1651	0.6345	0.54731
L[24-30]	-0.0568	0.7861*	0.6782	-0.760*	0.4730	0.43954
L[30-36]	-0.6169	0.2797	0.4380	-0.7385	0.3981	0.32178
L[36-42]	-0.6420	-0.8103*	-0.7119	-0.6274	-0.9054**	-0.7493
L[42-48]	-0.5732	-0.8366*	-0.7779*	-0.5697	-0.8881**	-0.7487
L[48-54]	-0.819*	-0.7777*	-0.7699*	-0.8054*	-0.8843**	-0.7481
L[54-60]	-0 5844	-0.4754	-0.2503	-0.6918	-0.5387	-0.2171

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Table (7)Coefficient of correlation between thin places/1000m and percentage of fibres in the different length categories

Length category(mm)	Weight length distribution			Numbre length distribution		
	Ne30	Ne50	Ne60	Ne30	Ne50	Ne60
L[0-6]	0.6391	0.4844	0.3659	0.6305	0.4874	0.34374
L[6-12]	0.7283	0.5002	0.3574	0.8686*	0.4829	0.24378
L[12-18]	0 6375	0.7036	0.7233	0.2209	0.4528	0 5983
L[18-24]	0.4081	0 8815*	0.7968*	-0.1567	0.6650	0.6796
L[24-30]	-0 0588	0.7725*	0.7600*	-0.6614	0 3541	0.5143
L[30-36]	-0.4531	0 2147	0.4312	-0.6033	0.4325	0.1924
L[36-42]	-0.5466	-0.8895**	-0.8444*	-0.5353	-0.8448*	-0.8287*
L[42-48]	-0.5502	-0.7811*	-0.8492*	-0.4744	-0.7459	-0 8226*
L[48-54]	-0.886**	-0.6474	-0.7437	-0.8076*	-0.7194	-0.7631*
L[54-60]	-0.5593	-0.4217	-0.2820	-0.5368	-0.3031	-0.3262

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level

Table (8)Coefficient of correlation between thick places/1000m and percentage of fibres in the different length categories

Length category(mm)	Weight length distribution			Numbre length distribution		
	Ne30	Ne50	Ne60	Ne30	Ne50	Ne60
L[0-6]	0.9207**	0.4008	0.6927	0.8687*	0.3094	0.7210
L[6-12]	0.9101**	0.3013	0 7058	0.7957*	0.2688	0.4987
L[12-18]	0.8005*	0.6511	0.6976	0.2268	0.5015	0.5091
L[18-24]	0.4517	0.8536*	0.6782	-0.2936	0.8375*	0.2470
L[24-30]	-0.2093	0.9037**	0.3961	-0.8395*	0.7364	-0.0672
L[30-36]	-0.695	0.5531	-0.0580	-0.7567*	0.2422	0.0008
L[36-42]	-0.6332	-0 831*	-0.6749	-0.5950	-0.88**	-0.7204
L[42-48]	-0.504	-0.967**	-0.5327	-0.6123	-0.974**	-0.5735
L[48-54]	-0.5846	-0.905**	-0.4614	-0.6147	-0 901**	-0.6606
L[54-60]	-0.4283	-0.6165	-0.2932	-0.892**	-0.6716	-0.1782

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level

Table (9)Coefficient of correlation between neps/1000m and percentage of fibres in the different length categories

Length category(mm)	Weight length distribution			Numbre length distribution		
	Ne30	Ne50	Ne60	Ne30	Ne50	Ne60
L[0-6]	0.902**	-0.306	0.006	0.8608*	-0.202	0.202
L[6-12]	0.893**	-0.303	0.028	0.810*	-0.393	-0.141
L[12-18]	0.8465*	-0.725	-0.528	0.2762	-0.491	-0.359
L[18-24]	0.4978	-0.936**	-0.719	-0.2209	-0.916**	-0.925**
L[24-30]	-0.1590	-0.940**	-0.847	-0.829*	-0.636	-0.742
L[30-36]	-0.6677	-0.486	-0.674	-0.7220	-0.392	-0.267
L[36-42]	-0.6898	0.968**	0.786	-0.681	0.849*	0.582
L[42-48]	-0.6140	0.931**	0.821*	-0.7378	0.831*	0.644
L[48-54]	-0.580	0.766*	0.671	-0.7110	0.718	0.467
L[54-60]	-0.5187	0.520	0.415	-0.7486	0.383	0.240

** Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level

Table (10) Regression equations between yarn properties and the percentages of fibres in the different length categories (mm)

Parameter	Regression equation	R^2
Weight- length distribution		
Tenacity		
Ne 30	=30.265 + 2.579 * L [42-48] + 0.525 * L [24-30]	0.972
Ne 50	=20.998 + 0.837 * L [42-48]	0.781
Ne 60	=20.225 + 0.790 * L [42-48]	0.929
CV%		
Ne 30	=10.581 + 0.260 * L [6-12]	0.714
Ne 50	=8.8690 + 0.374 * L [18-24]	0.710
Ne 60	=15.164 - 0.095 * L [42-48]	0.605
Thin places/1000m		
Ne 30	=7.154 – 3.066 * L [48-54]	0.785
Ne 50	=61.787 – 2.967 * L [36-42]	0.791
Ne 60	=35.115 – 2.501 * L [42-48]	0.721
Thick places/1000m		
Ne 30	=-35.357 + 11.909 * IFC	0.869
Ne 50	=-107.717 - 5.394 * L [42-48]	0.935
Neps/1000m		
Ne 30	=2 684 + 7.614 * L [0 - 6]	0.814
Ne 50	=514.091 – 16.968 * L [24-30]	0.956
Ne 60	1559.224 – 7.709 mtex	0.735
Number-length distribution		
Tenacity		
Ne 30	=18 796 + 6.323 * L [48-54]	0.834
Ne 50	=18.621 + 0.856 * L [36-42]	0.738
Ne 60	=23.356 +1.689* L [42-48] – 4.829* L [54-60]	0.979
CV%		
Ne 30	=9.112 + 0.269 * L [6 -12]	0.819
Ne 50	=16.336 – 0.269 * L [36 - 42]	0.820
Thin places/1000m		
Ne 30	=-5.025 + 0.576 * L [6 – 12]	0.754
Ne 50	=41.35 0 - 4.899 * L [36-42] + 20.780* L [54 -60]	0.922
Ne 60	=42.315 – 2.565 * L [36-42]	0.687
Thick places/1000m		
Ne 30	=-35.357 + 11.909 * IFC%	0.968
Ne 50	=136.506 - 8.721* L [42-48] – 0.849 * L [0-6] - 3.65 IFC	0.998
Neps/1000m		
Ne 30	=-5.506 + 1.595 * L [0 – 6]	0.741
Ne 50	=664.729 – 38.43 * L [18-24]	0.901
Ne 60	=1611.871-100.482 * L [18-24] -15.874 * L [36-42] + 5.413*L [30– 36]	0.998

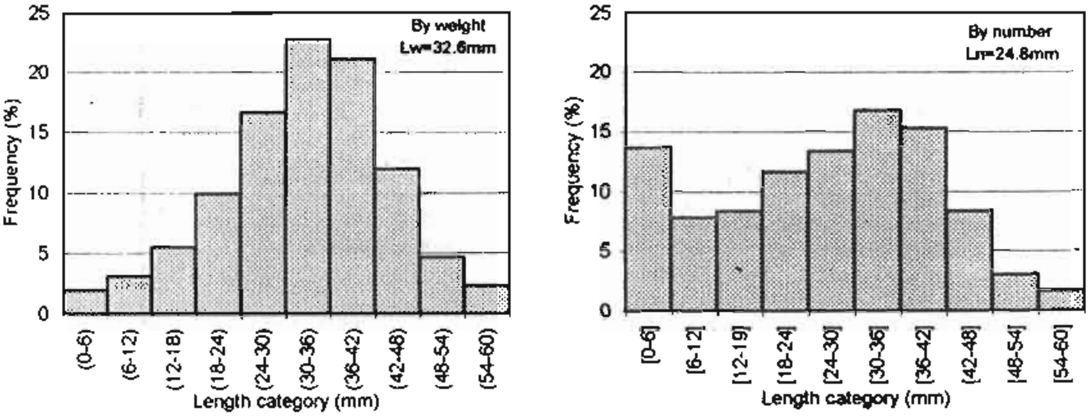

Fig (1) AFIS fibre length distribution for ELS cotton (G88)

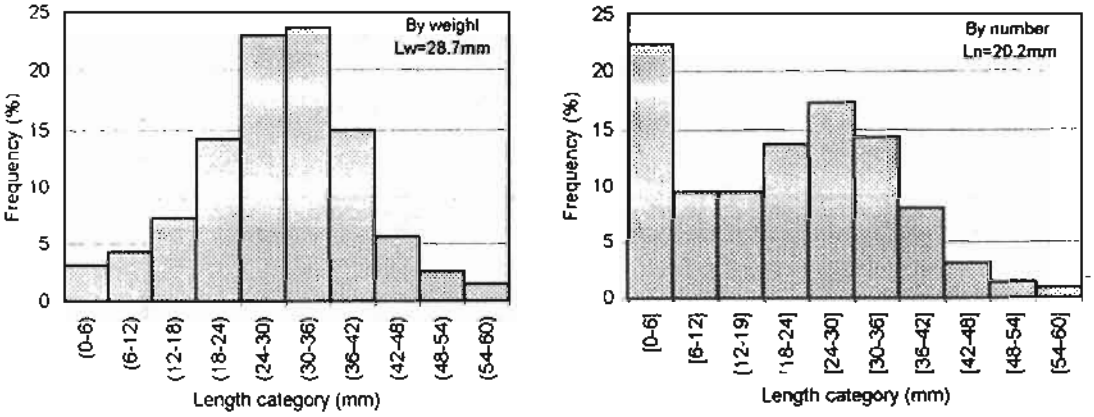

Fig. (2) AFIS fibre length distribution for LS$_n$ cotton (G86)

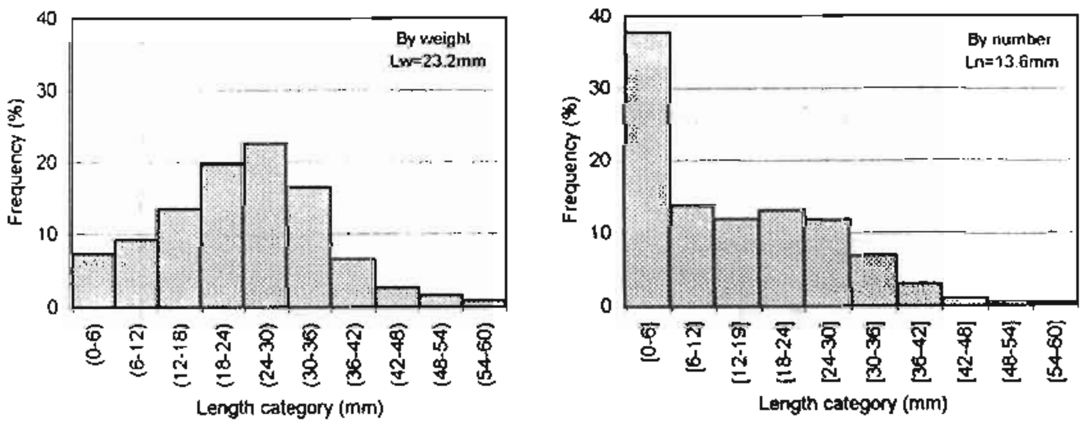

Fig. (3) AFIS fibre length distribution for LS$_s$ cotton (G90)

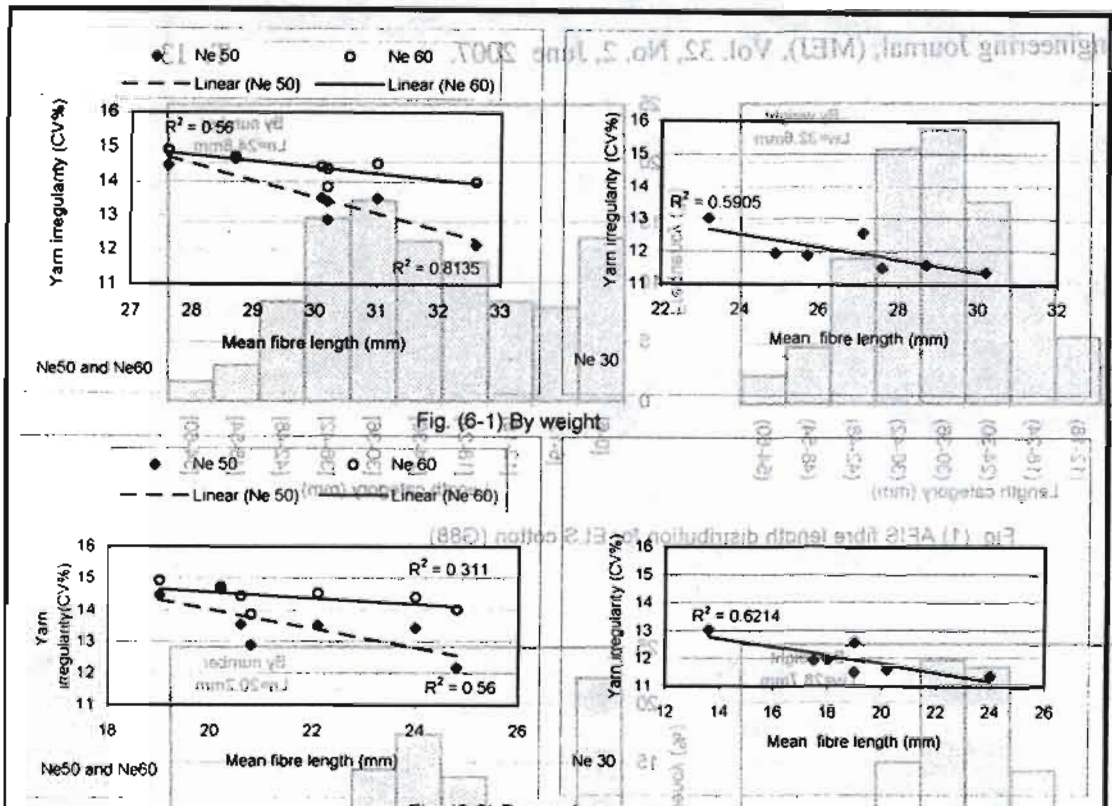

Fig. (6-1) By weight

Fig. (6-2) By number

Fig. (6) Relationship between yarn irregularity and mean fibre length

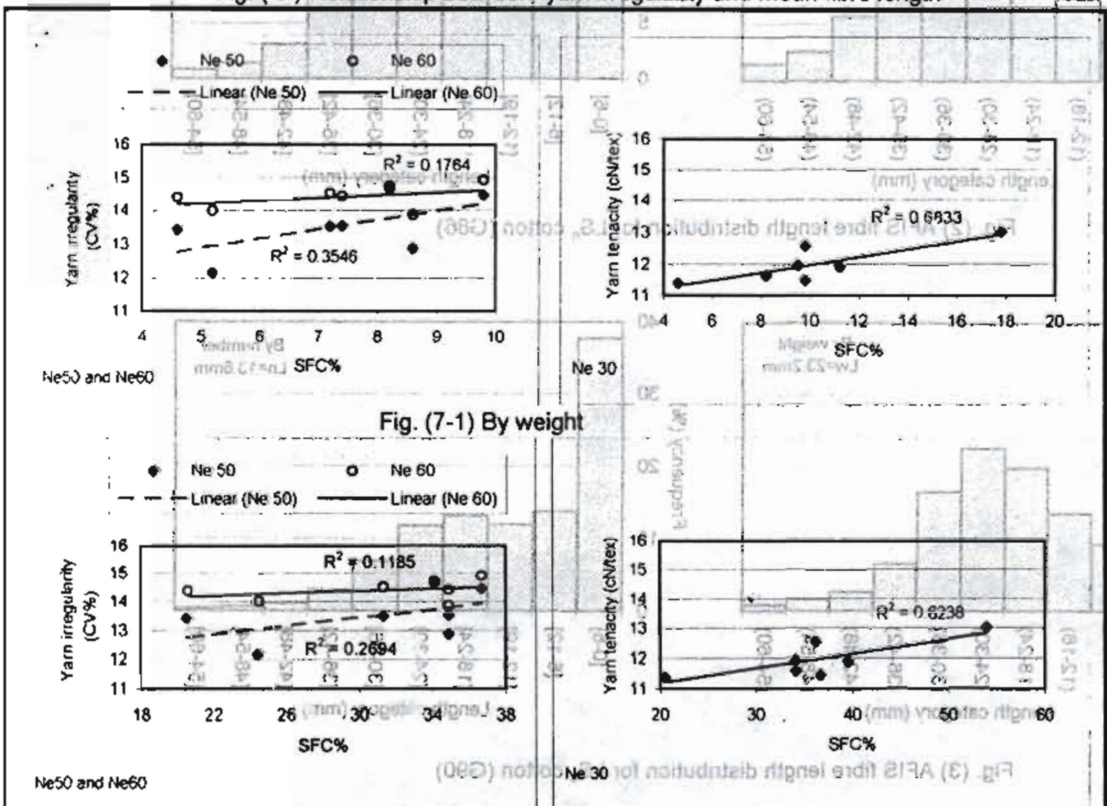

Fig. (7-1) By weight

Fig. (7-2) By number

Fig. (7) Relationship between yarn irregulrity and SFC%

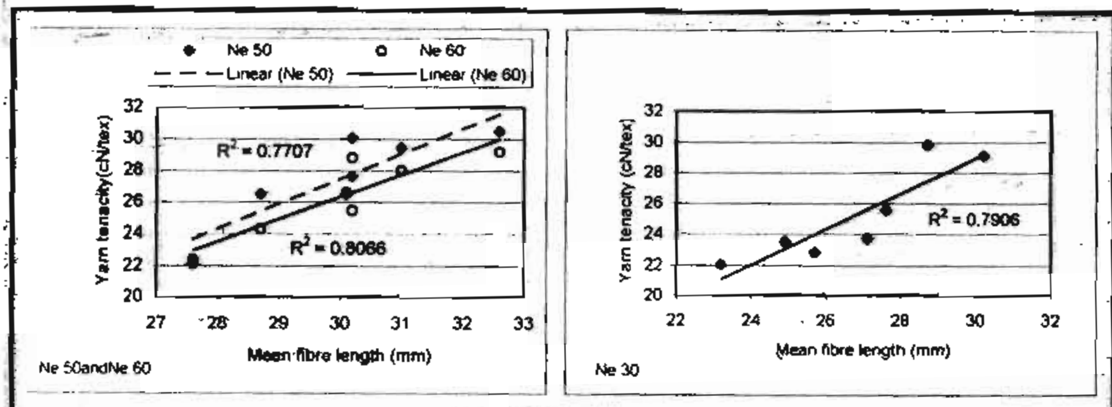

Fig. (4-1) By weight

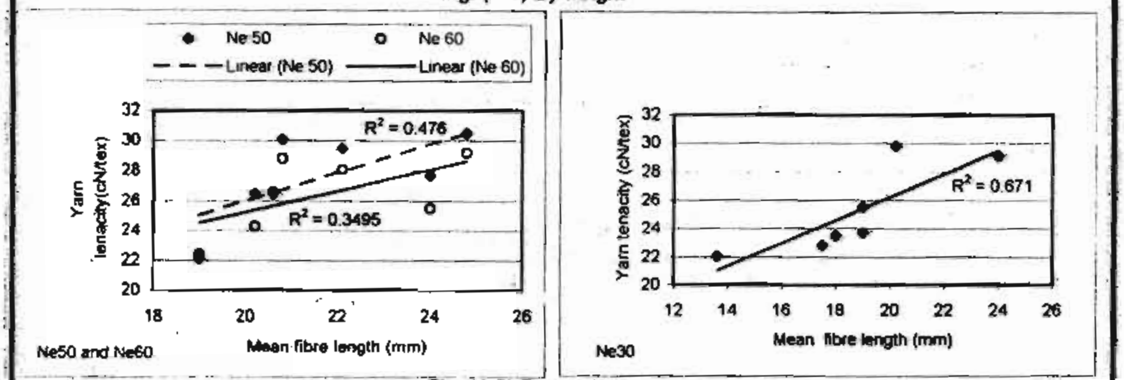

Fig. (4-2) By number

Fig. (4) Relationship between yarn tenacity and mean fibre length

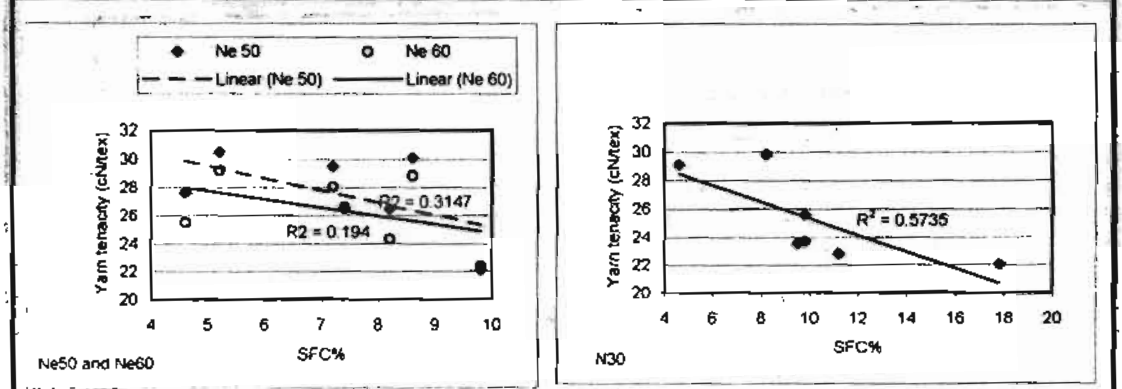

Fig. (5-1) By weight

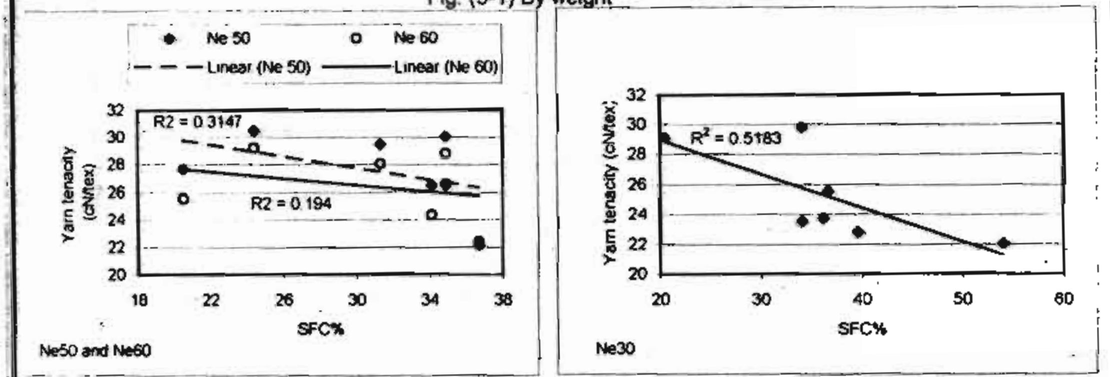

Fig. (5-2) By number

Fig. (5) Relationship between yarn tenacity and SFC%

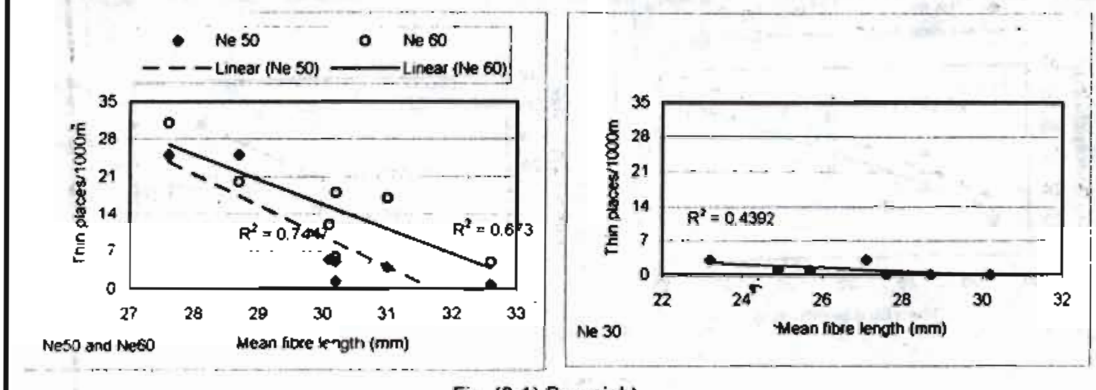

Fig. (8-1) By weight

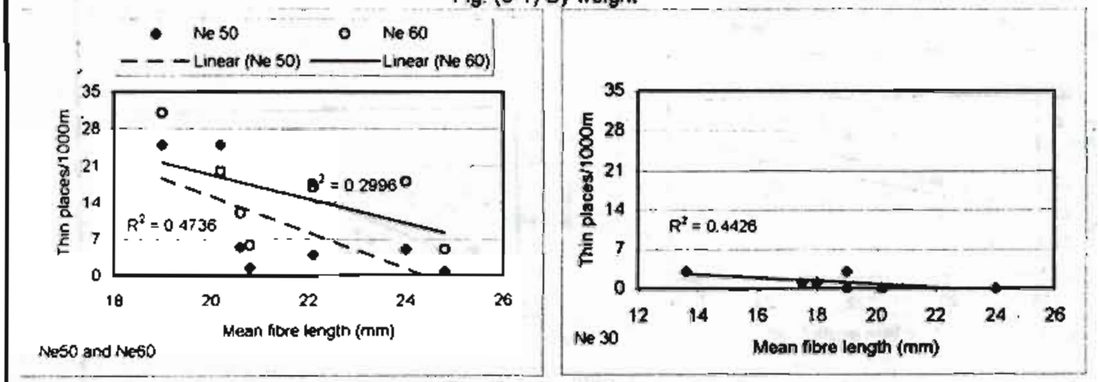

Fig. (8-2) By number

Fig. (8) Relationship between thin places/1000m and mean fibre length

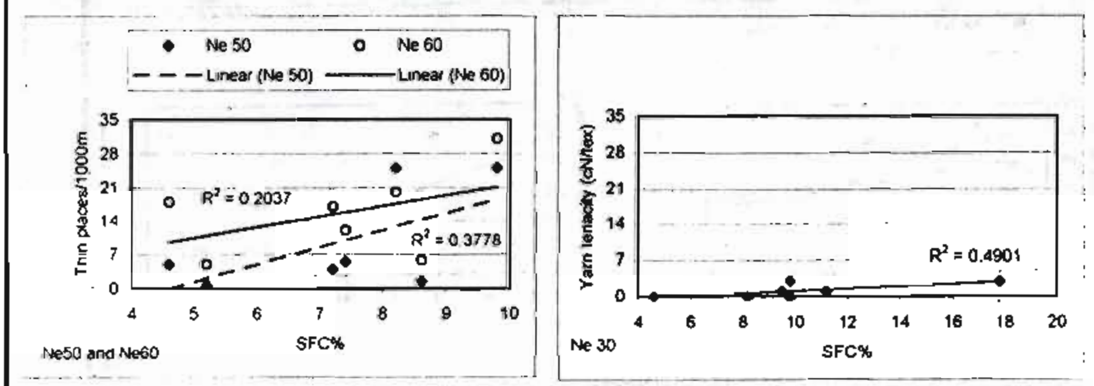

Fig. (9-1) By weight

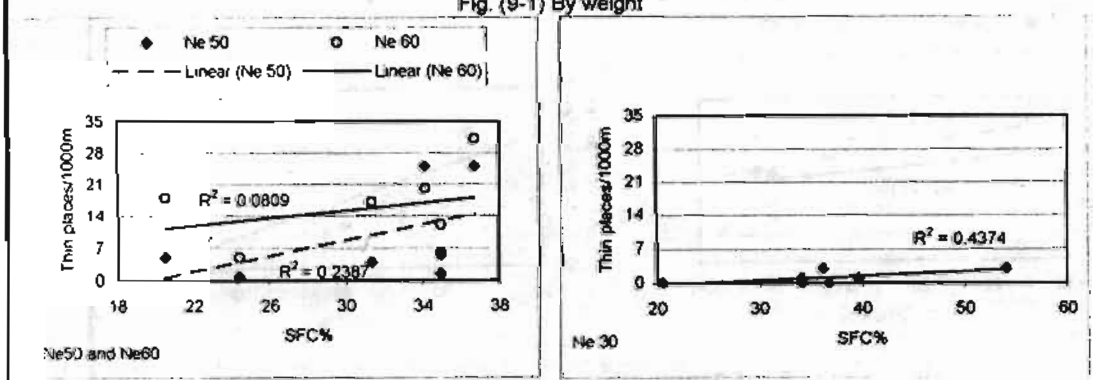

Fig. (9-2) By number

Fig. (9) Relationship between thin places/1000m and SFC%

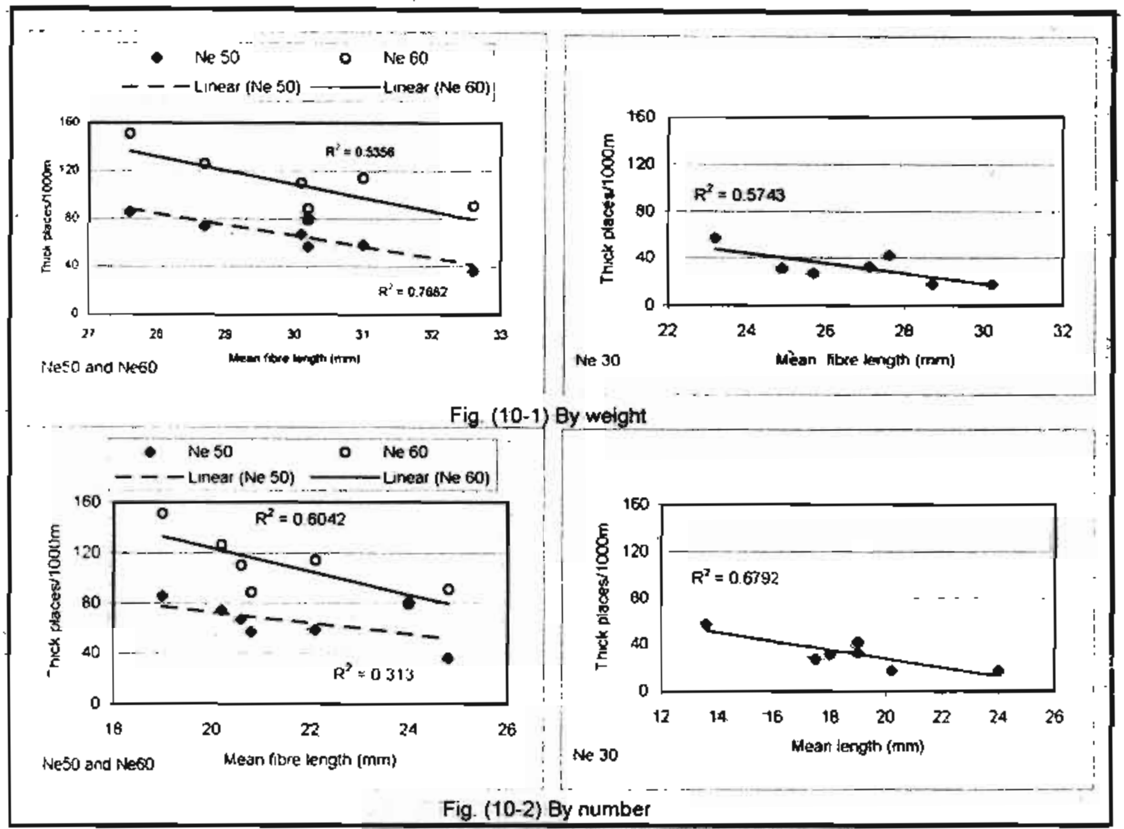

Fig. (10) Relationship between thick places/1000m and mean fibre length

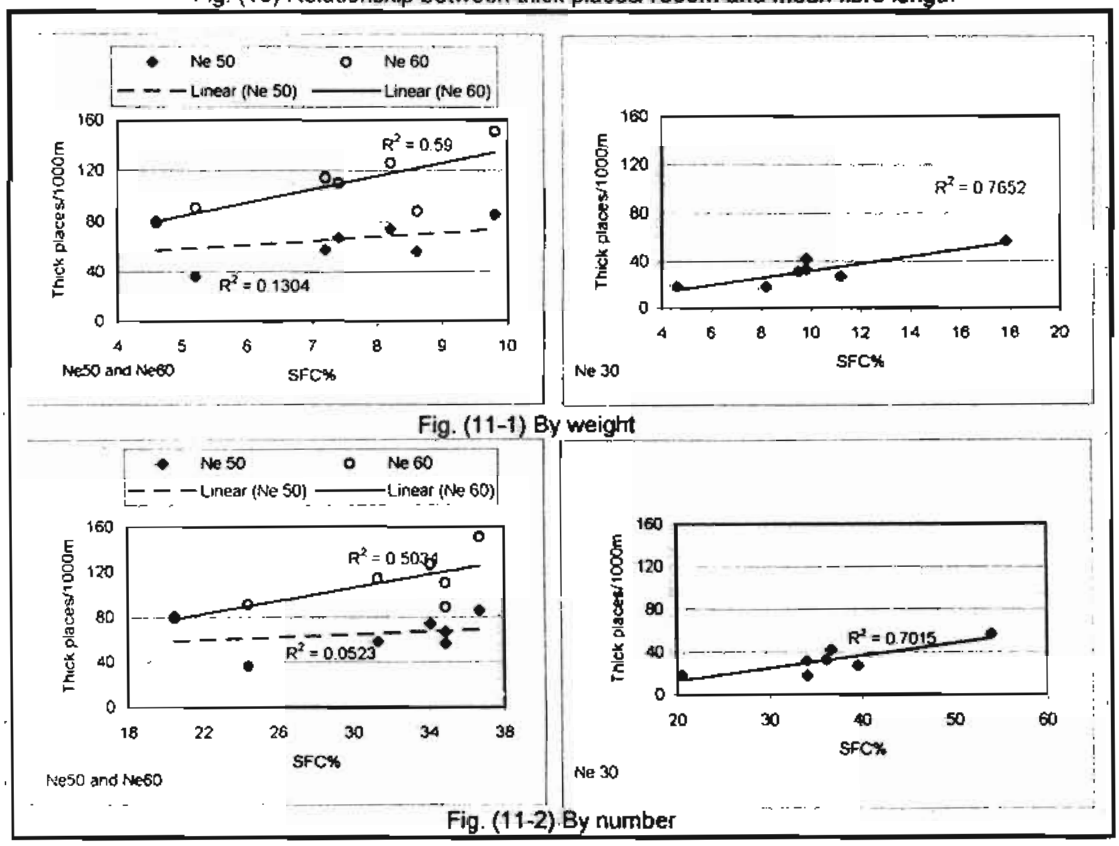

Fig. (11) Relationship between thick places/1000m and SFC%

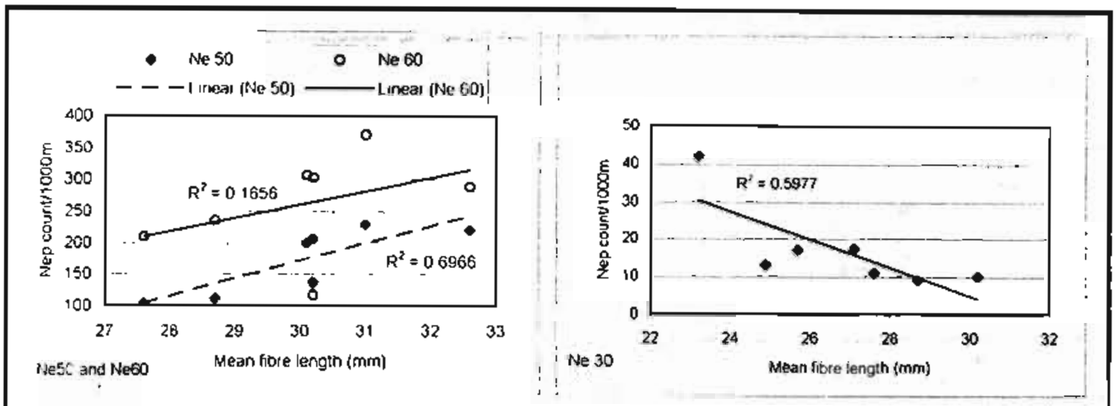

Fig. (12-1) By weight

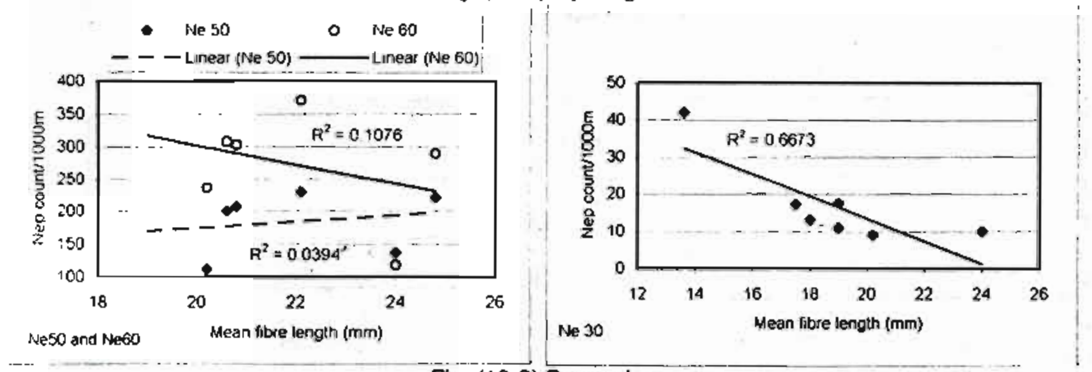

Fig. (12-2) By number

Fig. (12) Relationship between neps/1000m and mean fibre length

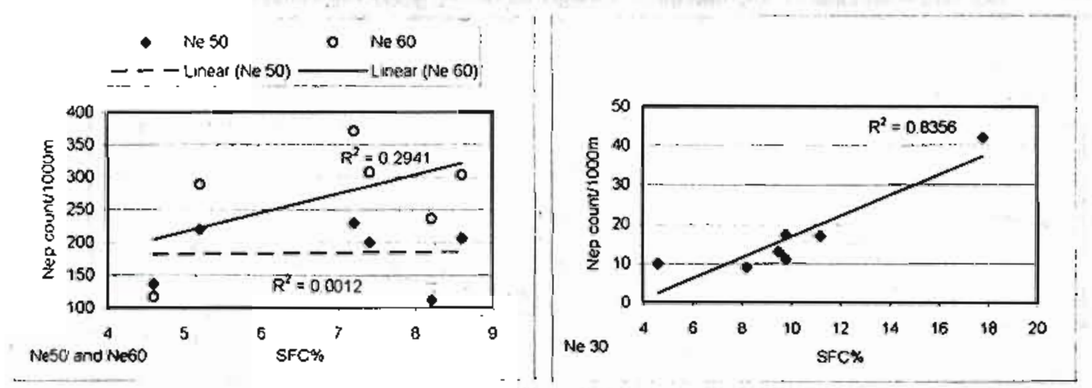

Fig. (13-1) By weight

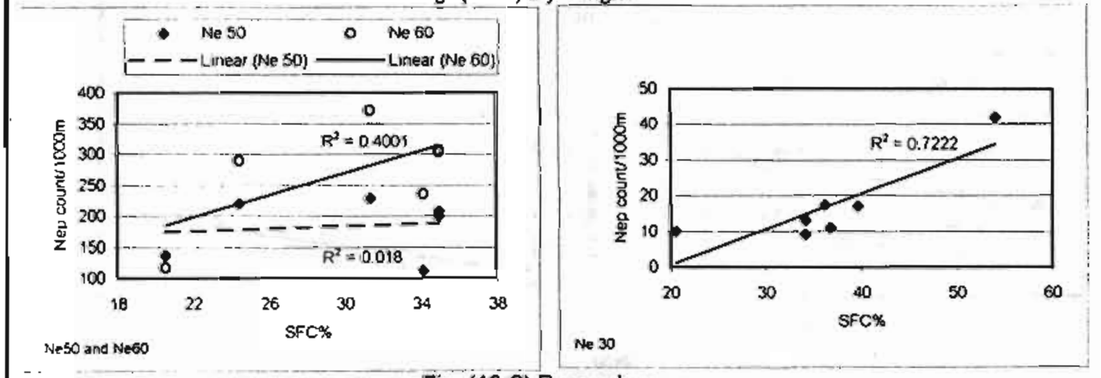

Fig. (13-2) By number

Fig. (13) Relationship between neps/1000m and SFC%

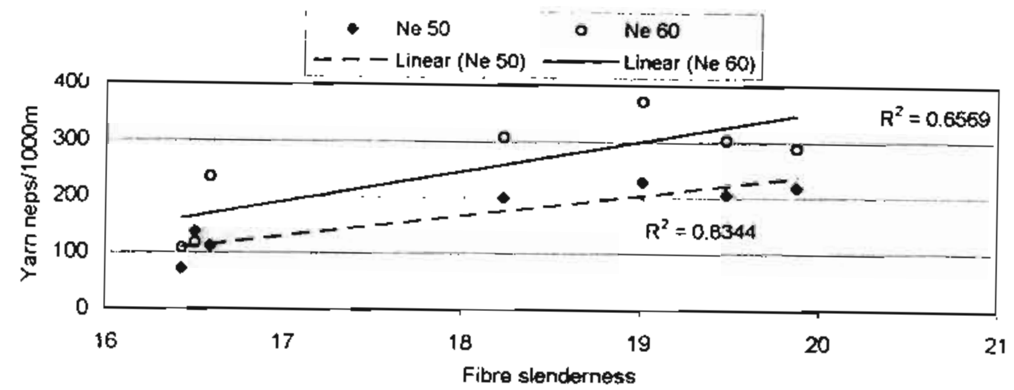

Fig. (14) Relationship between neps/1000m and slenderness of fibres

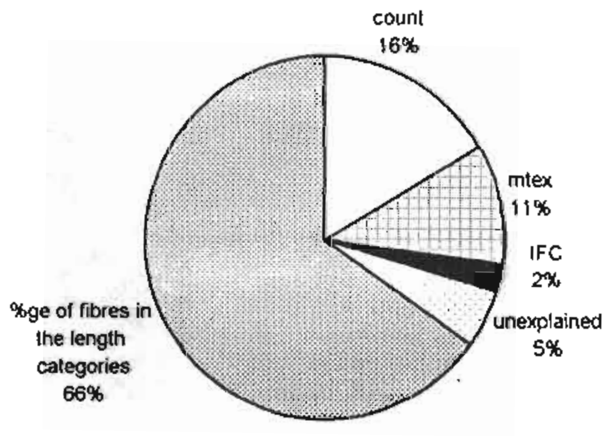

Fig (15-1) contribution offibre parameters on yarn irregularity (CV%)

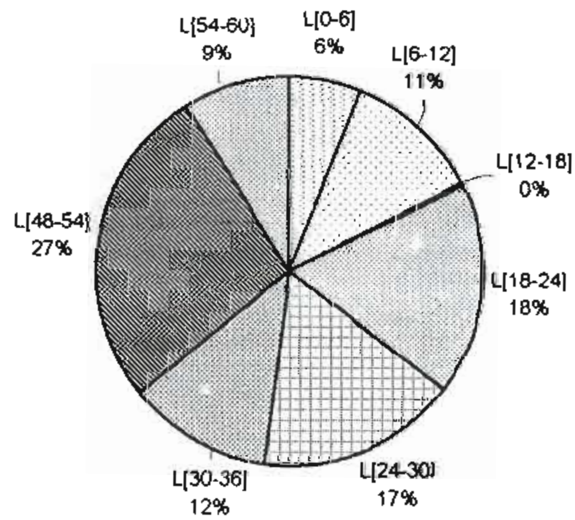

Fig (15-2) contribution of percentages of fibre indifferent length categories on yarn irregularity (CV%)

Fig (15)) contribution of fibre parameters on yarn irregularity (CV%)

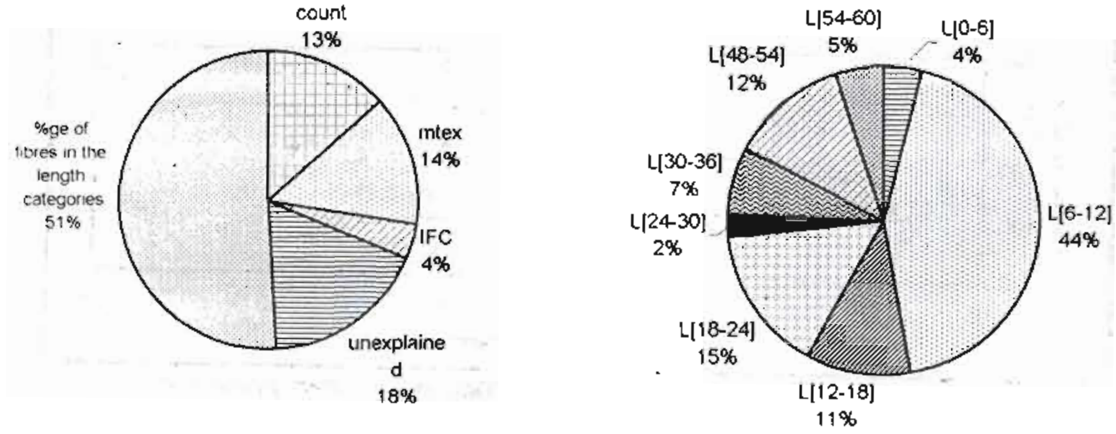

Fig (16-1) Thin places/1000m

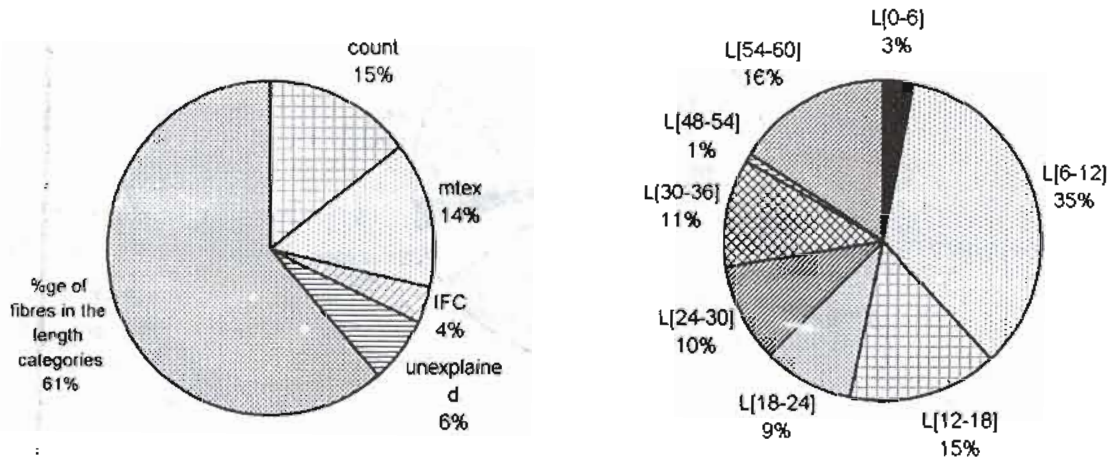

Fig (16-2) Thick places/1000m

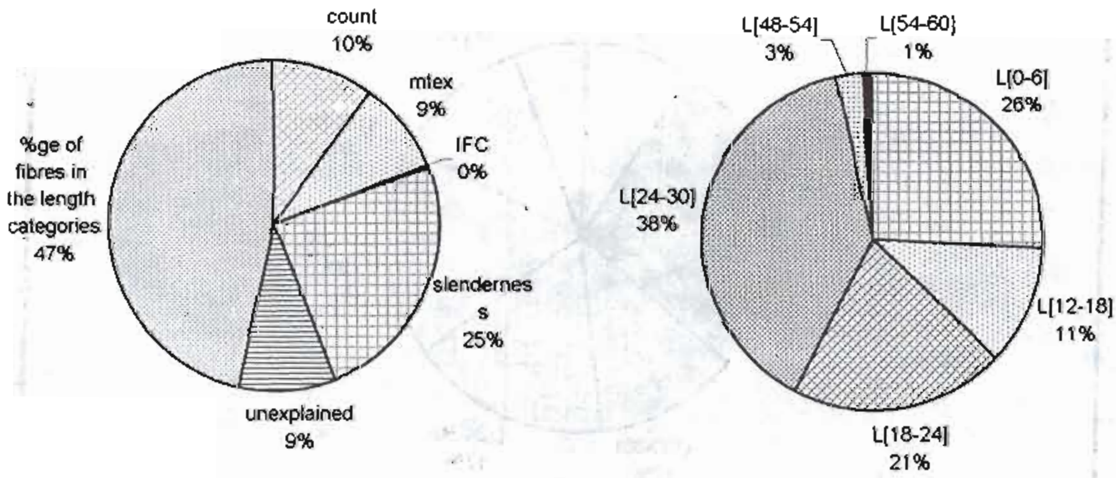

Fig (16-3) Neps/1000m

Fig (16) contribution of fibre parameters on yarn imperfections