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DESIGN OF RING-TRAVELLOR SPINNING SYETEM WITH A SEPARATE WINDING ASSEMBLY

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BONAFIDE CERTIFICATE

Certified that this project report titled **DESIGN OF RING-TRAVELLOR SPINNING SYETEM WITH A SEPARATE WINDING ASSEMBLY** is the bonafide work of Mr. S.Santhos Kumar who carried out the research under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

In ring spinning, the spindle speed is limited to 25,000rpm and this is because of the travellor speed limitation (40m/sec) causing travellor heat up and burning out resulting in end breakage. To overcome this limitation, an attempt was made first to separate winding and twisting which are presently accomplished separately. This separation also reduces the stoppage of frame for doffing or it might also be eliminated totally.

The above limitation is analyzed using TRIZ Methodology, which is a method for solving inventive problems, where there is no obvious solution and where there is at least one major contradiction that appears to be irresolvable.

Using contradiction matrix and based on the above analysis, the possible solution sets were determined and the best suited principles identified were principles of segmentation, taking out, intermediary and replacement of system.

Using these principles the design alternatives were considered in the project namely an inverted spindle, spindle with groove, spindle with guide and hollow spindle with and without ring travellor twisting system. A separate yarn winding assembly was used with all designed modifications. Many slight alterations were experimented based on the results of the trials.

The trials were carried out in a ring doubler, as it was easier to carry out the trial. After the first trial (with a groove spindle) ,it was converted into short inverted spindle, next a guide was introduced on the top of the spindle, but all these

alterations proved that it is impossible to twist and wind using this method as all of these caused entanglements.

Then a hollow spindle was attempted where the spindle with a guide proved successful in producing yarn with separation of winding and twisting. The trial was also carried out by the elimination of ring and travellor using a hollow spindle with a guide. Alternatively a curved propeller was used in place of guide. Though the twist inserted was less compared to the calculated twist by 25-30%, the system proved to be an effective working system.

From the analysis and trials, it can be concluded that the twisting efficiency can be increased further, by optimizing the profile and design parameters of the hollow spindle, guide or the propellor.

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CHAPTER 1

INTRODUCTION

Ring spinning is the lone reference to high quality yarn suitable for any type of textile end product and any improvement in this system is expected to improve the economy of the spinning industry. A number of yarn spinning systems such as self-twist spinning, wrap-spun yarns, fasciated yarns, composite yarns, twistless spinning, pot spinning, continuously felted yarns; and in open-end spinning such as rotor, electrostatic, friction spinning, and vortex spinning were used of which some are commercially available.

The above systems enjoy much higher production speed than the traditional ring spinning, as they are restricted to only narrow ranges of textile products by virtue of their technological limitations. At the same time, there were continued developments in ring spinning, with ventures into rotating ring and travellor systems, individual spindle drives, high draft systems, modified travellors, double roving spinning, and hybrid systems. Also the profile and metallurgical components of ring-travellor has much improved.

With the perspective of the number of installed spindles, ring spinning is still the most dominant spinning system.

The ring spinning technology has remained largely unchanged for many years, but significant refinements such as combination of spinning frame and winding, automatic doffing, introduction of splicing, reduction in ring size for higher speeds etc. offered only slight advantages.

These combinations meant that the potential maximum speed of ring spinning was raised from about 15,000 to 25,000 revolutions per minute.

The primary technological limitation of ring spinning lies in the ring-travellor system. In this regard, three specific issues must be addressed to overcome this limitation:

(i) The dependence of the yarn linear speed i.e. delivery speed on the rotational speed of travellor

(ii) The continuous need to stabilize yarn tension during spinning and the dependence of this stability on the travellor speed, and

(iii) The impact of travellor speed on fibre behavior in the spinning triangle.

Research in these areas has been practically exhausted with the results being slight improvement in the ring/travellor system to allow an increase in travellor speed by about 20% without affecting the travellor/ring contact thermal load capacity. This increase still puts ring spinning at a production rate disadvantage of 15 to 20 times in comparison with other spinning systems. Therefore, the challenging issue is how to break the traditional paradigm of ring spinning and revolutionize its principle in such a way that very high speed can be achieved without sacrificing the traditional reference quality of ring spinning.

As indicated above, the primary limitation of ring spinning lies in the ring/travellor system. Yarn formation takes place due to twisting imparted by the rotation of the travellor. Therefore, twisting speed is to be increased at the same time keeping the travellor linear speed within the limit of 40m/sec.This proposed work aims at this very objective through a truly revolutionized innovative idea.

In order to obtain the above objective, the limitations of the ring spinning system are studied using TRIZ Methodology. TRIZ is the Russian acronym for the "Solving of Inventive Problems", is a method for solving inventive problems where there is no obvious solution and where there is at least one major contradiction that appears to be irresolvable. It is a method for solving technical problems based upon studies of the world's most inventive patents [about 2 Million patents]. A huge number of patents were studied and the "Principles of Invention" (i.e., essence of ideas in inventions) was extracted and a procedural method was devised to think of such inventions (called "Algorithm of Inventive Problem Solving").

Based on the results of the above analysis, the current Ring-Travellor system of spinning are to be modified so as to covert it into a Twisting-Winding system wherein the twisting zone and the winding zone will be separated there by increasing the spindle speed and the size of the winding package, which will increase the production as well as reduce the doffing time.

1.1 CONCEPTS AND TECHNOLOGIES

1.1.1 Concept of Ring Spinning (J.shaw)

The Ring spinning machine was invented in the year 1828 by the American Throp. In 1830, another American, Jenk, contributed the travellor rotating on the ring. Nearly after two centuries, this machine has a considerable modification, but the basic concept has remained unchanged.

The ring spinning machine is designed to:

- Attenuate the roving until the required fineness is achieved
- To impact strength to the fiber strand by twisting it
- To wind up the resulting yarn in a forms suitable for storage, transportation and further processing.

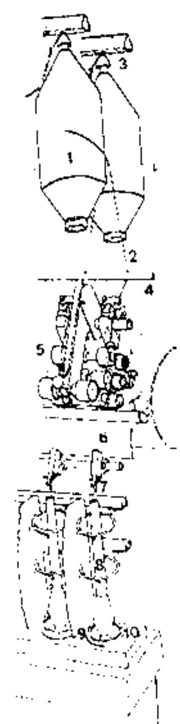


Figure1.1 Ring Spinning

Design and Operation

Roving bobbins (1) are creeled in appropriate holders (3). Guide rails (4) lead the rovings (2) into the drafting arrangement (5) which attenuates them to the final count. The drafting arrangement is inclined at an angle of about 45-60^0. It is one of the most assemblies on the machine since it has considerable influence on the irregularities in the yarn.

Upon leaving the front rollers, the emerging fine fiber strand (6) receives the turns of twist needed to give strength. This twist is generated by the spindle, which rotates at high speed. Each revolution of the spindle imparts one twist to the strand.

1.1.2 Concept and Working of Centrifugal Spinning

The centrifugal spinning frame (Eric Oxtoby,1987) differs from the described spinning frames by the design of the twisting-and-building motion, allowing a considerable increase in spinning speed.

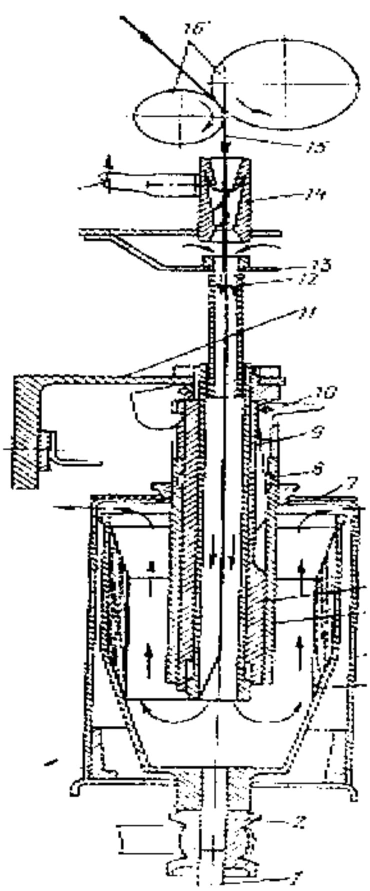
Design and Operation:

The centrifuge is a pot 3 made of light metal. It is rigidly fixed on the spindle blade 1. The spindle and centrifuge are rotated with a speed of 15 000-20 000 rpm by means of the block 2 rigidly fixed on the spindle blade.

The centrifuge is closed by the housing 4 and cover 7 made of transparent acrylic plastic which protects the centrifuge against damage.

A pipe traverse 9 is introduced strictly along its central line into the centrifuge. The traverse is attached to the winding plate 11 and together with it reciprocates vertically. Inserted into the traverse 9 is the pipe 12 suspended via a flange from the holder 13 under the web suction pipe 14. The inside surfaces of pipes 9 and 12 have a, mirror polish ensuring an easy passage of the thread.

Figure 1.2 Centrifugal Spinning



The web suction pipe serves for the initial strengthening of the web 15, coming from the delivery pair 16. Condensing is obtained by twisting the web by an air jet which is supplied under pressure along the pipe 17 from the central air duct by a rubber hose. The web, introduced into the pipe 14 and condensed by twisting is entrapped by air and drawn into the pipe 12, then further into the pipe 9 and into the centrifuge 3. At the entry into the centrifuge, air is rarefied and 'emerges from it through the holes provided in the walls of the housing 4.The thread entering into the rapidly rotating centrifuge is ejected to its wall by centrifugal force and pressed against it so that it is put in rotation around its own axis. On each rotation around its axis the thread is imparted one twist. The thread rotational speed around its axis is less than that of the centrifuge 3 by the number of revolutions which are necessary for complete spreading (winding) the yarn delivered per minute on the centrifuge wall.

Condition of Twisting:

Therefore, the first condition for the twisting and winding of yarn at centrifugal spinning is determined by the equation

$$n_t = n_c - n_w$$

$$n_t = n_c - \frac{v_w}{\pi d_w}$$

$$n_t = n_c - \frac{v_d \; K_t}{\pi d_w}$$

n_t, n_w - rotational speed (rpm) of twisting and winding, respectively; n_c- rotational speed of centrifuge, rpm; v_d, v_w_speed of delivery rollers and winding speed, m/min; K_t-take-up factor, d_w-winding diameter, m.

In the present case, the rotational speed necessary for twisting increases with the winding diameter.

Winding Operation:

The spreading of coils in centrifuge height is ensured by the reciprocation of the traverse 9. For shifting one layer in relation to the other, the traverse moves down over a certain distance with each consecutive layer. The plate 11 and traverse 9 are driven from the builder motion the design of which is in principle the same as in ring spinning frames.

The yarn is removed from the centrifuge on the completion of its winding on the paper bobbin 5 which is retained by the spring 8 on the holder 6 fixed on the traverse 9. The bobbin is easily removed from the holder by pressing the lever 10.

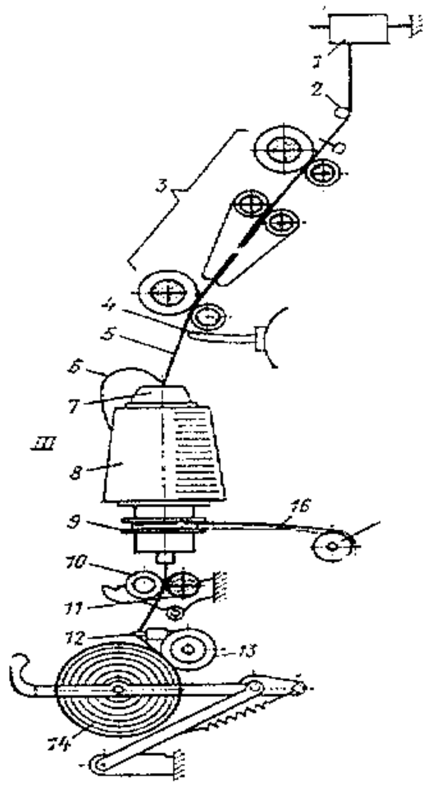
After spreading the last layer in the centrifuge, the winding plate 11 lowers on the centrifuge coyer, and the bobbin holder, moving down over 10 mm, grasps the thread with its lug. The drafting system is disengaged from operation and the machine passes to reduced speed (2/3 of the working speed) and winding of yarn on the paper bobbin 5 is started.

Upon the completion of winding, the plate is brought into top position, full packages are doffed and empty bobbins are creeled for the new doff. Centrifugal spinning frames have not yet found practical use in wool spinning.

1.1.3 Concept and Working of Hollow Spindle Spinning (Lipenkov)

The production of twisted yarn (in two ends) is usually carried out consecutively in three frames: spinning, doubling and twisting. The obtained packages of twisted yarn are of a comparatively small mass, and for this reason when prepared for weaving, yarn is wound into bobbins to increase the mass of packages.

Figure 1.3 Hollow Spindle Spinning



Design and Operation:

The consecutive operations in twisted yarn production on the Hollow spindle spinning frame are as follows.

The roving threads unwinding under tension from the bobbin 1 run around the smooth rod 2 and passing through the thread guide are brought into the two-apron drafting system 3.

The drafting system delivers a strand from which the spun yarn is formed. The latter passes above the hole of the nozzle 4 of the open end collector and is directed into the canal of the hollow spindle 7 carrying a tightly fitted package 8 with the twisted-in thread. This thread may be of man-made fibers, cotton or wool and may be produced on a conventional spinning frame. The spun yarn is pieced up to the end of the twisted-in yarn and they are together inserted in the hole of the hollow spindle. After passing the spindle, they are grasped and drawn outside by the drawing-off rollers 10 and 11. The roller 10 is pressed to the roller 11 so that the speed of dragging the yarns through the spindle hole is equal to the circumferential speed of these rollers.

The drawing-off rollers 10 and 11 deliver a twisted yarn which is directed by traverse 12 and cross wound on the cylindrical bobbin 14. Cross winding is obtained by the rotation imparted to the bobbin on its friction against the roller 13 and to the reciprocation of the traverse guide 12. The hollow spindle together with the package of the twisted-in yarn is rotated with a speed up to 8000 rpm by disks through the tape 16 and whorl 9. The guiding rollers 15 serve at the same time as tension rollers. In the result of the rotation of the twisted-in yarn 6 relative the spun yarn 5, there is a mutual spatial curving of these yarn axes relative to the common axis of the motion of two yarns in the spindle hole.

Owing to the spatial bending of the two yarns, at which the twisted in yarn turns around the axis of the spun yarn, the two component yarns are twisted simultaneously with the twisting of the spun yarn component rotating around its proper axis.

The yarn to be twisted-in from the bobbin is inserted in the spindle hole with a flexible hook, while the strand coming from the drafting system is pieced-up to' the end of the twisted-in yarn.

Condition of Twisting:

The twisting organ of this frame is a hollow spindle 3 carrying the package 4 with twisted-in yarn or man-made thread. The essence of spindle operation is in that the ballooned twisted-in yarn 5 unwound from the rotating package enters in tight contact 6 with the spun yarn7 at the apex of the hollow spindle and bringing it in rotation imparts it one turn for each spindle rotation. At the same time, the ballooned twisted-in yarn which is spatially bent relative to the spun yarn turns around its axis, and as a result it is twisted and forms the twisted yarn 2 which is continuously drawn away by the delivery rollers 1. at a speed close to that of the delivery rollers 8 of the drafting system 9.

The twist of the twisted yarn K is composed of two components: K_S-twist inserted by the rotation of the spindle with the package and K_U-twist obtained by the unwinding of the twisted-in yarn from the package.

$$K = K_s + K_u\ ;$$

$$K_s = \frac{n_s}{v_d};\ Ku = \frac{n_u}{v_d} = \frac{n_u}{l_c n_u} = \frac{1}{l_c} = \frac{1}{\frac{\pi d_x}{\cos\alpha}} = \frac{\cos\alpha}{\pi d_x}$$

Therefore

$$K = \frac{n_s}{v_d} + \frac{\cos\alpha}{\pi d_x}$$

where, n_s-rotational speed of spindle, rpm; v_d-speed of twisted yarn delivery, m/min;

n_u- number of unwound coils per minute; l_c-length of unwound coil; d_x-package diameter;

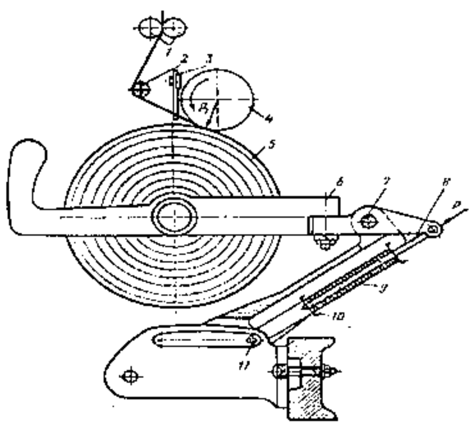
α - angle of twisted-in yarn spreading on the bobbin.

The twist from spindle rotation and twist from coil unwinding must be directed in the same sense, as otherwise the air flow will negatively influence the ballooned yarn.

Usually, the twist from unwinding is neglected and the total twist is calculated by the formula

$$K = \frac{n_s}{v_d}$$

Figure 1.4 Builder motion



Winding Operation

Winding of twisted yarn on the spinning-and-twisting frame is effected on 45mm diameter paper tubes into cylindrical bobbins. The diameter of the bobbin is 200 mm, its width 85 mm and the mass of the yarn on the bobbin is up to 1400 g. Twisted yarn emerging from the delivery pair 1, runs around the rod 2 and is guided by the thread-guide 3 to the bobbin 5 which is constantly pressed to the winding drum 4 by the bobbin holder 6 by the spring 9.

The winding drum rotating at a preset speed puts the bobbin in rotation by friction. A cross winding of yarn at an angle of 22-32° between the intersecting yarns is obtained by the rotation of the bobbin com pined with the reciprocation of the thread guide.

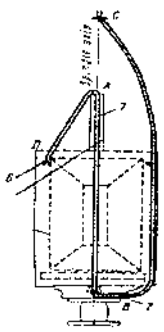
Progressively with an increase in the bobbin diameter, the bobbin holder 6 turns around the shaft 7 while the rod 8 and clip 10 turning around the shaft 11 compress the spring 9. The effort of the spring P increases while the force of bobbin pressure against the winding drum P_1 increases slightly owing to the corresponding rotation of the bobbin holder 6 and rod 8.

1.1.4 Concept of Two-for-One Twister

The combination of the twisting and winding processes limits the increase of spindle rotation and of the size of bobbins, so that the machine and labour productivity of the ring twisters cannot be materially increased.

In TFO, twisting and winding are carried out separately by different working organs, and the rotating spindle does not carry the package mass. All this creates condition for the efficient use of double twisters as compared to ring twisters.

Design and Operation



The bobbin 4 with doubled yarn is fixed on the rod of spindle 5. The doubled yarn, unwound by the thread guide 6 passes into the spindle hole 7 and next into the hole 2 of the compensator pulley 1. Emerging from the hole 2 it passes through the thread-guide 8, the feeler 9 and the tension roller 10 after which by means of the thread guide 11 and drum 12 it is cross wound on the bobbin 13.

Figure1.5 Principle

Condition of Twisting

Twist is imparted to the yarn by the rotation of the compensating pulley 1. For each revolution of the pulley, the yarn passing through the Figure 2.1.6: Twisting principle pulley hole receives its first twist in the portion *AB* and its second twist in the portion *BC.*

Thus, if the rotational speed of the spindle (pulley) is equal to n_s the speed of yarn passage through the spindle hole or the speed of its winding on the bobbin v_w, then the yarn twist on the double twister is determined by the formula,

$$K = 2\frac{n_s}{v_w}$$

i.e.for each spindle rotation the yarn is imparted two twists (for this reason the machine is called a double twister).

In the path of the yarn from the supply to the delivery package in the double twisting system, the yarn is subjected to tension in four points, which changes depending on different factors. In the portion AD tension is modified depending on the position of the point of unwinding on the package, its type and diameter, the rotational speed of the unwinding device and its mass.

The tension in the spindle hole (portion AB) is adjusted by a special braking arrangement of the capsule type located in the spindle cavity.

CHAPTER 2

LITERATURE REVIEW

2.1 RING SPINNING THEORY (Debarr AE & Catling)

2.1.1 Balloon theory and dynamics:

Balloon formation

If drafting roller is stationary, angular velocity of the travellor would be same as that of spindle and each revolution of spindle would cause one turn of twist to be inserted in the loop of yarn between roll nip and travellor. Since yarn is continually issuing from drafting rolls, angular velocity of travellor is less than that of spindle by an amount that is just sufficient to allow the yarn to be wound on to bobbin at the same rate of issuing of drafting rolls. Loop of yarn between thread guide and package is rotated at an angular velocity about the spindle axis. Portion of yarn between the package and travellor is constrained to remain straight, but the yarn between thread guide and travellor balloons outwards as a result of rotation. Basic balloon shape is such that vertical component of tension remains constant while horizontal component varies with radius i.e. tension on either side of yarn increases as the square of radius.

Finite balloon formed only when there is some mechanism for maintaining tension in yarn.

Tension in yarn is determined by energy consideration and when tension has been fixed in this way, the length of the yarn in the balloon and the shape of balloon are fixed such that tension in yarn provides necessary centripetal force on the element of yarn. When air drag is taken into account, the tension in yarn is not entirely independent of balloon shape; the actual balloon shape is thus one that is consistent with tension in yarn. Tension in yarn that is moving along its length means that work is being done, the only forces that can give rise to tension in yarn are those that are doing work i.e. tension is caused by centrifugal force as it just merely balances the tension already in yarn. Main source of tension in yarn is friction between ring and traveler, but air drag on yarn also contributes. The resistance of air to the movement of yarn through it is usually regarded as being proportional to the square of the velocity of the yarn relative to air. It will be assumed here that the air drag on any element of yarn is proportional to the square of the velocity of that element. The primary effect of the resistance offered by the air to the movement of yarn is that work must be done to rotate each movement of yarn i.e. each element must therefore be acted upon by a force with a moment about the axis i.e. with a tangential component, which provided only by tension in yarn.

YARN TENSION IN RING SPINNING:

The winding tension

At first sight it might appear that the length of yarn between travellor and package lie in straight line, and also T_U and T_w will be equal but neither is correct.

Factors to be considered with the weight of yarn are air-drag and the velocity of yarn along its length. The yarn has mass; a centripetal force is required on each element of yarn in order that it shall continue to rotate. To overcome the effect of normal air drag, there must be, on each element of yarn, a net tangential force in the direction of rotation i.e. the moment of tangential component of tension must increase from the travellor to the package. In the transition from a radius of R to R_1 the kinetic energy of rotation of each element of yarn is decreased. Each element of yarn is acted upon by a tangential force in the direction opposite to that of rotation. The moment about the axis of the tangential component of tension must decrease from the travellor to package and in order to provide this force the yarn must take up the form as shown in figure.

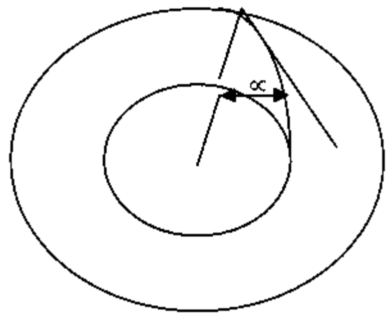


Figure 2.1 Yarn take-up

Yarn tension in the presence of air drag

In the absence of air-drag, the yarn between thread guide and travellor lies in a vertical plane rotating with travellor and no work is required to keep the yarn rotating. One effect of air drag is that a force is necessary on each element of yarn to overcome the resistance of air and there must now be a tangential component of tension in the yarn in the balloon. T_U is greater and must do work against both air drag and ring travellor friction as these two are not independent i.e. increase in T_U leads to a reduction in normal reaction between ring and travellor, S, and thus to a reduction in frictional force between ring and travellor. Air drag and ring travellor-friction the two together enabling the winding tension necessary for the production of a firm package. An increase in air drag allows ring traveler friction to be reduced by allowing a lighter traveler to be used to produce the same winding tension and reduces wear on the ring. The variation of air drag with balloon height and of winding tension with package radius means that the tension in the yarn is varying continuously throughout the build of package.

2.1.2 FRICTION IN RING SPINNING:

Ring- travellor friction

μ is co-efficient of friction between ring and traveler and this co-efficient is not constant

$\mu = 0.1 + 0.52/C$

for convenience in calculation

$$\mu = 0.1 + \frac{0.41}{\underset{\text{in inches}}{\text{ring radius}} * \underset{\text{in gms}}{\text{travellor weight}} * n^2}$$

Yarn- travellor friction

$$\mathbf{a} = \frac{1}{2 - 0.4\sin\alpha}$$

a practically varies between 0.5 and 0.95

-although the change in tension in yarn, as it passes travellor can be expressed in terms of μ_1,an apparent coefficient of friction between yarn and travellor and of η_1 the angle of wrap of yarn around the travellor, it is convenient to consider a ratio, a ,of the tensions on each side of traveler .

$$a = \exp(-\eta_1\mu_1) = T_T/T_U$$

2.1.3 ROLE OF AIR-DRAG IN RING SPINNING:

The effect of air drag on maximum spindle speed

Air drag enables stable single balloons to be formed with smaller values of P than would be possible without it. In practical ring spinning, it is usually necessary to avoid formation of necked balloons and there is considerable interest in the critical minimum value of P or more particularly in the maximum usable value of H/P.

$$(H/P)_{max} = b$$

Determination of maximum permissible spindle speed for a given specific tension in yarn or alternatively to determine minimum specific tension for a given spindle speed using the equations below

$$(\omega H)_{max} = b\sqrt{(T_0/m)}$$

$$(nH)_{max} = 94.6\ b\sqrt{(T_0/N)}$$

If the tension is less, or the spindle speed is greater than the theoretical values, a stable balloon cannot be formed. If at given spindle speed, the tension is reduced or the balloon height is increased, a point is reached, at which a balloon collapses and a neck is formed. Spinning tension decreases as the diameter of the package increases during the build of bobbin, so that the balloon collapse is most likely to occur when the yarn is winding onto the full diameter of the package .Balloon collapse occur due to the longest balloon and also the tension in the yarn increases as the balloon height increases.

Effect of air drag on balloon diameter

Maximum radius of balloon is given by

$$\frac{r_{max}}{P} = 2\sin(\theta_0/2)$$

The maximum balloon radius is independent of both spindle speed and balloon height i.e. maximum balloon radius increases as the balloon height decreases or as spindle speed increases.

Balloon collapse

It is most likely to occur when the yarn is winding on to a full diameter of the package with longest balloon. Spinning frames with balloon height constant, the collapse occurs when the tension has its minimum value and if made to vary it is more complicated. A reduction in balloon height at the greatest winding angle leads directly to a reduction in tension, which is more likely to effect balloon collapse. Balloon shape is independent of spindle speed and that change of spindle speed will not lead to balloon collapse.

2.1.4 TWIST INSERTION:

Twist is produced by the rotation of the travellor about the spindle axis .The amount of twist inserted into the yarn is determined by the number of revolutions made by travellor while unit length of yarn is delivered from drafting roll.

Actual turns per unit length = nominal turns per unit length $-1/2\pi R_1$

Nominal turns per unit length is equal to the ratio of spindle speed to yarn delivery speed. Twist is actually inserted into a region between the thread guide and travellor, the yarn between the front roller and the thread guide and that wound on to the package is also twisted. The important difference is that twist passes the travellor in same direction as the yarn while across the thread guide the yarn and twist are moving in opposite directions. The twist in the yarn in the balloon must be greater than that in yarn between front rolls and thread guide or in the yarn as it is wound onto package. Under steady state conditions the rate at which twist passes the travellor must be equal to the rate at which twist inserted in balloon zone. If the length of yarn in balloon changes then twist in yarn to be wound onto package also varies. The average twist of yarn wound during the ascent of ring rail is greater than equilibrium twist and as such descent of ring rail imparts less than equilibrium twist. Most end breaks occur in the material just issuing from the rolls and the rate of breakage is dependent upon the twist in the yarn between thread guide and roller nip because the twist in this zone is always greater than the equilibrium twist in the yarn on the package so that the strength of yarn here is normally greater than expected.

2.1.5 END -BREAKAGE:

The effect on end breakage, rate of changes in yarn strength and irregularity, mean tension, amplitude and frequency of tension variations and angle of lead are all to be considered. (also practical considerations such as bad piecing or slubs). The rate of increase of end breakage rate is due to decrease in minimum angle of lead, and increase in spindle speed. With yarn being wound onto the package with the twist calculated from the above equation, but with more than that of this amount of twist in the yarn is the balloon.

Winding Operation:

The travellor slides on the inside flange of the ring. When the travellor gets its power from the spindle via the yarn, the friction between the ring and travellor causes the travellor to lag behind the spindle. The difference in speed between spindle and travellor causes the yarn to wind on the package and the difference in speed adjusts itself automatically as required.

2.2 TRIZ Methodology

TRIZ, pronounced "trees", is an abbreviation for the Russian acronym "Solving of Inventive Problems". It is a method for solving inventive problems where there is no obvious solution and where there is at least one major contradiction that appears to be irresolvable.

2.2.1 Recognition of Technology

On the basis of the analysis of a huge number of patents, TRIZ has established new views of the whole system of technology as follows:

(1) Technology oriented: Oriented neither towards abstractness of academic science/technology nor towards concreteness of industrial technologies, but oriented towards both abstractness and concreteness as a new approach to technology. This has created a new stance for abstractness necessary for industry.

(2) Laws and trends of evolution of technical systems: Established from the analysis of history of evolution of technical systems. The law of evolution of technical systems towards the increase of ideality was revealed, where the ideality is defined qualitatively by "principal function / (mass + size + energy)".

(3) A hierarchical search system from target functions to technical means: Science and technology usually state their findings in the scheme of "experimental conditions ==> (natural laws) ==> resultant effects". On the other hand, technology applications want to find appropriate means for realizing the target functions. Since this requirement has the direction opposite to the statements of laws in science and technology, the search is often very difficult. TRIZ has developed a hierarchical representation system for the technological functional targets, analyzed and accumulated known means for realizing such functional

targets, and thus established a knowledge base stated in the format of "target function ==> technological means".

(4) "Principles of Invention": 40 principles of invention were established. They include 40 principles, such as "division", "separation", "local properties", etc., and many of the principles have two, three sub-principles. Multiple examples of application for each principle are also accumulated for illustration.

2.2.2 Methodology for Problem Solving

The original purpose of TRIZ development was to establish a methodology for creative problem solving. On the basis of the recognition of technology stated above, TRIZ has succeeded in establishing a new system of methodology which has much exceeded the level of "know-how to invent".

(5) "Basic Model": The basic model for problem solving in TRIZ is illustrated in the following figure.

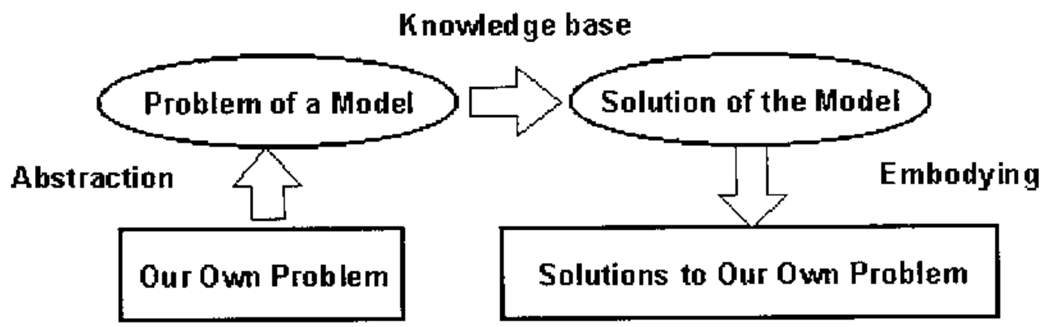


Figure 2.2 Basic Model of TRIZ

Trying to solve our own problems individually and concretely is rather difficult and often guides us to trial-and-errors. Thus, it is advised to utilize a collection of models (or templates) of problem solving, which were studied and accumulated beforehand. We first try to make our problem abstract into the problem in an appropriate model. Then the known solutions of the model are applied to our case to find some appropriate concrete solutions to our own problem.

(6) "Technical Contradictions [TC]": TRIZ has established a form of representing the essence of problems, i.e., technical contradictions, and provided a table of useful hints to solutions. Technical contradictions are the cases where if we try to improve an aspect (or a parameter) of the system, some other aspect becomes intolerably worse. In order to represent the situations of technical contradictions, TRIZ has selected 39 parameters of systems and has provided a problem matrix of size 39 x 39. Then, by surveying a huge number of patents, each patent was analyzed to find which type (among 39 x 39) of technical contradiction it treated and which principle of invention (among 40) it used in its solution. Accumulation of this analysis has revealed which principles were most used in each of the 39 x 39 types of problems. The top 4 principles in each type of problem were recorded in a tabular form of 39 x 39 elements; the resultant table is called "Altshuller's Contradiction Matrix". This is an incredible research achievement established in TRIZ.

For using this matrix, one has to think of which matrix element his/her problem should be assigned to and then has to consider about the four principles of inventions suggested by the matrix as the hints, so as to realize them into a solution to his/her own problem. For using these hints, capability of flexible thinking is needed.

(7) "Physical Contradictions & Separation Principles": TRIZ has defined the concept of "Physical Contradictions" and revealed the "Separation Principles" to solve such contradictions. Physical Contradictions are the cases where two mutually-opposite requirements to one aspect of a technical system need to be fulfilled at the same time. The situations like this are contradictory and absolutely impossible to solve, in our ordinary sense. On the contrary, however, TRIZ advises to reformulate the problems into the form of Physical Contradictions and then has demonstrated that they can readily be solved with "Separation Principles". By closer analysis of the apparently-opposite, simultaneous requirements, those requirements may be found separable in time, in space, or in

some other conditions. Then under such separate conditions, the system may simply satisfy the opposite conditions separately. This method is called Separation Principles.

(8) TRIZ has developed a problem-solving procedure where we first analyze the problems to formulate a Technical Contradiction, and then reformulate it with several steps into a Physical Contradiction, and finally solve it with Separation Principles. This procedure is called ARIZ (Algorithm of Inventive Problem Solving).It involves

Step 1: Analysis of the problem.

Step 2: Analysis of the problem's model.

Step 3: Formulation of the Ideal Final Result.

Step 4: Utilization of outside substances and field resources.

Step 5: Utilization of informational data bank.

Step 6: Change or reformulate the problem.

Step 7: Analysis of the method that removed the physical contradiction.

Step 8: Utilization of found solution.

Step 9: Analysis of steps that lead to the solution.

(9) A functional analysis method, named "Substance-Field Analysis" has been developed. And then useful solutions for various cases of the Substance-Field Model have been accumulated and concentrated into "76 Inventive Standard Solutions."

2.2.3 An Overall View

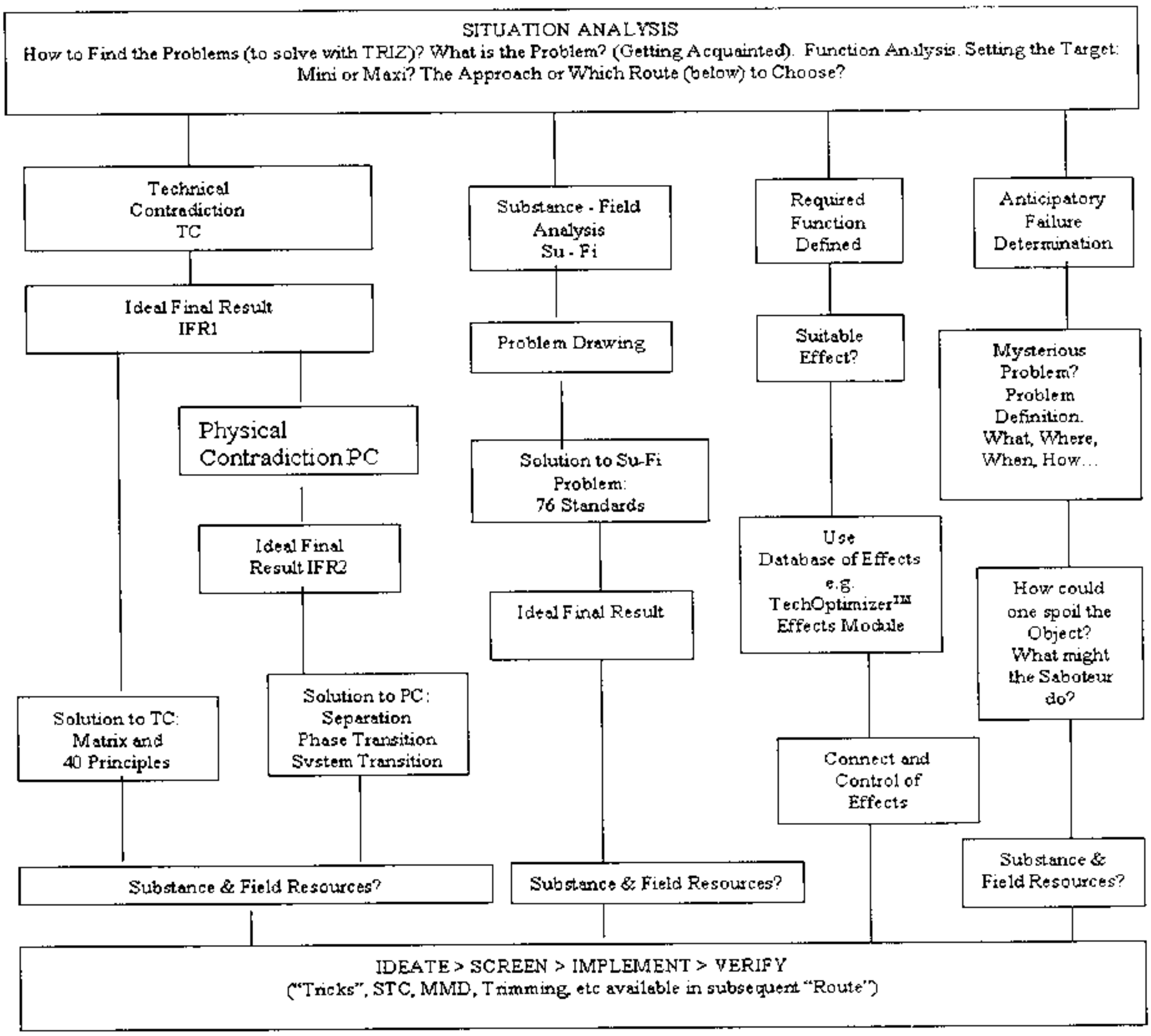


TABLE 2.1 TRIZ – An Overall View

The Table 1.1 shows an overall view where one can concentrate their thoughts on the "right" methodology or theory route (Principle: Segmentation). Maybe they will find it not possible to solve the problem through the route they have chosen. One can always choose the other one (Principle: Reject and regenerate), or even if successful, to check the outcome the other ways round or may also use the most advanced methods available for the Route (Principles: Nesting and Partial or excessive action).

2.2.4 40 Inventive Principles

Table 2.2 40 Inventive Principles

Principle No	Principle	Principle No	Principle
1	Segmentation	21	Skipping
2	Taking out	22	"Blessing in disguise" or "Turn Lemons into Lemonade"
3	Local quality	23	Feedback
4	Asymmetry	24	'Intermediary'
5	Merging	25	Self-service
6	Universality	26	Copying
7	"Nested doll"	27	Cheap short-living objects
8	Anti-weight	28	Mechanics substitution
9	Preliminary anti-action	29	Pneumatics and hydraulics
10	Preliminary action	30	Flexible shells and thin films
11	Beforehand cushioning	31	Porous materials
12	Equipotentiality	32	Color changes
13	'The other way round'	33	Homogeneity
14	Spheroidality - Curvature	34	Discarding and recovering
15	Dynamics	35	Parameter changes
16	Partial or excessive actions	36	Phase transitions
17	Another dimension	37	Thermal expansion
18	Mechanical vibration	38	Strong oxidants
19	Periodic action	39	Inert atmosphere
20	Continuity of useful action	40	Composite materials

2.2.5 TRIZ Advantages

TRIZ has the following advantages over traditional innovation supporting methods:

- Marked increase in creative productivity.
- Rapid acceleration in the search for inventive and innovative solutions.
- Scientifically founded approach to the forecasting of the evolution of technological systems, products and processes.

2.2.6 Application fields of TRIZ

The full potential of TRIZ can be utilized for the following tasks and application fields:

- Conceptual development of new products, processes und business strategies.
- Forecasting of the evolution of technological systems, products and processes.
- Inventive and technical problem solving.
- Comprehensive search for solutions and protection of company expertise with patent 'fences'.
- Evaluation of the hidden wants and needs of the customer; customer-driven market segmentation.
- Anticipatory failure identification and troubleshooting of new and existing products.
- Advanced solutions for idea and knowledge management.

2.2.7 TRIZ - Conclusion

So the conclusion of all about this is that the TRIZ methodology for solving inventive problems, as described above with its four groups Analysis, Analogy, Vision and Knowledge, is a never ending cycle, which is being renewed again and again like the four seasons of a year. With the understanding of this cycle it is able to describe not only the patterns of evolution of each product (system, organization, etc.,) but also how to optimize existing products and also develop absolutely new products. So this know-how about this cycle makes it easier to work with the TRIZ-methodology for getting new ideas.

2.3 Designs already proposed for Increasing Spindle Speed

The following are some of the designs proposed to increase the spindle speed. These designs are worth mentioning in this project.

2.3.1 The "Super - Travellor" System

In 1999, the first trials using a totally new type of ring spinning were conducted successfully in Russia, using the "super-travellor" technology. With this technology, for the first time ever, a ring using a rolling travellor replaced the old ring system using a gliding travellor.

Thereby (by spreading out the travellor friction) the question of increasing the travellor speed up to more than 100 m/sec. is solved, as are the questions of lowering the break rate and enlarging the range of workable yarn counts.

Working Principle

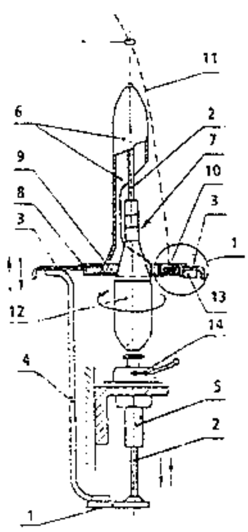


Figure 2.3 Super Travellor System

In order to apply the "super-traveler" system the spinning machine is equipped with a lover Table (1) with vertical axles (2) The lower table (I) is united with the traditional ring bank(3) using vertical bars(4). The axle (2) goes through the hollow spindle (5) (as on spindles widely used today), without touching it. On the top of the axle there is a plastic cap (6). The cap has a hole, "window", (7) so that yarn ends can be reached easily after breaks. The outer ring (9) is fastened onto the cap (6). The traveler (10) is circular in shape and placed in the groove formed between the outer and inner ring touches the traveler, turns below the inner ring and is wound onto the package (12). Bellow the ring bank there is a special cap spindles is fixed a special device (14) for quickly repairing yarn breaks.

2.3.2 Ring spinner with a tubular balloon limit shrouding

This system is patented under the name "Ring spinner with a tubular balloon limit shrouding uses a reduced traveler mass and an increased spindle drive speed for increased productivity without additional attachments [Pat. No. DE19848752]" by Rieter AG Maschf.

Working

The ring spinner has spinning stations with a spindle drive (20'), a ring (12) and a traveler (14) and a surrounding balloon limit shrouding (16). The ring spinner has spinning stations with a spindle drive (20'), a ring (12) and a traveler (14) and a surrounding balloon limit shrouding (16) The spindle rotary speed or the traveler speed are set to give the required yarn count number from a published comparative table in Braecker Handbook December 31, 1995, section 2.10 World of Performance According to the comparative table figures, the traveler mass is reduced by a divisor S' to lf)crease the speed of the spindle drive (20') by a factor S.

The S value is 1.0-2.5 and especially 1.5-2.5. With a ring (12) diameter of 35-55 mm, the mass of the traveler (14) is up to 50 mg. The spindle drive (20') can operate at a speed up to 40000 rpm.The shrouding (16) is a tube mounted on the ring frame (13), with) an inner diameter equal to or larger than the ring (12) diameter or the shrouding (16) is a coil of wire, concentric to the spindle. The ring (12) is a T-shaped or angled flange ring. An Independent claim is included for the operation of a ring spinner with an increased spindle drive speed and a reduced traveler mass. Preferred Features: A yarn with a count number of 100-30 is produced using a ring diameter of 36-42 mm and a travellor mass of 5-15 mg, with a spindle drive speed of 40000-30000 rpm.

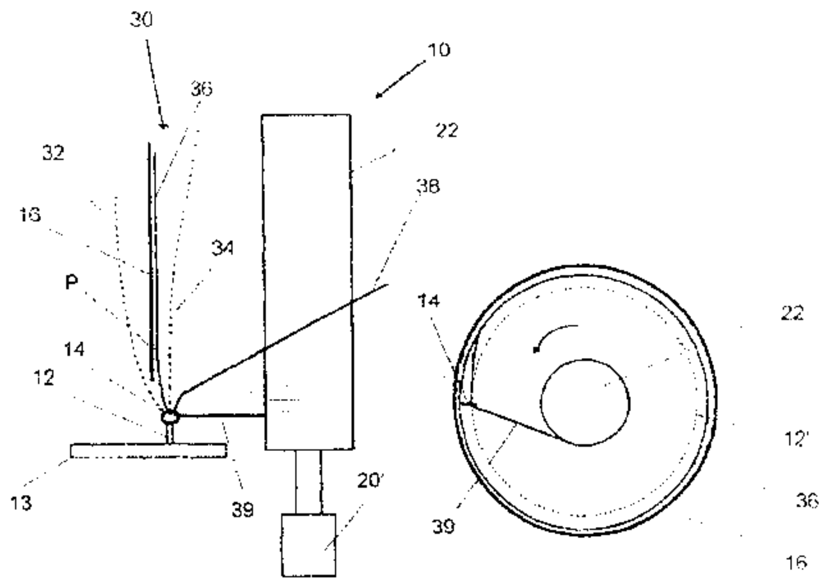


Figure 2.4 Ring Spinner with Balloon limit Shrouding

A yarn with a count number of 30-60 is produced using a ring diameter of 40-50 mm and a traveler mass of 15-50 mg, with a spindle drive speed of up to 30000 rpm. The yarn (30) is laid as a coil (36) at the inner wall of the shrouding (16). Only a short yarn length is at a free tension between the traveler (14) and the laying point (P) at the shrouding (16).

2.3.3 Magnetic Ring Spinning

Research into travellors has been practically exhausted with the result being only a slight increase in speed, leaving ring spinning at a production rate disadvantage of 15-20 times as compared with other spinning systems. Therefore, the challenging issue is how to revolutionize ring spinning in such a way that very high speed can be achieved without sacrificing the expected quality. This invention aims at that very objective through a truly revolutionary and innovative approach.

Figure 2.5 Magnetic Ring

The design approach, in this project, is to replace the travellor with a magnetically suspended light weight annular disc that rotates in a carefully pre-defined magnetic field. This will result in a super high spinning rotation that is robust against all the traditional limitations of the current travellor system.

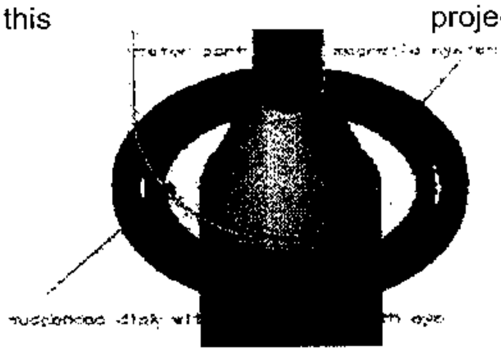


Figure 2.6 Magnetic ring spinning

The idea here is to create a non-touching environment of the rotating element of spinning system. The general concept underlying the proposed magnetic spinning is illustrated in Figure 1.12.

CHAPTER 3

THEME

3. OBJECTIVE & METHODOLOGY

3.1 Objective

1. To develop an improved spinning method, in which winding of yarn into a package will be separated from yarn twisting (formation) of ring / travellor and spindle.

2. To demonstrate the concept using working model/prototype.

3. To conduct performance study of the new system.

3.2 Methodology

- Analysis of the limitations of the Ring Traveller Spinning system.
- Application of TRIZ Methodology on the above limitations to develop alternate efficient spinning system.
- Designing of design alternatives for twisting mechanism.
- Fabrication of making models based on design alternatives.
- Trial running of the working models to select the suitable design.

3.3 ANALYSIS OF RING SPINNING TECHNIQUE

3.3.1 Analysis of Limitations of Ring Spinning

The parameters that mainly influence the production of the ring spinning machine are,

- Spindle Speed
- Travellor Speed
- Ring Diameter
- Package Diameter
- Lift

These parameters which influence the production rate, are interrelated. So these parameters are analyzed to arrive at an objective.

Travellor imparts twist to fibre strand to make it a yarn, spindle winds the yarn. Travellor is not driven, spindle is driven and the energy flows from spindle to travellor through yarn.

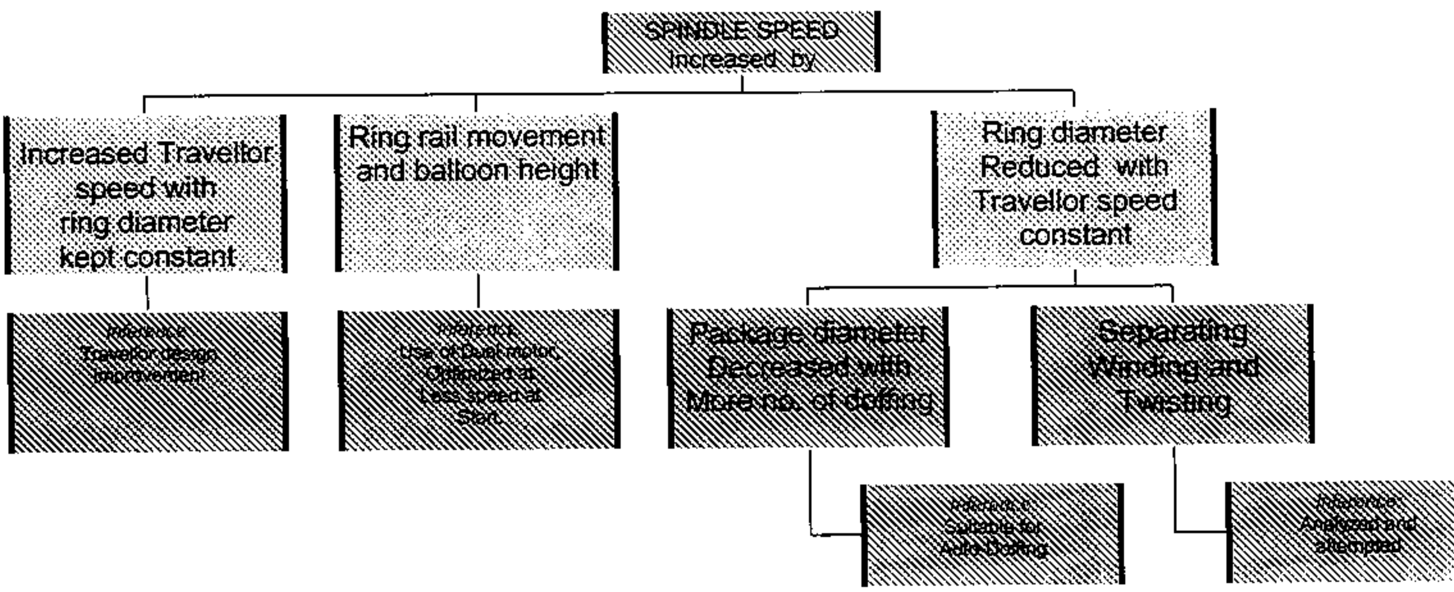


Figure 3.1 Analysis towards objective

3.3.2 Application of TRIZ on the Limitation of Ring Spinning

Problem

The system is the ring-spinning machine. The system consists of the spinning elements and the accessories for assisting the spinning elements. The fibers or filaments are given twist to form the yarn. The yarn passes through the travellor and gets wound on the package. The travellor goes around the ring inserting twist in the yarn, and there by the yarn being formed. Energy flows to the travellor from the power driven spindle through the yarn, which is a weak link in the process.

The problem lies in the fact that the speed of the spindle is, Textile technologically, restricted to about 25,000 rpm, mainly due to friction between the ring and travellor and yarn tension, which restricts the speed of the travellor [velocity of 40m/s] on the ring-spinning machine. If the speed is increased above 25,000 rpm the heat generated due to friction burns the travellor and the system collapses. The system has to be improved to get higher spindle speeds there by having higher production.

The machine stoppage during doffing increases the breakage rate and the machine's idle time thereby reducing the efficiency of the machine. This is due to the fact that the package size is restricted by the diameter of the ring and this diameter is restricted by the travellor velocity. The system has to be modified in such a way that the winding package is separated, or totally eliminated, from the twisting mechanism.

Contradiction Present in the System

The first contradiction present in this system is a technical contradiction. The contradiction here is that if the speed of the spindle is increased, which in turn increases the speed of the travellor, generating heat as the friction increases which in turn wears the travellor.

The other contradiction is the Ring diameter, if the ring diameter is increased to increase the package size; the velocity of the travellor increases there by wearing it out or else the no. of revolutions of the spindle has to be reduced which reduces the production rate.

The former contradiction can be transformed into a physical contradiction, which is that if there should be friction present so that the yarn is wound on the package but it should not be present as it would heat up the travellor and wear it out.

The latter contradiction is also a physical contradiction, which is that if the ring diameter is increased the travellor burns out and if the ring diameter is reduced the package size is reduced which increases the frequency of doffs.

Larger package needs longer lift, which increases the balloon height and hence yarn tension. This is the third contradiction.

Ideality

The ideal solution for this system would be that the yarn is formed at a high spindle speed say 100,000 rpm, which means high production and the yarn having excellent properties. Also, size of the package, which is to be wound independent of the spindle, is increased, which means less no. of breakages and doffs leading to better production and higher machine efficiency.

The ideal final result can be achieved by reducing the Ring diameter which keeps the friction between the ring and the travellor within the optimum even after the increase in the spindle speed and by separating the winding mechanism from the twisting zone which increases the package size.

Levels of Innovation

To find out which level of innovation this system is in at present, various factors of the levels of innovation was considered.

- There are a lot of trial and error tests conducted.
- There exists a strong sharp technical contradiction.
- The scope of knowledge applied so far is with the same field and from different fields.
- There was strong characteristic change in the system.
- There is a considerable impact on the knowledge of science.

After considering the above factors the system can be rated to lie between level 3 and level 4.

Innovative System Questionnaire

The innovative system questionnaire gathers information about the system, such as system name, primary function, system environment, available resources, about previous attempts, various criteria's and some information about the problem situation.

Contradiction Matrix

The contradiction present in this system is a technical contradiction. The contradiction matrix can be used to resolve the contradiction.

Using the contradiction matrix there were about 6 parameters which most suited the contradiction. They were;

- Speed [9]
- Productivity [39]
- Duration of Action of Moving Object [15]
- Temperature [17]
- Force [10]
- Object Generated Harmful Factors [31]

Using the contradiction matrix the possible solution sets were determined and the best possible suited principles were the principles "Segmentation [1]", "Taking out [2]", "The other way round [13], and "Intermediary [24]".

The principle "Segmentation [1]" says to divide an object into independent parts or increase the degree of fragmentation/ segmentation. The principle "Taking out [2]" separates an interfering part or property from an object, or single out the only necessary part (or property) of an object.

The principle "The other way round [13]" inverts the action(s) used to solve the problem or make movable parts (or the external environment) fixed, and fixed parts movable) or turn the object (or process) 'upside down'. The principle "Intermediary [24]" deals in using an intermediary carrier article or intermediary process and merging one object temporarily with another (which can be easily removed).

3.4 DESIGN OF ALTERNATIVE TWISTING SYSTEM

3.4.1 Spindle Design Alterations

Two design alternatives were designed, to separate the twisting and winding processes.

They are solid spindle and hollow spindle with a number of minor variations as given below

1. Solid spindle

   With travellor

   - Inverted spindle.
   - Grooved spindle.

   With out travellor

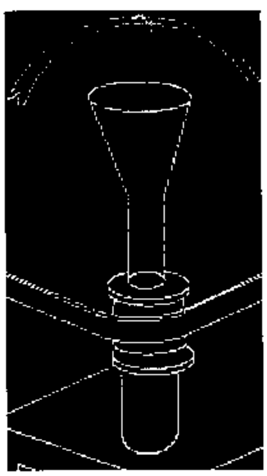
   - Spindle with guide.

2. Hollow spindle

   - Hollow spindle. (with and without travellor)

3. Hollow spindle with curved propeller.

3.4.1.1 Inverted Spindle

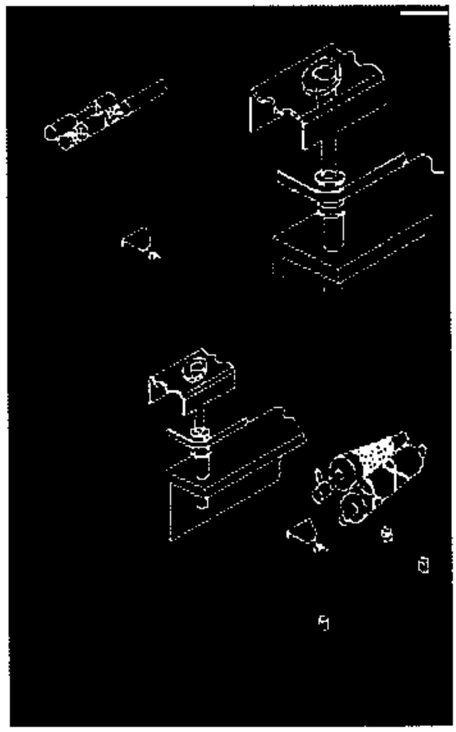


The regular ring frame spindle was modified by taking the taper of the spindle in the opposite direction. This alteration was done to facilitate the movement of yarn with minimum resistance.

Figure 3.1

Design Feature:

Material passage:



The yarn from the front roller is taken through the thread guide and passed on to the spindle via the travellor. The yarn makes 1 1/2 revolutions around the spindle and is taken out via the thread guide fixed on the ring rail.

To equal the take-up rate with that of the front roller delivery, the yarn is passed through the front roller of the next assembly is the opposite direction.

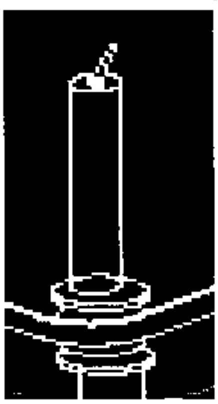
Figure 3.2

Alterations made:

Based on the trial run results, the long inverted spindle was converted to short inverted spindle such that the spindle top is below the ring.

Since it could not drive the travellor, a guide was provided on the spindle head. This guide facilitated the movement of the travellor over the ring.

3.4.1.2 Spindle with guide:



The yarn from the front roller is directly taken through the guide and let to the delivery roller but the result was that no

Figure 3.3

effective twist insertion as the yarn slips through guide and also entanglement due to yarn passage direction through guide.

3.4.1.3 Grooved spindle

As the yarn delivered from the drafting roll it is wound two to three revolutions over the groove of the spindle and has to be with drawn at the bottom of the spindle but yarn gets wounded at the top of the spindle.

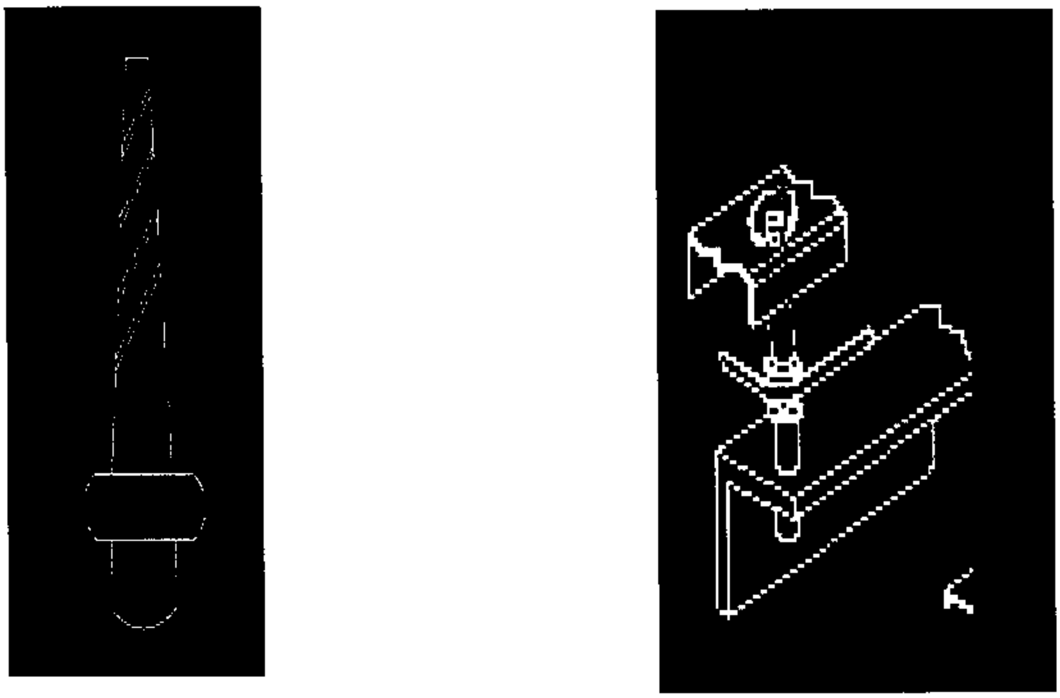


Figure 3.4

3.4.1.4 Hollow Spindle System

This is, the final design alteration, based on the hollow spindle spinning. Preliminary trials showed that the principle can work very well since then, this design was studied in detail.

3.4.2 Prototype of Selected Twisting-Winding System

The design, i.e., the hollow spindle system has been selected as a suitable working model.

Design feature:

For ease of manufacturing an opening roller of a rotor spinning machine was used as the spindle after turning off the pins. A hole of 4 mm was drilled in the center of the spindle. Ceramic guides are inserted on both the ends of the hole to prevent any damage to the yarn. A thread guide is placed on top, offset from the center. The length of the guide used is such that it is smaller than the ring diameter.

The hollow spindle is inserted into the hollow spindle bolster which has 2 bearings within it. This bolster is fixed to the ring frame using a 32 mm nut. The hollow spindle is clamped with a circlip below the bolster to prevent it from flying out to centrifugal force.

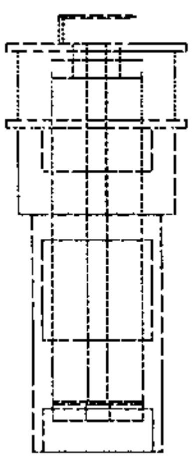
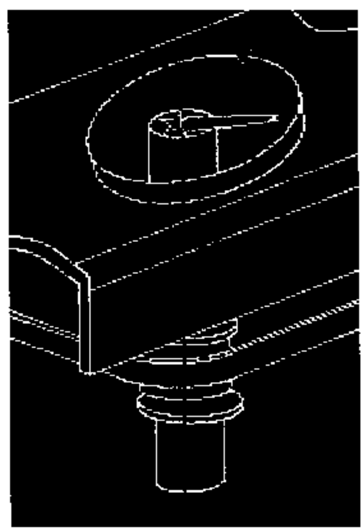


Figure3.5: (a) Opening roll modified into a Hollow Spindle



(b) Material passage through Hollow Spindle

Material passage:

The yarn from the front roller is passed through the lappet guide to the travellor. From here it enters the hollow spindle via the thread guide. The yarn is taken out from bottom fixed winding assembly fitted below the hollow spindle.

3.4.3 Take-Up and winding Assembly:

The Take-up and winding assembly should meet the following conditions met:

- The take-up rate is made less by 35-40 % to that of the delivery rate, considering the contraction and also lower withdrawal speed confirms the twist insertion.
- The take-up nip must be in line with the center of axis of the hollow spindle.
- The nip must be as close as possible to the spindle.
- The tension guide is used to control the contraction and also to help in traversing during winding over the package along with the winding drum.

The drive to the take-up assembly is taken from the front roller. The drive is transferred through chain, sprocket and then through tape driven to the winding drum.

CHAPTER 4

CONCLUSION

4.1 TRIALS NAND OBSERVATIONS

DEMONSTRATION:

Doubling frame is used because attempt was made first to separate traditional winding and twisting, so for separation and to study the twist level (coloured yarn used) this machine was preferred. Also it is similar to ring spinning with bigger ring-travellor and long spindle (compared to ring frame spindle), with slow speed it is easier to work with and also to fix the winding assembly.

4.1.1 Trials

All the trials in this project were conducted on the Ring Doubler so as to confirm the insertion of twist rates. The machine was run at drag speeds to observe the process.

The observations of the trial runs are summarized below:

Table 4.1: Summary of Trials and Observations

Trial No.	Mechanism Used	Observations	Remarks
1a.	Long inverted spindle	Entanglement on top part of the spindle.	The spindle was converted into short spindle.
1b.	Short inverted spindle	No power transmission to the travellor.	A guide was introduced on top of the spindle.
1c.	Short inverted spindle with guide	Travellor rotates but the yarn entangles and	Inferenced that this

		winds around the spindle.	model could not be used for twisting.
2.	Grooved spindle	Entanglement on top part of the spindle.	A spindle of uniform diameter with a guide at top was used.
3.	Spindle with guide	Entangles at the guide portion with the spindle top.	Spindle with hollow at the centre was used.
4.a	Hollow spindle	No entanglements. No power transmission to the travellor.	A thread guide was introduced.
4.b	Hollow spindle with guide	No entanglements. The travellor moves over the ring also without travellor- ring twist insertion was there.	Twist inserted was low compared but was effective.
4.c	Hollow spindle with curved propeller		

The above observation has given further scope for this project. The suggestions, by which the number of twists inserted can be increased as discussed below.

4.1.2 Inferences and Design Proposals

The following are the designs proposed, based on the above inferences, for further working on the workable model,

- Reduction of hollow spindle wharve diameter to less than 10 mm.
- Reduction of hollow spindle to least possible height i.e. to reduce the distance between take-up roller nip and the travellor.

- Reduction of ring diameter or eliminating ring.
- Redesigning of the ring flange so as to deliver the yarn almost vertically with minimum yarn tension.
- Redesigning hollow spindle with guide (curved propeller) so as to deliver yarn with twist without ring travellor assembly.
- By providing grooves in the hollow spindle, instead of thread guide to hold the yarn and transmit power.

4.2. SUMMARY AND CONCLUSION

4.2.1 Summary

The project work can be summarized as follows,

- The limitation, to attain the objective of higher spindle speed, in Ring-Travell0r spinning was studied and analyzed using TRIZ methodology.
- A possible solution, to separate twisting and winding assembly, was arrived at.
- The design alternatives were designed namely an inverted spindle, spindle with groove ,spindle with guide and a hollow spindle along with ring travellor twist system and also hollow spindle with guide (without ring travellor) along a separate yarn take-up and winding assembly.
- Trial runs and studies were conducted on the above models to select a workable design.

4.2.2 Conclusion

It can be finally concluded that,

- The limitations of present system are analyzed using TRIZ Methodology, and with the analysis the work was carried out and the alterations of designs were made.
- Use of the Inverted Spindle, grooved spindle and spindle with guide on a Ring-Travellor Spinning machine caused entanglements on the spindle and caused breakages.
- The Hollow Spindle with guide eliminated the problem of entanglement but the actual twist inserted was lower than the expected twist but effective, so further studies are to done on this workable model to improve twisting efficiency.
- From the analysis and trials on the working model, it could be inferred that, twist can be inserted using the hollow spindle model without ring-travellor along with a separated yarn take-up and winding assembly.

4.3 SUGGESTIONS FOR FURTHER WORK

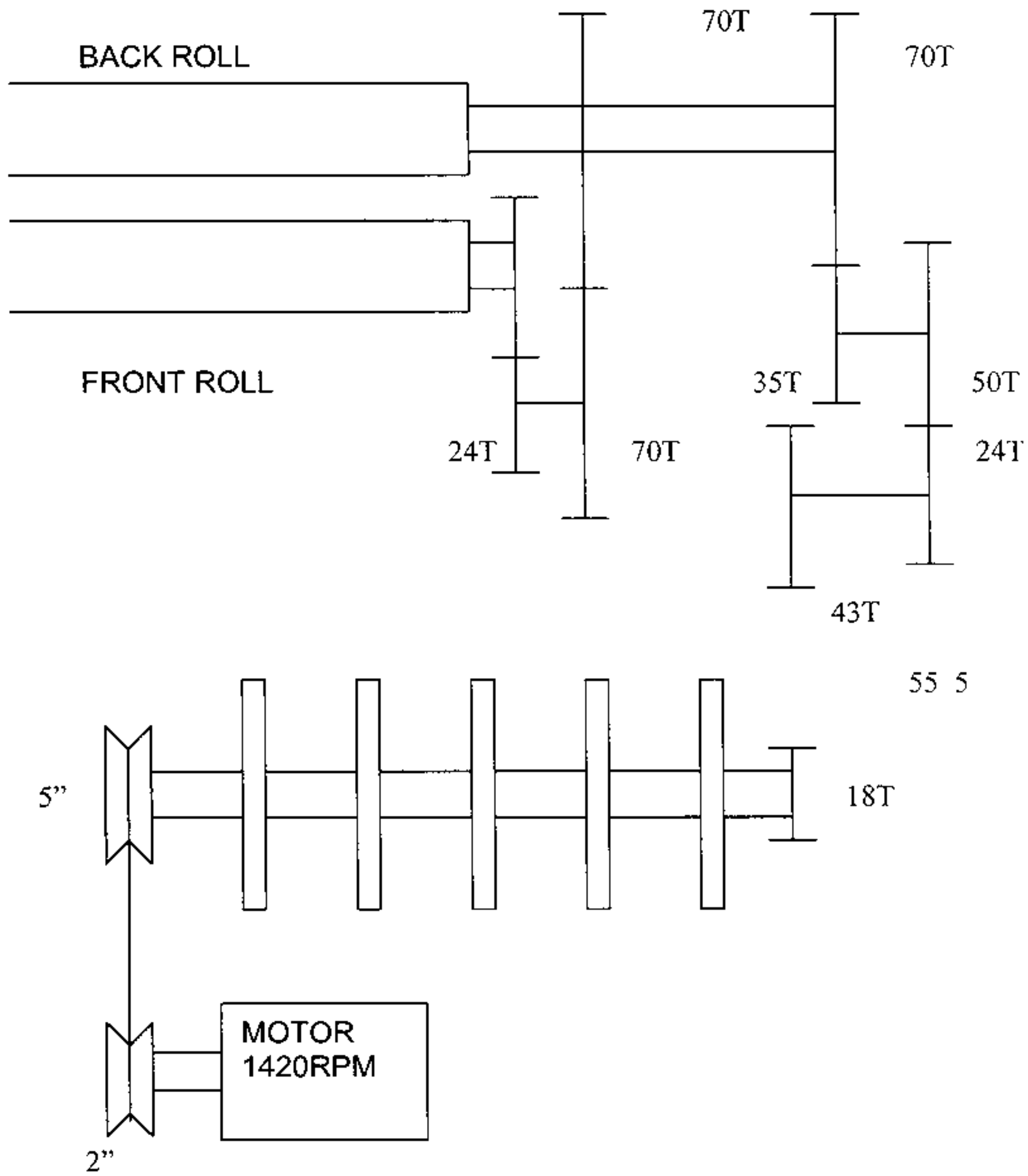
The successful insertion of low effective twist in the yarn has led to a large scope for further work on this project as summarized below:

- Hollow spindle along with elimination of ring travellor and separate winding has potential and can be further improved to make it achieve higher spindle speed.
- The guide could be redesigned by modifying its profile.

APPENDICES

Appendix 1

The gear diagram and the calculations are given below:



Gearing diagram of Ring Doubler

Calculations:

Motor speed = 1420 rpm

Motor pulley diameter = 2 inches

Machine pulley diameter = 5 inches

Diameter of winding drum = 3 inches

Tin roller speed = 1420 * 2/5 = 568 rpm

$$\text{Front delivery} = 1420 \times \frac{2''}{5''} \times \frac{18}{43} \times \frac{24}{50} \times \frac{35}{70} \times \frac{70}{70} \times \frac{24}{50}$$

= 57.06 rpm x 4 cm x

= 282.3 inches/min ~ 7.17 m/min

$$\text{Spindle Speed} = 1420 \times \frac{2''}{5''} \times \frac{12''}{4''} \times 2.54$$

= 4328 rpm.

$$\text{TPI} = \frac{\text{Spindle Speed}}{\text{Front Roller Delivery}} = \frac{4328}{282.3}$$

= 15.33 TPI .

$$\text{Winding drum speed} = 57.06 \times \frac{19}{30} \times \frac{1''}{2''} = 18 \text{ rpm}$$

Surface speed of winding drum = 18 rpm * 3 inch *

= 169.7 inches/min

Twist level imparted :

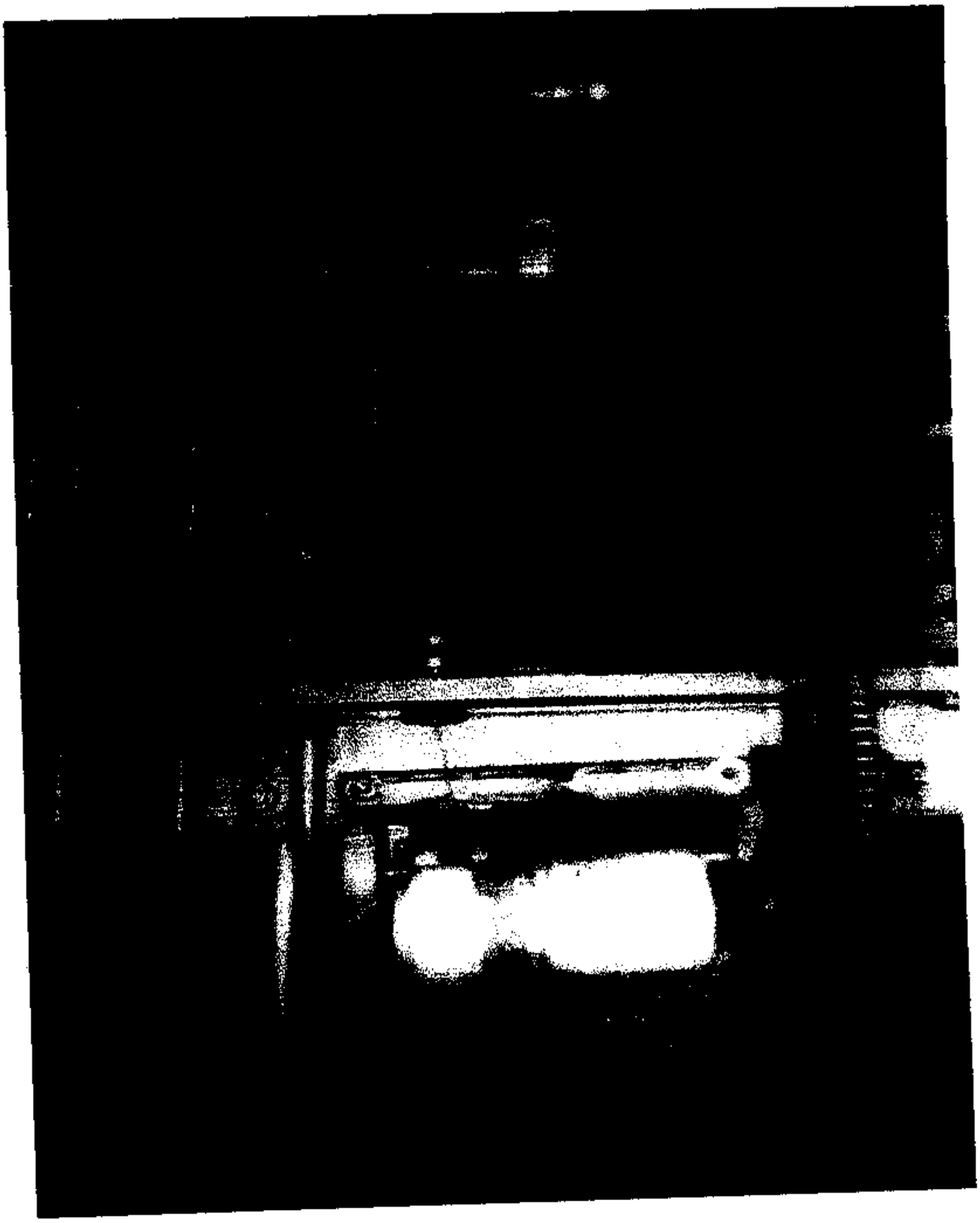
Twist expected = spindle speed / delivery speed

= 4328 / 282.3 = 16 TPI

Actual twist in yarn = 10 TPI

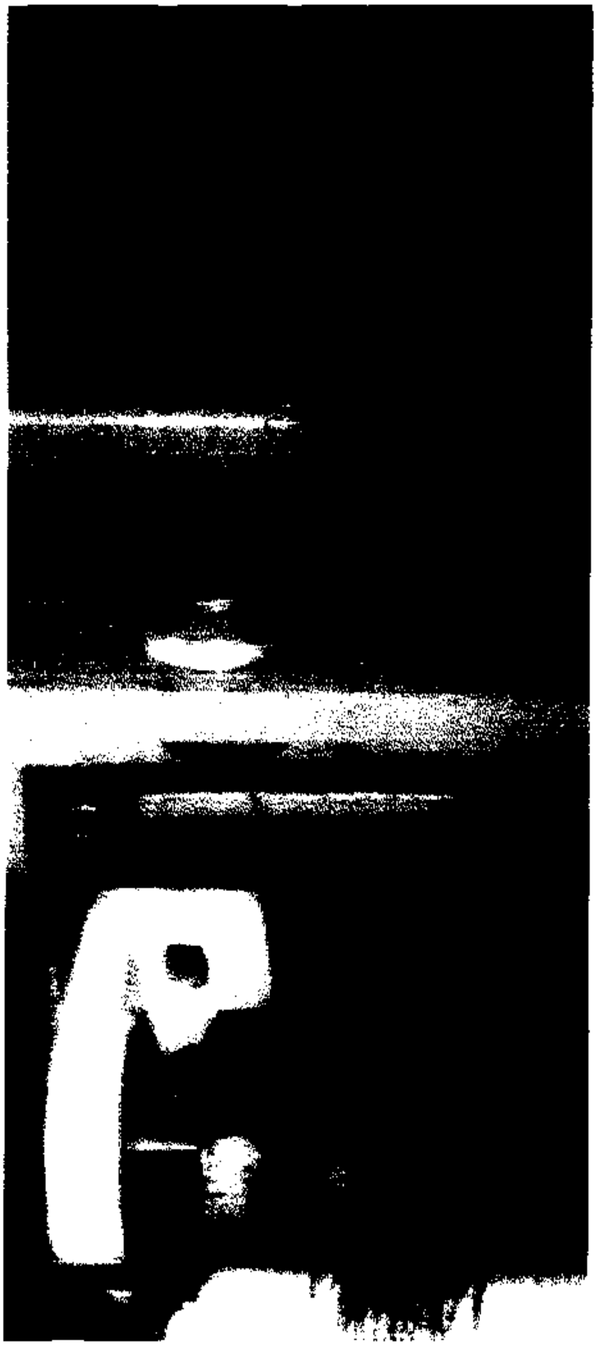
Appendix 2

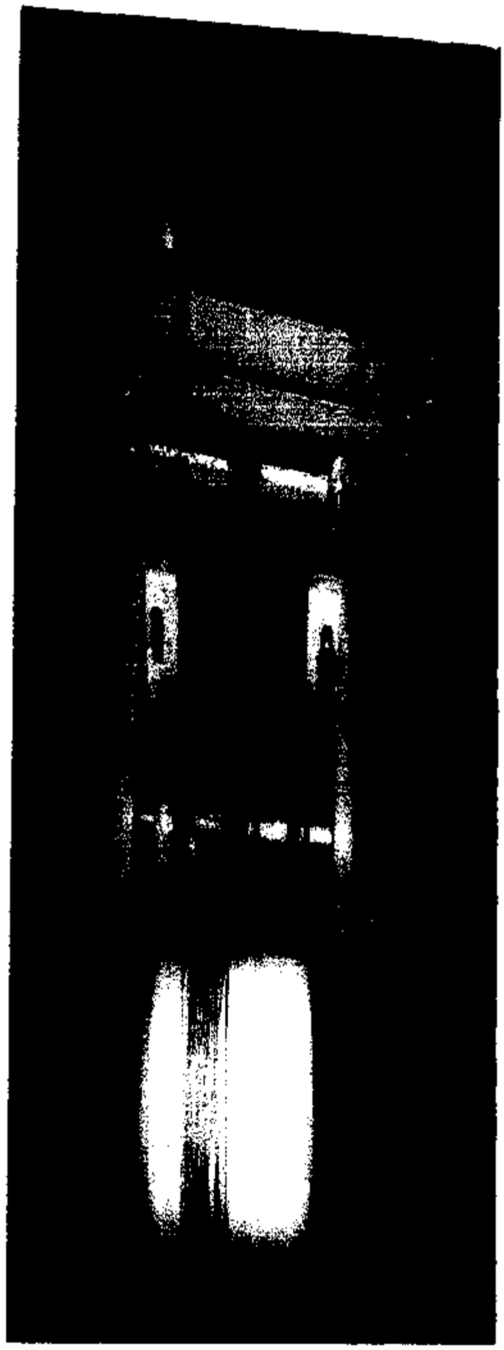
HOLLOW SPINDLE WITH YARN TAKE-UP ASSEMBLY IN A RING DOUBLER



Appendix 3

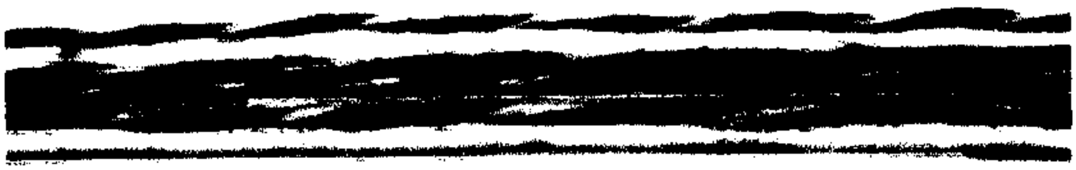
HOLLOW SPINDLE AND WINDING ASSEMBLY





Appendix 4

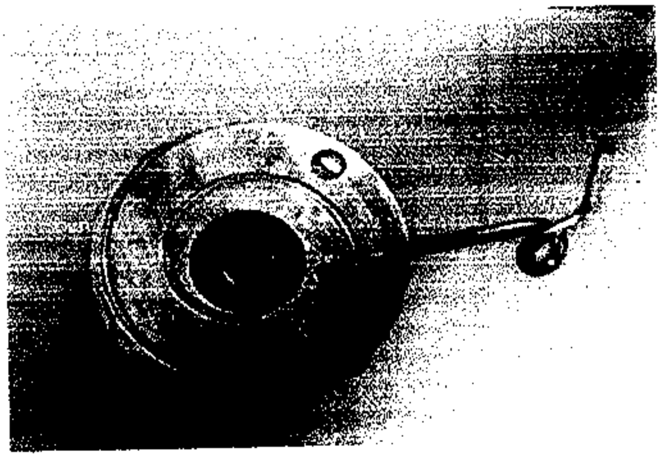
TWIST IMPARTED IN YARN OF HOLLOW SPINDLE WITH GUIDE (WITH RING AND TRAVELLOR)



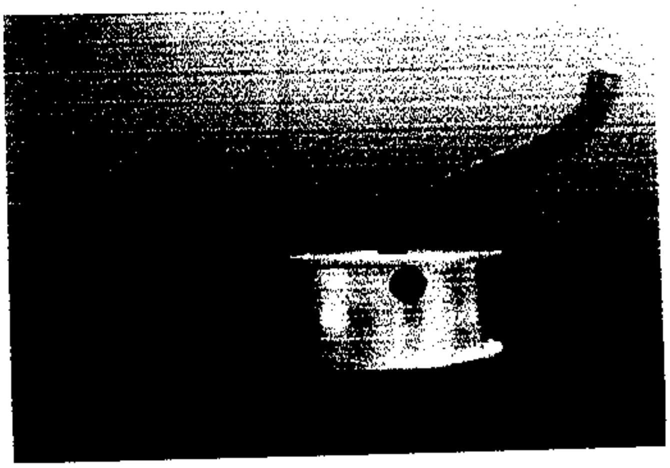
Appendix 5

HOLLOW SPINDLE

a) WITH GUIDE

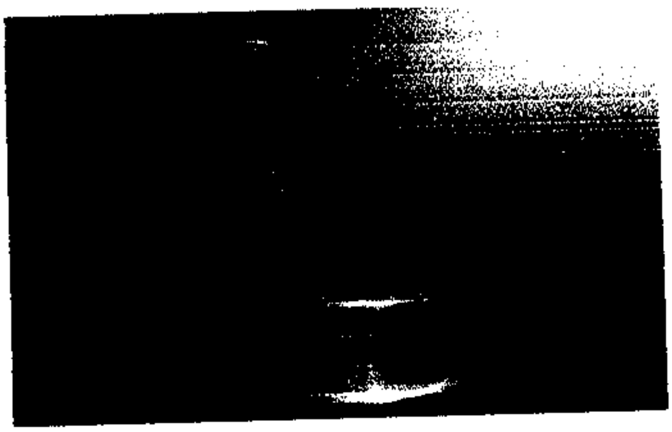


b) WITH CURVED PROPELLORS



Type 1

Top view



Type 2