ASSESSING THE INFLUENCE OF DIAGONAL YARN PATH OFFSETS IN SPINNING IN HAIRINESS CONTROL

PROJECT REPORT

Submitted by

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Register No:0920201004

in partial fulfillment for the award of degree

of

MASTER OF TECHNOLOGY

in

TEXTILE TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE – 641 049

(An Autonomous Institution Affiliated to Anna University of Technology: Coimbatore)

APRIL 2011

BONAFIDE CERTIFICATE

Certified that this project report **“ASSESING THE INFLUENCE OF DIAGONAL PATH OFFSETS IN SPINNING IN HARINESS CONTROL”** is the Bonafide work of GOPALAKRISHNAN.R who carried out this project work under my supervision.

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ACKNOWLEDGEMENT

I express my sincere gratitude to our beloved Co-Chairman, Dr. B.K. Krishnaraj Vanavarayar, Dr. J. Shanmugan, Director, Kumaraguru College of Technology and Dr. S. Ramachandran, Principal for their support and allowing to use the facilities of the institution.

I express my whole hearted thanks to Dr. K.Thangamani, Head of Department, Kumaraguru College of Technology, for having been a source of encouragement and for instilling the vigor to do the project.

It gives me great pleasure to express my deep sense of gratitude for my supervisor, **Mr.P.THANGESWARAN**, Assistant Professor, Department of Textile Technology, Kumaraguru College of Technology, for his innovative guidance, expert suggestions and constant encouragement at every step for the study.

Words can hardly express our hearty and sincere thanks to **Mr.Subramanian**, Director, M/S.Spindraft (P)Ltd, Coimbatore, **Mr. G. Ramachandran**, Partner, M/S Raam Ganapathy Mills Coimbatore and **Mr.A.Somasundaram**, Director M/S Sri Karpagam Mills India (P) LTD Coimbatore for their moral and professional supports and the valuable suggestions given for carrying out my work effectively.

I thank all the teaching and non-teaching staff for their help during this project.

Words fail to express my thanks to my beloved family members and friends who are my sounding board and pillar of strength.

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ABSTRACT

The spinning geometry of a ring frame plays an important role in affecting the yarn properties. This project examines the effect of diagonal yarn path in ring spinning on yarn properties. Both left diagonal and right diagonal yarn arrangements with three offsets are tried in ring spinning for two cotton counts 40^S C & $6O^S$ C .The various yarn results especially hairiness from Zweigle hairiness tester are compared with the results of yarn produced from conventional yarn path. The results shows that yarn hairiness values are significantly reduced with left diagonal path when compared to conventional straight path. It is also noticed that not only the hairiness value but the total imperfections also found reduced in left diagonal path when compared to straight yarn path in 40^S C in all the three offsets.

In right diagonal path, the total imperfections found get reduced in 40^SC in all the three offsets. But hairiness is increased. In 60^SC, both hairiness and imperfections are increased compared to straight yarn path.

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LIST OF ABBREVIATIONS

1. LDP	Left Diagonal Path
2. RDP	Right Diagonal Path
3. mpm	Meters Per Minute
4. rpm	Revolution Per Minute
5. TPI	Twist Per Inch
6. TM	Twist Multiplier
7. ANOVA	Analysis of Variance
8. LHSide	Left Hand Side
9. RHSide	Right Hand Side
10.DF	Degree of Freedom
11.SS	Sum of Squares
12.MS	Mean sum of square

CHAPTER 1

INTRODUCTION

1.1 over view of spinning triangle

The effect of yarn hairiness prominently reflects on the surface properties of the resultant fabric made from them particularly in their pilling propensity and uneven dye-uptake. The protruding fibers which are not adhere to the core of the yarn structure, will tend to increase the invisible loss in subsequent process.

Even though a lot of studies are conducted in order to reduce hairiness in industry such as using light / heavy weighted, big clearance travelers, usage of modified ring profiles, effect of the twist multiplier in both roving and yarn, effect of various parameter like break draft, spacers etc, quest for higher quality ring spun yarn are still continues.

In recent developments by Rieter and Zinser, spinning triangle is reduced to ensure less hairiness. The term "spinning geometry" includes all distances, inclinations and angles in the fibre flow between entering the drafting system and yarn take-up on the cop (Klein)[1]. Stalter[2] has confirmed that when spinning triangle gets smaller with increasing spinning tension, the hairiness is reduced. According to klein[1] when the spinning triangle is short, the fibres from the edges must be strongly deflected to get inserted into the core of yarn structure. Wang[3], in his study confirmed that the right diagonal produces less hairy yarn in worsted spinning. Thilagavathi[4] in her study exhibits that left diagonal path reduces yarn hairiness in coarser counts than straight path yarn.

The present work is aimed at to study the influence of diagonal path, both left and right, in controlling hairiness with three offsets in 40^{S}C and 60^{S}C by using newly designed (Modified) fluted bottom rollers in spinning.

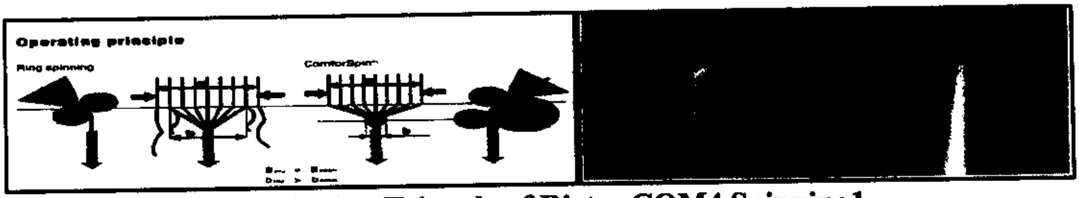


Fig. 1.1. Spinning Triangle of Rieter COM4 Spinning1

Hairiness denotes the extent to which fibres protrude from the yarn body. Hairiness is an important surface property which has a direct impact on the performance of the yarn in the subsequent processes.

It also has a bearing on the feel and appearance of the fabric. Certain minimum amount of hairiness is desirable for converting the yarn into fabric. However, when the length of the protruding hair crosses a critical limit, it poses severe constraints during fabric formation in Weaving and Knitting. The fabric quality also gets degraded due to Pilling and Fuzzy appearance created by the longer hairs.

Fig 1.2. Yarn With Hairiness

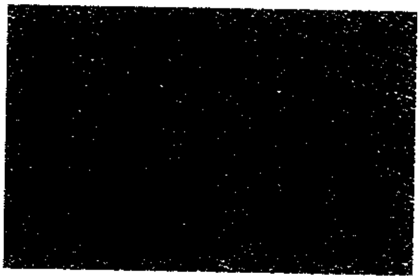
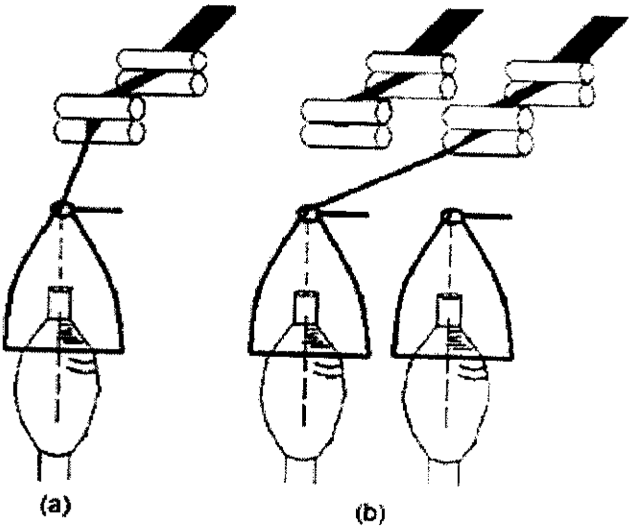


Fig 1.3. Fuzzy Fabric due to yarn hairiness

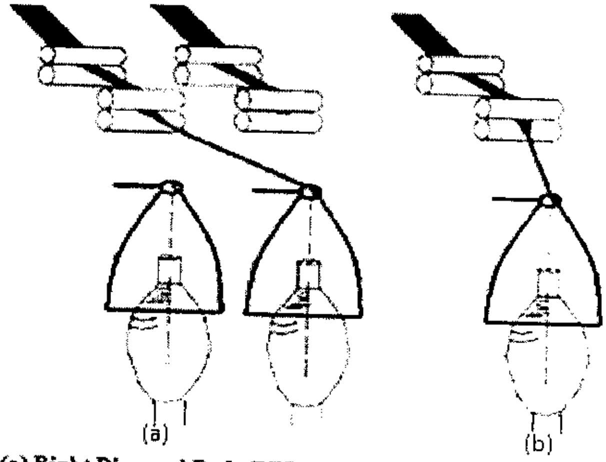
1.2 OBJECTIVE

Present work is aimed at developing less hairy yarn in ring spinning with left diagonal path offset and right diagonal path offset.



(a) Straight path yarn, and (b) left diagonal path (LDP) yarn

Fig. 1.4. Modified Yarn Path (Left)



(a) Right Diagonal Path (RDP) yarn, (b) Straight yarn path

Fig. 1.5. Modified Yarn Path (Right)

CHAPTER 2

LITERATURE REVIEW

2.1 THE SPINNING TRIANGLE

The compact ring spinning systems, the spinning triangle or twist triangle is reduced to a minimum to ensure improved fibre incorporation into the yarn structure and hence reduced yarn hairiness. The influence of modified yarn path on spinning triangle on yarn hairiness has been study using 100% cotton yarns of 40^s and 60^s counts. The spinning triangle is modified by taking left diagonal path offsets and right diagonal path offsets.

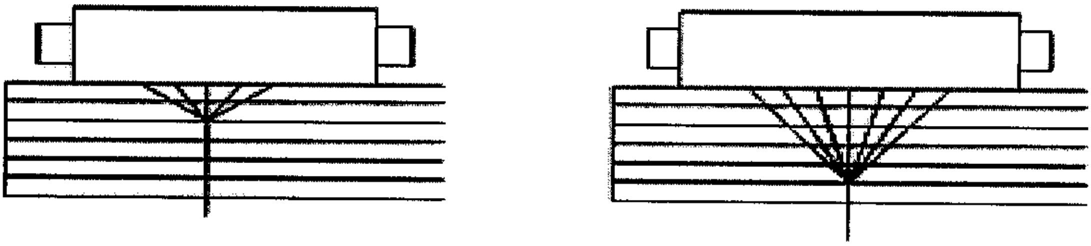


Fig- A

Fig- B

SPINNING TRIANGLES: (A) SHORT (B) LONG

Fig 2.1. Spinning Triangle

When the yarn is running in straight path it will create a spinning triangle in which the base of the triangle is equally divided. When the path of the yarn is changed to left diagonally and right diagonally with offsets, the distribution of fibres in the spinning triangle get varied.

The spinning triangle and spinning angle effect the yarn structure. The long width and narrow width spinning triangle implies a long weak point. (1) The resultant advantages of this smaller width triangle is that the edge fibres are better bound in the yarn which gives less hairy yarn and less fly generation. (2) Stalder states that yarn formation occurs immediately after the delivery nipline of the drafting system. The fibres supplied by the drafting system are collected by the spinning triangle and integrated to the yarn structure. For a specific yarn counts and elongation values, width ‘b’ of the spinning triangle depends on spinning tension ‘p’. Width ‘b’ varies in inverse proportion to spinning tension. Higher the tension ‘p’ results smaller width ‘b’ of this spinning triangle.

The relationship explain that in ring spinning width ‘B’ of the fibres fedin is always greater than the width ‘b’ of the spinning triangle.

‘Δ’ = B - b

‘Δ’ > 0

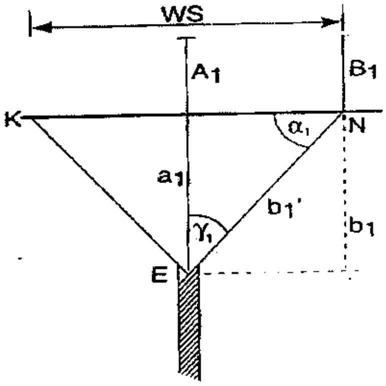


Fig. 2.2 short spinning triangle

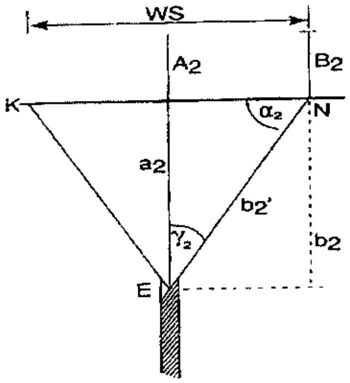


Fig. 2.3 Long spinning triangle

Δ is the difference between ‘B’ and ‘b’ therefore greater than zero. Therefc spinning triangle is unable to capture all the fibres presented to it. This means that ma peripheral fibres are either lost or attached completely in some way or other way to t already twisted yarn.

SIGNIFICANT AND LESS SIGNIFICANT FACTORS

The term “spinning geometry” includes all distances, inclinations and angles in the fibre flow between entering the draft system and yarn take-up on the cop. If we ignore the factors balloon height and yarn twist, we are left with the decisive factors.

Spinning triangle
Spinning distance (E) and
Spinning angle (C)

These will now be examined more closely, always paying attention to thei weighting. As the two graphs shows, above all the spinning triangle and spinning angl affect the fibre breakage considerably, while the spinning triangle also influences th yarn structure.

SPINNING TRIANGLE DIMENSIONS

The drafted fibre strand leaves the front roller at the nip K-N with a width W which depends on the fibre mass in the main draft zone and the drafting among othe things. After leaving the nip, if possible all fibres should be tied into a yarn by twistin the strand, the twist being imparted by the traveler and rising from this.

This twist determines one of the dimensions of the spinning triangle, namely th length (L), since the twists always rise till the tie-in angle (y1,y2) and yarn rise ang (y1,y2) at the tie-in point are equal it follows from this that high yarn twists result in short spinning triangle (L1) and low twists in a long one (L2).

With a given exit width (W), the length of the spinning triangle determines in tu its width (W2) which is always smaller than W. For one thing there is always more less necking, depending on the twist height, for another thing with a short triangle ma edge fibres are not tied in owing to the high deflection (angle α) required.

They are lost or attach themselves to the outside of the yarn formation. The greater the difference between W and Ws, i,e the shorter the spinning triangle, the more serious is the detriment to the yarn structure and ultimately to its quality. However not only the yarn twist but the machine design also affects the length of the spinning triangle through the wrap angle of the fibre strand on the front roller.

The greater this angle, the longer is the spinning triangle formed. But this deflection on the front roller has another advantage: it lends the spinning triangle additional guidance and above all prevents a very abrupt bending-off of the edge fibres emerging from the nip.

With guiding over the front roller up to the lift-off line H the fibres are gathered in curving from the edge tying them in better and more regularly. It is then primarily the angles which influence matters and not so much the length of the triangle as is usually the focus of discussion. Nevertheless work from the length dimension which is commonly used, since there are strong interdependences are seen. In reasoning ,it will also be assumed that the spinning triangle is shorter than most of the fibres. This is justified, since L measures 2.5 to 7 mm.

INFLUENCE OF END BREAKAGES

The reasoning is based on a short spinning triangle and a longer one due to a wider angle β and on the behavior of two fibres (A middle, B edge position). Both fibres are longer than the spinning triangle (distance KE). Whereas fibre A undergoes no change of direction during its passage; fibre B is bent off more or less at N (angle α) increasing the distance K.E.

Consequently the tensile forces from the yarn cause elongation of fibre B from b1 to b1' (or b2 to b2'). Now if the bending angle α is very small (short spinning triangle). the elongation must be very large. The tensile forces of the yarn pass into the edge fibres entirely.

Fibre A remains without tension and therefore without elongation, since before the tensile forces can act on A,B undergoes so much elongation that the forces acting on it would make the fibre break or the fibre formation slide apart the edge.

This danger is always present with short spinning triangle, because a situation of this kind arises when tension peaks due to shocks or unsmooth running from traveler and balloon affect the spinning triangle. The thread then breaks, always from the outside inwards. This means that with short spinning triangle, owing to the small angle, the tensile forces are distributed very unevenly exclusively and very high at the edge (Fs) and little or none at all in the middle (zone Zo).

On the other hand a long spinning triangle shows a much more (if not absolutely) uniform distribution of the forces. Since the tension and its peaks are distributed over the entire fibre formation here, fewer end breaks are the obvious result.

INFLUENCE ON THE YARN STRUCTURE

The yarn takes shape in the spinning triangle. If it is to possess high strength elongation and regularity together with low neps and hairiness, the fibres in the yarn mus be disposed

Parallel, Evenly distributed and spirally about the yarn axix, and all fibres must b tied in under tension of all spinning systems these requirements are best satisfied by rin spinning, especially the last very important one. However this holds true only with th proper spinning geometry, i,e, with optimal spinning triangle. If this is too short the cor fibres will be tied in without tension.

They can then take up tensile forced in the axial direction only to a limited exter or only after the fibres in the outer layer have ruptured. Not all the fibres are stressed bu only some of them. Because the twist insertion in the yarn is also insufficient (the edg fibres are wrapped round the core fibres ultimately) this negative effect is reinforced. Th yarn structure falls short of the optimum and most of the yarn parameters suffer more less. To be noted in this connection is the problem of the edge fibres. The greater th difference between Ws and W (short spinning triangle), bigger also is the proportion edge fibres which cannot follow the sharp deflection at angle α so that they are either lo or tied in badly. Consequently a spinning triangle lengthened by the wrap angle β always yields a better yarn structure with all its attendant benefits to quality.

THE SPINNING LENGTH AS BUFFER ZONE

Opinions about the weighting of the influences differ also somewhat regarding the distance from drafting exit to yarn lappet. In the spinning length a small secondary balloon often furms, or even two of them, which in extreme cases with very long spinning length may easily cause increased end breaks. Much more troublesome however in insufficient spinning length, because the spinning length is a buffer zone serving to take up the disturbances coming from the balloon. For the spinning length too there is an optimum.

DEFLECTION AT THE LAPPET A CRITICAL FACTOR

At the lappet the yarn is deflected more or less according to the design of the machine. This spinning angle too has great influence on the end break rate and yarn formation. To make things clearer, let us take a look twist insertion again. The twists in the yarn proceed from the traveler, since one rotation of this puts one twist into the yarn. This twist originating at the traveler must rise against the thread run up to the spinning triangle, where it ties in the fibres.

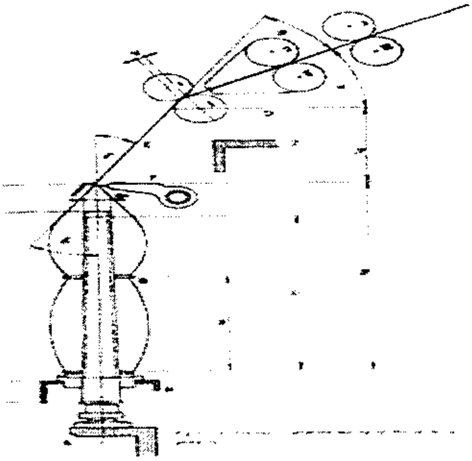
Now if the deflection at the lappet is excessive a substantial part of the rising twists will be held back at this point. This means that when the fibres are tied in at the tying-in point of the spinning triangle, there are fewer twists presents than ultimately in the yarn. This leads first to more end breaks, because the yarn strength between draft system and lappet is simply inadequate owing to insufficient twist, secondly the twisirs the tying-in of the fibres. The yarn receives its twist in two stages, most of it at the spinning triangle, then an additional twist into the already formed yarn after passing through the lappet.

It is important here, however is that the yarn should always lie on the lappet wire. Alternately touching and lifting clear causes tension peaks at the spinning triangle.

Oibrich, Zinser, Germany describes that the spinning triangle developed from the differences in width of the fibre bundle emerging from the drafting system and yarn diameter. The ends of the edge fibres are not always fully incorporated in to the yarn. These fibre ends standing out from the twisted core of the yarn, are the cause of the hairiness which is so disturbing during subsequent processing.

The hairiness of the yarn is essential parameter in predicting the yarn behavior in subsequent process. However, not all hairs which are protruding from yarn body creates a problem in further processing. A certain degree of yarn hairiness is desirable as it does the character of textiles eg. the wear comfort. All yarn hairs of 3 mm and above may cause considerable problem in subsequent processing. It is so essential to differentiate between the desirable and problematic hair lengths when evaluating the hairiness of the yarn.

This highlights the importance of the spinning geometry in ring spinning. The term ''spinning geometry'' includes all distances ,inclinations, and angles in the fibre flow between entering the draft system and yarn take up on the cop.



D - drafting arrangement
R - roller beam
E - stretch of yarn between the thread guide and front roller nip
F - thread guide
B - balloon control ring
R - ring rail
S - spindle
α - inclination of the drafting arrangement to the horizontal
β - inclination of the drafting arrangement to the axis of the stretch of yarn (E)

Fig 2.4. Spinning Geometry

2.2 EXPOSED SECTION OF THE YARN PATH[5]

In all probability, ends-down in ring spinning always occur between the front roller pair of the drafting system and the yarn guide, arranged centrically to the spindle. In this section, the yarn has a more or less reduced twist due to the twist-retaining effect of the yarn guide. (Fig. 2.5)

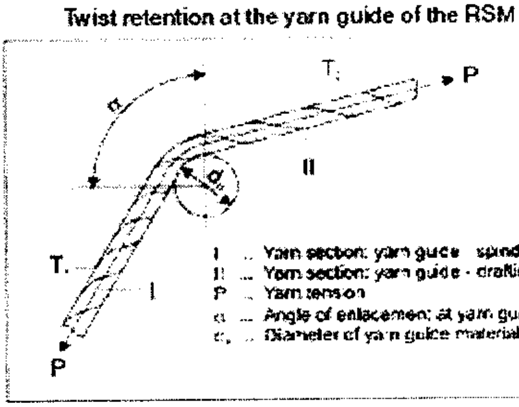

Twist retention at the yarn guide of the RSM

Fig. 2.5 Yarn guide.

This connection is inherent in ring spinning and can be influenced to a certain extent by re-arranging the spinning elements (spinning geometry). Twist reduction affects the stability of the spinning process. This negative effect is even increased by the following factors:

- high yarn tension
- smaller deviation radius of the yarn at the yarn guide
- smaller diameter of the yarn guide material
- reduced twist multiplier
- smaller elasticity module of the fibre

Ends-down will always occur just at the weakest point of the yarn within the described section. This may be either in the spinning triangle itself at the front roller pair of the drafting system or in the subsequent yarn section between spinning triangle and yarn guide.

2. 3 CONDITIONS IN THE SPINNING TRIANGLE

In a spinning triangle, fibres are always subjected to uneven load due to the spinning tension, while maximum load is exerted on marginal fibres. The fan-shaped fibre band is transferred into the more or less round cross-section of the yarn. The wider the spinning triangle, the more different is the pre-tension of the marginal fibres at the moment of twist impartation. As a result of this pre-tension, especially the marginal fibres are prevented from migrating between the different layers of the yarn cross-section.

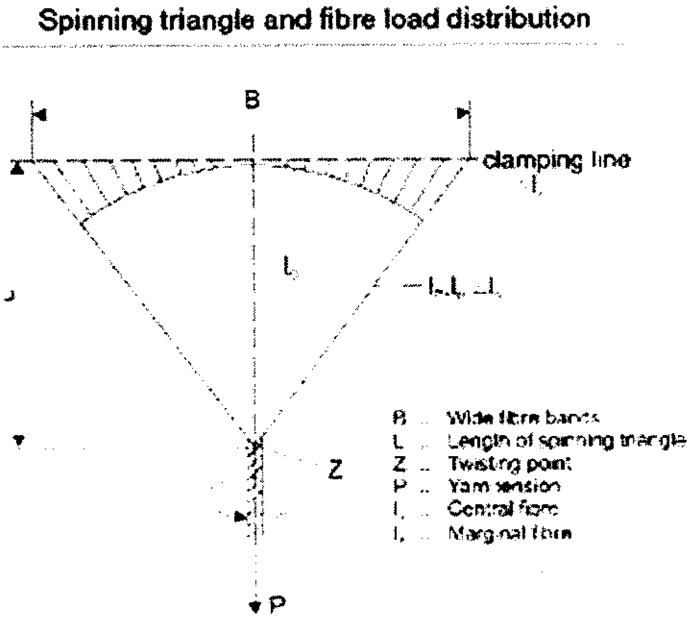


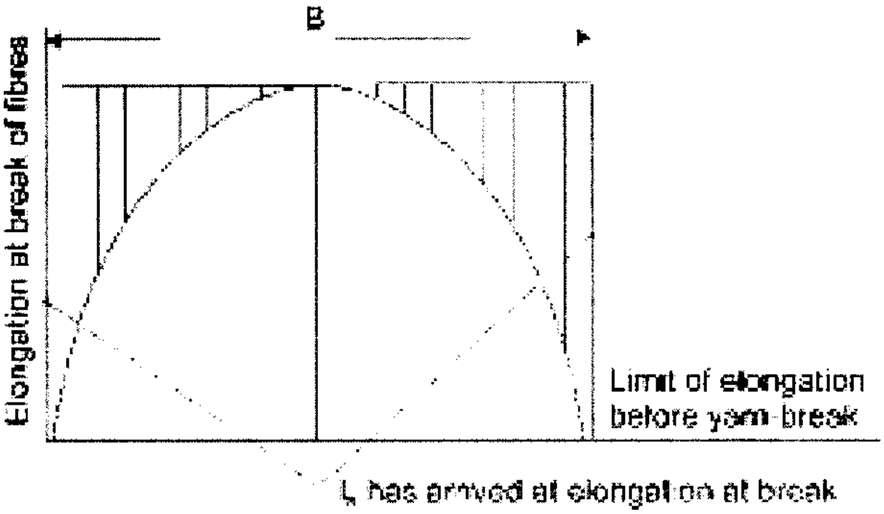
Fig . 2.6

The size of the spinning triangle is determined by width B of the fibre band leaving the drafting system and length L, which is confined by twisting point Z. The position of point Z depends on width B, the amount of turns per meter and the yarn tension applied.

When the outer marginal fibre arrives at its elongation at rupture, it will break. Then the next fibre will break and finally the resistance of the spinning triangle is exhausted and the yarn will break. On the assumption that fibre distribution is uniform and fan-like in the spinning triangle and that all fibres are clamped on both sides, which is coming very close to practice, there exist in theory the following two fundamental load scenarios:

The marginal fibre arrives at its elongation at rupture. The central fibre (middle of spinning triangle) is not yet under load.

This is the case in conventional ring spinning with higher twist multipliers, wide spinning triangle or low elongation at break of the fibres (cotton) (Fig. 2.7).



Load scenario 1 – Marginal fibre has arrived at its elongation at break. Central fibre not yet under load.

Fig. 2.7

The marginal fibre arrives at its elongation at break, when the central fibre is already under load.

This is the case in conventional ring spinning with low twist multiplier, narrow spinning triangle and high elongation at break of the fibres (synthetic fibres) (Fig. 2.8).

Load scenario 2 – Marginal fibre has arrived at its elongation at break. Central fibre is under load

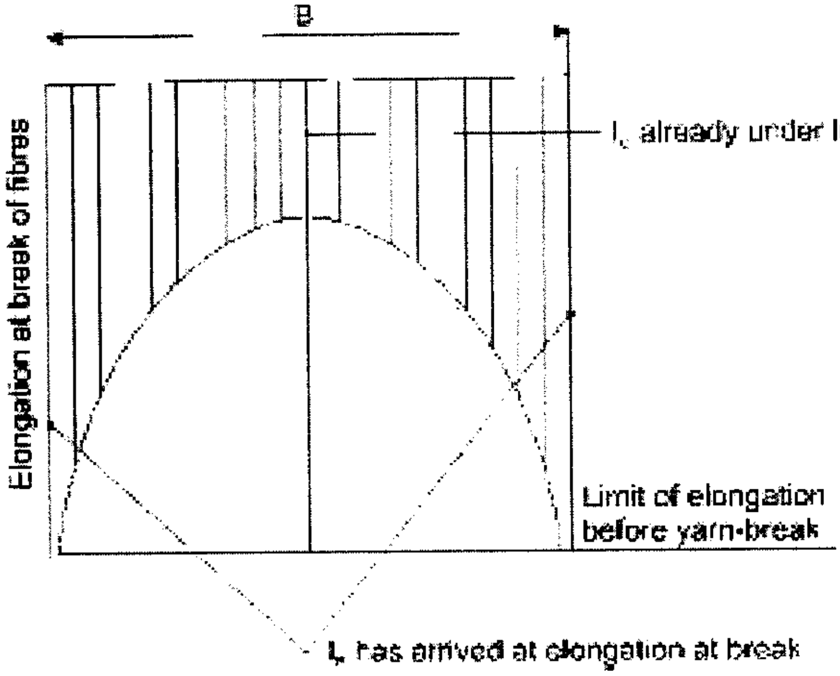


Fig. 2.8

2.4 FACTORS INFLUENCING THE STRENGTH OF THE SPINNING TRIANGLE

If the twist multiplier is increased at a constant width B of the fibre band, th strength of the spinning triangle will decrease accordingly. The reason is the increasin slope of the marginal fibres and consequently their higher load. When the fibre band i wider, but yarn tension maintained, the strength of the spinning triangle will als decrease, as the load of the marginal fibres is increasing in this case, too. When spinnin tension is raised, the other conditions being unchanged, the spinning triangle will get longer. As a result, the number of marginal fibres clamped on both sides will decrease. Simultaneously, however, the pre-tension of the fibres still being clamped on both sides is increased. A high spinning tension results in higher hairiness and more fibre loss. Fibre length has an analogous influence, but is not so important in practice, because the fibre length is significantly longer than the length of the spinning triangle.

All the above-mentioned factors alone are not decisive for the ends-down rate, but only take effect in combination with the elongation at break of the fibres. W. Krause and A. Soliman could prove both mathematically and by way of experiment, that above all the elongation at break of the fibres has a decisive influence on the strength of the spinning triangle.[2]

When fibres have a higher elongation at break, the spinning triangle will extend, so that the marginal fibres have less slope and can contribute better to the strength. As a result, cotton yarns and synthetic yarns have a fundamentally different ends-down distribution between spinning triangle and yarn section.

2.5 ENDS-DOWN DISTRIBUTION

For industrial practice and technical development of the ring spinning technique it is of importance - apart from knowing the factors of influence , in which relation the two critical areas, i.e. spinning triangle and yarn section between spinning triangle and yarn guide, contribute to the total ends down rate.

Trials have shown that with cotton yarns with an α range from 3.5 to 5.5 almost 100% of all ends-down happen at the spinning triangle. Some yarns with a twist multiplier $\alpha e < 3.5$ can have a lower strength than the spinning triangle. So, when spinning cotton, the spinning triangle is clearly the weak point.

Percentage of ends-down occurring at the spinning triangle of total ends-down according to [1]

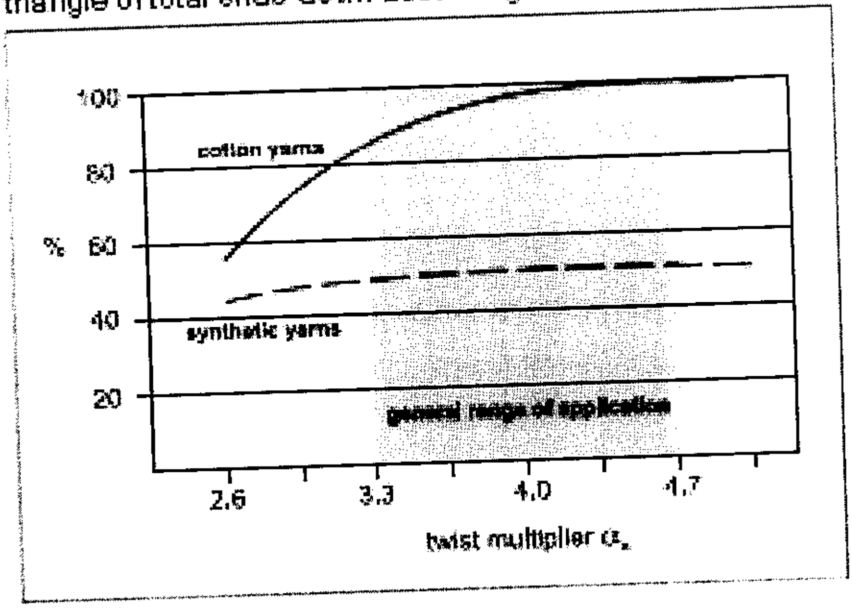


Fig. 2.9

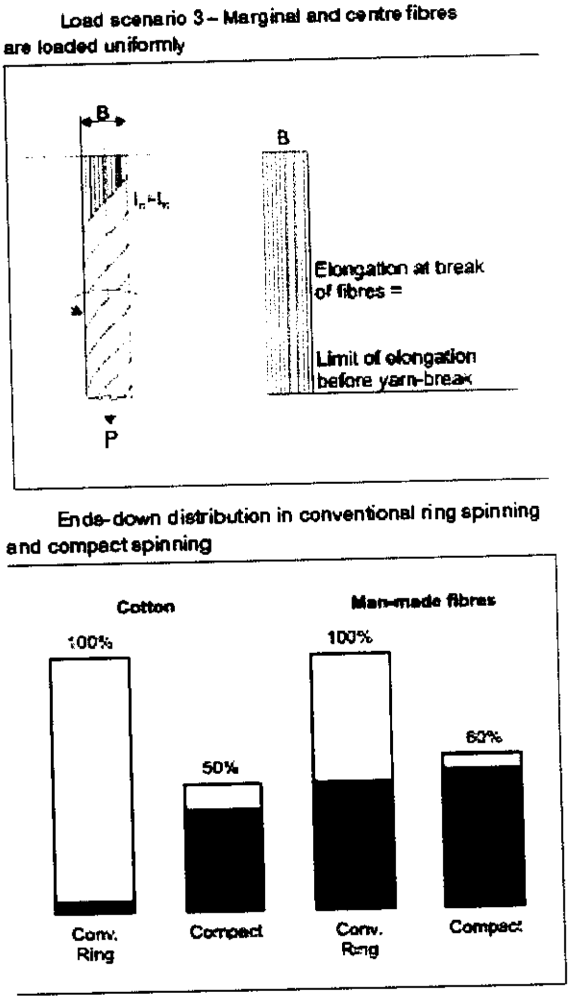
Synthetic yarns on the other hand have an ends-down portion of about 50% at the spinning triangle, largely irrespective of yarn twist, what underlines again the vast influence of elongation at break of the fibres on the spinning triangle strength.

2.6 INFLUENCE OF COMPACTING

By adding a compacting zone to the actual drafting process, the spreading o fibres at the front roller pair of the drafting system is minimized until the spinnin triangle is virtually eliminated. The re-arrangement of the fibres from two-dimensional t three dimensional structure is drastically reduced. Twist is imparted to a compacte bundle of largely parallel fibres and can extend almost up to the clamping line. Optimu results are achieved, if compacting takes place without fibre elongation and only with slight tension of the fibre band. This is perfectly put into effect with th EliTeQ®Compact Spinning System. A fibre band compacted in such a way helps th fibres to migrate better between the different yarn layers when twist is imparted.

Inter-fibre friction of the fibre band is increased all through the yarn cross section, and this is the reason for higher yarn strength in compact spinning.

Contrary to load scenarios 1 and 2 (see item 2), we now have load scenario 3. All fibres have almost the same load. This permits to achieve strength values with cotton at the drafting system front roller pair, which correspond to the yarn strength or often are even better. The reduction of the ends-down rate by 40 to 50% in compact spinning is mainly due to the drastic decrease of ends-down at the front roller pair of the drafting system. In comparison with conventional ring yarn, the ends down distribution between front roller pair of the drafting system and subsequent yarn section is different. (Fig.2.10).


Load scenario 3 – Marginal and centre fibres are loaded uniformly

Ends-down distribution in conventional ring spinning and compact spinning

Fig. 2.10

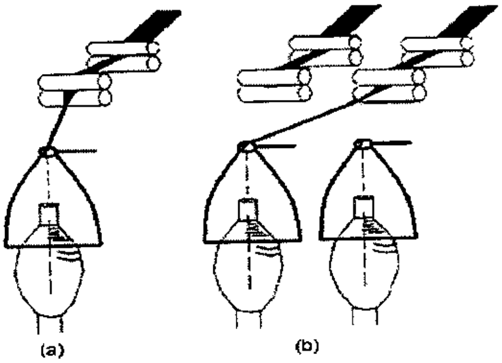
The great influence of elongation at break of the fibres almost disappears as a result of the eliminated spinning triangle, so that compact yarns from cotton and man-made fibres now have a very similar ends-down distribution.

As a result of different elongation at break of cotton and man-made fibres, the ends-down rate at the spinning triangle of such yarns is different. A compacting zone installed subsequent to the drafting system largely eliminates the influence of this elongation at break, so that compacted cotton and synthetic yarns have a similar ends-down distribution between drafting system and subsequent yarn section. Ends-down of a compact yarn mainly occur at the yarn portion between front roller pair of the drafting system and yarn guide.

According to Mr.Klein(1) the twist determines the length of the spinning triangle. Since the twist always rise till the tie in angle and yarn rise angle at the tie in point are equal. It follows from that high yarn twist results in a short spinning triangle L and low twist in a long one. In short triangle,,many edge fibres are not tied in owing to the deflection required. They are lost or attach themselves to the outside of the yarn formation. However not only the yarn twist but the machine design also affects the length of the spinning triangle through wrap angle of the fibres strand on the front roller. The greater this angle, the longer is the spinning triangle formed; but this deflection in the front roller has an advantage that it prevents a very abrupt bending off the edge fibres emerging from the nip. The greater the difference between 'ws' and 'w' in shorts spinning triangle proportion of edge fibre which can't follow the sharp deflection at angle α is bigger so that they are either lost are tied in body.

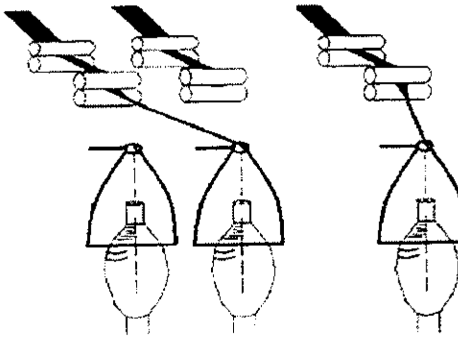
From Xungwang(3) states that the spinning triangle often assumed to be symmetrical but in reality it is not correct. For a 'Z' twist yarn fibres on the right hand side (RH) of the triangle often undergo a pre twisting process that effectively binds the fibres while fibres on the left hand side are less controlled. Often these fibres on the LH side of the triangle become hair fibres when the yarn is formed. One hypothesis is that if we can shorten the distance, the fibres on the LH side of the triangle have to travel before reaching the convergence point, yarn hairiness likely to be reduced.

There are two ways to reduce the distance; one way is to increase the twist level so that a smaller triangle is formed during spinning. Another approach is to modify the yarn path. We have used here that approach with left diagonal and right diagonal configuration.



(a) Straight path yarn, and (b) left diagonal path (LDP) yarn

Fig. 2.11 .Modified Yarn Path (Left)



(a) Right Diagonal Path (RDP) yarn, (b) Straight yarn pat

Fig. 2.12 . Modified Yarn Path (Right)

One drawback of the diagonal arrangement may be that "twist blockage" at pig tail guide (lappet hook) will be more severe than the conventional setup which could lead to the increased ends down in spinning. But the spinning tension (with diagonal yar path) above pig tail guide may be lower due to the increased "Capstain effect" betwee the yarn and pig tail guide. These two factors may counter act each other and result an effect on edge down could be minimized.

G. Thilagavathi(6) observed that there is 50% reduction in case of long hair (>3mm length) in left diagonal path as compare to that in conventional straight yar path. A reduction 10% - 15% is observed in case of short hairs (<3mm). The tota number of hairs both long and shorts in case of left diagonal path is found to be 50% o the straight yarn path. This may due to the reduction in distance between the front rolle nip and the convergence point resulting in reducing the traveling distance of les controlled fibre.

To explain the mechanism of hairiness control she adopted following hypothesis.

i. Spinning triangle become arranged as shown in figure. Fibres aligned in yarn path travel longer distance and those in the other side of the triangle travels shortest distance before reaching the convergence point.
ii. There is differential tension acting on the fibres on two sides of the spinning triangle.
iii. For spinning 'Z' twist yarn follows left diagonal path fibres in the shorter side of the spinning triangle are better controlled and reduced the hairiness while fibres on the right side of the spinning are controlled by higher tension and pre twisting.

According to her findings the tenacity of left diagonal path is slightly higher than that of corresponding straight path yarn and also C.V% of the tenacity in left diagonal path is lower than that in straight path. This may be due to the better binding of fibre in to the yarn structure because of reduced triangle width and differential fibre tension in both sides of spinning triangle.

CHAPTER 3

3.1. METHODOLOGY

The methodology of the project is shown in picture. With left diagona arrangement, the yarn is passing from a drafting unit is taken up by the adjacent spindl to the left of the drafting unit instead of the spindle directly below it.

For the right diagonal arrangement, the yarn from the drafting unit is taken up b the adjacent spindle to the right of drafting unit, instead of the one directly below it.

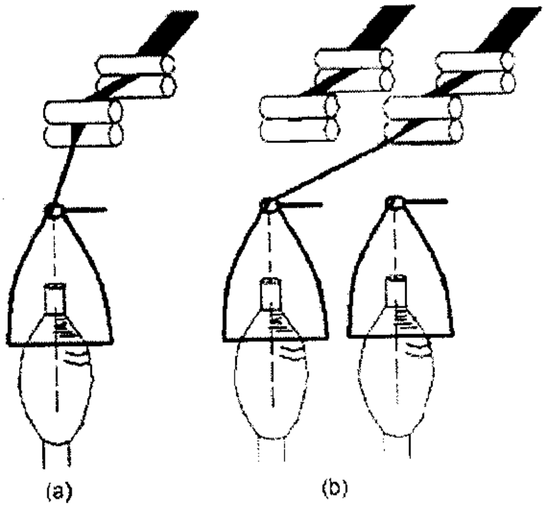


Fig. 3.1

(a) Straight path yarn, and (b) left diagonal path (LDP) yarn

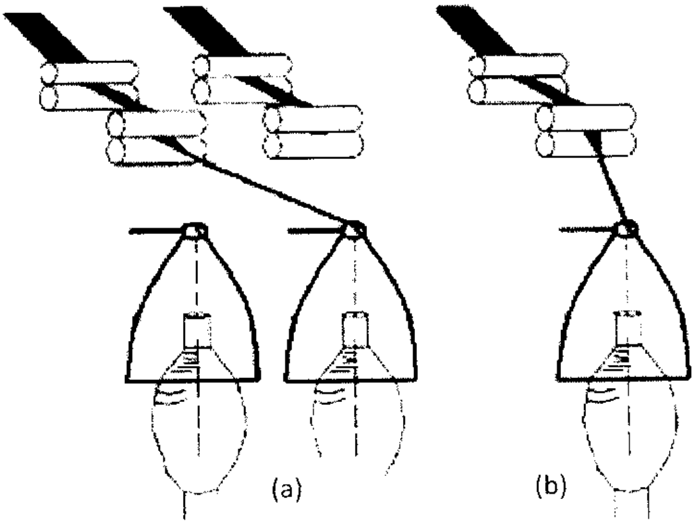


Fig. 3.2

(a) Right Diagonal Path (RDP) yarn, (b) Straight yarn path

3.2. MATERIALS AND METHODS

The study is conducted in 40^{s} Ne and 60^{s} Ne. Fibres specification and machinery details along with process parameter are listed in the flow chart. Three offsets are selected namely 70mm, 50mm, and 30mm for each left and right diagonal path.

		40^{s}c	60^{s}C
COTTON	variety	Bunny	Mcu 5
	2.5% span length	28.2mm	30.5 mm
	50% span length	13.8 mm	14.2mm
	Strength in g/ tex	21.5 g/ tex	22.8 g
	Fineness in mic	3.8 mic	3.4 mic

		40^{s}C	60^{s}C
Blow room Make Ramaraj machine works 1992	variety	Bunny	Mcu 5
	Hopper bale breaker	do	do
	Step cleaner	do	do
	Hopper feeder with condensor	do	do
	Double beater scutcher with Two bladed beater and Kirschner beater	do	do
	Delivery speed meter/min	7.5 meter/min	7.5 meter/min
	Weight in grams/ meter	400 grm/mtr	350 grm/mtr
	Lap hank	0.001475	0.00169

		40^{S}C	60^{S}C
Carding Make India Tex(40sc) Tex.Howa (60sc)	Delivery speed mtr/min	52 mtr/min	52 mtr/min
	Sliver hank	0.125	0.180

Draw frame LMW DO/2s	Delivery speed mtr/min	180	180
	No.of doubling	8	8
	Sliver hank	0.12	0.20

		40^{S}C	60^{S}C
Speed frame Tex.Howa (40sc) LF 1400 A 60sc	Flyer speed	800	800
	TPI/TM	1.53/1.4	1.85/1.25
	Hank of roving	1.2	2.2
Spinning HOWA ring frame SKF PK 225 drafting	spindle speed rpm	12,000	12,000
	TM/TPI	4.5/28.5	4.2/32
	Total draft (actual)	34.5	28.4
	Spacer	4mm black	3.5mm white
	traveller	6/o umudr	12 / o umudr

In order to get the above offsets ,three lines of fluted rollers are modified .The pneumafil broken end collecting orfice, bottom apron guiding positions, roving condensers also modified according to the offsets selected.

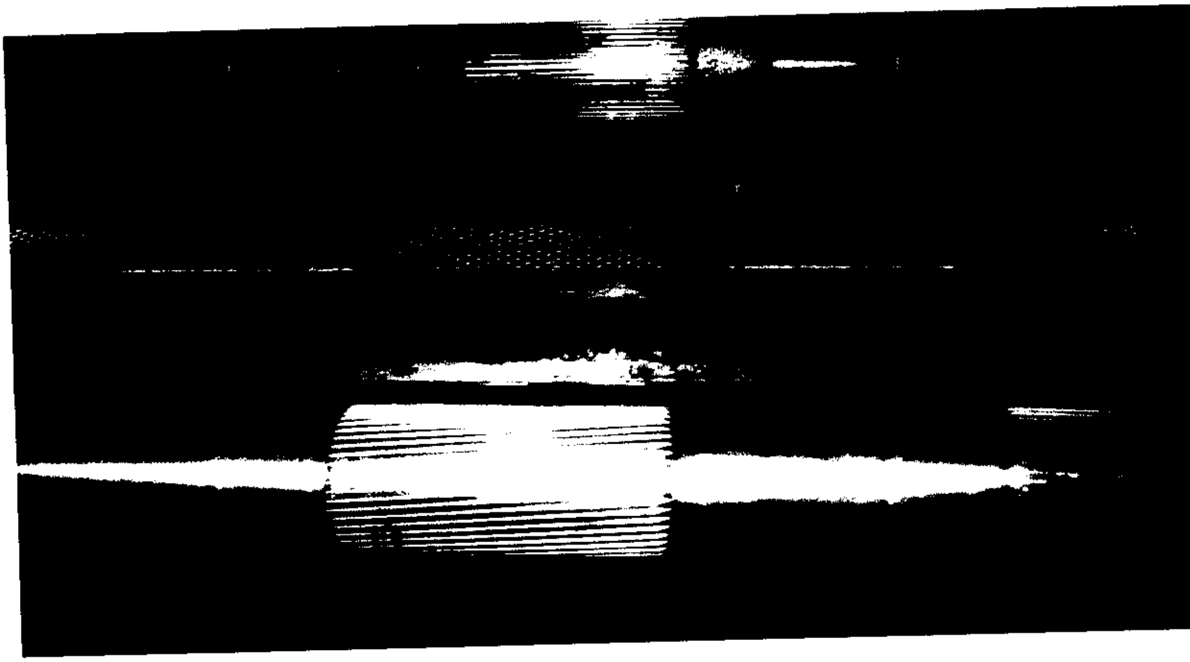


Fig. 3.3 Existing Bottom fluted roller

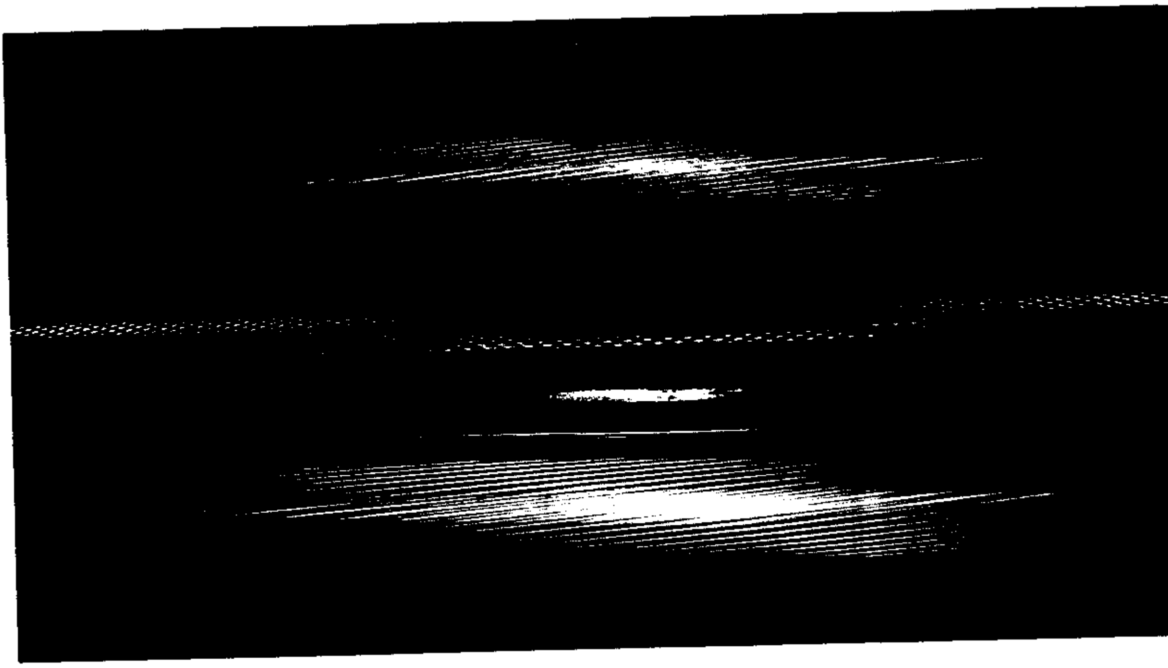


Fig. 3.4 Modified Bottom fluted roller

3.3. TESTING METHODS

- The hairiness was tested using Zweigle G565 hairiness tester at standard conditions of 100m/min speed and 5g pretension. The numbers of hairs for all classes were observed. S3 values (number of fibers greater than 3mm in 100 meter of yarn) are taken for comparison.

- The tensile properties of yarn were tested on Tensorapid at a speed of 5000 mm/min
- and a pretension of 0.5kgf.

- The imperfections were studied by using USTER TESTER 3 at standard condition of 100m/min speed.

- ANOVA tables are prepared with Minitab 15 software.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 EFFECTS OF OFFSETS ON HAIRINESS

The S3 values obtained in 3 offsets (70mm, 50mm and 30mm) of left and right diagonal path for both s the counts are tabulated below.

TABLE NO. 1 S3 VALUES

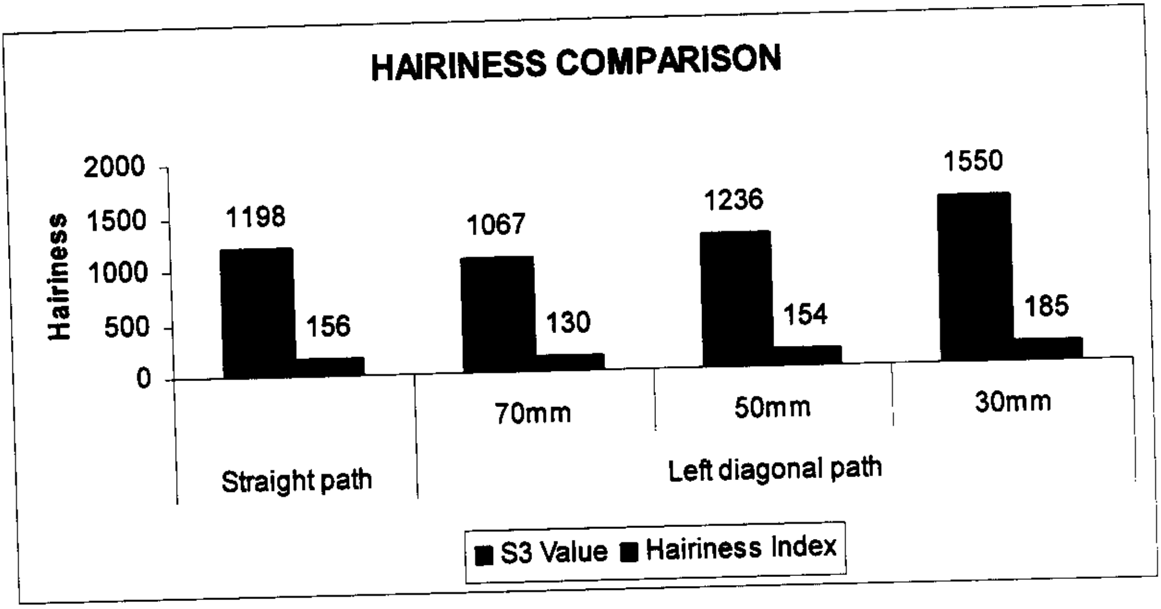
	Straight path	Left diagonal path.			Right diagonal path		
		70mm	50mm	30mm	70mm	50mm	30n
40^{S}C	1198	1067	1236	1550	1443	1664	16
60 ^{S}C	1612	1211	1529	1452	1995	1877	25

It is observed that there is reduction in hairiness is found in left diagonal path in 70mm offset of both counts. The reduction was in the order of 11% in 40Nec and in count 60Nec the reduction was about 25%.

In right diagonal path, in all offsets ie, 70mm, 50mm and 30mm of both the counts, the hairiness value are increased significantly.

It confirmed with the findings6and the reason for the low hairiness on lef diagonal is said to be the direction of twist namely "Z" in ring spinning. The "Z" twis direction and left diagonal path will shortening the spinning triangle at left side which reduces the distance travelled by the uncontrolled fibers to reach the convergence point as compared to conventional straight path. Therefore with left diagonal arrangement, yarn hairiness is reduced.

40^{S}C



40^{S}C

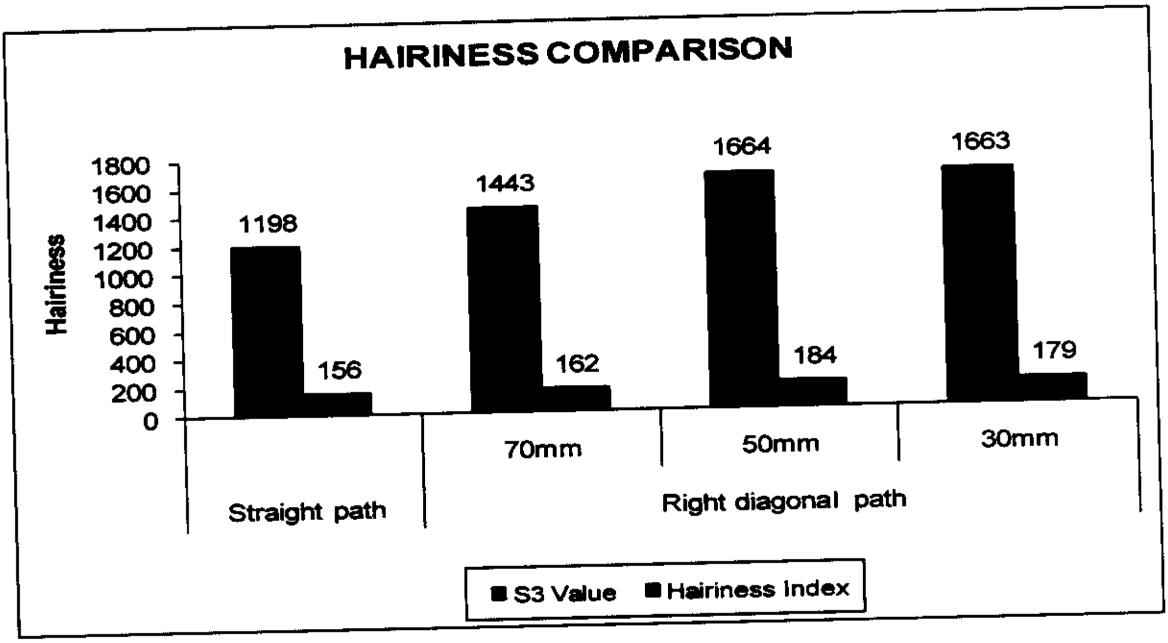
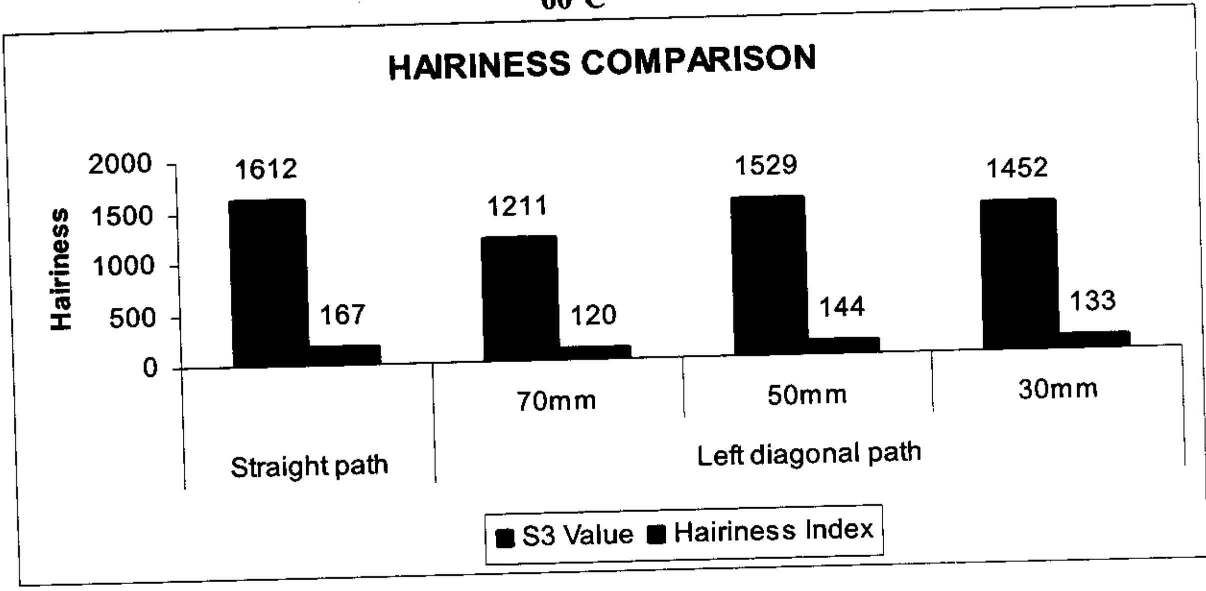


fig.4.1

$60^{S}C$



$60^{S}C$

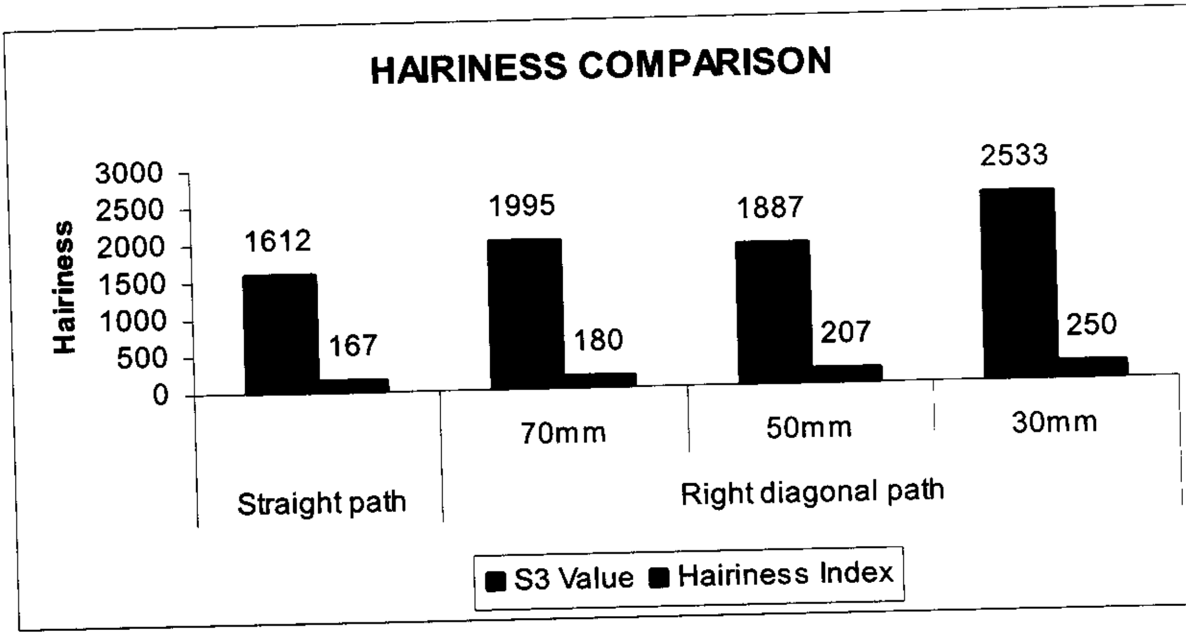


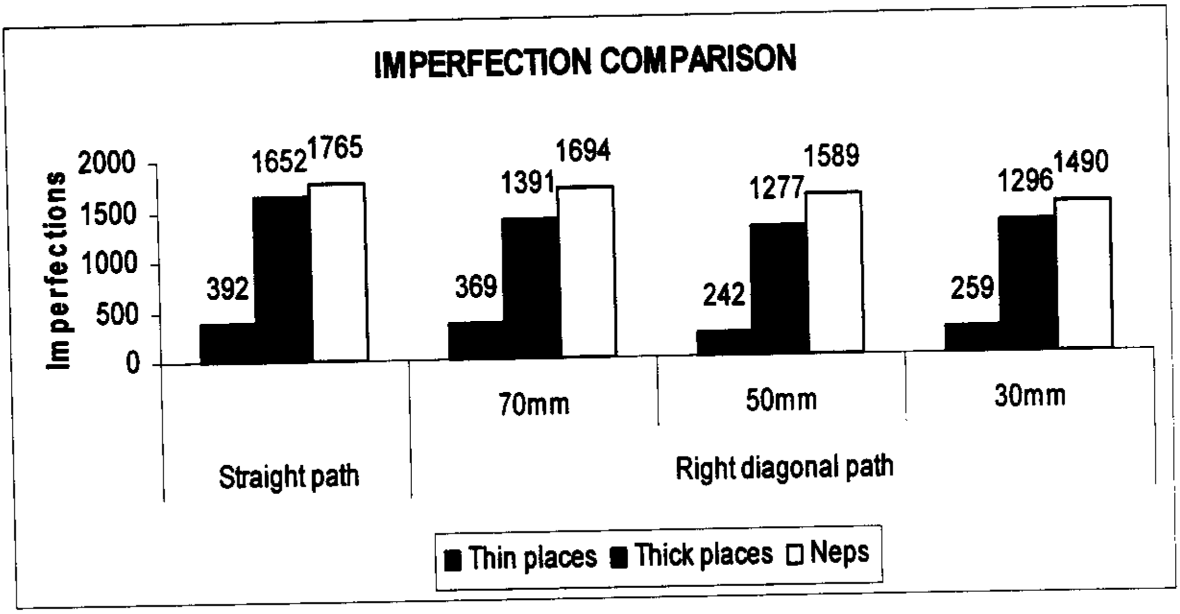
Fig :4.2

TABLE NO. 2 EFFECTS OF DIAGONAL PATHS ON YARN IMPERFECTIONS

40^SC	Straight path	Left diagonal path			Right diagonal path		
		70mm	50mm	30mm	70mm	50mm	30mm
U%	17.36	17.12	16.37	16.47	16.87	16.34	16.4
Thin -50%	392	359	247	259	369	242	259
Thick +50%	1652	1496	1289	1343	1391	1277	1296
Neps 200%	1765	1685	1586	1643	1694	1589	1490
Total	3809	3540	3122	3245	3454	3108	3045

In 40^SC, yarn imperfections are reduced to significant level in both the diagonal and in all offsets compared to straight yarn path. Reduction is ranged from 7.0% to 20%. In 50 mm offset in both left and right diagonal gives a reduction of 18%. It can be noticed that reduction took place in all the three categories (Thin, Thick and Neps).

40^SC



40^SC

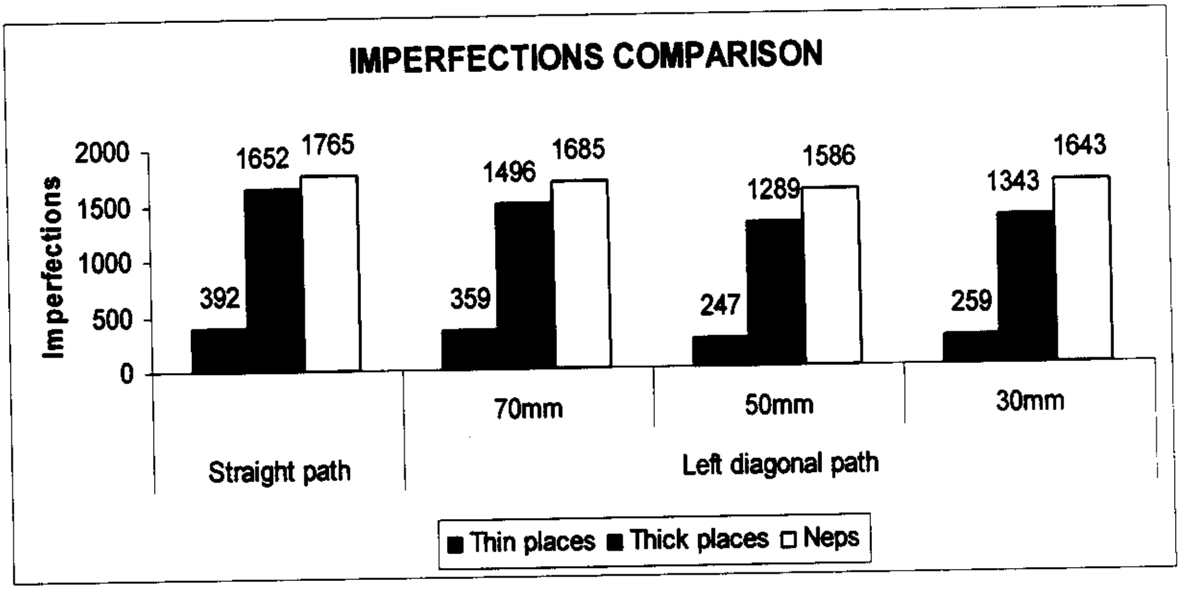
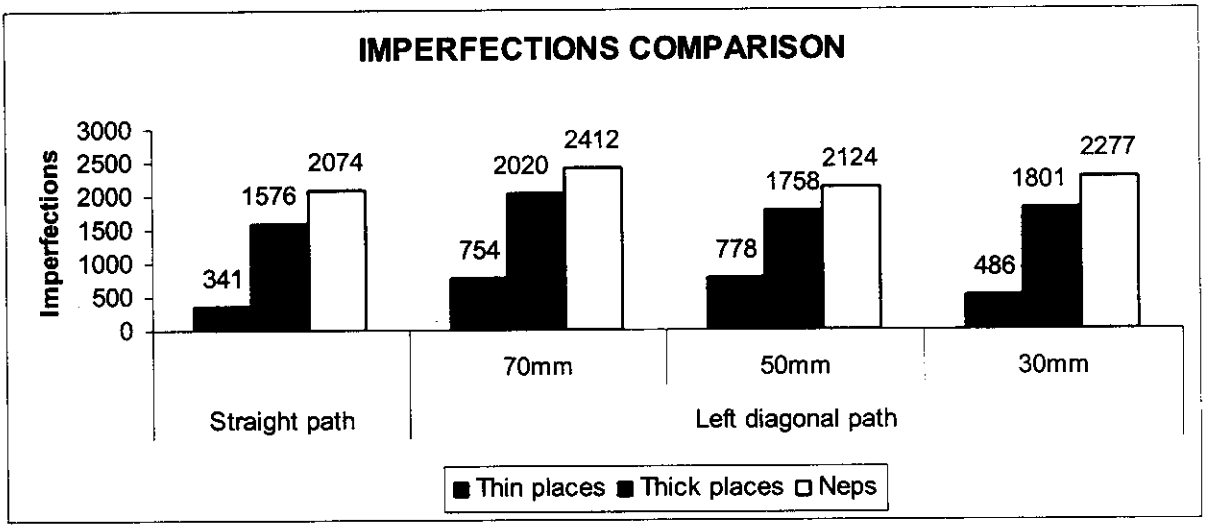


Fig 4.3

TABLE NO. 3 EFFECTS OF DIAGONAL PATHS ON YARN IMPERFECTIONS

60^SC	Straight path	Left diagonal path			Right diagonal path		
		70mm	50mm	30mm	70mm	50mm	30mm
U%	16.73	18.3	18.27	17.76	18.10	16.48	16.93
Thin -50%	341	754	778	486	505	461	317
Thick +50%	1576	2020	1758	1801	2111	1192	1572
Neps 200%	2074	2412	2124	2277	3027	1939	2166
Total	3991	5186	4660	4564	5643	3592	4055

60^SC



60^SC

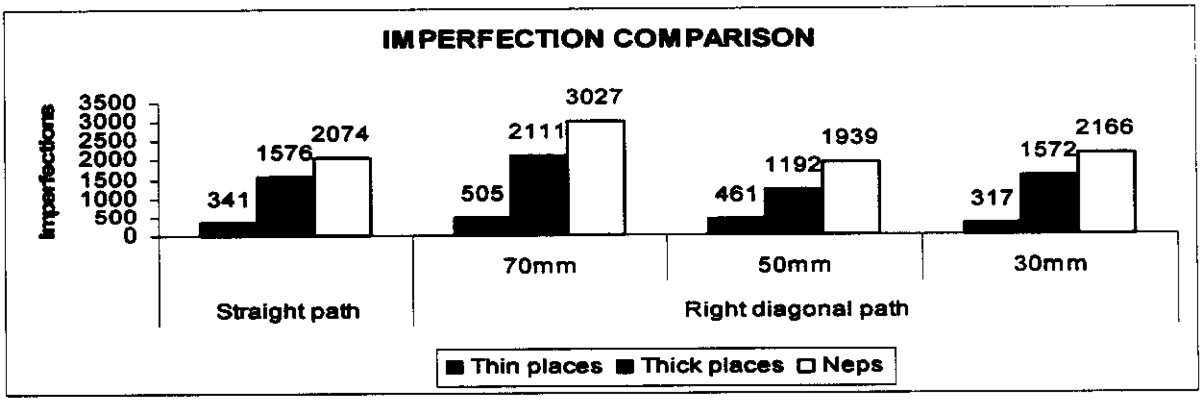


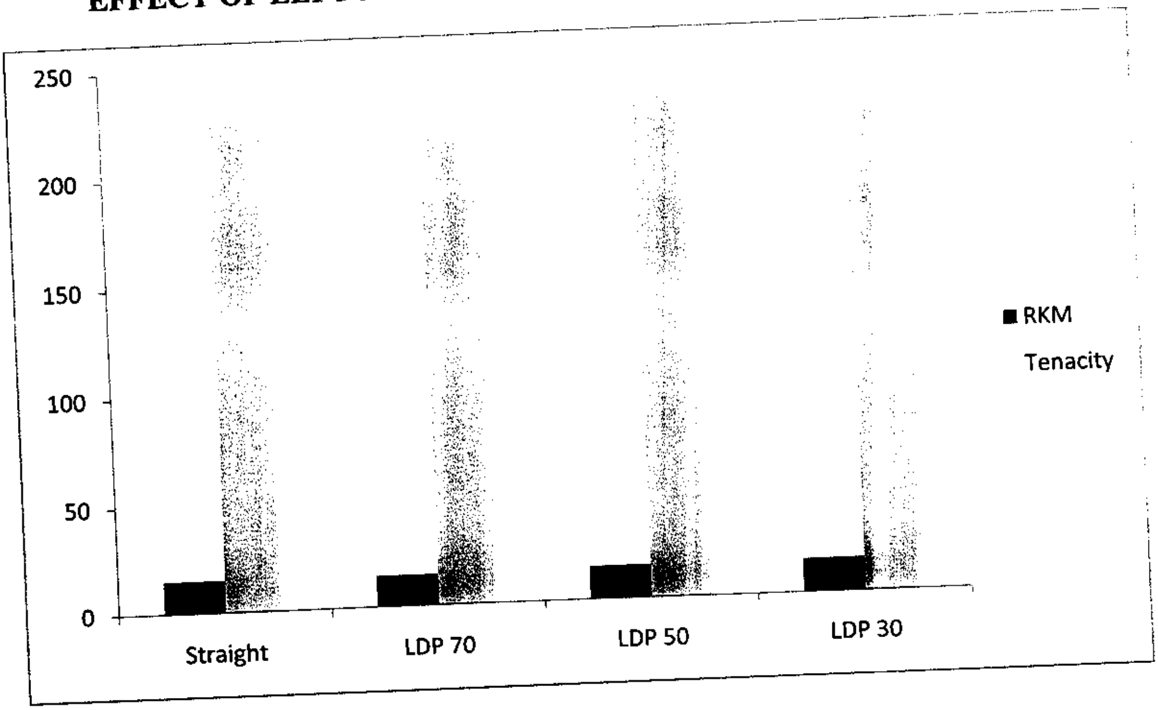
Fig:4.4

In 60^SC, increase in imperfection is seen in both the left and right diagonal path in three offsets compared to straight path except 50mm offsets in Right diagonal path. The range of increase is from 2% to 41%.

TABLE NO.4 EFFECT OF DIAGONAL PATH ON TENSILE PROPERTIES

40^SC	Straight path	Left diagonal path			Right diagonal path		
		70mm	50mm	30mm	70mm	50mm	30mm
Single yarn strength in gms	225	219	232	229	231.1	229.9	244.6
RKM	15.3	14.89	15.74	15.57	15.65	15.57	16.57

EFFECT OF LEFT DIAGONAL PATH ON TENSILE PROPERTIES



EFFECT OF RIGHT DIAGONAL PATH ON TENSILE PROPERTIES

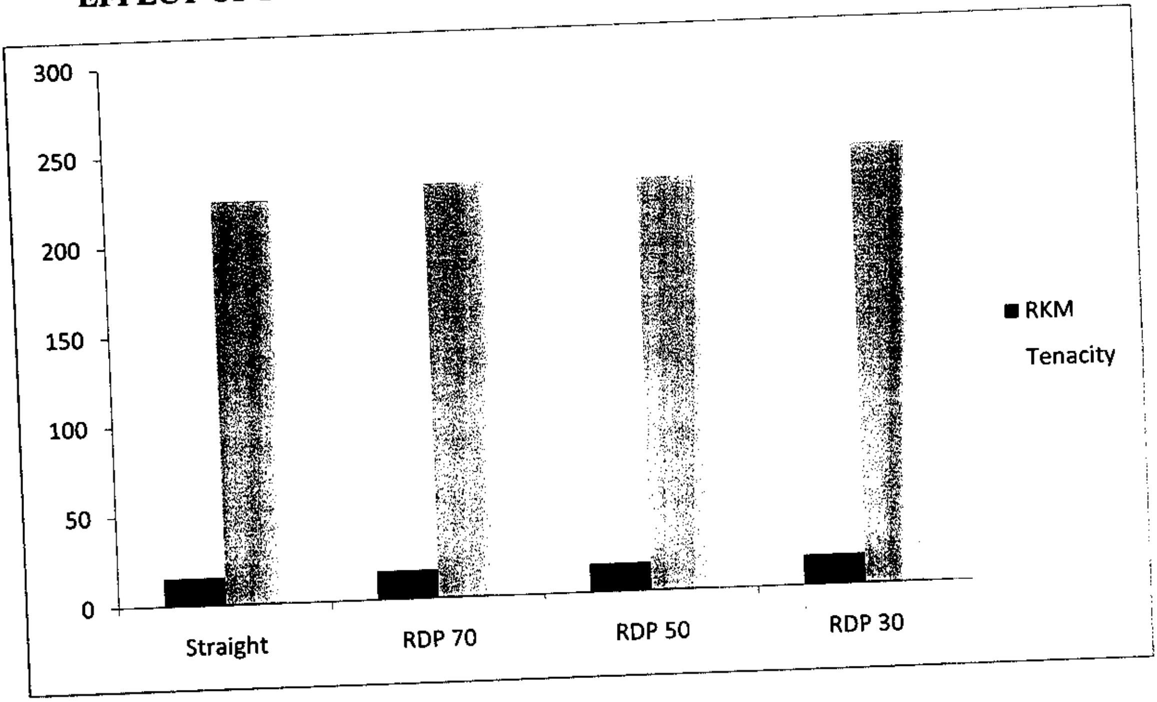
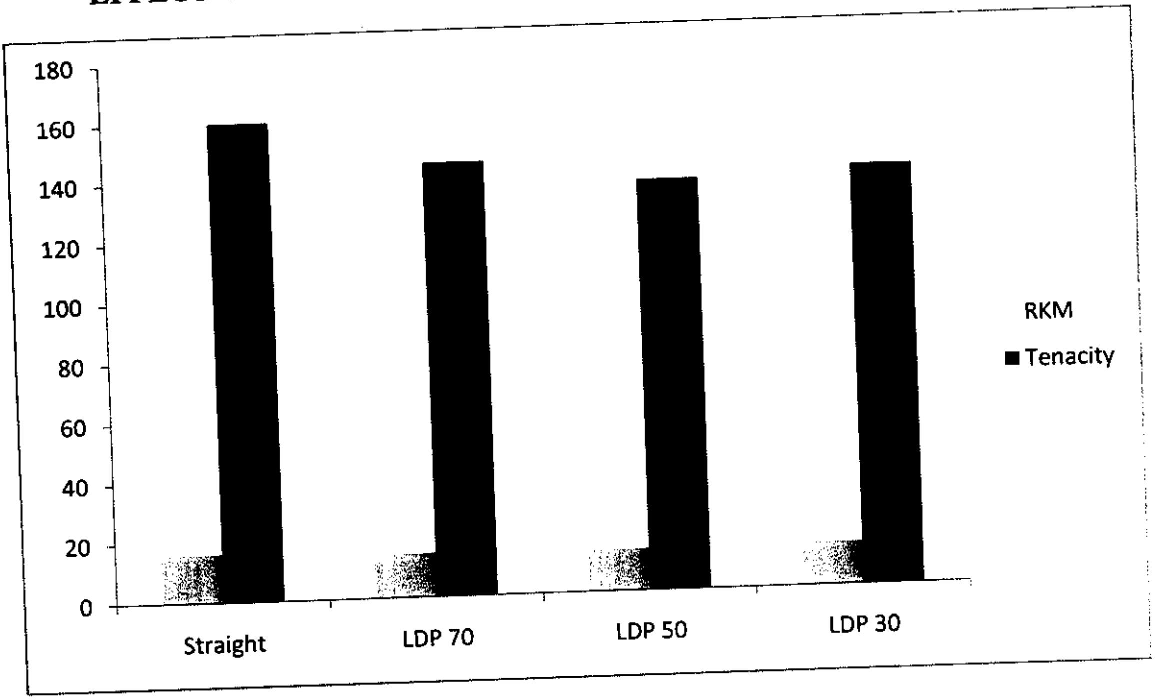


Fig:4.5

TABLE NO. 5 EFFECT OF DIAGONAL PATH ON TENSILE PROPERTIES

60^SC	Straight path	Left diagonal path			Right diagonal path		
		70mm	50mm	30mm	70mm	50mm	30mm
Single yarn strength in gms	160.1	145.1	137.2	139.5	146.3	145.3	154
RKM	16.27	14.74	13.93	14.18	14.87	14.76	15.65

EFFECT OF LEFT DIAGONAL PATH ON TENSILE PROPERTIES



EFFECT OF RIGHT DIAGONAL PATH ON TENSILE PROPERTIES

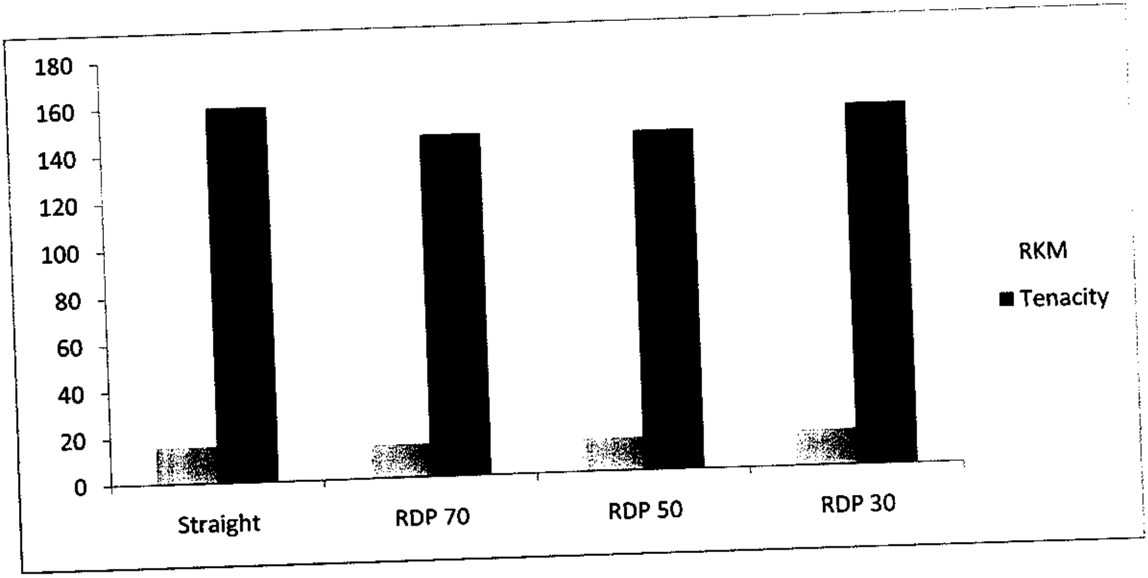


Fig:4.6

There is no significant difference noticed in Tenacity and RKM value of 40^{S}C and 60^{S}C in both left and right diagonal path at all the three offsets.

40^{S}C CLASSIMAT FAULTS LEFT DIAGONAL PATH

Category	Straight	70 mm	50 mm	30 mm
Objectional faults	511	570	330	510
Short thick faults	18172	19154	12945	18152
Long thick faults	299	299	304	300
Long thin faults	1820	1841	1860	1845

40^{S} C LEFT DIAGONAL PATH CLASSIMAT FAULTS

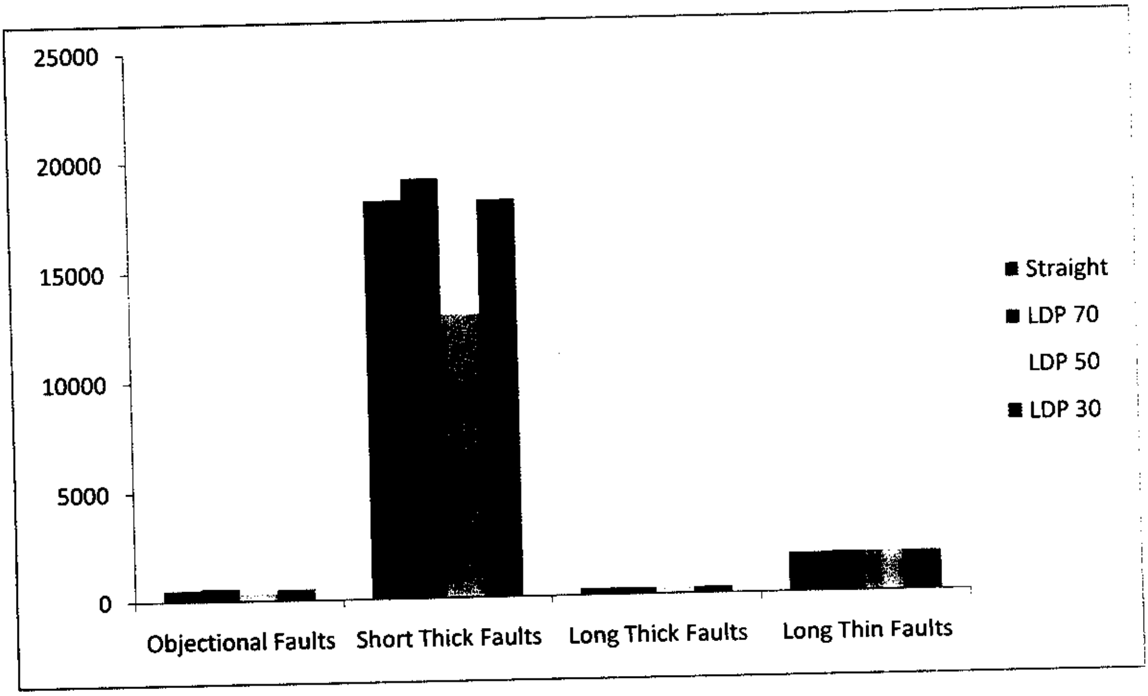


Fig:4.7

40^S C RIGHT DIAGONAL PATH CLASSIMAT FAULTS

Category	Straight	70 mm	50 mm	30 mm
Objectional faults	511	511	506	506
Short thick faults	18172	18152	18141	18145
Long thick faults	299	299	297	298
Long thin faults	1820	1830	1809	1812

40^S C RIGHT DIAGONAL PATH CLASSIMAT FAULTS

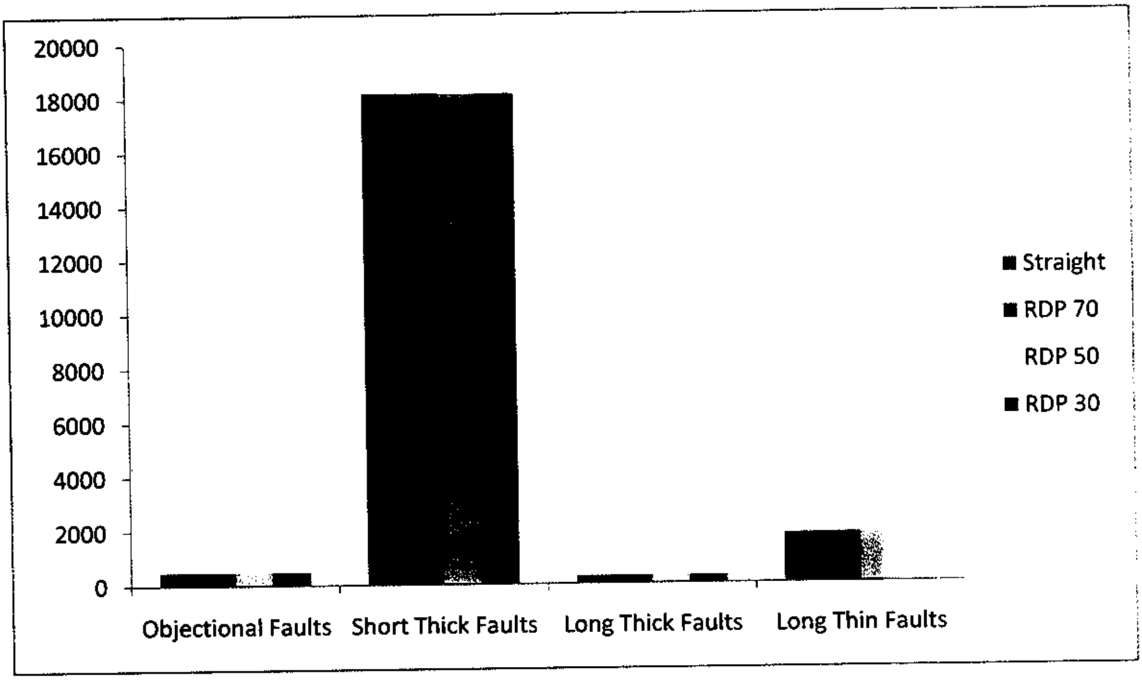


Fig:4.8

60^S C LEFT DIAGONAL PATH CLASSIMAT FAULTS

Category	Straight	70 mm	50 mm	30 mm
Objectional faults	88	92	94	96
Short thick faults	11962	12151	12289	12422
Long thick faults	273	282	287	293
Long thin faults	1496	1582	1661	1707

60^S C LEFT DIAGONAL PATH CLASSIMAT FAULTS

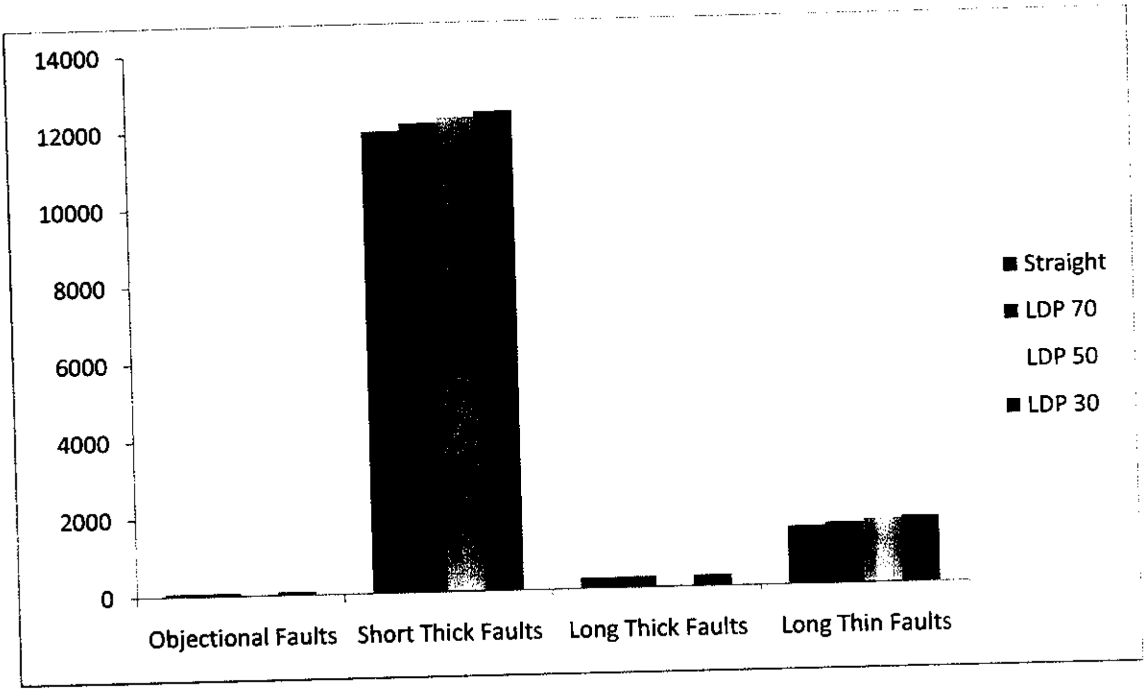


Fig:4.9

60^S C RIGHT DIAGONAL PATH CLASSIMAT FAULTS

Category	Straight	70 mm	50 mm	30 mm
Objectional faults	88	102	105	110
Short thick faults	11962	12668	12746	12909
Long thick faults	273	296	298	303
Long thin faults	1496	1753	1811	1849

60^S C RIGHT DIAGONAL PATH CLASSIMAT FAULTS

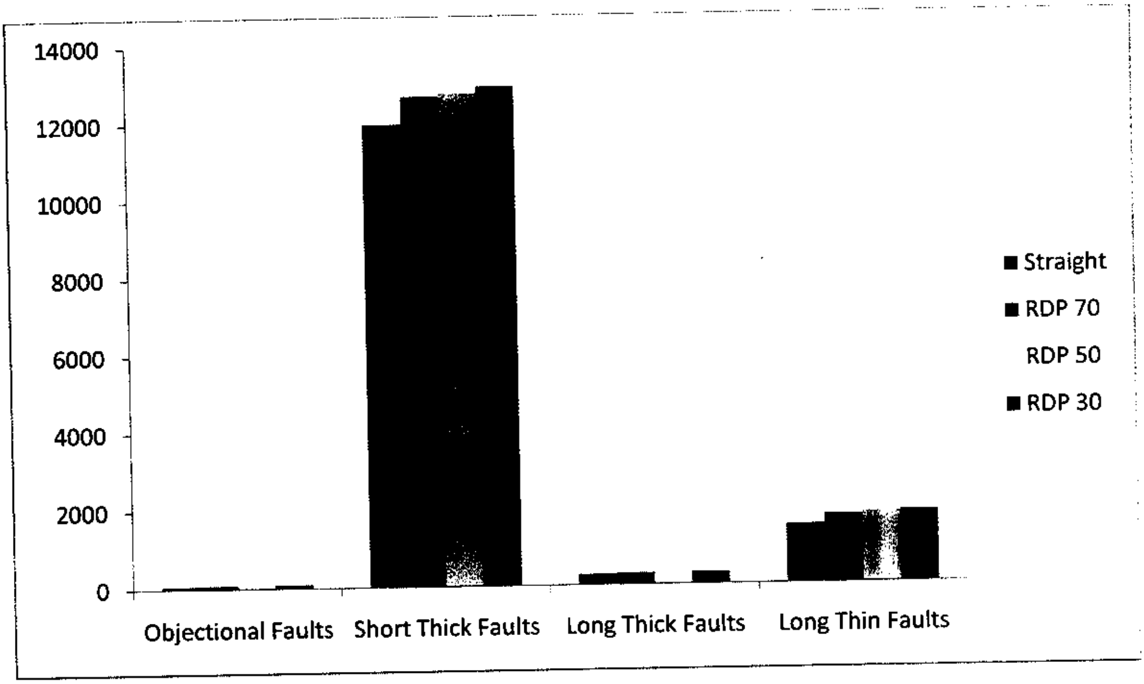


Fig:4.10

4.2. STATISTICAL ANALYSIS

ANOVA ANALYSIS

LEFT DIAGONAL PATH

THIN PLACE

Source	DF	SS	MS	F	P
40^{S}C LDP offsets	3	155404	51801	5.27	0.004
Error	36	353736	9826		
Total	39	509140			

THICK PLACE

Source	DF	SS	MS	F	P
40^{S}C LDP offsets	3	813147	271049	7.87	0.000
Error	36	1239590	34933		
Total	39	2052738			

NEPS

Source	DF	SS	MS	F	P
40^{S}C LDP offsets	3	171463	57154	1.05	0.381
Error	36	1955061	54307		
Total	39	2126524			

For DF ^{3} **V** $_{36,}$ the table value F_b = 2.872 @ 5% significant level

So difference is significant for Thin place and Thick place

Not significant with respect to Neps

S3 VALUES					
Source	DF	SS	MS	F	P
40^{S}C LDP offsets	3	1256946	418982	8.47	0.000
Error	36	1780370	49455		
Total	39	3037316			

TENACITY					
Source	DF	SS	MS	F	P
40^{S}C LDP offsets	3	33939405	11313135	1.00	0.404
Error	36	407402730	11316743		
Total	39	441342135			

The difference in S3 values is significant but the difference in tenacity value is not significant

RIGHT DIAGONAL PATH

THIN PLACE					
Source	DF	SS	MS	F	P
40^{S}C RDP offsets	3	171984	57328	3.74	0.019
Error	36	551300	15314		
Total	39	723284			

THICK PLACE					
Source	DF	SS	MS	F	P
40^{S}C RDP offsets	3	892593	297531	5.38	0.004
Error	36	1989986	55277		
Total	39	2882578			

NEPS					
Source	DF	SS	MS	F	P
40^{S}C RDP offsets	3	436255	145418	2.32	0.092
Error	36	2259205	62756		
Total	39	2695460			

For DF ^{3}**V** $_{36,}$ the table value F_b = 2.872 @ 5% significant level

So difference is significant for Thin place and Thick place

Not significant with respect to Neps

S3 VALUES					
Source	DF	SS	MS	F	P
40^{S}C RDP offsets	3	1379501	459834	5.65	0.003
Error	36	2927787	81327		
Total	39	4307288			

TENACITY					
Source	DF	SS	MS	F	P
40^{S}C RDP offsets	3	1988	663	3.31	0.031
Error	36	7211	200		
Total	39	9199			

The difference in S3 values is significant and the difference in Tenacity value is also significant

60^SC LEFT DIAGONAL PATH

THIN PLACE					
Source	DF	SS	MS	F	P
60^SC LDP offsets	3	1348290	449430	4.13	0.013
Error	36	3920533	108904		
Total	39	5268823			

THICK PLACE					
Source	DF	SS	MS	F	P
60^SC LDP offsets	3	1001688	333896	2.01	0.130
Error	36	5991561	166432		
Total	39	6993248			

NEPS					
Source	DF	SS	MS	F	P
60^SC LDP offsets	3	2233247	744416	3.10	0.039
Error	36	8654782	240411		
Total	39	10888029			

For DF ^{3}**V** $_{36,}$ the table value $F_b = 2.872$ @ 5% significant level

So difference is significant for Thin place and Neps

Not significant with respect to Thick place

S3 VALUES					
Source	DF	SS	MS	F	P
60^{S}C LDP offsets	3	898946	299649	2.67	0.062
Error	36	4043127	112309		
Total	39	4942074			

TENACITY					
Source	DF	SS	MS	F	P
60^{S}C LDP offsets	3	3198	1066	10.22	0.000
Error	36	3757	104		
Total	39	6955			

For S3 values difference is not significant but Tenacity the difference is significant

60^SC RIGHT DIAGONAL PATH

THIN PLACE					
Source	DF	SS	MS	F	P
60^SC RDP offsets	3	249402	83134	2.79	0.055
Error	36	1073638	29823		
Total	39	132040			

THICK PLACE					
Source	DF	SS	MS	F	P
60^SC RDP offsets	3	4290429	1430143	13.11	0.005
Error	36	3927063	109085		
Total	39	8217492			

NEPS					
Source	DF	SS	MS	F	P
60^SC RDP offsets	3	7282372	2427457	26.41	0.000
Error	36	3309198	91922		
Total	39	10591569			

For DF $^3\mathbf{V}_{36,}$ the table value $F_b = 2.872$ @ 5% significant level

So difference is not significant for Thin place and Neps

ignificant with respect to Thick place

S3 VALUES

Source	DF	SS	MS	F	P
60^{S}C RDP offsets	3	44944266	1478089	8.84	0.000
Error	36	6103103	169531		
Total	39	10597369			

TENACITY

Source	DF	SS	MS	F	P
60^{S}C RDP offsets	3	1459.6	486.5	6.75	0.001
Error	36	2594.2	72.1		
Total	39	4053.8			

For S3 values and Tenacity values the difference is significant

5.CONCLUSION

- The effect of LDP & RDP for 3 offsets on yarn hairiness, total imperfections, Tenacity & RKM for 40^S & 60^S count carded yarn is studied.
- In case of hairiness (S3) the left diagonal path show improvement than straight path. But the RDP yarn show increase in S3 values with respect to straight yarn path and LDP.
- The total imperfection/Km of yarn decreases in case of 40^S C in both LDP & RDP. But it is getting is in case of 60^S C yarn in both LDP & RDP. The RDP shows decrease in total imperfection/Km than LDP in both 40^S & 60^S yarn.
- Tenacity of yarn spun from three offsets with left diagonal and right diagonals have not shown any significant difference in both 40^S & 60^S yarn. With regard to classimat faults in 40^S C, there is significant difference noticed in the yarn produced from left diagonal 50mmoffset when compared to all the other sets of samples.
- In 60^S C, there is no significant difference noticed in all the yarns manufactured in three offsets of left and right diagonal path.

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Yarn Test Report No.:4702 Sri Karpagam Mills India (P) Ltd

Samples Tested at : R.H. 65% +/- 2% and Temp. 21 Degree C +/- 1 Degree C

Lab Code No.	Y_10211	Y_10212	Y_10213	Y_10214
Sample Particulars.:	40S K MARK-A1 10 COPS	40S K MARK-B1 10 COPS	40S K MARK-B2 10 COPS	40S K MARK-B3 10 COPS
U% Imperfection (As per ASTM D 1425-96)				
Mean U%	17.36	17.12	16.37	16.47
Mean CV%	22.55	22.03	21.07	21.24
Imperfections/1000 m				
Thin Places (-50%)	392	359	247	259
Thick Places (+50%)	1652	1496	1289	1343
Neps (+200%)	1765	1685	1586	1643

Lab Code No.	Y_10215	Y_10216	Y_10217
Sample Particulars.:	40S K MARK-C1 10 COPS	40S K MARK-C2 10 COPS	40S K MARK-C3 10 COPS
U% Imperfection (As per ASTM D 1425-96)			
Mean U%	16.87	16.34	16.40
Mean CV%	21.76	20.99	21.11
Imperfections/1000 m			
Thin Places (-50%)	369	242	259
Thick Places (+50%)	1391	1277	1296
Neps (+200%)	1694	1589	1490

End of Report

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

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Yarn Test Report No.:4702 Sri Karpagam Mills India (P) Ltd

Samples Tested at : R.H. 65% +/- 2% and Temp. 21 Degree C +/- 1 Degree C

Lab Code No.	Y_10211	Y_10212	Y_10213	Y_10214
Sample Particulars.:	40S K MARK-A1 10 COPS	40S K MARK-B1 10 COPS	40S K MARK-B2 10 COPS	40S K MARK-B3 10 COPS
Hairiness Index with CV% (Additional) (As per Uster Std Method)				
Hairiness	4.72	4.54	4.64	4.69
Standard Deviation of Hairiness	1.48	1.37	1.40	1.42

Lab Code No.	Y_10215	Y_10216	Y_10217
Sample Particulars.:	40S K MARK-C1 10 COPS	40S K MARK-C2 10 COPS	40S K MARK-C3 10 COPS
Hairiness Index with CV% (Additional) (As per Uster Std Method)			
Hairiness	4.65	4.75	4.76
Standard Deviation of Hairiness	1.39	1.42	1.40

End of Report

Yarn Test Report No.:4900 Raam Ganapathy Mills

Samples Tested at : R.H. 65% +/- 2% and Temp. 21 Degree C +/- 1 Degree C

Lab Code No.	Y_10682	Y_10683	Y_10684	Y_10685
Sample Particulars.:	40s KWP 10 COPS A1	40s KWP 10 COPS B1	40s KWP 10 COPS B2	40s KWP 10 COPS B3
Hairiness (Zweigle) (As per ASTM D-5647-07)				
No. of Protruding Hairs per 100 Mtrs (3mm and above)	1198	1067	1236	1550
Hairiness Index	156	130	154	185

Lab Code No.	Y_10686	Y_10687	Y_10688
Sample Particulars.:	40s KWP 10 COPS C1	40s KWP 10 COPS C2	40s KWP 10 COPS C3
Hairiness (Zweigle) (As per ASTM D-5647-07)			
No. of Protruding Hairs per 100 Mtrs (3mm and above)	1443	1664	1633
Hairiness Index	162	184	179

End of Report

R. Ganapathy

Yarn Test Report No.:4702 Sri Karpagam Mills India (P) Ltd

Samples Tested at : R.H. 65% +/- 2% and Temp. 21 Degree C +/- 1 Degree C

Lab Code No.	Y_10211	Y_10212	Y_10213	Y_10214
Sample Particulars.:	40S K MARK-A1 10 COPS	40S K MARK-B1 10 COPS	40S K MARK-B2 10 COPS	40S K MARK-B3 10 COPS
Single Yarn Tenacity and Elongation (UTR) (As per Uster Standard Method ASTM D 2256-02)				
Actual Strength (g)	225.9	219.9	232.5	229.9
CV% of Strength	12.05	12.84	11.47	9.68
% Elongation	5.43	5.34	5.36	5.58
CV% of Elongation	9.12	10.58	10.09	8.45
RKm (g/tex)	15.30	14.89	15.74	15.57

Lab Code No.	Y_10215	Y_10216	Y_10217
Sample Particulars.:	40S K MARK-C1 10 COPS	40S K MARK-C2 10 COPS	40S K MARK-C3 10 COPS
Single Yarn Tenacity and Elongation (UTR) (As per Uster Standard Method ASTM D 2256-02)			
Actual Strength (g)	231.1	229.9	244.6
CV% of Strength	13.05	11.65	11.54
% Elongation	5.07	4.91	5.49
CV% of Elongation	11.21	9.51	8.23
RKm (g/tex)	15.65	15.57	16.57

One-way ANOVA: THICKPLACES versus OFFSETS

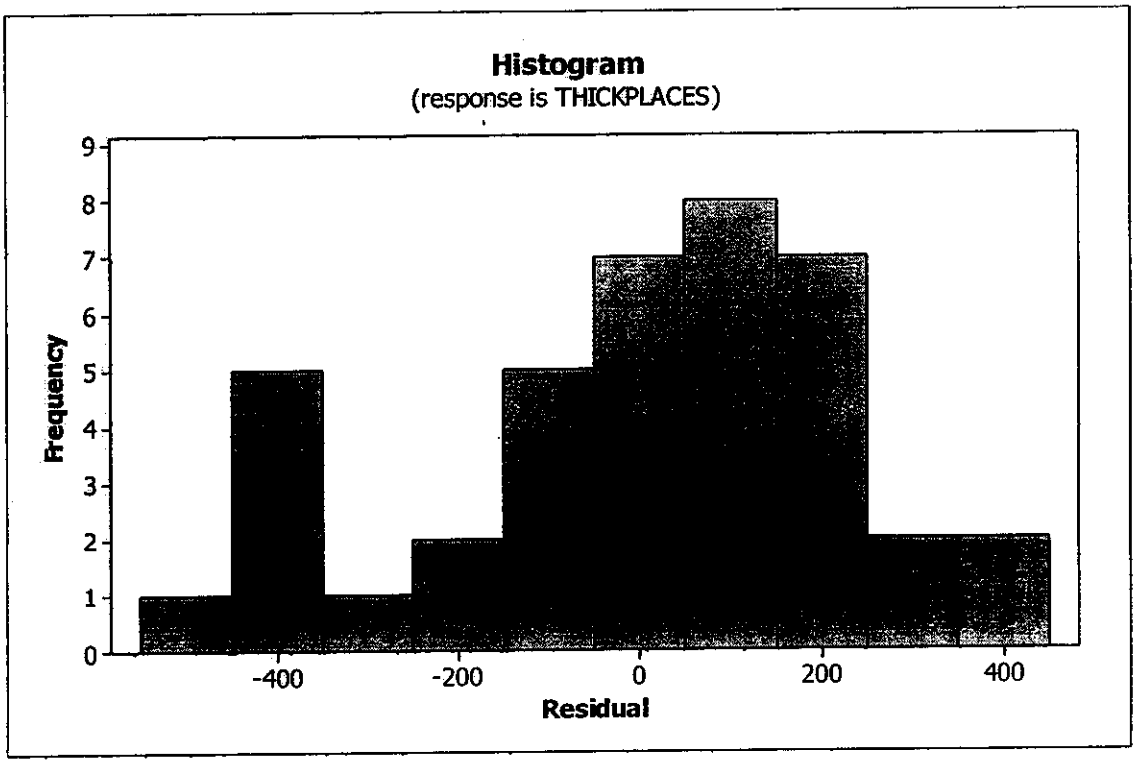
```
Source   DF       SS      MS     F      P
OFFSETS   3   892566  297522  5.38  0.004
Error    36  1990075   55280
Total    39  2882641

S = 235.1   R-Sq = 30.96%   R-Sq(adj) = 25.21%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean  StDev  ----+---------+---------+---------+-----
1      10  1652.0  246.3                     (-------*------)
2      10  1391.0  197.3        (-------*------)
3      10  1277.4  212.8  (-------*------)
4      10  1296.5  276.2   (-------*------)
                          ----+---------+---------+---------+-----
                            1200      1400      1600      1800

Pooled StDev = 235.1
```

Residual Histogram for THICKPLACES



UNT;40KNe
RIGHT DIAGONAL PATH OFFSETS VERSES NEPS

One-way ANOVA: neps versus 40scrdp offsets

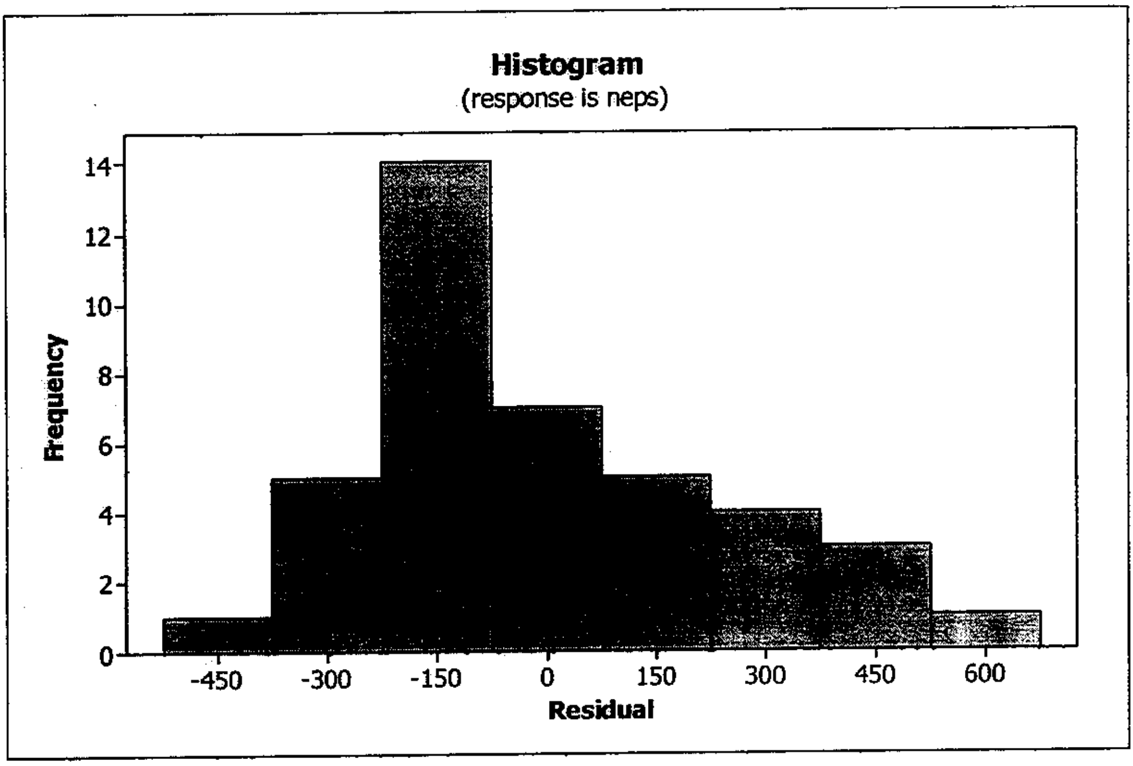
```
Source           DF       SS      MS     F      P
40scrdp offsets   3   436255  145418  2.32  0.092
Error            36  2259205   62756
Total            39  2695460

S = 250.5   R-Sq = 16.18%   R-Sq(adj) = 9.20%


                          Individual 95% CIs For Mean Based on Pooled StdDev
Level   N    Mean  StdDev    -+---------+---------+---------+--------
1      10  1765.3  216.8                       (----------*---------)
2      10  1693.9  319.4                   (----------*----------)
3      10  1588.9  210.8            (----------*----------)
4      10  1489.9  240.0      (---------*----------)
                             -+---------+---------+---------+--------
                          1350      1500      1650      1800

Pooled StdDev = 250.5
```

Residual Histogram for neps



COUNT;40KNe
RIGHT DIGONAL PATH OFFSETS VERSES S3 VALUES

One-way ANOVA: s3 values versus 40knerdpoffsets

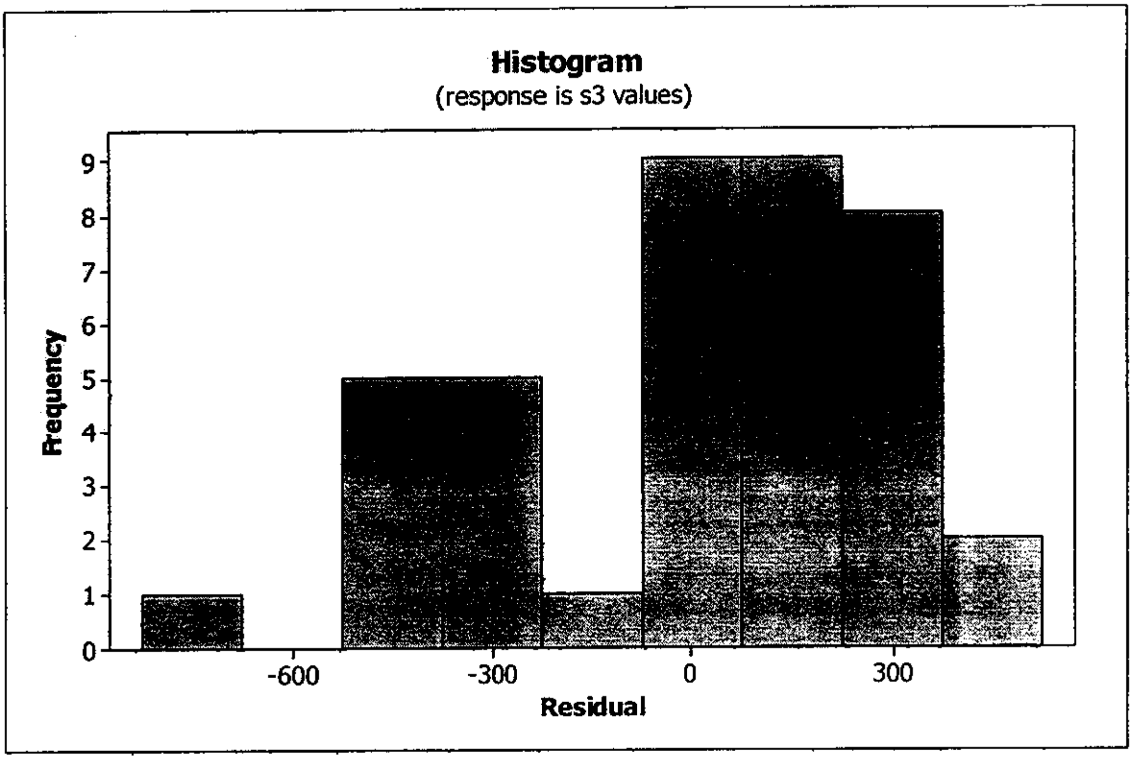
```
Source           DF       SS      MS     F      P
40knerdpoffsets   3  1394554  464851  5.67  0.003
Error            36  2949827   81940
Total            39  4344380

S = 286.3   R-Sq = 32.10%   R-Sq(adj) = 26.44%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level   N    Mean  StDev  ---------+---------+---------+---------+
1      10  1198.1  247.2  (------*------)
2      10  1442.9  347.0           (-------*------)
3      10  1663.7  248.5                    (-------*------)
4      10  1638.1  290.7                   (-------*------)
                          ---------+---------+---------+---------+
                                1250      1500      1750      2000

Pooled StDev = 286.3
```

Residual Histogram for s3 values



```
Welcome to Minitab, press F1 for help.
```

One-way ANOVA: tenacity versus 40knerdp offsets

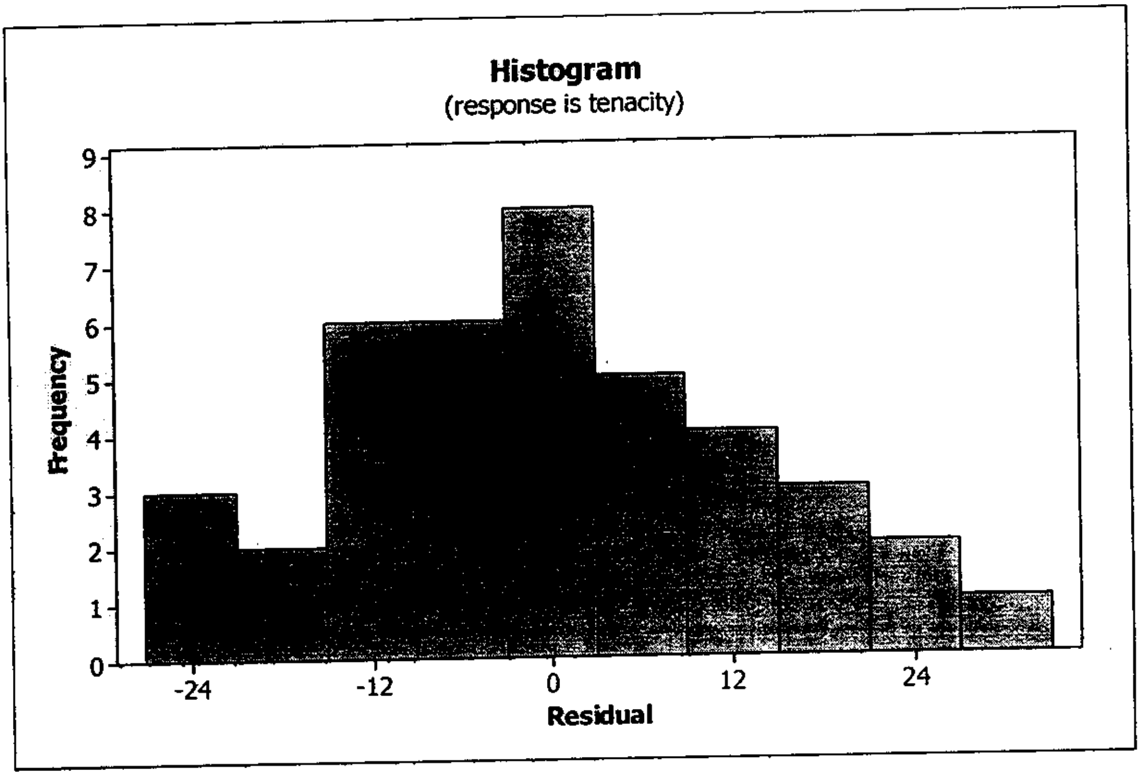
```
Source             DF    SS   MS     F      P
40knerdp offsets    3  2007  669  3.34  0.030
Error              36  7216  200
Total              39  9223

S = 14.16   R-Sq = 21.76%   R-Sq(adj) = 15.24%


                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level   N    Mean  StDev  ---+---------+---------+---------+------
1      10  225.80  11.68  (--------*--------)
2      10  231.10  17.18       (--------*--------)
3      10  230.10  13.10      (--------*--------)
4      10  244.70  14.09                      (--------*--------)
                          ---+---------+---------+---------+------
                            220       230       240       250

Pooled StDev = 14.16
```

Residual Histogram for tenacity



One-way ANOVA: THINPLACES versus OFFSETS

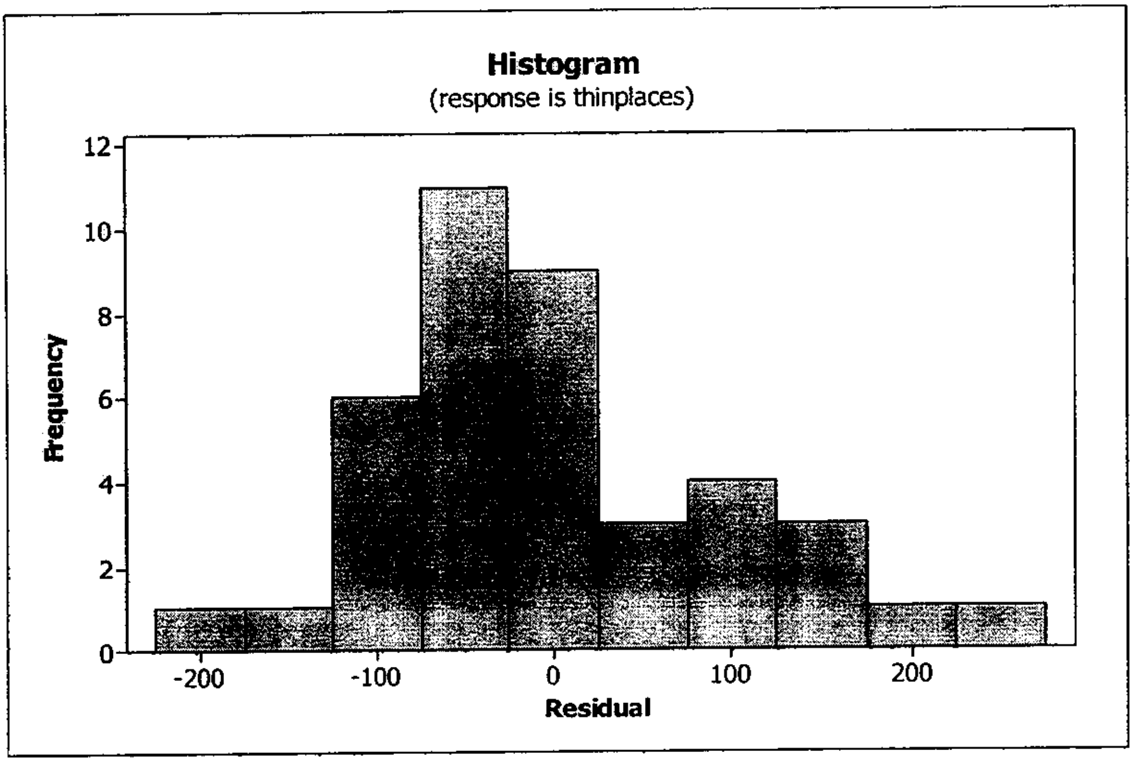
```
Source   DF      SS     MS     F      P
OFFSETS   3  155404  51801  5.27  0.004
Error    36  353736   9826
Total    39  509140

S = 99.13   R-Sq = 30.52%   R-Sq(adj) = 24.73%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean   StDev  ----+---------+---------+---------+-----
1      10  392.00  129.46                      (--------*--------)
2      10  359.20   47.05                 (--------*--------)
3      10  247.50  108.89  (--------*--------)
4      10  259.30   92.05    (--------*--------)
                           ----+---------+---------+---------+-----
                             210       280       350       420

Pooled StDev = 99.13
```

Residual Histogram for THINPLACES



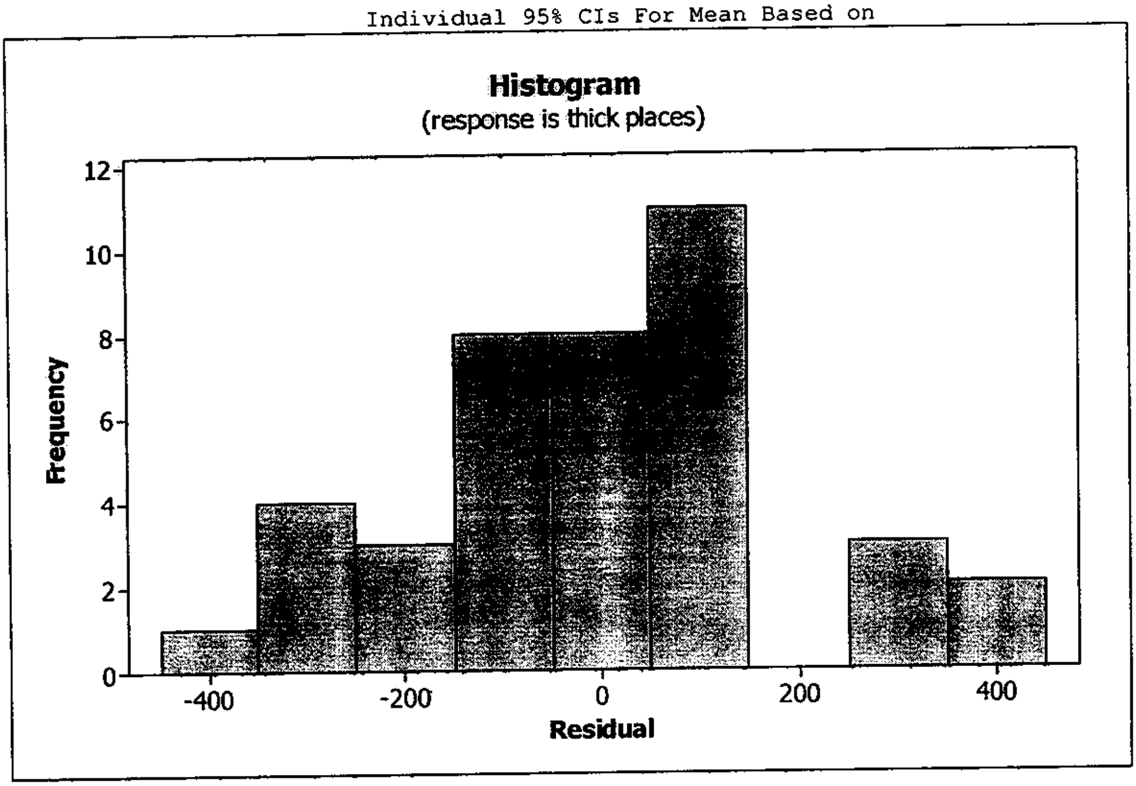
COUNT;40KNe
LEFT DIAGONAL PATHOFFSETS VERSES THICK PLACES

One-way ANOVA: thick places versus Offsets

```
Source   DF       SS      MS     F      P
Offsets   3   813147  271049  7.87  0.000
Error    36  1239590   34433
Total    39  2052738

S = 185.6   R-Sq = 39.61%   R-Sq(adj) = 34.58%


                         Individual 95% CIs For Mean Based on
```



COUNT;40KNe LEFT DIAGONAL PATH OFFSETS VERSES NEPS

One-way ANOVA: NEPS versus OFFSETS

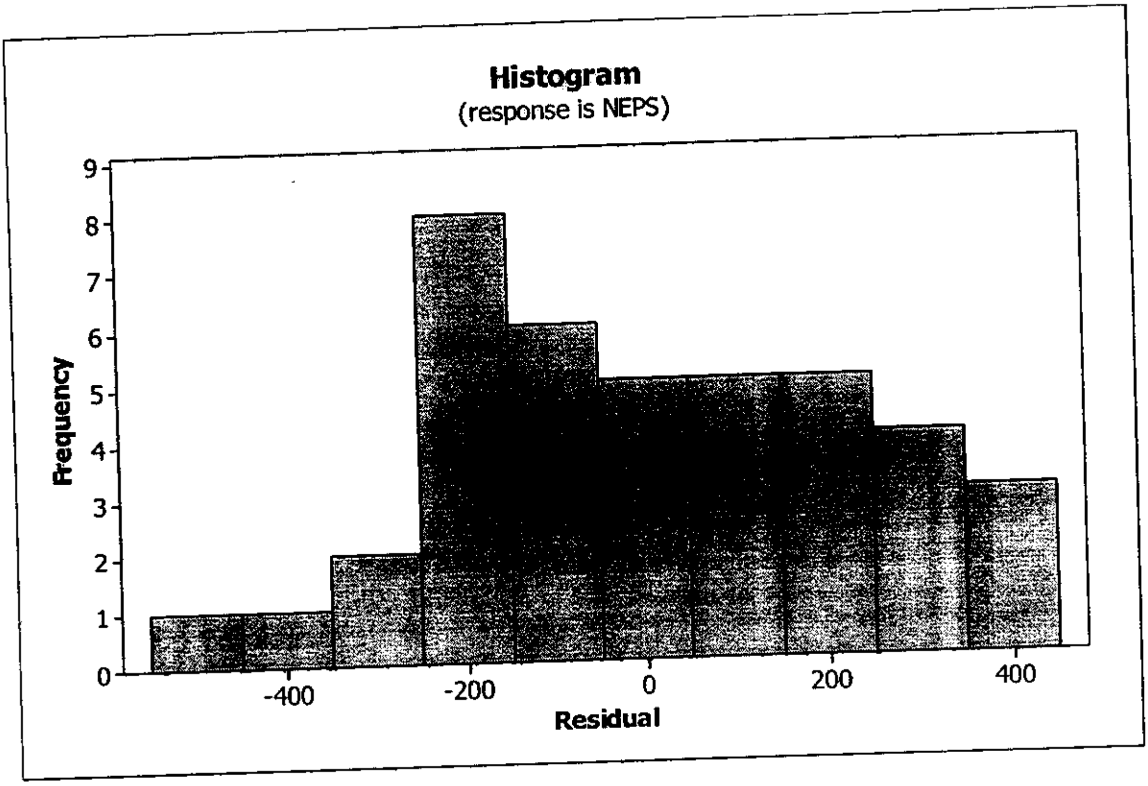
```
Source   DF       SS     MS     F      P
OFFSETS   3   171273  57091  1.05  0.382
Error    36  1955767  54327
Total    39  2127039

S = 233.1   R-Sq = 8.05%   R-Sq(adj) = 0.39%

                               Individual 95% CIs For Mean Based on Pooled StDev
Level   N    Mean  StDev   +---------+---------+---------+---------
1      10  1765.2  217.0                (------------*-------------)
2      10  1685.5  301.2          (------------*-------------)
3      10  1585.8  186.9   (------------*------------)
4      10  1642.9  211.1       (-------------*-----------)
                           +---------+---------+---------+---------
                         1440      1560      1680      1800

Pooled StDev = 233.1
```

Residual Histogram for NEPS



OUNT; 40KNe
LEFT DIAGONAL PATH OFFSETS VERSES S3 VALUE

One-way ANOVA: s3 values versus 40ne ldp offsets

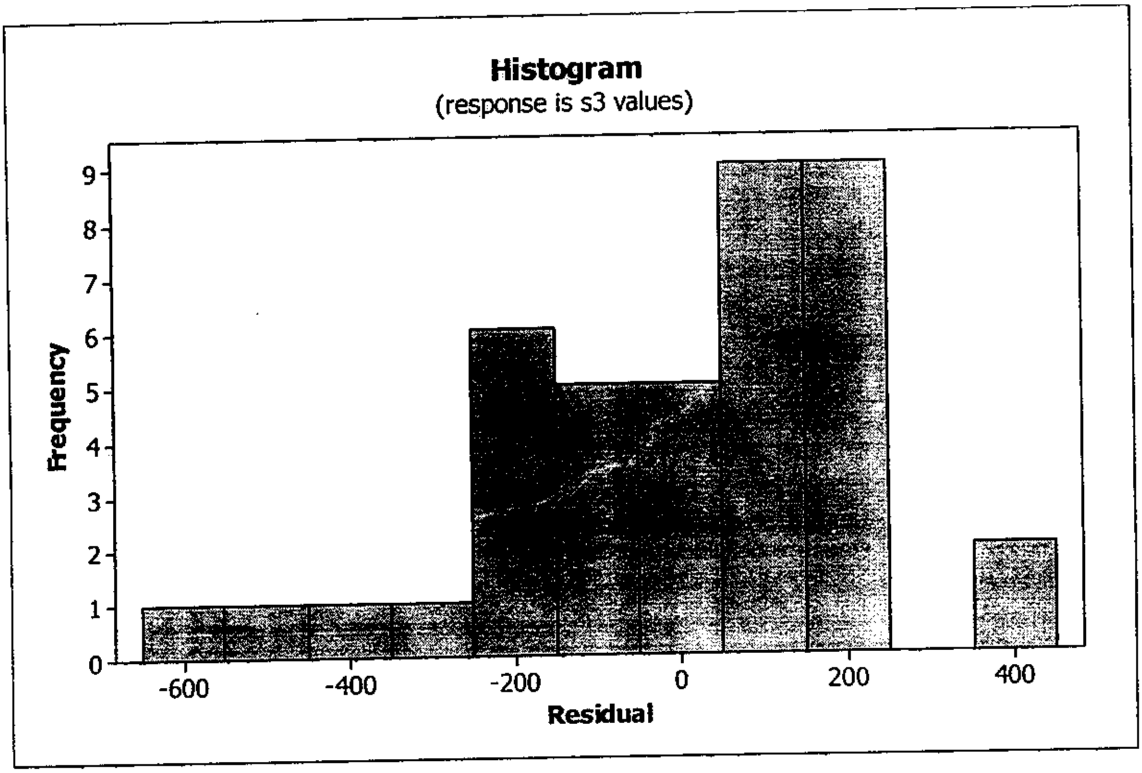
```
Source             DF       SS      MS     F      P
40ne ldp offsets    3  1199874  399958  7.84  0.000
Error              36  1837442   51040
Total              39  3037316

S = 225.9   R-Sq = 39.50%   R-Sq(adj) = 34.46%


                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level   N    Mean  StDev  ----+---------+---------+---------+-----
1      10  1199.1  246.1         (------*------)
2      10  1067.1  280.1  (------*-------)
3       9  1229.3  178.6          (------*-------)
4      11  1526.7  181.9                        (------*------)
                          ----+---------+---------+---------+-----
                            1000      1200      1400      1600

Pooled StDev = 225.9
```

Residual Histogram for s3 values



COUNT;4OSKNe
LEFT DIAGONAL PATH OFFSETS VERSES TENACITY

One-way ANOVA: tenacity versus 4okne ldp offsets

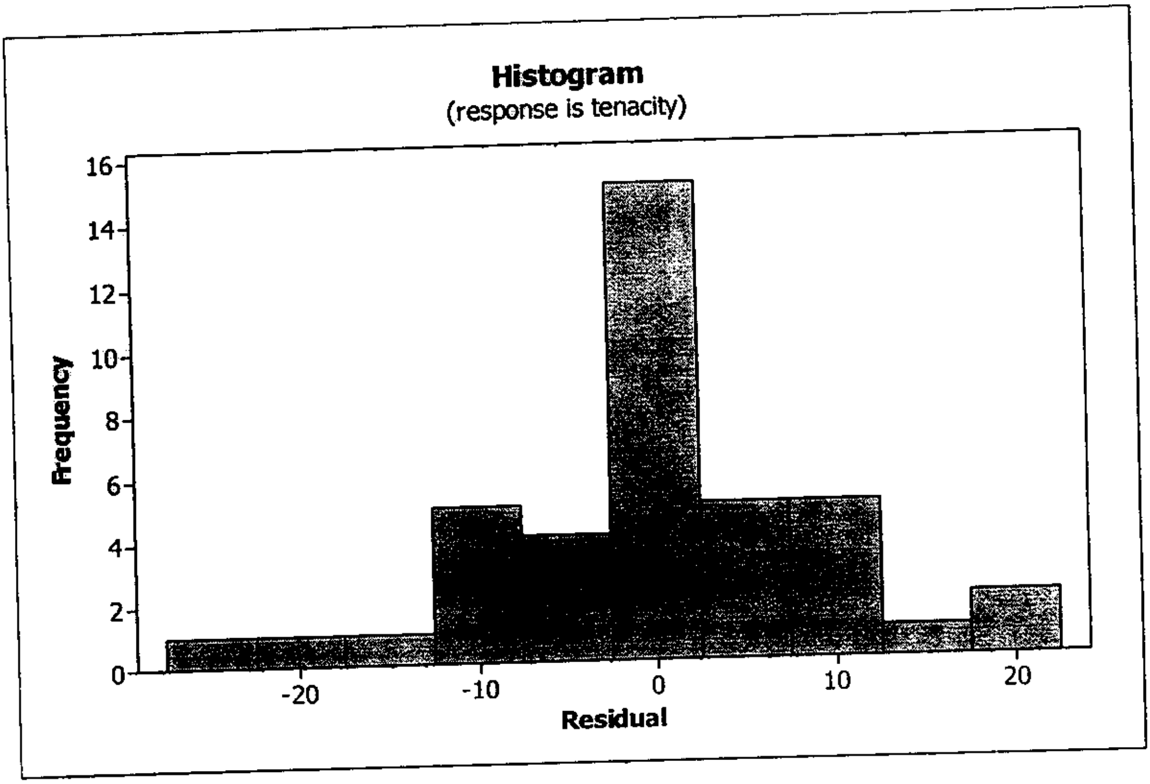
```
Source               DF      SS     MS     F      P
4okne ldp  offsets    3   903.7  301.2  3.39  0.028
Error                36  3198.0   88.8
Total                39  4101.6

S = 9.425   R-Sq = 22.03%   R-Sq(adj) = 15.53%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean  StDev  -----+---------+---------+---------+----
1      10  225.87  11.53           (--------*-------)
2      10  219.86  10.85  (--------*--------)
3      10  232.45   8.07                    (--------*--------)
4      10  229.90   6.29                 (-------*--------)
                          -----+---------+---------+---------+----
                           217.0     224.0     231.0     238.0

Pooled StDev = 9.43
```

Residual Histogram for tenacity



One-way ANOVA: THINPLACES versus 60KNe LDP OFFSETS

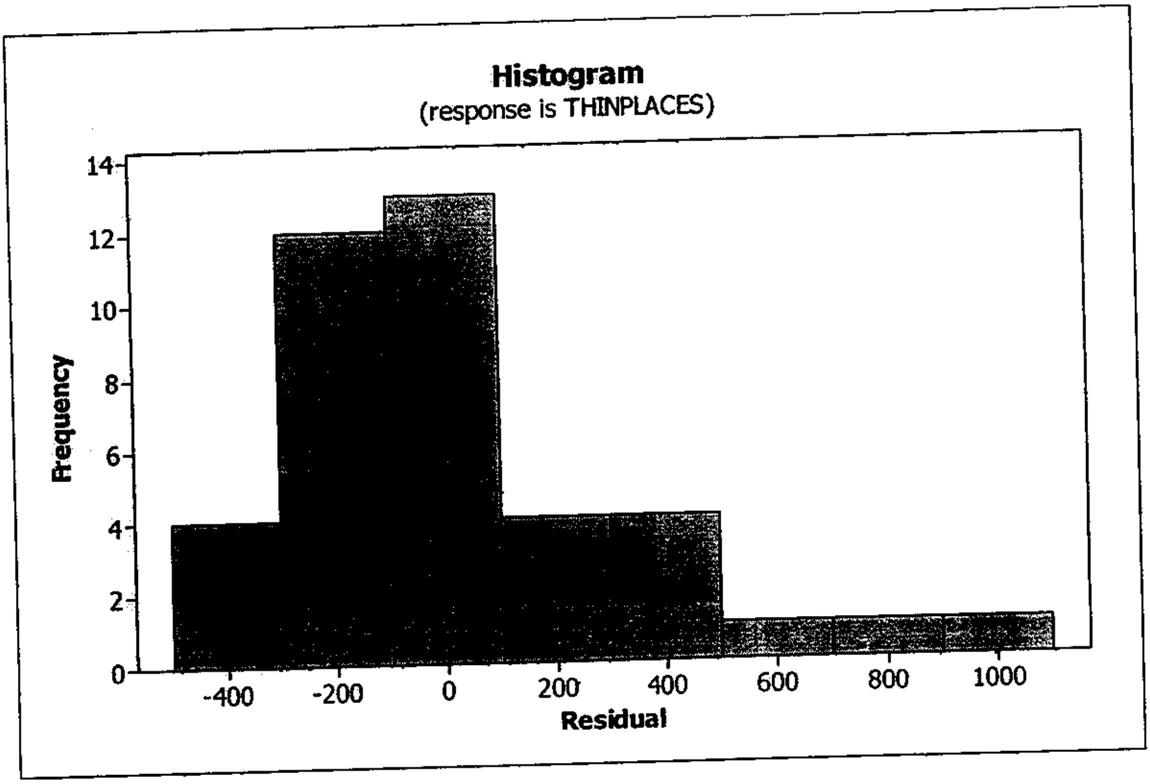
```
Source             DF       SS      MS     F      P
60KNe LDP OFFSETS   3  1350173  450058  4.13  0.013
Error              36  3923608  108989
Total              39  5273781

S = 330.1   R-Sq = 25.60%   R-Sq(adj) = 19.40%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N   Mean  StDev  -----+---------+---------+---------+----
1      10  341.3  180.1  (--------*-------)
2      10  753.8  415.9                   (-------*--------)
3      10  778.3  282.3                    (-------*--------)
4      10  485.7  388.3        (-------*--------)
                         -----+---------+---------+---------+----
                            250       500       750      1000

Pooled StDev = 330.1
```

Residual Histogram for THINPLACES



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```

COUNT;60KNe
LDP Offsets VS THICKPLACES

One-way ANOVA: THICKPLACES versus 60KNE LDP OFFSETS

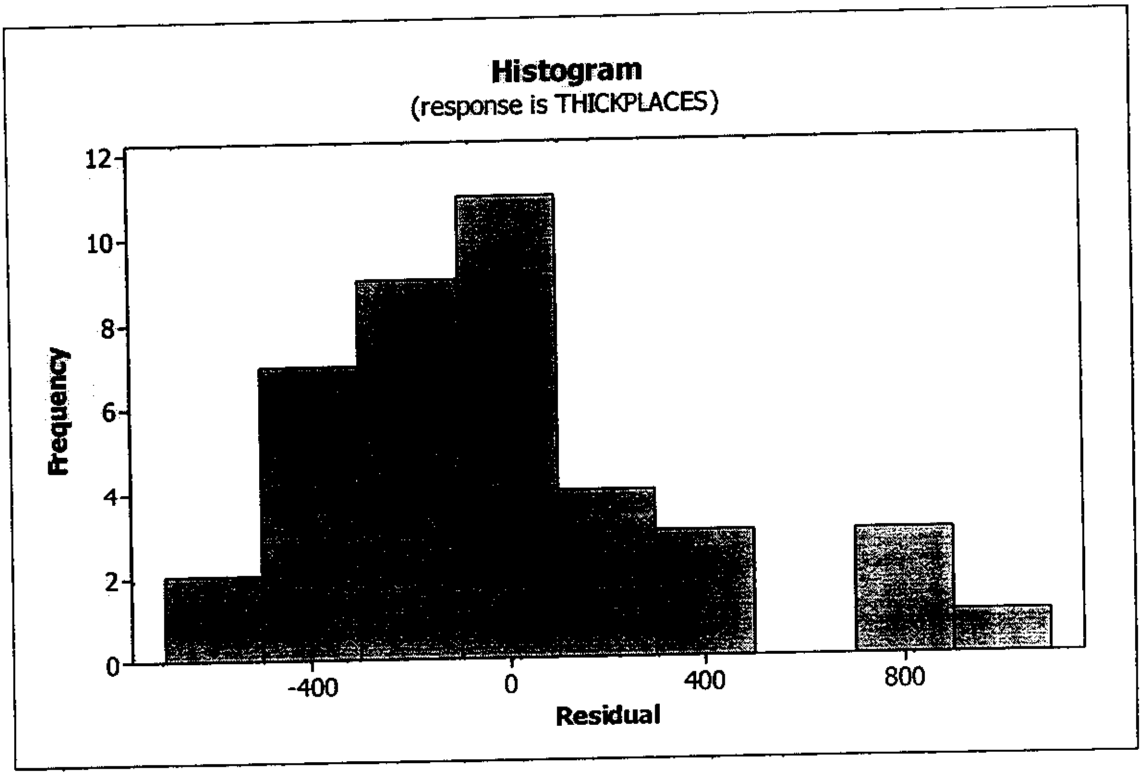
```
Source             DF       SS      MS     F      P
60KNE LDP OFFSETS   3  1001688  333896  2.01  0.130
Error              36  5991561  166432
Total              39  6993248

S = 408.0   R-Sq = 14.32%   R-Sq(adj) = 7.18%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean  StDev  -------+---------+---------+---------+--
1      10  1575.6  343.7  (---------*----------)
2      10  2020.3  478.6                 (----------*---------)
3      10  1757.8  344.2         (---------*----------)
4      10  1801.5  447.3           (---------*----------)
                          -------+---------+---------+---------+--
                              1500      1750      2000      2250

Pooled StDev = 408.0
```

Residual Histogram for THICKPLACES



```
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```

COUNT;60KNe

LDP Offsets VS Neps

One-way ANOVA: neps versus 60ne LDP Offsets

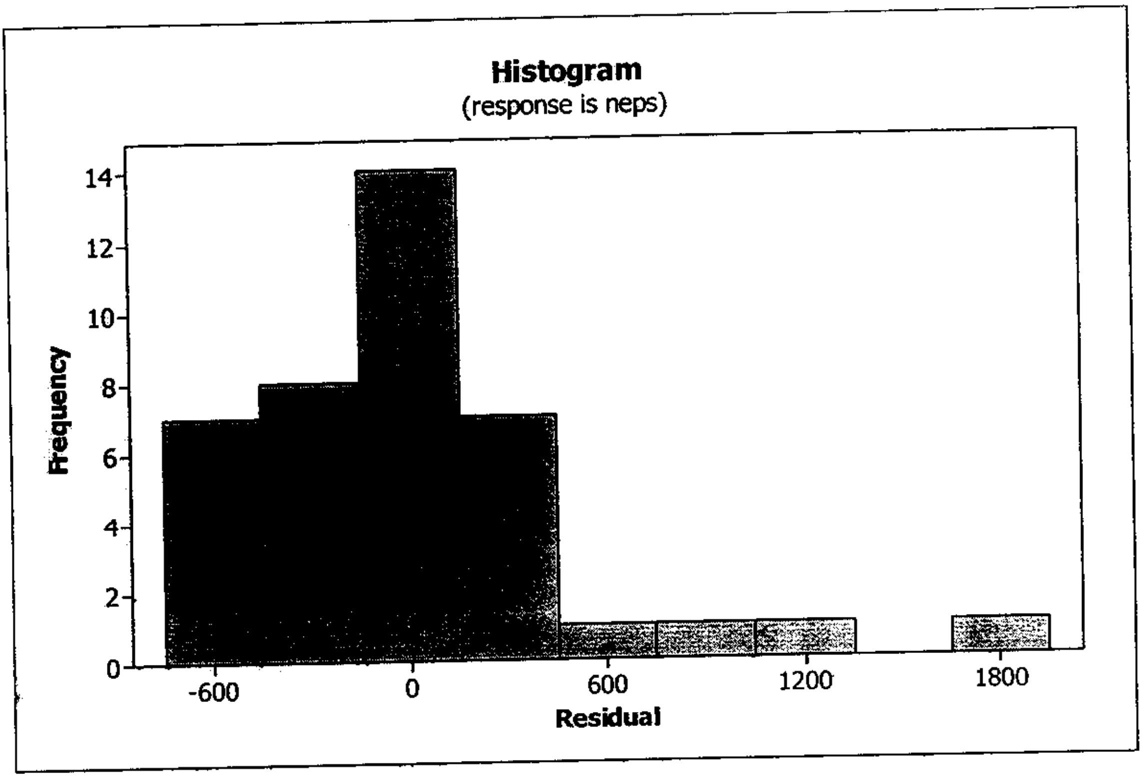
```
Source             DF        SS      MS     F      P
60ne LDP Offsets    3   2233247  744416  3.10  0.039
Error              36   8654782  240411
Total              39  10888029

S = 490.3   R-Sq = 20.51%   R-Sq(adj) = 13.89%


                          Individual 95% CIs For Mean Based on Pooled StDev
Level   N    Mean  StDev     +---------+---------+---------+---------
1      10  2073.7  280.5     (--------*--------)
2      10  2411.9  425.7               (--------*--------)
3      10  2723.8  690.6                        (--------*--------)
4      10  2277.2  474.0           (--------*--------)
                             +---------+---------+---------+---------
                          1750      2100      2450      2800

Pooled StDev = 490.3
```

Residual Histogram for neps



```
lcome to Minitab, press F1 for help
COUNT;6OSKNe
LDP OFFSETS VS S3 VALUE.
```

One-way ANOVA: S3 VALUE versus 6ONeLDPOFFSETS

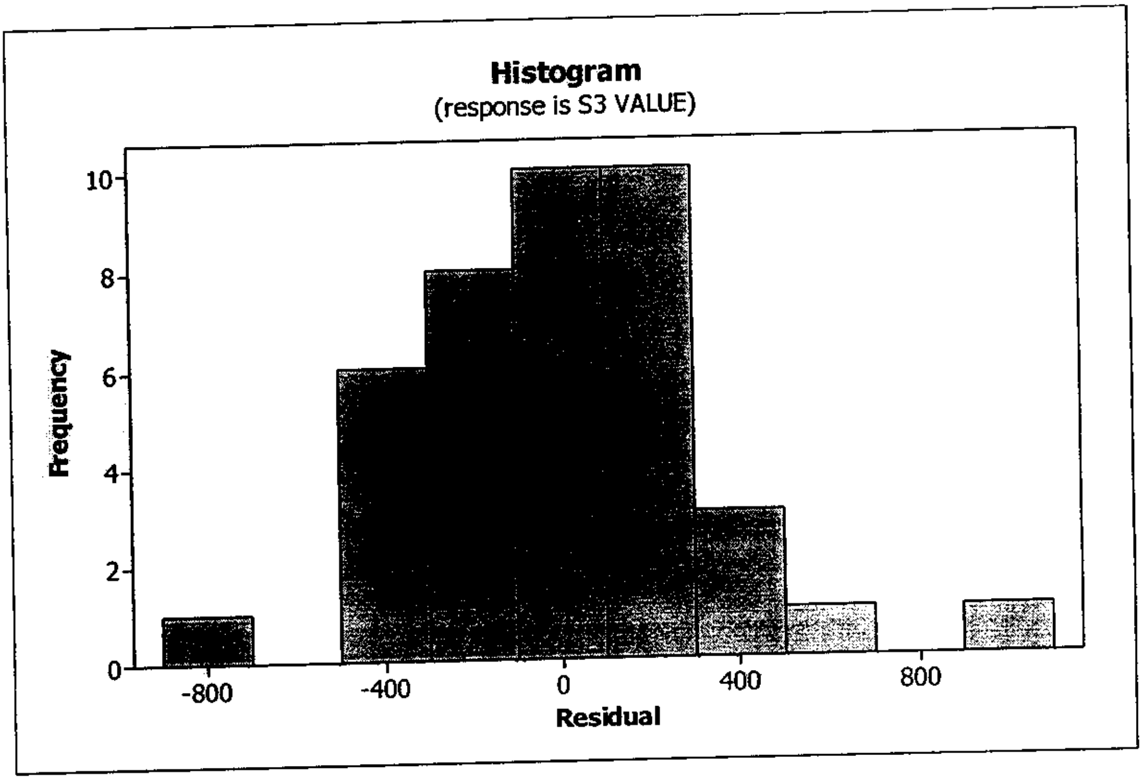
```
Source          DF       SS      MS     F      P
6ONeLDPOFFSETS   3   898946  299649  2.67  0.062
Error           36  4043127  112309
Total           39  4942074

S = 335.1   R-Sq = 18.19%   R-Sq(adj) = 11.37%


                              Individual 95% CIs For Mean Based on Pooled StDev
Level   N    Mean  StDev    +---------+---------+---------+---------
1      10  1612.4  327.0                        (-------*--------)
2      10  1210.7  402.1    (-------*--------)
3      10  1529.1  226.3                     (-------*--------)
4      10  1452.0  359.7                 (--------*---------)
                            +---------+---------+---------+---------
                         1000      1250      1500      1750

Pooled StDev = 335.1
```

Residual Histogram for S3 VALUE



```
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```

COUNT;6OKNe
LDP Offsets VS Tenacity

One-way ANOVA: Tenacity versus 6OKNeLDP Offsets

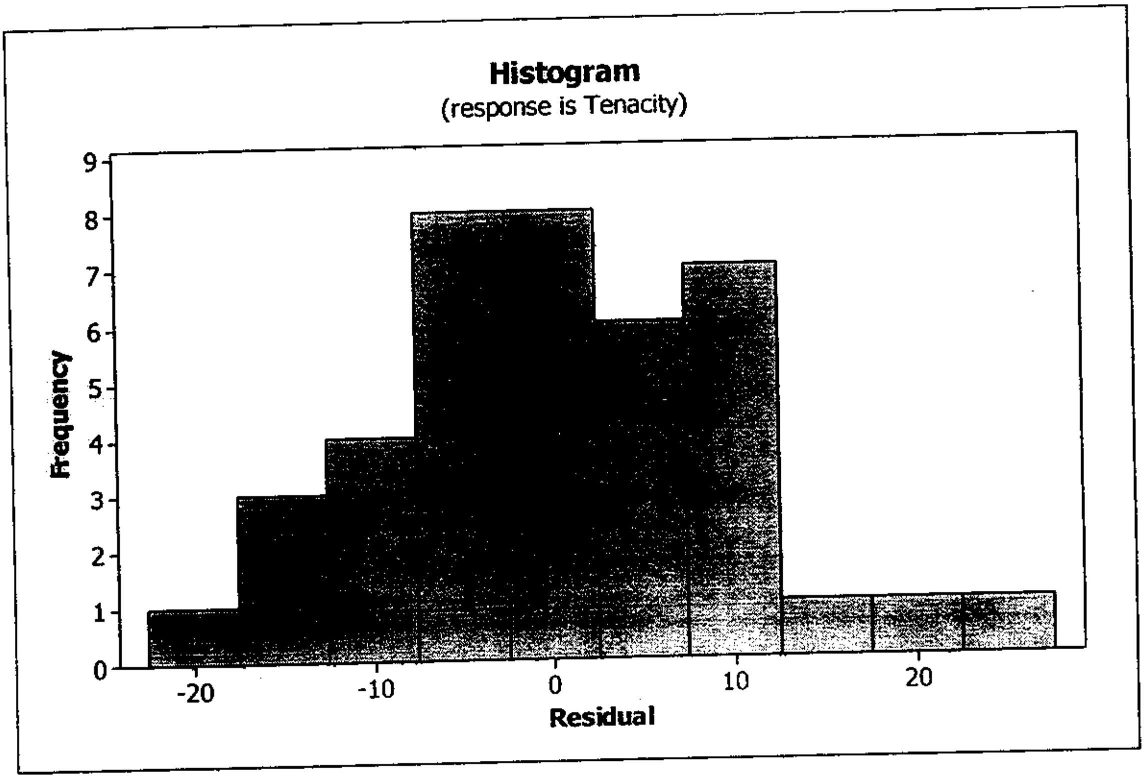
```
Source            DF    SS    MS      F      P
6OKNeLDP Offsets   3  3198  1066  10.22  0.000
Error             36  3757   104
Total             39  6955

S = 10.22   R-Sq = 45.98%   R-Sq(adj) = 41.48%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean  StDev  ---------+---------+---------+---------+
1      10  160.15  10.67                         (-----*------)
2      10  144.91   7.26         (------*-----)
3      10  137.18  14.00  (-----*------)
4      10  139.53   7.41    (------*-----)
                          ---------+---------+---------+---------+
                                  140       150       160       170


Pooled StDev = 10.22
```

Residual Histogram for Tenacity



```
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```

COUNT;60SNe
RDP OFFSETS VS THINPLACES

One-way ANOVA: thin places versus 60SNe rdp offsets

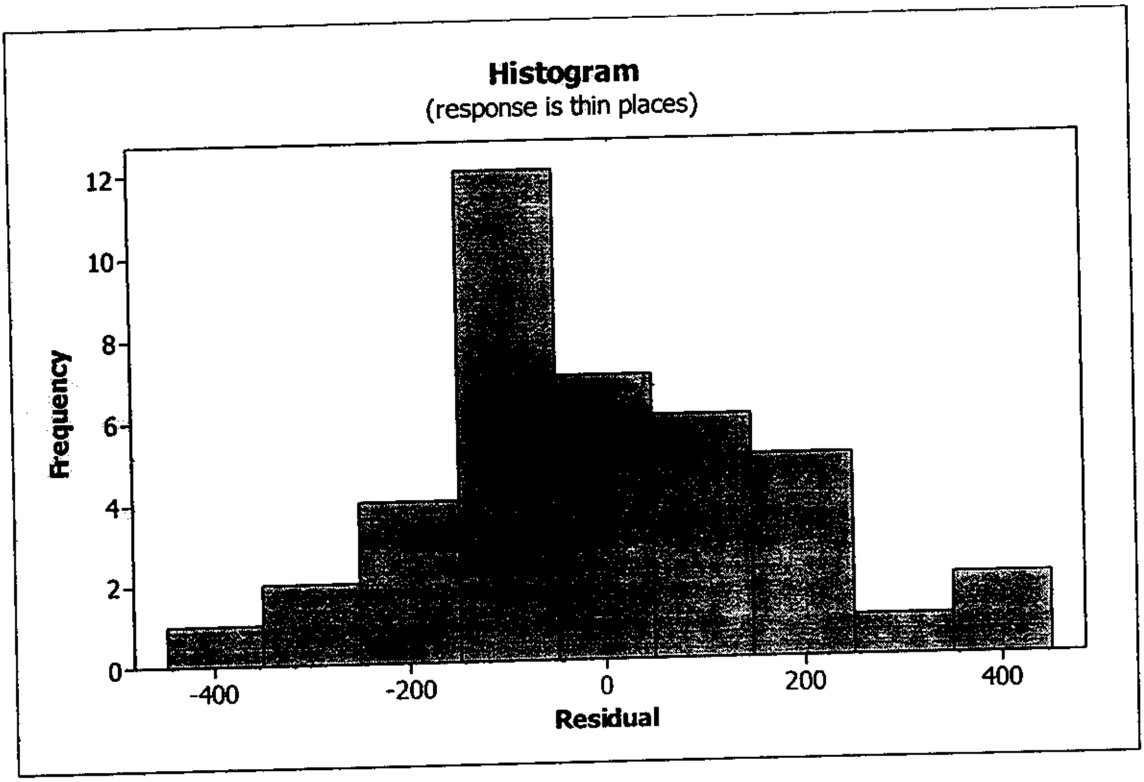
```
Source             DF       SS     MS     F      P
60SNe rdp offsets   3   196872  65624  1.88  0.151
Error              36  1257718  34937
Total              39  1454590

S = 186.9   R-Sq = 13.53%   R-Sq(adj) = 6.33%

                                Individual 95% CIs For Mean Based on Pooled StDev
Level   N   Mean  StDev  +---------+---------+---------+---------
1      10  341.3  180.1    (-----------*-----------)
2      10  474.8  247.5                (-----------*-----------)
3      10  461.1  187.8               (-----------*-----------)
4      10  316.8  103.8  (-----------*-----------)
                         +---------+---------+---------+---------
                       200       300       400       500

Pooled StDev = 186.9
```

Residual Histogram for thin places



```
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```

COUNT;60KNe
RDP OFFSETS VS THICK PLACES

One-way ANOVA: Thick places versus 6ONErdp oFFSETS

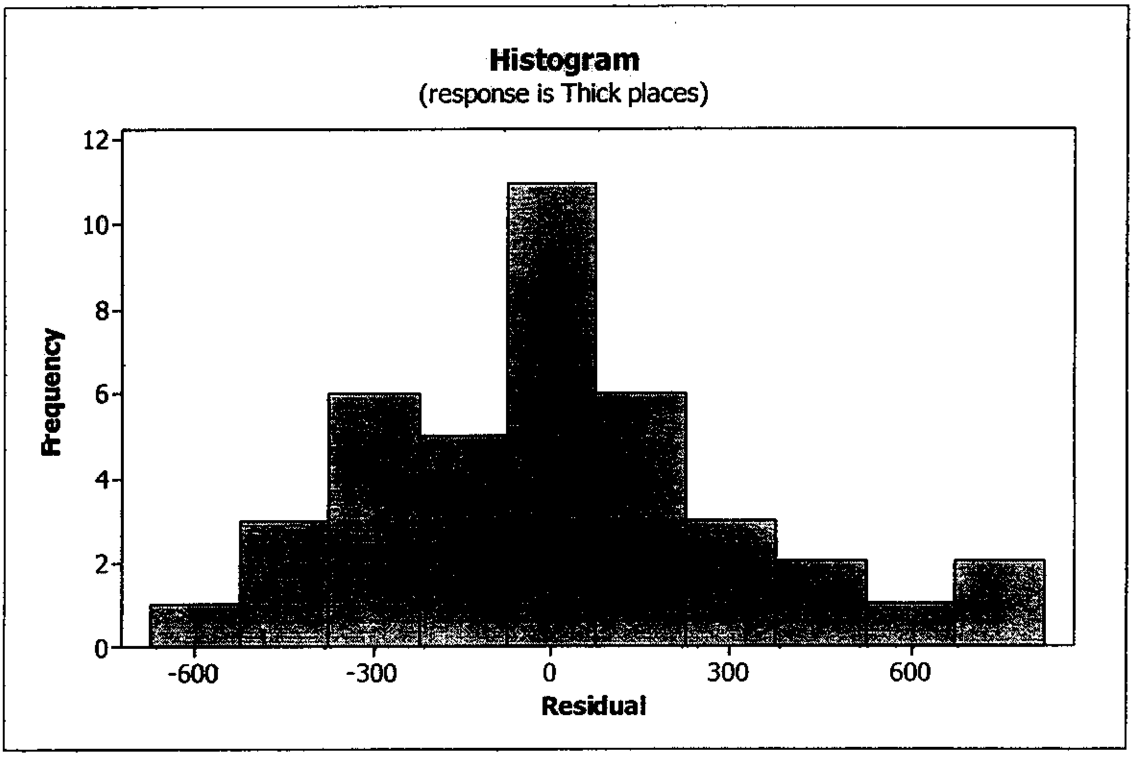
```
Source           DF       SS       MS      F      P
6ONErdp oFFSETS   3  4290429  1430143  13.11  0.000
Error            36  3927063   109085
Total            39  8217492

S = 330.3   R-Sq = 52.21%   R-Sq(adj) = 48.23%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean  StDev   --+---------+---------+---------+-------
1      10  1575.6  343.7             (-----*-----)
2      10  2111.5  328.5                            (-----*-----)
3      10  1191.7  376.9   (-----*-----)
4      10  1572.4  261.2             (-----*-----)
                           --+---------+---------+---------+-------
                           1050      1400      1750      2100

Pooled StDev = 330.3
```

Residual Histogram for Thick places



```
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```

COUNT;60SKNe
RDP Offsets VS Neps

One-way ANOVA: NEPS versus 60Ne RDP OFFSETS

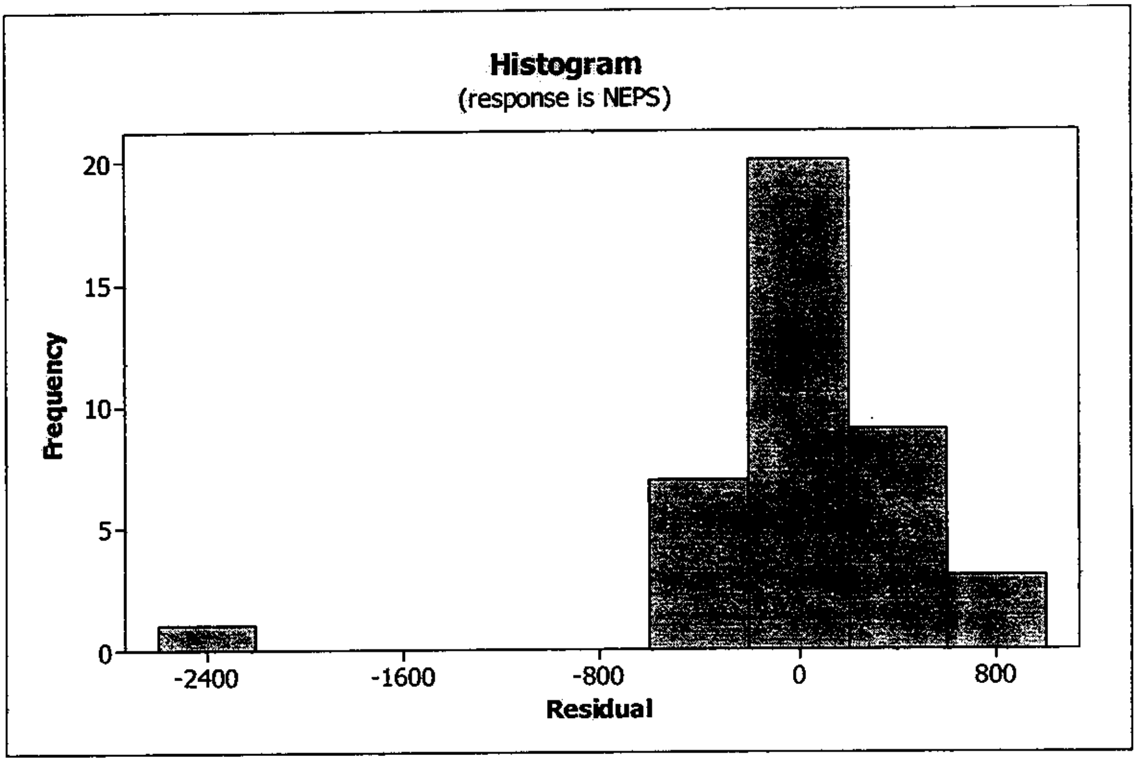
```
Source             DF        SS       MS     F      P
60Ne RDP OFFSETS    3   3911254  1303751  4.69  0.007
Error              36  10017924   278276
Total              39  13929178

S = 527.5   R-Sq = 28.08%   R-Sq(adj) = 22.09%


                          Individual 95% CIs For Mean Based on Pooled StDev
Level   N    Mean  StDev     +---------+---------+---------+---------
1      10  2073.5  280.6        (--------*-------)
2      10  2757.3  910.9                         (--------*-------)
3      10  1939.1  285.2     (-------*--------)
4      10  2166.5  351.1           (-------*--------)
                             +---------+---------+---------+---------
                          1600      2000      2400      2800

Pooled StDev = 527.5
```

Residual Histogram for NEPS



```
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```

COUNT;6OKNe
RDP OFFSETS VS S3 VALUES

One-way ANOVA: s3 values versus 6OKNeRDP offsets

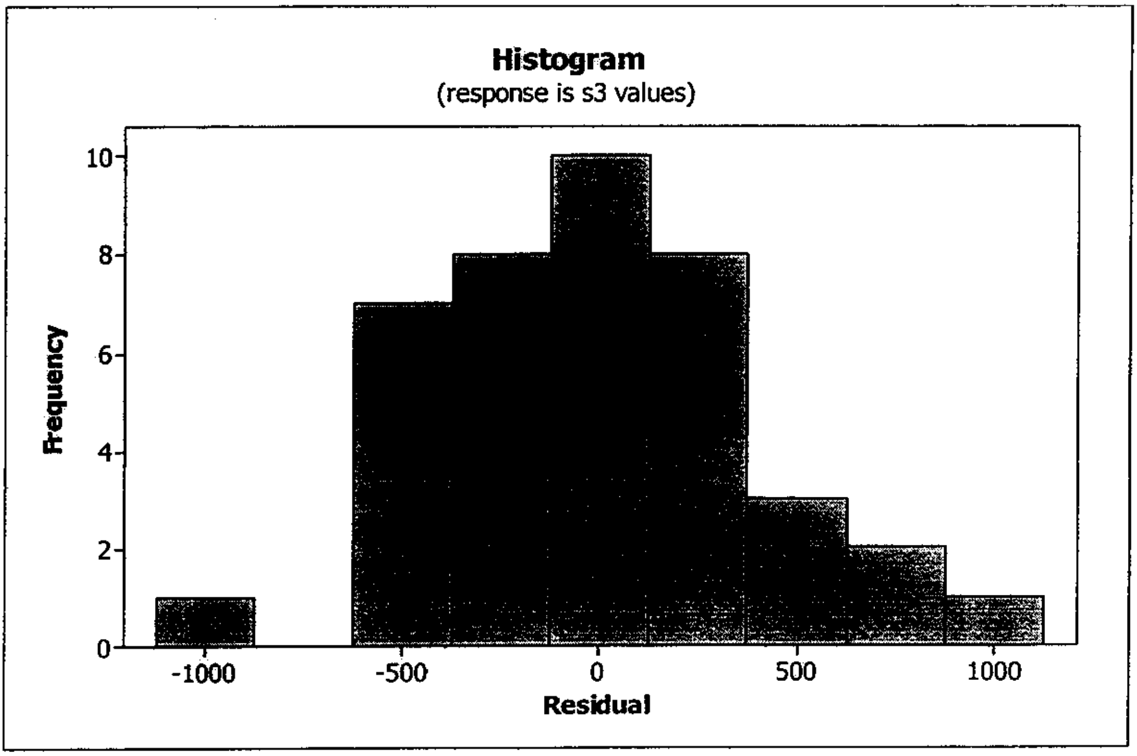
```
Source            DF         SS       MS     F      P
6OKNeRDP offsets   3    4492151  1497384  8.84  0.000
Error             36    6099763   169438
Total             39   10591914

S = 411.6   R-Sq = 42.41%   R-Sq(adj) = 37.61%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean  StDev  ------+---------+---------+---------+---
1      10  1612.4  327.0  (-----*------)
2      10  1994.8  251.5           (------*-----)
3      10  1876.5  458.9        (------*------)
4      10  2532.7  544.9                       (-----*------)
                          ------+---------+---------+---------+---
                             1600      2000      2400      2800

Pooled StDev = 411.6
```

Residual Histogram for s3 values



```
Welcome to Minitab, press F1 for help.
```

COUNT; 60KNe

RDP Offsets VS Tenacity

One-way ANOVA: TENACITY versus 60KNeRDP OFFSETS

```
Source            DF      SS     MS      F      P
60KNeRDP OFFSETS   3  1460.7  486.9   6.75  0.001
Error             36  2594.9   72.1
Total             39  4055.5

S = 8.490   R-Sq = 36.02%   R-Sq(adj) = 30.68%


                          Individual 95% CIs For Mean Based on Pooled StDev
Level   N    Mean  StDev      +---------+---------+---------+---------
1      10  160.15  10.67                              (-------*-------)
2      10  146.42   8.98        (-------*-------)
3      10  145.26   5.53       (-------*------)
4      10  154.05   7.95                   (-------*-------)
                              +---------+---------+---------+---------
                          140.0     147.0     154.0     161.0

Pooled StDev = 8.49
```

Residual Histogram for TENACITY