EFFECTS OF SPINNIG SPEED AND COURT VARIATION ON THE IRREGULARITY OF OE-ROTOR-SPUN YARNS

BY

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DEDICATION

This research work is dedicated to the righteous.

CERTIFICATION

This dissertation entitled "EFFECTS OF SPINNING SPEED AND COUNT VARIATIONS ON THE IRREGULARITY OF OE-ROTOR SPUN YARNS" by Abdullahi Danladi meets the regulations governing the award of the degree of Master of Science in Textile Science and Technology of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

Open end rotor yarns were spun at six different counts, each count at five different, speeds on a BD 200 machine. A constant twist factor and fixed opening roller speed were used throughout the spinning operations. Cutting and weighing technique was used to analyse the spun yarns to assess the influence of speed and count variation on the irregularity of the OE-rotor yarns.

Uster evenness tester was used to analyse the yarns for irregularities, neps, etc.

From the results obtained, it became clear that increasing rotor speed increases the level of irregularity in OE-rotor yarns, and increasing the yarn count (tex) from fine to coarse values also increases the level of irregularity of the rotor yarns analysed.

It was observed that the level of irregularity in the yarns produced was low compared to that of rotor yarns of similar counts reported in the literature.

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INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Few innovations in the field of Textiles have created such intersts as open-end spinning. Despite tremendous efforts that have been made over the years to further the development of ring spinning, it seems to be generally accepted that, owing to mechanical, technological and, above all, economic limitations, the potential of that well-established process has been virtually exhausted and that further advancement will only be achieved through an entirely new approach. This led to the development of open-end spinning. The idea of OE-spinning was first mentioned by Samuel Williams as long as 1807. The first really commercial machine, the BD 200 appeared in 1967, and since then a large number of patents relating to open-end spinning and associated mechanism have been filed[1].

Undisputedly, the advent of open-end spinning gave a fresh inpetus to spinning technology as well as fabric design. About two decades after its commercial use, open-end spinning has shown steady development to the point where in 1981, rotor represented some 70% world's total short staple spinning capacity (on yarn weight basis).[2]

In conventional spinning, the fibre supply is reduced to the required mass per unit length by roller drafting and then consilidated into a yarn by the application of twist. Twist insertion starts at the leading tips of the fibres as they emerge from the nip of the front drafting roller and works progressively along the fibres. The whole process is carried out under tension, so that there is opportunity for the internal stresses created in the fibres during drafting to relax[1].

In open-end spinning, the fibre supply is reduced as far as possible to individual fibres, which are then carried forward on an air-stream as free fibres. This permits internal fibre stresses to be relaxed and gives rise to the term 'Free-fibre spinning'. The fibres are progressively attached to the tail or 'Open-end' of the already formed yarn. This interruption in the fibre supply accounts for the alternative name of the process 'break-spinning'[1].

Open-end spinning offers both economic and processing performance advantages over ring-spinning[2].

Economic advantages include: (i) lower labour cost, (ii) lower power cost, (iii) cheaper raw materials, and (iv) larger packages.

The processing performance advantages include: (i) fewer knots, (ii) fewer weak places, (iii) low fault rate (iv) low hairiness and less tendency for lint shedding[1,2].

Some of the properties of open-end spun yarns are very different from those of more conventionally produced yarns. In some respects, open-end spun yarns are indisputably better; in others, they are inferior or at least may appear to be so when judged by the criteria normally applied to ring-spun yarns, for example, it is agreed that rotor-spun yarns are more even, have fewer imperfections and faults, higher extensions, lower variations in strength and better abrasion resistance than carded ring-spun yarns[1,7]. However, a rotor-spun yarn is weaker and harsher than an equivalent ring-spun yarn. The advantages of rotor spinning are however not always realised since the properties of rotor spun yarns are generally influenced by small changes in spinning conditions such as rotor speed and doffing tube characteristics, and small difference in processing conditions, which, together probably explain the many contraditions that appear in literature concerning rotor-spun yarn properties compared to ring spun yarn properties[4].

The project is intended to spin different counts of OE-rotor yarns at different speeds from the same sliver and determine the level of irregularity in each yarn produced. These levels of irregularities will then be compared to see the effects of increasing rotor speed on yarn irregularity and the spinning system irregularity as a whole. The effects of varying yarn count on the irregularity of the yarns produced will also be examined.

1.2 LITERATURE REVIEW

1.2.1 BASIC PRINCIPLES OF OPEN-END SPINNING SYSTEM

Several attempts have been made to catalogue and classify the many embodiments of the OE principle that have materialised over the years. This is not simple, because many variables are involved and certain features are common to several of the various systems[1,7]. The variables include the state of materials as it is fed to the opening system; the method of feed; the means of opening, separating and conveying the fibres; and the techniques of reassembling the fibres and of imparting twist to them[1].

The method of fibre assembly was considered the most convinient criterion for classification by the Shirley Institute[1,4,8]. These methods are:- (i) vortex assembly, (ii) axial assembly (iii) discontinous assembly and (iv) rotor assembly.

1.2.1.1 Vortex assembly System

There are great advantages in this method because there are few moving parts. Fibres are carried in a fluid vortex (air or water) against the direction of withdrawl of the yarn, so that fibres making contact with the yarn become twisted around its axis and thus attached to it. With this method, power consumption is low especially with water vortex systems, but the twisting efficiency is low, hence weak yarns are produced and there is considerable fibre loss.

1.2.1.2 Axial assembly system

In this system, the airborne fibres are channelled into a rotating funnel, from which the yarn emerges at the apex. Thus the fibres are collected about the axis of the yarn while twist is inserted by some mechanical means, such as a rotating gripper. In one particular interesting embodiment of this principle, the fibres are funnelled into the twisting element by means of an electrostatic field.

1.2.1.3 Discontinuous assembly system

This method incoprates means to pluck tufts of fibres from the end of the supply package (normally roving) and to overlap them successively to form a strand, which is then processed in the spinning element. This method has not yet been commercially exploited.

1.2.1.4 Rotor assembly system

Here, airbone fibres are deposited continuously upon the external or more usually, the internal peripherial surface of a rapidly rotating drum so as to form a ring of fibres, which is then peeled off and withdrawn along the axis of rotation of the drum. Thus twist is imparted and a yarn is formed.

The phases in open-end spinning operation generally comprises of: (a) drafting, (b) fibre transport, (c) fibre condensation, (d) twist insertion, (e) yarn-removal (f) winding of the yarn[2].

Rotor system of spinning has very high production capacity because the twist insertion phase is isolated from the yarn winding phase, this enables high rotor speeds of 30,000 rpm to more than 80,000 rpm to be achieved with rotor, whereas with ring frame, the normal operating speed is about 10,000 rpm[1,2].

In the literature, it is reported that the intensive development phase of open-end rotor spinning which characterised the 1970's has now reached a plateau[1,2].

1.2.2 Open-end rotor spinning technique

The technique of open-end spinning is illustrated diadramatically in fig 1.1, which may be explained as follows.

Sliver is slowly drawn into the machine by a feed roller, operating in conjuction with a spring-loaded feed-pedal. The rapidly rotating opening roller, which may be pinned or covered with metallic card clothing, combs out the leading ends of the fibres until they are released, when it carries them forward virtually as individual fibres. It is possible to spin if the fibres are fed in small groups, but, the larger the number of fibres in the groups approaching the spinner, the worse the resultant yarn is likely to be.

Provision may be made for trash to escape through an aperture in the beater casing while the fibres are sucked through the transit tube and onto the inner, grooved, peripheral surface of the rotor. The transit tube may be tapered so as to create an accelarating air-stream, which will tend to straighten the fibres in flight.[9,11]

Lord[1] suggested that the ideal fibre flux, i.e the number of fibres in cross-section, in the transport tube was unity, sothat the fibres entered the rotor end-to-end in single file, but he pointed out that, in order to achieve this, the air speed in the tube would be as high as 75m/sec for fine yarns and 600m/sec for coarse yarns. In practice, the fibre flux in the tube is greater than unity, good results with a flux as high as 7 or 8 has been reported in the literature.[1,4,11]

Some straightening of the fibres should occur as they enter the rotor, since the surface speed of the rotor is greater than the air-speed.

Centrifugal force flings the fibres outwards and presses them onto the collecting surface of the rotor, where a ring consisting of many layers of fibres forms. To start spinning, an existing yarn (prime yarn) is introduced through the exit tube. Since the rotor and the air contained in it are rotating, the yarn tail is also caused to rotate. Centrifugal force throws it against the inner peripheral surface of the rotor, where it makes contact with the ring of fibres. As soon as this occurs, the prime yarn is withdrawn, and yarn production begins. Each revolution of the yarn arm puts a turn of twist into the yarn in the exit tube, and, since there is little to stop it, some of this twist leaks back along the yarn arm to the rotor surface, which causes the tip of the prime yarn to become entangled with the ring fibres, which can then be progressively peeled off the surface of the rotor to form a yarn.[1] The yarn produced is simply wound onto a package, usually a cheese.

1.2.3 YARN IRREGULARITY, ITS CAUSES AND EFFECTS

1.2.3.1 The incidence of irregularity and its effects

All staple-fibre yarns vary in linear density, and most problems of yarn quality are related to this basic property.[8]

Irregularity in yarns is recognised in one of a number of ways:

(i) variation in linear density,

(ii) variation in thickness as seen by the eye,

(iii) variation in twist,

(iv) variation in strength

(v) variation in colour.

All these arise from the same underlaying cause i.e. the uneven distribution of fibres along the length of the yarn. This produces variation in the number of fibres per cross-section and in linear density. When twist is inserted in a yarn, it is distributed in such away that the angle of twist is approximately constant. This means that thin places have more turns per unit length than thick places, and are relatively hard, wereas thick places are soft and comparatively bulky. This accentuates the visual appearance of irregularities[5,11].

The combination of varying number of fibres per cross-section with varying forces binding these fibres together (bacause of twist variation) leads to varying tensile properties.

For the purpose of processing efficiency, and in the interest of cloth appearance, there are level of unevenness beyond which the yarn is unacceptable; these are not necessarily the same in the two cases.[5]

Colour variation in single-fibre yarn is not usually related to variations in linear density but to inadequate mixing of differently coloured fibre components of the blend. When blends of different fibres are used, there is also the possibility of

uneven distribution of types of fibres; this can produce colour variations on subsequent yarn or piece dyeing if different types have different dyeing characteristics, and can also be responsible for increased variability of yarn strength.
With the exception of colour variation, all other forms of irregularity arise from the first, the variation in linear density.

1.2.3.2 Causes of irregularity

A broad classification of the causes of yarn irregularity has been given by Martindale.[12]

1.2.3.2.1 Properties of raw materials

The design and adjustment of spinning machinery is in effect a compromise which aims at processing at an optimum efficiency the majority of fibres in a particular mixing. Natural fibres have variable properties and set the spinner a variety of problems. A major variable is the fibre length. However, other variables such as surface character, finness, shape of cross-section, maturity, crimp, etc, have some effect on the yarn properties.

1.2.3.2.2 Inherent short coming in yarn making & preparatory machinery

In many engineering processes the units from which the final product emerge are positively controlled by hand and machine and only a few thousands of an inch tolerance is allowed. However, in spinning operation, the individual fibres are only negatively controlled at times they are carried forward by air currents (e.g. rotor spinning) or carried along by surrounding fibres, or they are held in a position by friction and twist.

Fibre manipulation by rollers, aprons, gills and other machine parts is hampered by fibre variation, and the machines can only be set to give the best results within the limits imposed by the material.

The 'drafting wave' is one example of irregularity due to the inability of a drafting system to control each fibre. Where roller drafting is used, the distance from one nip to the other is greater than the length of the shorter fibres. These short fibres 'float' in the drafting zone and move forward in an irregular but cyclical manner which results in the drafted strand having thick and thin places. The wavelength of this type of irregularity is about 2.5 times the mean fibre length but is not necessarily constant for a particular strand. In addition to varying wavelength, the amplitude of the drafting wave is also variable. In rotor spinning where the sliver produced by the cards is converted to yarn, only a small draft is used, and due to the large degree of doubling obtained drafting waves do not arise but other variatins peculiar to the system are found, e.g. variations between the card slivers fed to the rotor.

As the rotor diameter increases, the number of wrapper fibres is increased owing to the greater insertion of false twist, while the miminum twist factors and the number of wrapper fibres are reduced. Despite fewer wrapper fibres, the influence of the greater number of wraps by the individual wrapper fibres predominates often, so that yarn spun with greater rotors display a more pronounced OE character.

1.2.3.2.3 Mechanically defective machinery

Since machines even in good condition produce irregular yarns, it is reasonable to assume that deffective machinery will increase the amount of irregularity. The implementation of an efficient maintenance system is essential if the level of irregularity is to be kept within bounds. Machines drift out of adjustment, bearings become worn, components get damaged (e.g working angles of the teeth of the combing roller in rotor) lubrication systems clog and dirt finds its way into the mechanism. Many spinning machine mechanisms are based on rollers and their associated drives. Faulty rollers and gear wheels usually produce periodic variation, a fact which helps the technologist to tract down the probable cause by analysis of the traces made on the evenness tester.

1.2.3.2.4 External causes

To achieve a first class product, a first-class team of managers, technicians and operatives is essential. Schemes of mainteanace and quality control which look good on paper can be reduced to second rate if the operatives neglect their duties. Poor piecings, careless oiling and cleaning and general slack work can spoil yarn. Automation of machines greatly improves the quality of the product.

1.2.3.3 EFFECTS OF IRREGULARITY

The knowledge of nature and causes of irregularity will not be much appreciated without understanding how it effects the yarn and fabric produced from the material[11].
J.E. Booth[6] gave a broad classification of the effect of irregularity.

1.2.3.3.1 Strength

Thin places whether in slivers, rovings or yarns will be weak places. As the irregularity of any strand increases, so does the chance of it beaking, this will cause lower machine efficiency and the repair of breaks usually means the introduction of other faults, such as thick places at the piecing or knots in yarns.

Due to the introduction of twist in yarn which helps inbinding the fibres together even in weak places, the relationship between irregularity and strength is not as straight forward as might be excpected.

1.2.3.3.2 Fabric appearance

Fabric produced from spun yarns will possess irregularity in appearance because of certain amounts of irregularity in the yarn which is inevitable. The surface variation in some ways give 'character' to a fabric, but excess of variation will produce a fabric with an objectionable apprearance. The way and manner in which yarn irregularity affects a fabric depends on several factors e.g. the type of variation (periodic or non periodic), the fabric structure, fabric dimension, use of yarns (e.g warp or weft) and fabric finish.

Where a weft-yarn contains periodic faults, fabric fault known as 'diamond bars' and 'block barns' can arise.

1.2.3.3.3 Stripy knitted goods

In some ways the weaver fares little better than the knitter because the irregularuty in one set of threads may be partially concealed by the other set. In a weft knitting machine, the weft must stand on its own feet, as it were. Knitting machines are set to produce a given quality of fabric from a known count of yarn. When count varies from cone to cone or where one cone contains yarn of differing count, the result is stripy fabric.

1.2.3.3.4 Dyeing and finishing faults

The thicker and softer parts of the yarn take up more size than the thinner and harder regions, after the desizing process perior to dyeing, the distribution of residual size may be uneven and cause difficulty in achieving a level dyeing.

1.2.4 YARN EVENNESS IN OPEN-END SPINNING

Open-end yarn is said to have a better evennes than ring yarn, but the truth of this statement depends on the error wavelength. It has been shown that errors are reduced when the error wavelength in the yarn is less than the circumsference of the collecting surface. In practice the main advantages in open-end spinning as far as evenness is concerned originate from the suppression or avoidance of draftingwaves and the manufacture of large packages. In consequence of the multiple doubling inherent in the layering which occurs in rotor-type open-end spinning, there is usually an improvement in the short-term regularity of the yarn. However, long term variations arising from prior processes are not greatly affected.[9,11]

The normal unevenness of a yarn consists of a spectrum of wavelengths, and apart from the obvious effects caused by suppressing the short wavelengths, there is also an effect on transients. Suppression of the short-term wavelengths tend to "smear" sudden changes in linear density. It is unlikely that slub-like faults will be produced, and such faults that are produced are likely to have slowly tappered ends, the length of the tapered portions being at least several inches long.

Long-and medium-term variations affect the CV of linear-density. The normally measured CV is the integral of the errors of all wavelengths within the capacity of the measuring device. Thus suppression of only the short-term errors still leaves those of longer wavelength.

Yarn evennes deteriorates beyond the theoretical values because the bridging fibres fail to assemble on the yarn at the first opportunity. If the fibres are heavily crimped and tend to flow in bunches, delay in assembly causes thin spots to be created followed by thick spots. The bridging fibres are laid once per revolution of the rotor, and an error wavelength equal to the rotor circumference can often be detected. Particles embeded in (or damage to) the vee of the collecting surfaces also provides error of the same wavelength. The chances of such particles being deposited depends on how well the fibre stock has been cleaned.

It is clear that to get even yarns it is necessary to take particular care in the prior processes to achieve evenness and cleanliness of the sliver to be used for spinning, and it is also necessary to use appropriate fibres[7].

Damage to the combing roller can also produce a periodic defect of several times the wavelength just discussed. It is clear that doubling is unable to help much with defects caused mechanically, and the area of greatest benefit is in the suppression or avoidance of drafting waves. While it is true that the multiple doubling helps but little with the long-term errors, there is an advantage which arises from the fact that open-end spinning machines produce large packages. With ring yarns, it is possible for the bobbins to be used in a dissimilar order to that in which they were produced. In this case very long-term errors in the yarn are broken up, and there are yarn count discontinuities at each bobbin change. The defects in the fabric become more evident than if strict order had been preserved. With large packages such as those produced in open-end spinning, any sudden changes are infrequent and much less noticeable[7,11]

There are various methods of measuring and assessing irregularity, the cheapest and quickest method for yarn at least, is to make a visual examination by looking at it as a yard or so is drawn off the package by hand. At the other extreme, highly complicated electronic apparatus may be used. Some of the important methods are given below:

Visual methods; Blackboards, drums, photographic devices, projection.

Cutting and weighing methods; hank wrapping, count variation, short cut lengths.

Variation in thickness under compression; LINRA roller yarn diameter tester.

Electronic capacitance testers; Fielden-Walker, Uster.

1.2.4.1 The 'Uster' evenness tester

The apparatus consists of two oscillators which have equal frequencies when there is no material in the measuring capacitor. When the two frequencies are superimposed the difference in frequency is zero. The presence of material in the capacitor causes its capacity to change and so alter the frequency of the oscillator. There will then be a difference between the two frequencies which varies according to the amount of material between the capacitor plates. Suitable circuits translate these frequency differences into signals which (i) are indicated on a meter, (ii) drive the pen of the recorder, and (iii) are fed into the integrator which indicates the average irregularity either as percentage mean deviation or coefficient of variation according to the model used.

1.2.5 Structure and Properties of Rotor spun yarn

Rotor spun OE yarns (particularly short staple cotton yarn) and other uncoventional yarns are now coming forward, notably in coarse counts for use in the carpet and home furnishing. Streoscan pictures of these new type of yarns show the complexity of the surface arrangement of the fibres on the outside of their fibrous structures, and, at the same time, gives some idea of their interval structres.[1,11]

The internal arrangement of the fibres in the yarn are best studied by direct examination of distribution of single fibre in the body of the yarn and by analysing their migration in the cross-section of the yarn and along its length.[11]

The significance of the fibre shape has been discussed in the literature and in various conference papers[11]. A particular significance of the shape of the fibre and the use made of its length being duely emphasized.

A textile product is a complex system which cannot be considered structurally as a homogeneous body, but rather should be seen as a complex of partial groupings of elementary particles. Its general classification will depend on the analytical approach to the problem assumed, thus e.g in a Morphological approach, single fibre could be taken as yarn elements. In nonwovens, the elements will be fibre and bonding agents, while in other textile products, they might be even spun yarns or filaments.

In a broad sense the word or term "yarn structure" includes not only the geometrical properties of the yarn such as bulkiness, twist, appearance, hairiness and irregularity, but also the relations between the fibre and yarn properties. The interaction between single fibres and the arrangement in the yarn body analysed by means of the sectional distribution of the longitudinal arrangement of the length and fibre shapes are features of the structure in the narrower sense[11].

The shape of the fibres, its arrangement and the position of the textile structure are accidential, and, it is therefore necessary to use the mean value and its variation in subsequent processing. It is known that the number of fibres in 1kg of a textile product may be as high as 5×10^{5} to 2×10^{9} depending on the nature of the raw material. The corresponding number of fibres depends on the fibre fineness and staple length. Cotton rotor spun yarn should contain 90 to 100 fibres in its cross-section, while rotor spun yarns designed for use in carpet should contain 200 or more fibres if they are to be spun successfully.[1,3,11]

Fibres have different shapes in the textile structure, each shape is characterized by its corresponding fibre extent coefficient Kp, while space arrangement is neglected. As the real mean fibre length and its variation can be determined after every technological operation, Kp coefficient provides general characteristics for the assessment of the fibre length exploitation in any given textile structure. Moreover, it indicates indirectly the characteristics of the fibre shape distribution, and consequently the structure in the direction of product orientation''.

In rotor spinning the fibre retains their shapes to a greater or lesser extent, even at the collecting surface of the rotor and after yarn formation this shapes remain in the yarn and textile product.

In contrast with cotton yarn, the elongation of rotor spun yarns for man made fibres was somewhat lower than that of ring spun yarn from the same fibres; the Uster irregularity value of rotor spun yarns were however found to be better than those of the ring yarns as expected.[1,11]

The inner structure of rotor spun MMF yarns as charcaterised by a statistical model of the longitudinal distribution of the effective fibre length is entirely different from that of the ring spun yarns.[11]

Measurement of the internal structure of the yarns suggests that the yarns which are rotor spun from MMF differ distinctly in structure from comparable ring spun yarns. The fibre length exploitation in rotor yarns is about 50%, but is known that the fibre strength exploitation in tensile strength of conventional ring spun yarn ranges from 0.45 to 0.55, depending on the fibre. Hence, it follows that it is not to be expected that similar effectiveness and consequently, a similar tensile strength effect will be achieved, with fibres exploiting only half their length in the yarn. Accordingly to obtain the desired tensile strength in rotor spun yarns, it will be necessary to choose a suitable fibrous material with regards to the specific coefficient of the fibre length and tensile strength expoitation typical on the particular system of spinning to be used. This selection can be helped by the use of the equation.

$$R_F C_S = R_Y$$

where R_F = the tenacity of the fibre

C_S = coefficient of the fibre strength exploitation in the yarn.

R_Y = yarn tenacity.

1.2.6 EFFECT OF FIBRE PROPERTIES ON OE-ROTOR YARN

Three basic properties will be considered, namely:- Fibre length, Fibre fineness and Fibre strength.[2,6,11]

1.2.6.1 Fibre length

As the fibre length increases so does the possibility of fibres wrapping themselves around the yarn core, giving more obvious look to the OE-yarn. This means the yarn irregularity increases due to more wrapper fibre formation, however, as the fibre length increases the yarn strength also increases.

1.2.6.2 Fibre Fineness

Martindale[13] shows that the irregularity in the strand is dependent upon the average number of bires in a cross-section. With a greater number of fibres in the cross-section, the basic irregularity is reduced. For a given count the average number of fibres in the cross-section will depend on the fibre finness; the finer the fibre, the higher the number and the lower the irregularity.

As the yarn becomes finer, the number of fibres in the cross-section diminishes and the irregularity increases until a point is reached when spinning any finer yarn becomes impracticable and the spinning limit has been reached. With coarse fibres, the spinning limits is reached fairly soon.

1.2.6.3 Fibre strength

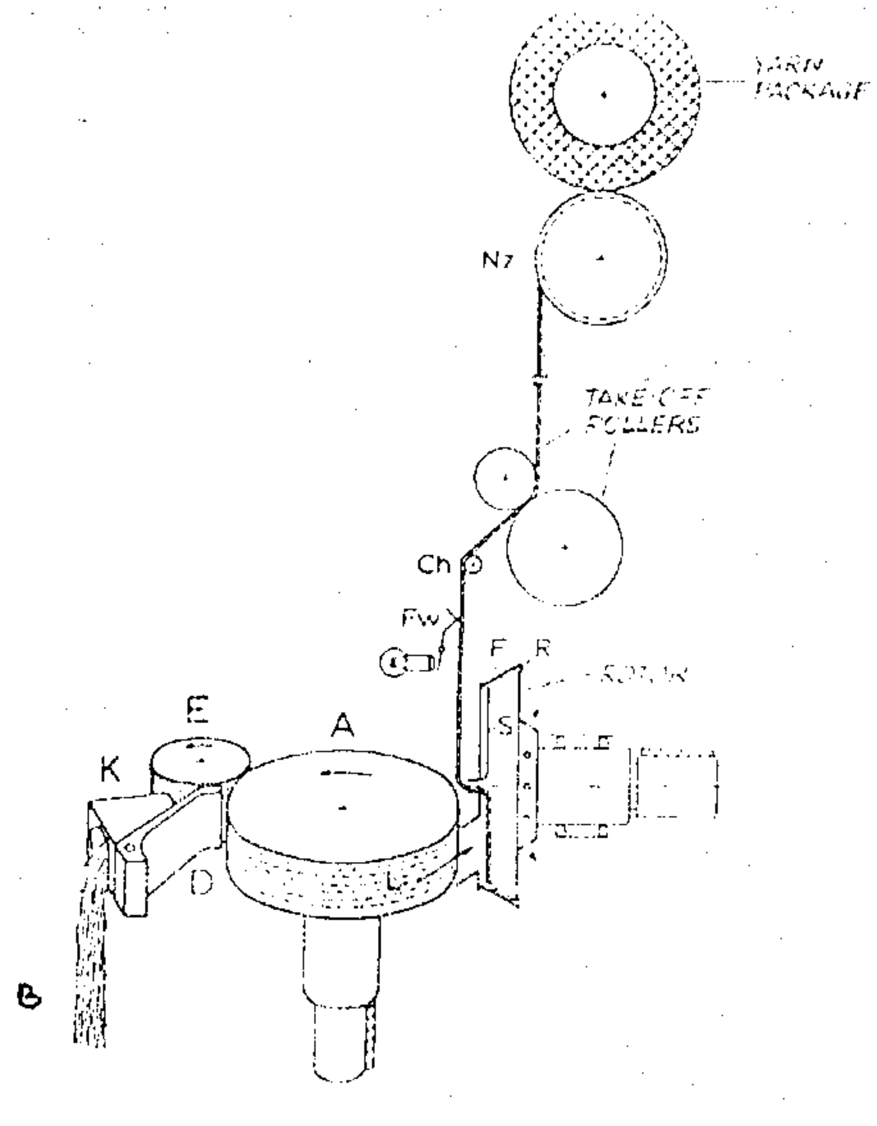
In rotor spinning where combing roller is used, fibre strength is of great importance, because if the fibre is weak, as the tufts are being flucked from the fed sliver by the teeth of the combing roller, the fibres tend to break into shorter lengths which are deposited in the collecting surface of the rotor as debris which lower the quality of the yarn produced there from[3,11].

1.2.7 Count Range in OE-spinning

It is often said that OE-spinning is applicable only over a certain limited count range and that there are two main reasons for this[3]. One is purely technical in as much as it seems to be true that this method of spinning requires a certain number of fibres in the yarn cross-section in order for the yarn to be effectively withdrawn from the spiining rotor. Estimates of minimum number actually vary between 80 to 120[1,3,7,11].

The other limitation is the economic one, because above a certain count level, the cost of spinning OE-yarn is actually higher than for the ring system.[1,3] The point at which OE yarn becomes more costly to produce than ring yarn depends, to a great extent upon the capital cost of the large packages and better processing performance of OE-yarns, the extent to which rewinding can be eliminated, and the extent to which savings in raw materials can be made.[1,3]

It has been claimed that 40 CC cotton yarns are both technically and economically viable, whereas doubts have been expressed whether OE-spinning anything finner than 20 CC can be justified.[3]



A = Opening (combing) Roller,
B = Sliver,
E = Feed roller.

Fig. 1.1 A diagramatic representation of BD 200 O - E Spinning Machine.

CHAPTER TWO

EXPERIMENTAL

2.1 MATERIALS AND EQUIPMENTS

2.1.1 MATERIALS

100% cotton, secondpassage drawframe sliver was used for spinning the yarns. The staple length and finess of the fibres were determined from the cotton sliver (the values are shown in the appendix I).

2.1.2 EQUIPMENT

BD 200 Rotor spinning machine,

Uster evenness tester,

25mm roller apparatus,

Micro balance,

Safety razor blade and holder,

Pair of forceps

2.2 PRODUCTION OF ROTOR SPUN YARNS

2.2.1 Brief description of the "BD 200 Rotor Spinning Machine" (Prototype)

This is the machine used for spinning of the yarns used in this project. The principles of this type of machine are well known and have been described in the literature, however, a brief summary of the essential features of the machine is given for completeness.

The machine can produce yarn in the count range of 14.9 to 74tex for all commercial grades of cotton. It can process sliver in the range of 2.2 to 4.0 Ktex. Full-sized yarn packages having weights up to approximately 1.5kg are produced at production rates upto 100metres/min, or more depending on rotor speed and yarn twist.

The rotor speed can be set to any value upto 40,000 rpm and the opening roller speed up to 10,000rpm. The standard change-wheels enable drafts between 36 and 225 to be employed.

The machine is single sided with four spinning rotors and is equiped with drive motors which drive the rotor, the feed and the combing rollers. The speeds of these rollers are controlled with the use of transducer knobs.

2.2.2 Production of yarn samples

To produce a yarn, the required change wheels were obtained from the appendix of the machine mannual. The number of teeth on the lower and upper change wheels depend on draft which is obtained as follows.

$$\text{Required draft} = \frac{\text{Sliver count}}{\text{Yarn count}}$$

Appendix I shows the draft and change wheels used. In some cases, the draft used deviated a little from the calculated draft because yarn samples tested did not measure up to the expected count. This was attributed to the high count of the sliver used. In order to produce yarns at different counts (23, 24, 28, 29, 30 and 40tex) the appropriate drafts were calculated and the right change wheels selected (as shown in appendix I). The opening roller speed was kept constant at 6,000rpm. A constant twist multiplier of 4.7 was used and the corresponding withdrawal speeds calculated. These are shown in appendix I. Having established the necessary spinning parameters for the yarn production, a speed of 17,000rpm was used to spin all the above mentioned counts. Similarly speeds of 20,000, 23,000, 26,000 and 28,000rpm were used to spin all the counts.

During spinning, the sliver was fed in to the drafting system at constant opening roller speed of 6,000rpm as a result of which the fibres were deposited in the V-shape groove of the rotor running at a selected speed. As soon as this was done, a prime yarn was fed to the rotor via the yarn outlet tube to initiate spinning. The prime yarn was sucked in by air current, and the end inside the rotor pee-off the deposited fibres from the collecting surface and twist the fibres to form a continous yarn which was later drawn out and wound onto a yarn package.

2.3 Determination of Yarn Irregularity

2.3.1 Cutting and Weighing Technique

The method used is based on the determination of local and general irregularity, on twenty 300mm lengths.

Yarn pieces of about 300mm long were removed from a package at irregular intervals of about 2 meters. 20 of these were knotted together to form a continous length and wound onto a convinient holder (empty bobbin).

The small package obtained was mounted by a suitable means so that the yarn could be freely withdrawn. From this 25 mm lengths were cut with a razor blade.

The 25mm lengths thus obtained were weighed with an analytical balance which measures upto 4 decimal places.

It was ensured that the ten 25mm lengths, the masses of which made up a column of readings were all from one of the 300mm lengths of yarn, so that at the end, each of the 20 columns of readings corresponded to one of the 300mm length of yarn in the original package.

The above procedure was done for each of the yarn counts produced.

An average of each 20 readings in a group was calculated and tabled to condense the figures as in tables 3.1.1 to 3.1.30. The irregularity for each yarn was calculated and recorded in table 3.2.

2.3.2 Uster evenness test

The test was carried out in a conditioned laboratory (at 65±2% r.h. and 20°±2°C) after the yarns have been stored for at least 48hrs in the laboratory.

The uster evenness tester was used to measure the irregularity of the yarns produced at 23,000 and 28,000 rpm, the results of these tests were expressed in terms of linear uster irregularity U%.

Material speed of 400m/min, diagram speed of 25cm/min, range of 100% and evaluation time of 1 minute were used. The variation in the yarnmass per unit length was recorded as U% (integral per cent mean-deviation). For each yarn sample, ten U% readings were recorded. Table 3.3 shows the mean of the ten readings for each yarn with its corresponding number of thick and thin places.

CHAPTER THREE

3. RESULTS AND DISCUSSIONS

3.1 RESULTS

3.1.1 Determination of yarn irregularity

3.1.1.1 Cutting and Weighing Technique

X represents an average of 20 readings

$|X-\bar{X}|$ = Deviation from mean

$|X-\bar{X}|^2$ = Deviation squared

$$\text{Standard deviation } \sigma = \sqrt{\frac{\Sigma|X-\bar{X}|^2}{n-1}}$$

where n = number of values = 10

$$\text{Coefficient of variation (C.V)} = \frac{\sigma}{\bar{X}} \times 100$$

$$\% \text{ irregularity} = \frac{\text{Mean range}}{\text{Mean Mass} \times 3.08} \quad \text{(BS Handbook 11:1974)}$$

The following tables (a) show the values X with their deviations. The readings of weight determination were condensed to groups of 10 and the corresponding ranges in each group determined. These results are shown in tables (b).

Table 3.1.1: 23tex yarn at the speed of 17.00 rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X} \rvert$	Deviation² $\lvert X-\bar{X} \rvert^2$	Group	Range	Group	Range
6.00	0.02	0.0004	1	2	11	2
5.97	0.01	0.0001	2	2	12	2
5.97	0.01	0.0001	3	1	13	2
5.88	0.10	0.0100	4	2	14	2
6.21	0.23	0.0529	5	2	15	2
6.10	0.12	0.0144	6	1	16	2
5.98	0.00	0.0000	7	2	17	2
5.96	0.02	0.0004	8	3	18	2
5.96	0.02	0.0004	9	2	19	2
5.81	0.17	0.0289	10	2	20	3
$\bar{X}$ = 5.98		0.1076			Mean range	2.00

σ = 0.11, C.V = 1.83%, Irregularity = 10.85%.

Table 3.1.2: 25 tex yarn at the speed of 20,000rpm

(a) Values of X with their deviation			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X} \rvert$	Deviation² $\lvert X-\bar{X} \rvert$	Group	Range	Group	Range
5.70	0.07	0.0049	1	2	11	3
5.60	0.17	0.0289	2	2	12	2
5.74	0.03	0.0009	3	3	13	1
5.63	0.14	0.0196	4	2	14	1
5.71	0.06	0.0036	5	1	15	2
5.73	0.04	0.0016	6	2	16	2
5.72	0.05	0.0025	7	3	17	2
6.01	0.24	0.0576	8	2	18	1
6.03	0.26	0.0676	9	2	19	3
5.79	0.02	0.0004	10	1	20	3
$\bar{X}$ = 5.77		0.1876			Mean range	1.95

σ = 0.14, C.V = 2.5%, Irregularity = 11%

Table 3.1.2: 23tex yarn at the speed of 20,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\|X-\bar{X}\|$	Deviation² $\|X-\bar{X}\|^2$	Group	Range	Group	Range
5.70	0.07	0.0049	1	2	11	3
5.60	0.17	0.0289	2	2	12	2
5.74	0.03	0.0009	3	3	13	1
5.63	0.14	0.0196	4	2	14	1
5.71	0.06	0.0036	5	1	15	2
5.73	0.04	0.0016	6	2	16	2
5.72	0.05	0.0025	7	3	17	2
6.01	0.24	0.0576	8	2	18	1
6.03	0.26	0.0676	9	2	19	3
5.79	0.02	0.0004	10	1	20	3
$\bar{X}$ = 5.77		0.1876			Mean range	1.95

σ = 0.14, C.V = 2.5%, Irregularity = 11%

Table 3.1.3: 23tex yarn at the speed of 23,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
6.60	0.48	0.2304	1	3	11	3
6.70	0.58	0.3364	2	3	12	2
6.25	0.13	0.0169	3	2	13	3
5.80	0.32	0.1024	4	3	14	2
5.80	0.32	0.1024	5	2	15	2
5.70	0.42	0.1764	6	2	16	2
6.40	0.28	0.0784	7	3	17	3
6.32	0.20	0.0400	8	3	18	3
5.84	0.28	0.0784	9	3	19	3
5.75	0.37	0.1369	10	1	20	3
$\bar{X}$ = 6.12		1.2986			Mean range:	2.5

σ = 0.38, C.V = 6.21%, Irregularity = 13.26

Table 3.1.4: 23tex yarn at the speed of 26,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
5.80	0.00	0.0000	1	2	11	2
5.76	0.04	0.0016	2	2	12	3
5.84	0.04	0.0016	3	2	13	2
5.91	0.11	0.0121	4	1	14	2
5.61	0.21	0.0441	5	2	15	1
5.74	0.06	0.0036	6	2	16	2
5.63	0.17	0.0289	7	2	17	2
5.81	0.03	0.0009	8	3	18	2
5.84	0.04	0.0016	9	2	19	1
5.91	0.11	0.0121	10	1	20	3
$\bar{X}$ = 5.80:		0.0776			Mean Range:	1.95

σ = 5.80, C.V = 1.6%, Irregularity = 10.91%

Table 3.1.5: 23tex yarn at the speed of 28,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
5.45	0.02	0.0004	1	2	11	3
5.40	0.03	0.0009	2	3	12	2
5.25	0.18	0.0324	3	3	13	3
5.60	0.17	0.0289	4	3	14	2
5.40	0.03	0.0009	5	2	15	3
5.40	0.03	0.0009	6	3	16	2
5.45	0.02	0.0004	7	3	17	3
5.55	0.12	0.0144	8	2	18	3
5.40	0.03	0.0009	9	3	19	2
5.35	0.08	0.0064	10	2	20	2
$\bar{X}$ = 5.43		0.0865			Mean range:	2.08

σ = 0.098, C.V = 1.8%, % Irregularity = 12.4%

Table 3.1.6: 24tex yarn at the speed of 17,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
6.10	0.01	0.0001	1	2	11	2
6.11	0.02	0.0004	2	2	12	1
6.11	0.02	0.0004	3	3	13	2
5.83	0.26	0.0676	4	2	14	2
5.87	0.22	0.0484	5	2	15	2
5.94	0.15	0.0225	6	1	16	2
6.19	0.10	0.0010	7	2	17	3
6.22	0.13	0.0169	8	3	18	1
6.31	0.22	0.0484	9	3	19	2
5.99	0.10	0.0010	10	1	20	1
$\bar{X}$ = 6.09		0.2067			Mean range:	2.05

σ = 0.15, C.V = 2.49%, Irregularity = 10.91%

Table 3.1.7: 24tex yarn at the speed of 20,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value	Deviation	Deviation²				
X	$\lvert X-\bar{X}\rvert$	$\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
5.91	0.00	0.0000	1	2	11	2
5.83	0.08	0.0064	2	2	12	2
5.90	0.01	0.0001	3	2	13	2
6.01	0.10	0.0010	4	3	14	2
5.83	0.08	0.0064	5	2	15	3
5.90	0.01	0.0010	6	1	16	3
5.91	0.00	0.0000	7	2	17	2
5.97	0.06	0.0036	8	2	18	2
5.97	0.06	0.0036	9	2	19	2
5.89	0.02	0.0004	10	1	20	1
$\bar{X}$ = 5.91		0.0235			Mean range:	2.00

σ = 0.05, C.V = 0.09, Irregularity = 11.05%

Table 3.1.8: 23tex yarn at the speed of 23,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X} \rvert$	Deviation² $\lvert X-\bar{X} \rvert^2$	Group	Range	Group	Range
6.20	0.15	0.0225	1	2	11	2
5.95	0.10	0.0100	2	2	12	3
5.90	0.15	0.0225	3	2	13	2
5.95	0.05	0.0025	4	2	14	3
6.10	0.05	0.0025	5	2	15	1
6.00	0.10	0.0100	6	2	16	2
5.95	0.10	0.0100	7	2	17	2
6.40	0.35	0.1225	8	2	18	2
6.05	0.00	0.0000	9	3	19	2
6.00	0.05	0.0025	10	2	20	2
$\bar{X}$ = 6.05		0.1950			Mean Range:	2.1

σ = 0.147, C.V = 2.43%, Irregularity = 11.27%

Table 3.1.9: 24tex yarn at the speed of 26,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
6.17	0.00	0.0000	1	2	11	2
6.08	0.09	0.0081	2	2	12	2
6.10	0.07	0.0049	3	2	13	2
5.98	0.19	0.0361	4	3	14	2
5.67	0.50	0.2500	5	2	15	2
6.13	0.04	0.0016	6	2	16	2
6.21	0.04	0.0016	7	2	17	2
6.21	0.04	0.0016	8	3	18	3
5.99	0.18	0.0324	9	2	19	3
5.40	0.77	0.5929	10	3	20	3
$\bar{X}$ = 6.17:		0.9436			Mean Range:	2.3

σ = 0.32, C.V = 5.25%, Irregularity = 12.10%

Table 3.1.10: 24tex yarn at the speed of 28,000rpm

(a) Values of X with their Deviations

Value X	Deviation $\|X-\bar{X}\|$	Deviation² $\|X-\bar{X}\|^2$
5.85	0.03	0.0009
5.85	0.03	0.0009
5.85	0.03	0.0009
6.05	0.23	0.0529
5.65	0.11	0.0289
5.85	0.03	0.0009
5.75	0.07	0.0049
5.85	0.03	0.0009
5.80	0.02	0.0004
5.65	0.17	0.0289
$\bar{X}$ = 6.13		0.1205

(b) Groups and their ranges

Group	Range	Group	Range
1	2	11	3
2	2	12	2
3	3	13	2
4	2	14	3
5	3	15	3
6	2	16	3
7	2	17	2
8	2	18	3
9	3	19	3
10	3	20	3
		Mean range:	2.55

σ = 0.116, C.V = 1.99%, Irregularity = 13.5%

Table 3.1.11: 28tex yarn at the speed of 17,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value	Deviation	Deviation²				
X	|X-X̄|	|X-X̄|²	Group	Range	Group	Range
6.90	0.02	0.0004	1	2	11	2
6.81	0.11	0.0121	2	3	12	3
6.92	0.00	0.0000	3	2	13	3
6.95	0.03	0.0009	4	2	14	2
6.94	0.02	0.0009	5	2	15	2
6.71	0.21	0.0441	6	3	16	2
6.78	0.14	0.0196	7	2	17	2
7.01	0.09	0.0081	8	2	18	3
6.99	0.03	0.0009	9	2	19	2
7.13	0.21	0.0441	10	3	20	2
X̄ = 6.92		0.1509			Mean range:	2.30

r = 0.13, C.V = 1.87, Irregularity = 10.80

Table 3.1.12: 28tex yarn at the speed of 20,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value	Deviation	Deviation²				
X	$\lvert X-\bar{X}\rvert$	$\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.00	0.05	0.0025	1	3	11	2
7.01	0.04	0.0016	2	2	12	2
6.94	0.11	0.0121	3	2	13	2
7.05	0.00	0.0000	4	2	14	3
7.10	0.05	0.0025	5	3	15	2
6.99	0.06	0.0036	6	3	16	3
7.09	0.04	0.0016	7	3	17	3
7.20	0.15	0.0225	8	2	18	2
6.98	0.07	0.0049	9	2	19	3
7.14	0.09	0.0081	10	3	20	2
$\bar{X}$ = 7.05		0.0594			Mean range	2.45

σ = 0.08, C.V = 1.15%, Irregularity = 11.28%

Table 3.1.13: 28tex yarn at the speed of 23,000rpm

(a) Values of X and their Deviations

Value X	Deviation $\|X-\bar{X}\|$	Deviation² $\|X-\bar{X}\|^2$
6.95	0.05	0.0025
6.70	0.20	0.0040
6.70	0.20	0.0040
6.70	0.20	0.0040
6.95	0.05	0.0025
6.95	0.05	0.0025
7.10	0.20	0.0040
7.05	0.15	0.0225
6.85	0.05	0.0025
7.10	0.20	0.0400
$\bar{X}$ = 6.90		0.2325

(b) Groups and their ranges

Group	Range	Group	Range
1	2	11	2
2	2	12	4
3	2	13	2
4	3	14	3
5	3	15	2
6	3	16	3
7	3	17	2
8	2	18	2
9	2	19	3
10	2	20	2
		Mean range:	2.45

σ = 0.161, C.V = 2.33%, Irregularity = 11.53%

Table 3.1.14: 28tex yarn at the speed of 26,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value	Deviation	Deviation²				
X	$\lvert X-\bar{X}\rvert$	$\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.05	0.02	0.0004	1	3	11	2
6.98	0.07	0.0049	2	3	12	3
6.99	0.06	0.0036	3	2	13	3
7.05	0.02	0.0004	4	3	14	3
7.04	0.01	0.0001	5	3	15	2
6.81	0.24	0.0484	6	2	16	2
7.03	0.00	0.0000	7	3	17	3
7.09	0.06	0.0036	8	3	18	3
6.79	0.24	0.0576	9	2	19	3
7.48	0.45	0.2025	10	3	20	3
$\bar{X}$ = 7.03		0.3215			Mean range	2.70

σ = 0.19, C.V = 2.69%, Irregularity = 12.47%

Table 3.1.15: 28tex yarn at the speed of 28,000rpm

(a) Values of X with their Deviations					(b) Groups and their ranges						
Value	:	Deviation:	Deviation²		:		:		:	
X	:	$\|X-\bar{X}\|$:	$\|X-\bar{X}\|^2$	Group	:	Range	:	Group	:	Range
7.25	:	0.14 :	0.0196	1	:	2	:	11	:	2
7.30	:	0.19 :	0.0361	2	:	2	:	12	:	2
6.85	:	0.26 :	0.0676	3	:	2	:	13	:	4
7.30	:	0.19 :	0.0361	4	:	3	:	14	:	3
7.35	:	0.24 :	0.0576	5	:	3	:	15	:	3
6.85	:	0.26 :	0.0676	6	:	3	:	16	:	2
6.90	:	0.21 :	0.0441	7	:	3	:	17	:	2
7.15	:	0.04 :	0.0016	8	:	3	:	18	:	2
7.00	:	0.11 :	0.0121	9	:	3	:	19	:	2
7.15	:	0.04 :	0.0016	10	:	3	:	20	:	3
$\bar{X}$ = 7.11:		:	0.3440		:		:	Mean range:	:	2.6

σ = 0.20, C.V = 2.81%, Irregularity = 11.87.

Table 3.1.16: 29tex yarn at the speed of 17,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\|X-\bar{X}\|$	Deviation² $\|X-\bar{X}\|^2$	Group	Range	Group	Range
7.21	0.02	0.0004	1	3	11	2
7.31	0.12	0.0144	2	3	12	2
7.29	0.10	0.0100	3	2	13	3
7.18	0.01	0.0001	4	3	14	3
7.21	0.02	0.0004	5	2	15	2
6.98	0.21	0.0441	6	3	16	2
7.19	0.00	0.0000	7	3	17	3
7.21	0.02	0.0004	8	2	18	3
6.98	0.21	0.0441	9	2	19	3
7.34	0.15	0.0225	10	2	20	2
$\bar{X}$ = 7.19		0.1360			Mean range:	2.5

σ = 0.12, C.V = 1.71%, Irregularity = 11.29%

Table 3.1.17: 29tex yarn at the speed of 20,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value	Deviation	Deviation²				
X	|X-X̄|	|X-X̄|²	Group	Range	Group	Range
7.31	0.03	0.0009	1	2	11	4
7.21	0.07	0.0049	2	3	12	3
6.99	0.29	0.0841	3	4	13	2
6.89	0.39	0.1521	4	3	14	2
7.21	0.07	0.0049	5	2	15	2
7.19	0.09	0.0081	6	3	16	2
7.28	0.00	0.0000	7	4	17	3
7.27	0.01	0.0001	8	2	18	4
7.26	0.02	0.0004	9	2	19	2
8.09	0.81	0.6561	10	3	20	2
$\bar{X}$ = 7.28		0.9116			Mean range	2.6

σ = 0.32, C.V = 4.37, Irregularity = 11.59%

Table 3.1.18: 29tex yarn at the speed of 23,000rpm

(a) Values of X with their Deviation			(b) Groups and their ranges			
Value X	Deviation $\|X-\bar{X}\|$	Deviation² $\|X-\bar{X}\|^2$	Group	Range	Group	Range
7.40	0.19	0.0361	1	2	11	2
7.45	0.24	0.0576	2	3	12	2
7.25	0.04	0.0016	3	2	13	2
7.40	0.19	0.0361	4	3	14	2
6.85	0.36	0.1296	5	3	15	2
7.15	0.06	0.0036	6	3	16	2
7.05	0.16	0.0256	7	3	17	2
7.08	0.21	0.0441	8	3	18	2
7.10	0.11	0.0121	9	2	19	3
7.40	0.19	0.0361	10	2	20	3
$\bar{X}$ = 7.21		0.3825			Mean range	2.4

σ = 0.21, C.V = 2.91%, Irregularity = 10.81

Table 3.1.19: 29tex yarn at the speed of 26,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.23	0.01	0.0001	1	4	11	3
7.19	0.03	0.0009	2	3	12	3
7.04	0.18	0.0324	3	2	13	4
8.01	0.79	0.6241	4	4	14	3
7.21	0.01	0.0001	5	2	15	2
7.19	0.03	0.0009	6	2	16	3
7.31	0.09	0.0081	7	2	17	4
7.41	0.19	0.0361	8	3	18	3
7.32	0.10	0.0010	9	4	19	2
6.29	0.93	0.8649	10	2	20	3
$\bar{X}$ = 7.22		1.5686			Mean range	2.7

σ = 0.42, CV = 5.78%, Irregularity = 12.14%

Table 3.1.20: 29tex yarn at the speed of 28,000rpm

(a) Values of X with their Deviations			Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.45	0.17	0.0289	1	3	11	2
7.20	0.08	0.0064	2	3	12	3
7.55	0.27	0.0729	3	3	13	3
7.15	0.13	0.0169	4	3	14	2
7.25	0.03	0.0009	5	3	15	3
7.25	0.03	0.0009	6	3	16	3
7.10	0.18	0.0324	7	2	17	3
7.45	0.17	0.0289	8	1	18	3
7.15	0.13	0.0169	9	3	19	3
7.25	0.03	0.0009	10	3	20	4
$\bar{X}$ = 7.28		0.2060			Mean range	2.8

σ = 0.15, C.V = 1.98%, Irregularity = 12.49

Table 3.1.21: 30tex yarn at the speed of 17,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.61	0.09	0.0081	1	4	11	2
7.77	0.25	0.0625	2	3	12	2
7.81	0.29	0.0841	3	2	13	3
6.99	0.53	0.2809	4	2	14	2
7.52	0.00	0.0000	5	3	15	2
7.24	0.28	0.0784	6	3	16	3
7.54	0.02	0.0004	7	2	17	3
6.99	0.53	0.2809	8	4	18	3
7.69	0.17	0.0289	9	3	19	2
8.01	0.59	0.3481	10	2	20	3
$\bar{X}$ = 7.52		1.1723			Mean range	2.65

σ = 0.36, C.V = 4.8%, Irregularity = 11.44%

Table 3.1.22: 30tex yarn at the speed of 20,000rpm

(a) Values of X with their Deviations ‖ (b) Groups and their ranges

Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.50	0.02	0.0004	1	4	11	3
7.51	0.03	0.0009	2	3	12	3
7.48	0.00	0.0000	3	2	13	2
7.31	0.17	0.0289	4	2	14	3
7.51	0.03	0.0009	5	3	15	2
6.99	0.49	0.2410	6	2	16	3
7.81	0.33	0.1089	7	4	17	3
7.62	0.14	0.0196	8	3	18	3
7.54	0.06	0.0036	9	3	19	2
7.53	0.05	0.0025	10	2	20	2
$\bar{X}$ = 7.48		0.4067			Mean range	2.7

σ = 0.21, C.V = 2.84%, Irregularity = 11.72%

Table 3.1.23: 30tex yarn at the speed of 23,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.45	0.06	0.0036	1	3	11	3
7.30	0.21	0.0441	2	3	12	3
7.45	0.06	0.0036	3	4	13	3
7.55	0.04	0.0016	4	3	14	4
7.60	0.09	0.0081	5	3	15	3
7.65	0.14	0.0196	6	2	16	2
7.80	0.29	0.0841	7	3	17	2
7.50	0.01	0.0001	8	3	18	4
7.45	0.06	0.0036	9	3	19	3
7.30	0.21	0.0441	10	3	20	2
$\bar{X}$ = 7.51		0.2125			Mean range	2.95

σ = 0.15, C.V = 2.00%, Irregularity = 12.75%

Table 3.1.24: 30tex yarn at the speed of 26,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value	Deviation	Deviation²				
X	$\lvert X-\bar{X}\rvert$	$\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
7.70	0.10	0.0010	1	3	11	3
7.21	0.39	0.1521	2	3	12	3
7.31	0.29	0.0841	3	3	13	2
7.61	0.01	0.0001	4	2	14	2
7.99	0.39	0.1521	5	3	15	3
8.01	0.41	0.1681	6	3	16	4
7.62	0.02	0.0004	7	4	17	4
7.91	0.31	0.0961	8	3	18	3
7.41	0.19	0.0361	9	2	19	3
7.23	0.37	0.1369	10	4	20	3
$\bar{X}$ = 7.60:		0.827			Mean range	3.00

σ = 0.30%, C.V = 3.99%, Irregularity = 12.82%

Table 3.1.25: 30tex yarn at the speed of 28,000rpm

(a) Values of X with their Deviations

Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$
7.45	0.03	0.0009
7.10	0.38	0.1444
7.75	0.27	0.0729
7.60	0.12	0.0144
7.40	0.08	0.0064
7.65	0.17	0.0289
7.20	0.28	0.0784
7.30	0.18	0.0324
7.65	0.17	0.0289
7.65	0.17	0.0289
$\bar{X}$ = 7.48		0.4346

(b) Groups and their ranges

Group	Range	Group	Range
1	3	11	4
2	3	12	2
3	2	13	2
4	4	14	3
5	2	15	2
6	4	16	3
7	3	17	3
8	3	18	4
9	3	19	4
10	3	20	3
		Mean range	3.0

σ = 0.22, C.V = 2.94%, Irregularity = 13.02%

Table 3.1.26: 40tex yarn at the speed of 17,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X} \rvert$	Deviation² $\lvert X-\bar{X} \rvert^2$	Group	Range	Group	Range
10.00	0.01	0.0001	1	3	11	3
10.01	0.00	0.0000	2	4	12	3
10.03	0.02	0.0004	3	3	13	4
9.96	0.05	0.0025	4	4	14	4
9.97	0.04	0.0016	5	3	15	3
9.98	0.03	0.0009	6	4	16	3
10.01	0.00	0.0000	7	4	17	4
10.00	0.01	0.0001	8	4	18	4
9.96	0.05	0.0025	9	4	19	4
10.18	0.17	0.0289	10	4	20	4
$\bar{X}$ = 10.01		0.0370			Mean range	3.65

σ = 0.06, C.V = 0.64%, Irregularity = 11.73%

Table 3.1.27: 40tex yarn at the speed of 20,000rpm

(a) Values of X with their Deviations			Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X} \rvert$	Deviation² $\lvert X-\bar{X} \rvert^2$	Group	Range	Group	Range
10.05	0.05	0.0025	1	5	11	4
9.96	0.04	0.0016	2	4	12	3
10.10	0.10	0.0100	3	4	13	4
10.10	0.10	0.0100	4	4	14	2
10.00	0.00	0.0000	5	3	15	4
10.21	0.21	0.0441	6	4	16	3
10.31	0.31	0.0961	7	4	17	4
9.69	0.31	0.0961	8	4	18	4
9.80	0.20	0.0400	9	3	19	4
9.78	0.22	0.0484	10	4	20	4
$\bar{X}$ = 10.00		0.3488			Mean range	3.75

σ = 0.20, CV = 1.97, Irregularity = 12.18%

Table 3.1.28: 40tex yarn at the speed of 23,000rpm

(a) Values of X with their Deviations

Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$
9.75	0.32	0.1024
9.65	0.23	0.0529
10.05	0.62	0.3844
9.10	0.33	0.1089
9.90	0.47	0.2209
9.35	0.08	0.0064
9.30	0.13	0.0169
9.30	0.13	0.0169
8.80	0.63	0.3969
9.10	0.33	0.1089
$\bar{X}$ = 9.43:		1.4091

(b) Groups and their ranges

Group	Range	Group	Range
1	2	11	3
2	4	12	4
3	4	13	3
4	2	14	4
5	4	15	3
6	4	16	3
7	4	17	4
8	5	18	4
9	3	19	4
10	4	20	3
		Mean range	3.6

σ = 0.40, C.V = 4.24%, Irregularity = 12.39

Table 3.1.29: 40tex yarn at the speed of 26,000rpm

(a) Values of X with their Deviations			(b) Groups and their ranges			
Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$	Group	Range	Group	Range
10.00	0.03	0.0009	1	4	11	4
10.10	0.13	0.0169	2	4	12	4
10.09	0.12	0.0144	3	5	13	3
9.91	0.06	0.0036	4	5	14	4
9.94	0.03	0.0009	5	6	15	4
9.86	0.11	0.0121	6	5	16	4
9.99	0.02	0.0004	7	5	17	4
9.96	0.01	0.0001	8	4	18	4
9.81	0.16	0.0256	9	3	19	4
10.04	0.07	0.0049	10	2	20	5
$\bar{X}$ = 9.97		0.0789			Mean range	3.90

σ = 0.09, C.V. 0.09%, Irregularity = 12.70%

Table 3.1.30: 40tex yarn at the speend of 28,000rpm

(a) Values of X with their Deviations

Value X	Deviation $\lvert X-\bar{X}\rvert$	Deviation² $\lvert X-\bar{X}\rvert^2$
9.55	0.04	0.0016
9.60	0.01	0.0001
9.25	0.34	0.1156
9.90	0.31	0.0961
9.40	0.19	0.0361
9.80	0.21	0.0441
9.60	0.01	0.0001
9.90	0.31	0.0961
9.70	0.11	0.0121
9.20	0.39	0.1521
$\bar{X}$ = 9.59		0.5540

(b) Groups and their ranges

Group	Range	Group	Range
1	4	11	4
2	4	12	4
3	3	13	4
4	5	14	6
5	4	15	5
6	4	16	4
7	3	17	3
8	3	18	3
9	4	19	3
10	4	20	3
		Mean range	4.00

σ = 0.25, C.V = 2.61%, Irregularity = 13.54

Table 3.2: Influence of speed on the irregularity of yarns at different counts

Yarn Counts (tex)	Irregularity Values (in percentage) at speeds of 17000 rpm	20,000 rmp	23,0000 rpm	26,000 rpm	28,000 rpm
23	10.35	11.00	13.26	10.91	12.40
24	10.91	11.05	11.27	12.10	13.50
28	10.80	11.28	11.53	12.47	11.87
29	11.29	11.59	10.81	12.14	12.49
30	11.44	11.72	12.75	12.62	13.02
40	11.73	12.18	12.39	12.70	13.54

Note: Method of linear regression was used to obtain the best fit line

Table 3.3: Results of Uster* analysis

Material speed (m/min): 400

Diagram speed (m/min): 25

Evaluation time (min): 1

Slot position : 4

Yarn count	Rotor speed (rpm)	$\bar{X}$ U%	Neps/1000m	Thin places /1000m	Thick places/ 1000m
23	23,000	14.76	537	24	257
23	28,000	13.69	546	7	278
24	23,000	12.89	469	4	260
24	28,000	13.08	490	6	255
28	23,000	12.50	585	13	250
28	28,000	13.72	527	11	250
29	23,000	13.09	506	7	244
29	28,000	12.60	531	7	234
30	23,000	14.15	632	27	302
30	28.000	14.32	673	29	312
40	23,000	14.58	661	25	320
40	28,000	13.96	647	22	303

* Uster Evenness tester used is from Funtua Textiles Ltd

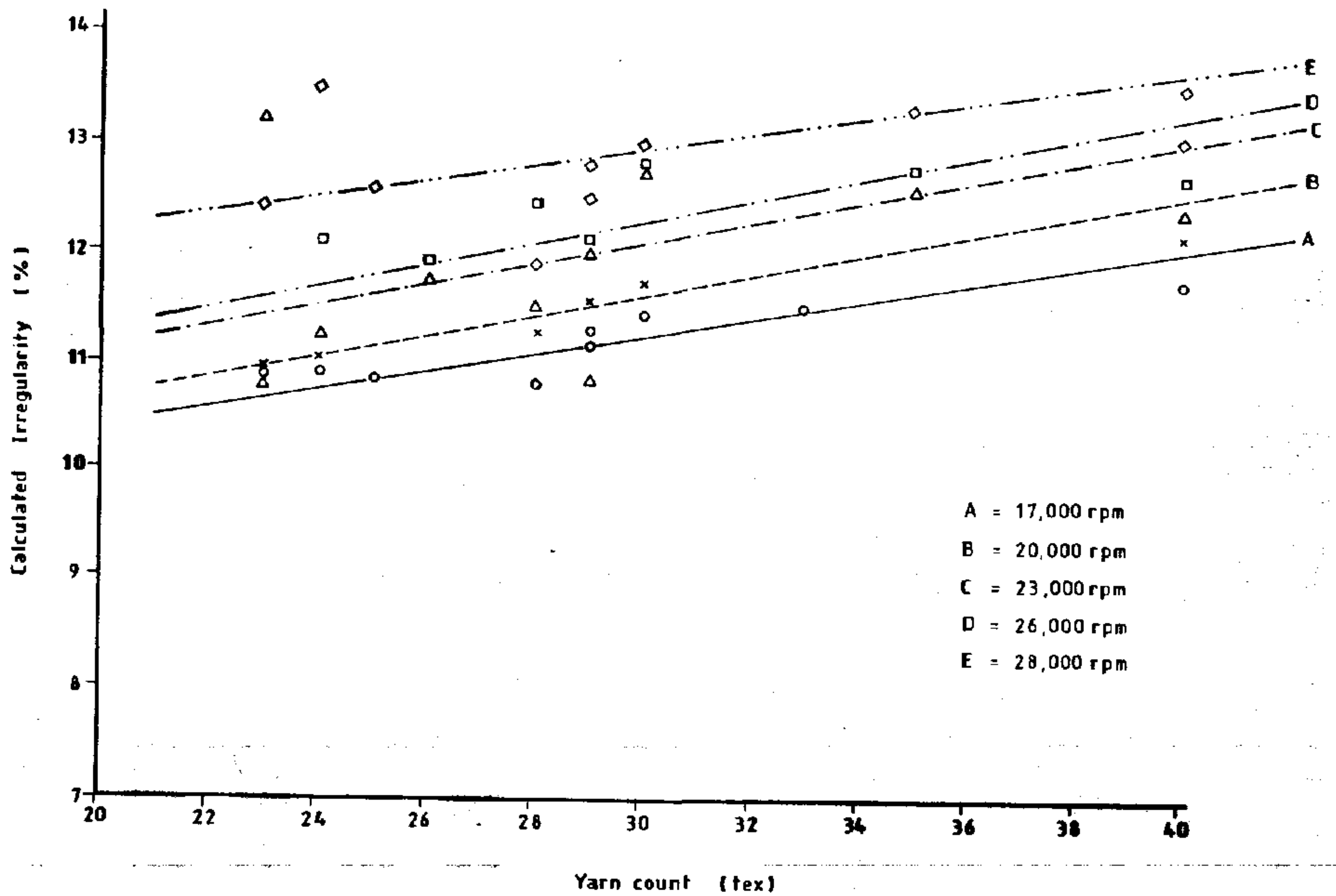


Fig. 3.1 **Calculated Irregularity Vs yarn count at different speeds.**

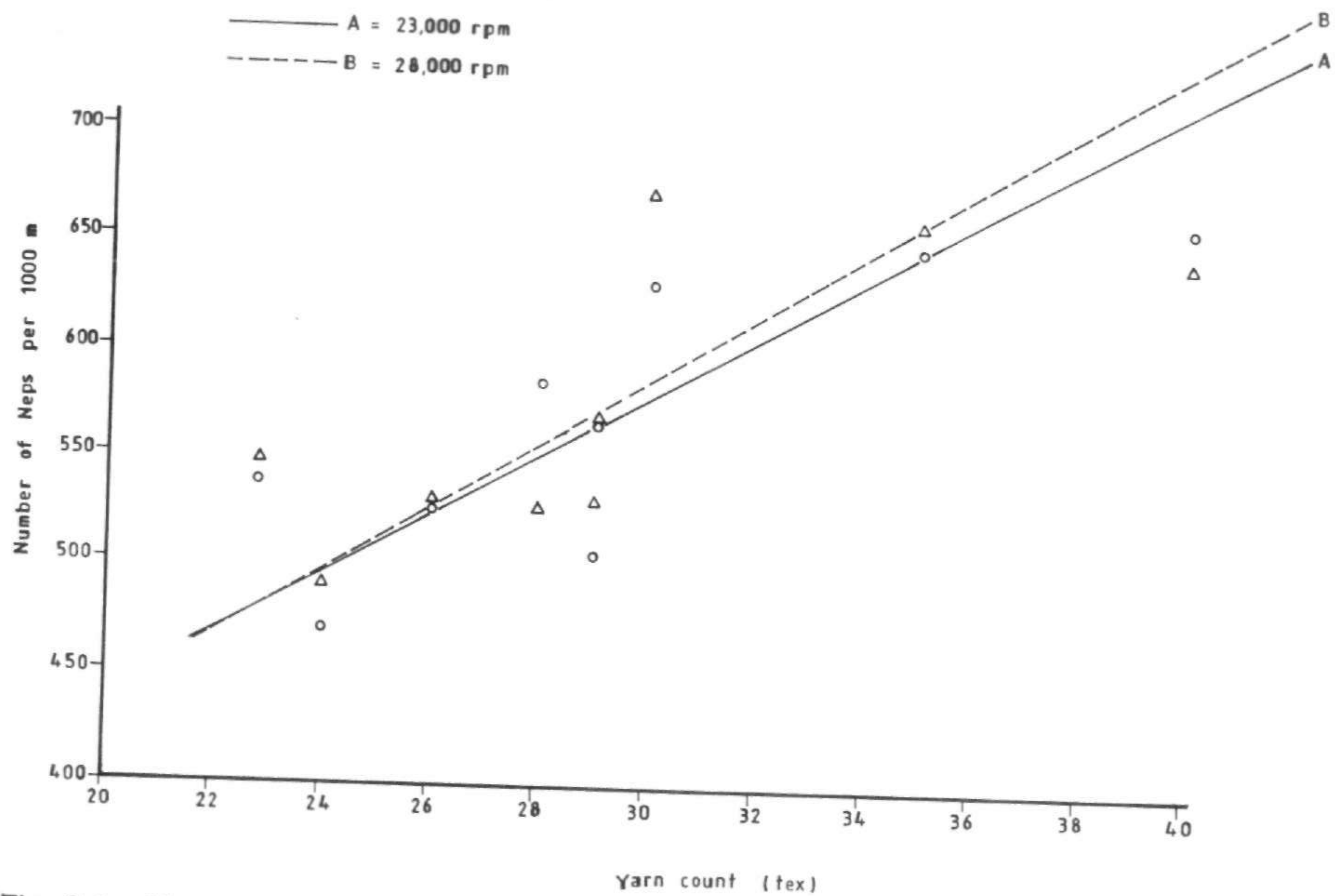


Fig. 3.2 **Number** of Neps per 1000 m Vs yarn count at different speeds.

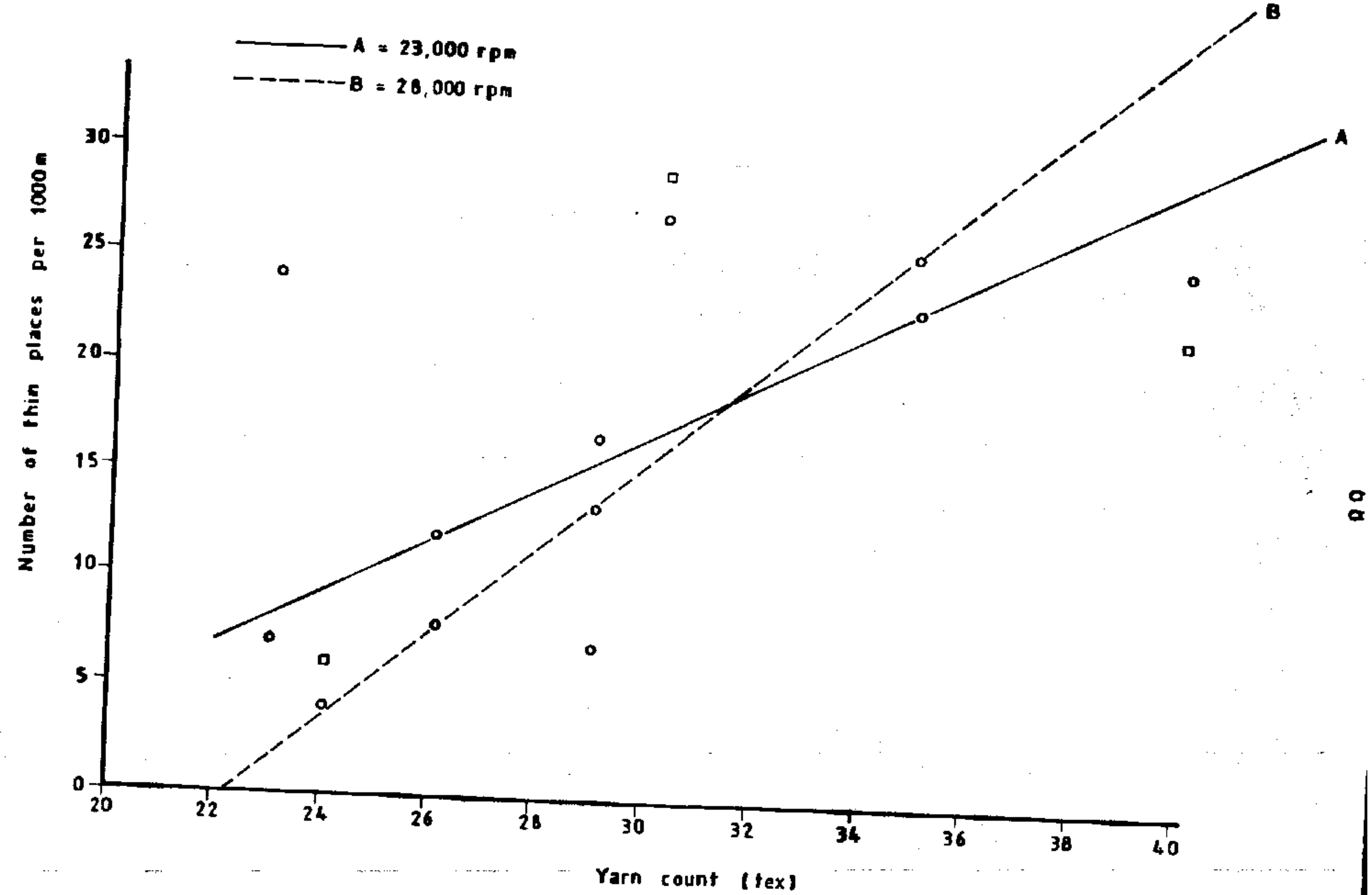


Fig. 3.3 Number of thin places per 1000m Vs yarn count at different

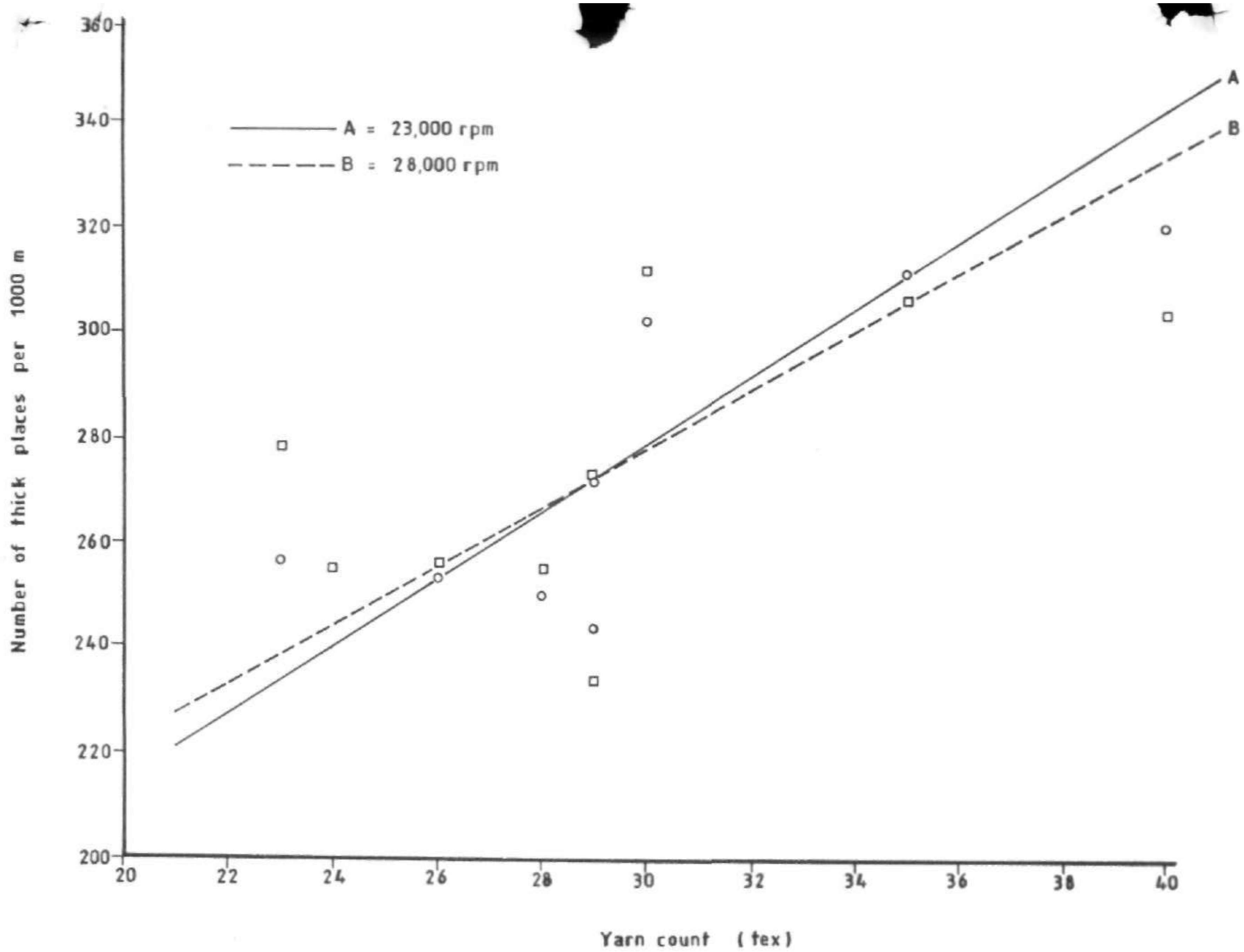


Fig. 3.4 Number of thick places per 1000 m Vs yarn count at different speeds.

3.2 DISCUSSION OF RESULTS

3.2.1 Effects of Increasing rotor speed on the Irregularity of rotor spun yarns

From the results in table 3.2 and figure 3.1, it can be seen that the level of irregularity of the yarns analysed increases as the rotor speed increases. This could be explained thus; as the rotor speed is increased, the feed roller speed also increases as can be seen in the appendix. The opening roller speed was kept constant at 6,000rpm throughout the spinning operation, this means that as the rotor speed increases, the size of tufts being flucked from the fed sliver by the combing roller increases. This leads to poor opening and cleaning actions being received by the fed-in material. Therefore, as the spinning (rotor) speed inccreases, the chances of separating the fed sliver into single fibre state needed for OE-spinning system decreases, therefore the level of irregularity increases.

R.J. Townsend[14] states that 'the most important property of a yarn is the number of fibres in a cross-section and the variation of this number along the yarn is the most fundamental measure of irregularity', and as discussed under the literature review, for OE-spinning there is a minimum number of fibres needed per cross-section of a yarn in order for the yarn to be successfully spun. The extent to which fibres can be arranged in a regular order in a yarn depends on the extent to which they can be made to float about as single fibre, hence, it can be seen that the observation made in this research that the irregularity of yarns increases a the rotor speed increases is in line with the theory of OE-spinning.

3.2.2 Effect of varying yarn count on the irregularity of OE-rotor yarns

From the results in table 3.2 and figure 3.1, it can be seen that the level of irregularity increases as the yarn count varies from fine to coarse values.

The appendix shows that as the count of the yarn (tex) increases, the feed rate increases accordingly, this means that the tufts of fibres being removed per unit time by the teeth of the combingroller increases accordingly since the opening roller speed was kept constant as discussed earlier. As the size of the tuft growns, the extent of cleaning and opening received by the tuft decreases, this means the fibres are being peeled-off and twisted into yarns in a more irregular order as the size of the tuft grows as a result of increase in yarn count (tex), therefore, the level of irregularity in the final yarns increases as the yarn count (tex) moves from fine to coarse values.

The irregularity in a yarn depends on the presence of thick and thin places and also on the amount of neps present in the yarn being analysed. Figs 3.2 to 3.4 show that as the yarn count moves from fine to coarse values, the number of neps, thick and thin places per 1000meter of yarn increase.

It was observed that the level of irregularity of the yarns analysed is low compared to irregularity values of similar counts reported in the literature. This could be attributed to the care taken to prepare the sliver and careful control of the machine during spinning operations.

3.3 Conclusions

It was intended through this research work to study the effect of increasing rotor speen on the irregularity of OE-rotor yarns. The effect of count variation on the irregularity of OE-rotor yarns was also studied.

Rotor yarns were spun on a BD 200 machine in the department of Textile Science & Technology, A.B.U, Zaria at different speeds and different counts, the irregularity was studied by cutting and weighing technique, Uster evenness tester at Funtua Textiles Limited was also used to analyse some of the spun yarns.

From the results of the analysis carried out, it can be concluded that increasing rotor speed leads to an increase in the level of irregularity of an OE-rotor yarn. Similarly as the yarn count (text) increases, the level of irregularity in the yarns increases.

3.4 Recommendations

It is recommended that the machine should be given a more permanent and stable foundation than it has now, because, it was observed that above the speed of 30,000rpm, the machine was vibrating. This itself could lead to false values on the parameters being analysed on the yarns spun from this machine if speeds higher than 30,000rpm are used.

It is also recommended that further work should be done to examine the effect of increasing rotor speed and count variation on other yarn properties such as strength, elongation, twist, etc.

APPENDIX I

DETAILS OF PROCESSING MACHINE

OE Rotor spinner	BD 200 ROTOR SPINNER
Rotor diameter	Internal = 5.55cm, External = 7.21cm
Rotor speeds	17,000; 20,000; 23,000; 26,000 and 28,000rpm.
Openning Roller type	FLAT LIN F3P
Opening Roller Speed	6,000rpm
Feed Roller diameter	2.50cm
Delivery Roller diameter	5.33cm
Sliver count	5.120Xtex
Yarn counts	23, 24, 28, 29, 30tex
Fibre length	27mm
Micronaire reading	5.2
No of clothing raws	11

The twist wheels required to give the drafts were obtained from a table in the machine mannual. The basic formulae for calculating the different parameters are as follows:-

$$\text{Draft} = \frac{\text{Sliver count (tex)}}{\text{Yarn count (tex)}}$$

$$\text{Twist (tpm)} = \frac{\text{Twist factor}}{\sqrt{\text{tex}}} \times 100$$

$$\text{Delivery rate (m/min)} = \frac{\text{Rotor speed}}{\text{twist (tpm)}}$$

$$\text{Feed rate (m/min)} = \frac{\text{Delivery rate}}{\text{Draft}}$$

Details for different calculations are as shown below:

Yarn count (tex)	Rotor speed x 1000rpm	Draft	Change Wheel: Upper	Change Wheel: Lower	Twist: per m (tpm)	Delivery rate (m/min)	Feed rate (m/min)
23	17	217.3	40	95	937.51	18.14	0.083
"	20	"	"	"	"	21.33	0.098
"	23	"	"	"	"	24.53	0.113
"	26	"	"	"	"	27.73	0.123
"	28	"	"	"	"	29.92	0.138
24	17	205.8	40	90	917.00	18.54	0.090
"	20	"	"	"	"	21.81	0.106
"	23	"	"	"	"	25.00	0.127
"	26	"	"	"	"	28.35	0.138
"	28	"	"	"	"	30.00	0.145
28	17	173.9	50	95	850.00	20.00	0.115

"	20	"	"	"	"	23.53	0.135
"	23	"	"	"	"	27.06	0.156
"	26	"	"	"	"	30.59	0.176
"	28	"	"	"	"	33.00	0.189
29	17	172.8	45	85	830.00	20.48	0.119
"	20	"	"	"	"	24.10	0.139
"	23	"	"	"	"	28.00	0.161
"	26	"	"	"	"	31.33	0.181
"	28	"	"	"	"	34.00	0.200
30	17	164.7	50	90	821.00	20.71	0.126
"	20	"	"	"	"	24.36	0.148
"	23	"	"	"	"	28.21	0.164
"	26	"	"	"	"	31.21	0.192
"	28	"	"	"	"	34.10	0.207
40	17	122.0	60	80	710.00	23.94	0.196
"	20	"	"	"	"	28.17	0.231
"	23	"	"	"	"	32.32	0.264
"	26	"	"	"	"	36.62	0.300
"	28	"	"	"	"	39.40	0.323

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