OPTIMIZING THE YARN QUALITY BY DESIGN OF EXPERIMENT

By

S. M. SHOEL AKTER

A thesis submitted to the Department of Industrial & Production Engineering, Bangladesh University of Engineering and Technology, Dhaka, in partial fulfillment of the requirement for the degree of Master of Engineering in Industrial & Production Engineering.

December , 2004

Department of Industrial and Production Engineering
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY.

Dhaka 1000, Bangladesh

The thesis titled "OPTIMIZING THE YARN QUALITY BY DESIGN OF EXPERIMENT" submitted by S.M.Shoel Akter. RollNo.040208009F, Session: April 2002 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Engineering in Industrial and Production Engineering on 8,December 2004.

BOARD OF EXAMINARS

1. ______________ 13/12/04

Dr. Mahiuddin Ahmed — Chairman
Professor and Head, IPE department

2. ______________

Dr.Md. Ahsan Akhtar Hasin — Member
Associate professor, IPE department

3. ______________

Dr.A.K.M. Masud — Member
Assistant professor, IPE department

DECLERATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Signature of the candidate

S. M. SHOEL AKTER
Name of the candidate

ACKNOWLEDGEMENT

I express my deep sense of gratitude to Dr. Mahiuddin Ahmed, Professor, head of the department of Industrial and Production Engineering for his involvement, careful supervision, constant guidance and important suggestions at all stages in conduction of this project work. I am gratefully indebted to him for the efforts he put to provide me useful comments and correction.

I wish to acknowledge the assistance received and knowledge gained form Professor Dr.A.F.Anwarul Haque, The honorable teacher of the course IPE 6009, Advanced Quality Control. He opened a new door in front of us by delivering valuable lecture with lots of information and case studies. I wish to thank Dr. A.F.M. Anwarul Haque as well all other teachers of IPE department.

This project/thesis was prepared on the basis of the data obtained from the experiment conducted in Padma Textile Mills Ltd (BEXIMCO Group) Bangladesh and Personal findings, related to yarn manufacturing as my industrial attachment with Padma Textile Mills as a student of Industrial and Production Engineering.

I would like to thanks Mr.Mahbub, General Manager, Padma Textile Mills for providing me such great opportunity to conduct all expensive experiments. I am also grateful to the company for supplying me all raw materials required for experiments and for permitting me to use different valuable machine. I grateful to a number of employees of the company for providing me relevant information and accessories. In this regard I must mention the names of Mr. Mustafa Ali , Administration Senior Manager, Mr. Hamid and Mr. Sohel Anwar ,Quality Assistant Manager , Mr. Safiullah , Production Manager .Further , I would like to thanks the technicians who were involved directly in carrying out the experiments by showing me the operating procedure of different machines and provide me the relevant information.

I would like to express my gratitude to the student of IPE who presented valuable information in the class during the schedule course. Finally it is a pleasure for me to acknowledge gratefully the kind help of all members of the IPE department of BUET, in course of my study.

S.M.SHOEL AKETER

ABSTRACT

The manufacturing process, especially in a reputed industry like Padma Textile mills Ltd (Group of Beximco), is equipped with the modern and sophisticated machine and equipment However, there is still room for optimizing the levels of processing parameters Three machines such as carding, ring frame & winding are such machines Experiments were conducted by the design of experiment (DOE) approach to optimize some selected parameters with the aim of making greater amount of quality yarn with the same amount of cotton. A terminology is used in D O.E to indicate the target parameter and the higher the yarn quality, the better is the situation for the industry. But there is a precondition of increasing the quality of yarn must be achieved meeting certain set condition. The condition of the yarn quality is measure of material utilization

Three machines are operated maintaining a range of set conditions. These conditions are varied by the operator according to operation, the demand and capacity. To take into account the natural variation in the response of the output, several experiments were conducted at the same set conditions of the parameter. The average was taken as the estimated of the true outputs. The quality standard was verified in each case

PTML has to be very serious on the quality of its yarn. Presently the mill controls the process parameter according to the manufacturer suggestion or by the experience gained by the operating personnel. It is strongly felt that the yarn quality can be improved by the process parameters thorough scientific observation like factorial experiments.

All tests are conducted randomly to eliminate errors and considered individuals section to get accurate results. To avoid the variation of data and complexity In the individuals section, each parameter has to be maintained within certain range and the combined effect of parameter determines the final yarn quality.

The individual section was not synchronized because a test or series of test in which purposeful changes were made to the input variables of a process or system so that one may observe and identify the reasons for change in the output.

Carding machine is used to produce sliver and experiments were conducted to find the most desired combination of the levels of carding delivery speed, flat speed and cylinder speed. These three factors were varied into two levels and their influence was determined. The two levels of the factors are 80 and 100 m/min for delivery speed, 135 and 153m/min for flat speed, 375 and 426rpmfor cylinder speed. All the three factors/parameters were found to have individual effect on the quality. Small interactive effect of the parameters on the quality was observed. A delivery speed 80m/min, flat speed 135m/min and cylinder speed 426 rpm were found to increase the production Significance tests were conducted by the analysis of variance. It was found that the delivery speed, flat speed and cylinder speed - all three parameters had significant effect

on the quality. The interactions between cylinder speed & flat speed and cylinder speed & delivery speed have significance effect on the quality. In all cases the desired levels of quality standard was verified.

Ring frame is performed to produce yarn and experiments were conducted to find the most desired combination of the levels of ring speed and twist per inch. The level are varied with into three levels i.e. ring speed 18100,18600 and 19000 rpm and twist per inch 25.18,25.48 and 25.78. Both the ring speed and twist per inch were found to have main effect on the quality. With the experimental limits of the factors, the min quality was observed for ring speed 19000 and the twist per inch 25.78.

The most desirable condition was observed at ring speed 18600 rpm and twist per inch 25.48. A significance test was also conducted by the analysis of variance. It was a significant interaction effect of the ring speed and twist per inch on the quality.

Winding machine is used to produce cone and experiments was conducted to find out the most desired condition It may be mentioned here that each set condition, experiment was replicated for three times With three values standard deviation was calculated to check the variability Quality standard, a parameter to measure the retained material, was checked individually with very experiment to confirm the minimum acceptable level At winding speed 1450 m/min, the variability was the lowest leading to the consistency and customer satisfaction. Maximum quality standard was observed to occur at 1350m/min.

LIST OF ABBREVIATONS AND TERMINOLOGIES

C.V - Co-efficient of Variation

UI - Uniformity Index

UR -Uniformity ratio

SL - Spun Length.

HVI - High Value Instrument.

G/tex - Grams/tex.

GM – Good middling

SM – Strict middling.

M – Middling

SLM – Strict low middling

LM – Low middling

SGO – Strict good ordinary

GO – Good ordinary

D.O.E – Design of experiment.

SPC – Statistically process control.

R H – Relative humidity

N - Neps

S- Short fault

L-Long faults

CCP – Coarse counts

CCM-Fine counts

CONTENTS

Chapter 4 EXPERIMENTAL PROCEDURE AND DATA COLLECTION

Chapter 5 ANALYSIS AND OBSERVATIONS

Chapter 6 CONCLUSION AND RECOMENDATONS

Chapter -1

INTRODUCTION

1.1 HISTORY OF COTTON

It was cultivated in India and Pakistan and in Mexico and Peru 5000 years ago. In these two widely separated parts of the world, cotton must have grown wild. Then people learned to cultivate cotton plants in their fields. In Europe, wool was the only fibre used to make clothing. Then from the Far East came tales of plants that grew "wool". Traders claimed that cotton was the wool of tiny animals called Scythian lambs that grew on the stalks of a plant. The stalks, each with a lamb as its flower, were said to bend over so the small sheep could graze on the grass around the plant. These fantastic stories were shown to be untrue when Arabs brought the cotton plant to Spain in middle Ages.

In the fourteenth century cotton was grown in Mediterranean countries and shipped from there to mills in the Netherlands in Western Europe for spinning and weaving. Until the mid eighteenth century, cotton was not manufactured in England, because the wool manufacturers there did not want it to compete with their own product. They had managed to pass a law in 1720 making the manufacture or sale of cotton cloth illegal. When the law was finally repealed in 1736, cotton mills grew in number. In the United States though, cotton mills could not be established, as the English would not allow any of the machinery to leave the country because they feared the colonies would compete with them. But a man named Samuel Slater, who had worked in a mill in England, was able to build an American cotton mill from memory in 1790.

The earliest evidence of using cotton as a textile fiber is from India. Cotton cultivation first spread from India to Egypt, China and the South Pacific. Even though cotton fibers had been known already in Southern America, the large scale cotton cultivation in Northern America began in the 16th century with the arrival of colonists to southern parts of today's United States.

The largest rise in cotton production is connected with the invention of the saw-tooth cotton gin by Eli Whitney in 1793. With this new technology, it was possible to produce more cotton fibers, which resulted in big changes in the spinning and weaving industry, especially in England. Today, cotton is grown in more than 80 countries worldwide.

1.2 COTTON

Cotton is defined as white fibrous substance covering seeds harvested from cotton plant. Seed cotton harvested from cotton Plant.

LINT COTTON. Lint cotton is obtained by removing the seeds in a ginning machine. Lint cotton spun into yarn, which is woven or knitted into a fabric. Researchers have found that cotton was grown more than 9000 years ago. However large scale cultivation commenced during middle of 17th Century.

Many varieties of cotton are cultivated mainly from 3 important genetic species of Gossypium.

1. HIRSUTUM – Plant grows in America, Africa, Asia also Australia. Plant grows to a height of 2 meters.

2. BARBADENSE- Plant grows in America, Africa & Asia. Plant grows to a height of 2.5 meters with yellow flowers, long fiber with good quality, fiber with long staple and fineness.

3. ARBORETUM - Perennial plant grows up to 2 meters with red flowers, poor quality fiber in East Africa and South East Asia.

There are four other species grown in very negligible quantities. Cotton harvested from the plant by hand - picking or machine picking is ginned to remove seeds and the lint is pressed into bales for delivery to spinning mills. Cotton is Roller Ginned (RG) or Saw Ginned (SG) depending on varieties and ginning practices.

Cotton is cultivated in 75 Countries with an area of 32 million hectares. Cultivation period varies from 175 days to 225 days depending on variety. Cotton is harvested in two seasons, summer and winter seasons.

Saw ginned cotton is more uniform and cleaner than roller ginned cotton. But fiber quality is retained better in roller ginning than saw ginning which has high productivity.

A Cotton fiber has a tubular structure in twisted form. Now researchers have developed colored cotton also. As on date, percentage of cotton fibers use is more than synthetic fiber. But, its share is gradually reducing. Cotton is preferred for under garments due its comfort to body skin. Synthetics have more versatile uses and advantage for Industrial purposes.

Fibers obtained from the mature capsule of the cotton plant, a shrub about 40 cm high, with leaves and flowers of a red or yellow colour.When the flower is fecundated it loses its petals and within 25 days a capsule surrounded by a leaf called bract grows. The capsule is sustained by a cup and has a drop shape rounded at the lower extremity. Inside the capsule there are from five to eight seeds on which the fibers developed. When the capsule is mature it opens into four parts showing the cotton ball. On the same plant the maturation of the capsules does not occur simultaneously, therefore more passages are required for the harvest of the cotton. The harvest is carried out a week after maturation. The first operation after harvesting is husking, which permits the removal of the fiber from the seeds. Then the cotton is carded and combed so as to eliminate all the impurities. 4000 Fiber is the seed average. Staple length = 1/8" - 2.5" (0.32 - 6.35cm)

Fig 1.1 Cotton flower (Initial stage)

for manufacturing yarns, fabrics, 7/8" - 11/4" (2.22 - 3.18cm) is standard. Figure 1.1 shown the initial stage of flower.

The requisites on the basis of which to judge the quality of the cotton are the grade, the co lour, and the length of the fiber and the character. The final stage of flower figure is shown in fig 1.2

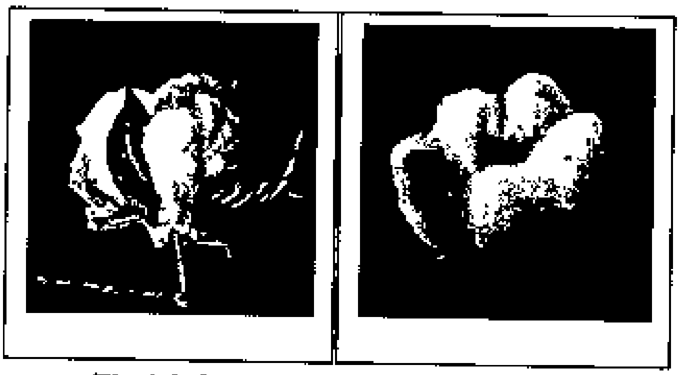


Fig 1.2 Cotton flower (Final stage)

The grade is given by the external appearance of the cotton and is determined on the basis of the major or minor brightness of the fiber, by its more or less white color, by the major or minor presence of particles of the leaf or other extraneous substances.

The color is another important element of evaluation of cotton. In fact, from the major or minor whiteness of the cotton depends the facility of later workings and the possibility of obtaining good yarns. The color of cotton fibers differs greatly: that of cultivated cotton is generally white, more or less candid or tending towards grey; but there are also reddish, tawny, chamois, etc. colored varieties.

The length is the most important attribute of the fibers. In this regards, cotton is divided into two large categories: long fibers cottons (long staple), which measures more than 28 mms and amongst which Sea Island in the United States holds the record and the Egyptian Makò and Sakellaridis which arrive at and sometimes over reach 50 mms, and short fibers cotton (short staple), that do not reach the length of 18 mms and that derive from the Asian regions; there is also an intermediate category of cottons whose fibers length is included between 18 and 28 mms, such as those from the United States Uplands and which constitute the grand mass of the world production.

The character is the attribute determined with more difficulty. It is in part connected with the origin, variety and maturity, but at the end a cotton of good character is that whose fiber are the most strong and robust, so as to resist traction and breakage, homogenous and uniform, so as to produce few losses in working, and have a complete physical-chemical constitution, so as to give the cotton mass notable solidity and compactness, smoothness and silkiness. The biggest cultivations of cotton are to be found in America, India, China, Egypt, Pakistan, Sudan and Eastern Europe.

1.2.1 THE FIBRES

Before it is processed, the cotton fiber is called lint. The lint grows inside the cotton balls, which are the fruit of the plant. Inside each ball there are around 30 seeds.

When the cotton balls open, one can see the fluffy white cotton fibers that have been growing inside. Cotton plants are grown. So the fibers can be made into many different products, some of which we use everyday. After the cotton has been picked, it needs to be cleaned, and the fiber from the cotton plant is then made into yarn or fabric. The seeds that are taken out of the fibers can be fed to animals, or crushed to make oil. The leaves can be turned into mulch.

1.2.2 DIFFERENT TYPE OF FIBERS

All textile fiber has different properties which make them suitable for a variety of end uses.

Fiber can be grouped into:

- **staple** - short, needing to be spun into yarn
- **Filament** - long, used as they are or cut up and spun into thread.

Natural fiber

Here are some examples:

- cotton, a staple fibers, comes from the cotton plant
- linen, a staple fibers, comes from the flax plant
- wool, a staple fibers, comes from animal hair
- silk, a filament fibers, comes from silk worms

Natural fibers are made from fibers harvested from plants and animals.

Synthetic fiber

These are mostly derived from oil products and burn easily.

Synthetic fibers include:

- acrylic, from oil
- nylon, from oil and coal
- viscose, from wood pulp
- acetate, from wood pulp

Most synthetics can be either staple or filament fiber.

Fibers blending

This is the process manufacturers use to combine two or more different staple fiber within the same yarn. A fibers blend has the combined properties and benefits of each component fibers.

COTTON

Fibers type - staple fibers
Source - natural
Properties - absorbent, soft, creases easily
Blends with - polyester, nylon
Examples - jeans, t-shirts, work wear

POLYESTER

Fibers type - continuous filament
Source - manufactured synthetic fibers from petrochemicals
Properties - non-absorbent, crease-resistant, easy-care
Blends with - wool, cotton
Examples - tents, shirts, work wear

ELASTANE

Fibers type - core elastane filament, covered with staple fiber
Source - manufactured synthetic fibers from petrochemicals
Properties - elastic/stretchy, good fit, comfortable, easy-care
Blends with - most fiber
Examples - sportswear, underwear, fashion wear

1.2.3 THE COTTON PLANT

Cotton is a natural fiber as it comes from a plant, and makes up nearly half of all the fibers sold in the world. The cotton grows on a plant that is a member of the Hibiscus family, botanically known as Gossypium hirsutum.

If left to grow on it's own in nature, the cotton plant can grow as high as 3.5 meters. When grown on a farm, it only gets the chance to grow to about 1.2 meters. Cotton plant is given below in figure1.3.

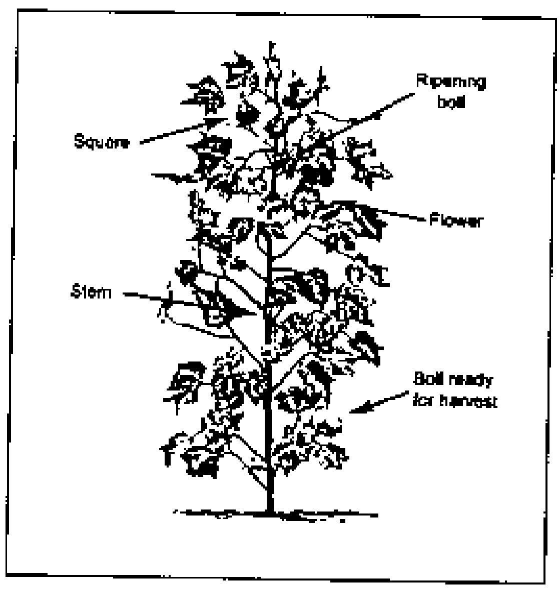


Fig 1.3 Cotton Plant

There are many different varieties of cotton; the most common type grown in Australia is American Upland cotton (Gossypium hirsutum). This is a leafy green shrub that produces cream and pink flowers that turns into the fruit or cotton bolls.

1.2.4 GROWING THE COTTON

Cotton plant's leaves resemble maple leaves and flowers look very much like pink mallow flowers that grow in swampy areas. They are relatives and belong in the same plant family.

Cotton is grown in about 80 countries, in a band that stretches around the world between latitudes 45 North to 30 South. For a good crop of cotton a long, sunny growing season with at least 160 frost-free days and ample water are required. Well drained, crumbly soils that can keep moisture well are the best. In most regions extra water must be supplied by irrigation. Because of its long growing season it is best to plant early but not before the sun has warmed the soil enough. Seedlings appear about 5 days after planting the seeds. Weeds have to be removed because they compete with seedlings for water, light and minerals and also encourage pests and diseases. The first flower buds appear after 5-6 weeks, and in another 3-5 weeks these buds become flowers.

Each flower falls after only 3 days leaving behind a small seed pot, known as the boll. Children in cotton-growing areas in the South sometimes sing this song about the flowers: Each fibers grows its full length in 3 weeks and for the following 4-7 weeks each fibers gets thicker as layers of cellulose build up the cell walls. While this is happening the boll matures and in about 10 weeks after flowering it splits open.

The raw cotton fiber burst out to dry in the sun. As they lose water and die, each fiber collapses into what looks like a twisted ribbon. Now is time for harvesting. Most cotton is hand-picked. This is the best method of obtaining fully grown cotton because unwanted material, called "trash", like leaves and the remains of the boll are left behind. Also the cotton that is too young to harvest is left for a second and third picking. A crop can be picked over a period of two months as the bolls ripen. Countries that are wealthy and where the land is flat enough usually pick cotton with machines - cotton harvesters. Global cotton verities according to the planting and harvesting periods is given the following table 1.1

GLOBAL COTTON - VERITIES - PLANTING AND HARVESTING PERIODS

SL.No	Country	Planting Period	Harvesting	Staple-mm	Mic	Variety
1	AFGHANISTAN	APRIL-MAY	OCT-DEC	26-28	4.0	ACALA
2	ARGENTINA	SEPT-OCT	FEB-JUNE	24-28	3.9-4.1	TOBA
3	AUSTRALIA	SEPT-NOV	MAR-JUNE	24-29	3.2-4.9	DPL
4	BRAZIL	OCT-NOV	MAR-JUNE	26-28	3.2-4.0	IAC
	BRAZIL	PERENNIAL		32-35	3.2-4.8	MOCO
6	CAMERRON	JUNE	NOV-DEC	25-28	3.8-4.3	ALLEN
9	CHINA	APRIL-JUNE	SEP-OCT	22-28	3.5-4.7	SHANDONG
10	COTED IVORIE	JUN-AUG	OCT-JAN	24-28	2.6-4.6	ALLEN
11	EGYPT	MARCH	SEP-OCT	31-40	3.24.6	GIZA
12	GREECE	APRIL	SEPT-OCT	26-28	3.8-4.2	4S
13	INDIA	APRIL-NOV	SEP-NOV	16-38	2.8-7.9	SEPARATE LIST
14	IRAN	MAR-APR	SEP-NOV	26-28	3.9-4.5	COKER
18	MEXICO	MAR-JUNE	AUG-DEC	26-29	3.5-4.5	DELTAPINE
19	MOZAMBIQUE	NOV-DEC	APR-MAY	25-29	3.6-4.2	A637
20	NIGARIA	JUL-AUG	DEC-FEB	24-26	2.5-4.0	SAMARU
21	PAKISTAN	APR-JUN	SEP-DEC	12-33	3.5-6.0	
22	PARAGUAY	OCT-DEC	MAR-APR	26-28	3.3-4.2	EMPIRE
23	PERU	JUL-NOV	FEB-AUG	29-.8	3.3-4.2	TANGUIS
24	SPAIN	APR-MAY	SEP-NOV	25-28	3.3-4.9	CAROLINA
25	SUDAN	AUG	JUN-APR	27-E0	3.8-4.2	BARAKAT
26	SYRIA	APR-MAY	SEP-NOV	25-29	3.8-4.8	ALEPPO
28	TOGO	JUN-JUL	NOV-DEC	28-29	4.3-5.5	ALLEN
29	TURKMENISTAN	APR-MAY	SEP-NOV	24-29	3.5-5.5	DELTAPINE
30	TURKEY	APR-MAY	SEP-NOV	24-28	3.5-5.5	DELTAPINE
31	UGANDA	APR-JUN	NOV-FEB	26-28	3.3-4.8	BAP-SATU

Table 1.1 Global cotton verities according to the planting and harvesting periods.

1.3 COTTON AND YARN QUALITY CO-RELATION

Essential characteristics of cotton quality and characteristics of yarn quality of yarn are given from detailed experimental investigations. Some of the important conclusions which help to find co-relation between yarn quality and cotton quality are given below:

- **NEPS:** A nep is a small tangled fibers knot often caused by processing. Neps can be measured by a nep tester and reported as the total number of neps per 0.5 grams of the fibers and average size in millimeters.Nep formation reflects the mechanical processing stage, especially from the point of view of the quality and condition of the machinery used.
- **STAPLE LENGTH:** If the length of fibers is longer, it can be spun into finer counts of yarn which can fetch higher prices. It also gives stronger yarn.
- **STRENGTH:** Stronger fiber gives stronger yarns. Further, processing speeds can be higher so that higher productivity can be achieved with less end-breakage.
- **FIBERS FINENESS:** Finer fiber produce finer count of yarn and it also helps to produce stronger yarns.
- **FIBERS MATURITY:** Mature fiber give better evenness of yarn. There will be fewer ends - breakages. Better dyes' absorbency is additional benefit.
- **UNIFORMITY RATIO:** Yarn uniformity ratio higher is more even and there are reduced end-breakages.
- **ELONGATION:** A better value of elongation will help to reduce end-breakages in spinning and hence higher productivity with low wastage of raw material.
- **NON-LINT CONTENT:** Low percentage of trash will reduce the process waste in blow Room and cards. There will be fewer chances of yarn defects.
- **SUGAR CONTENT:** Higher sugar content will .create stickiness of fibers and create processing problem of licking in the machines.
- **MOISTURE CONTENT:** If moisture content is more than standard value of 8.5%, there will be more invisible loss. If moisture is less than 8.5%, then there will be tendency for brittleness of fibers resulting in frequent yarn breakages.
- **FEEL:** If the feel of the cotton is smooth, it will be.produce more smooth yarn which has potential for weaving better fabric.
- **CLASS:** Cotton having better grade in classing will produce less process waste and yarn will have better appearance.
- **GREY VALUE:** It means it can reflect light better and yarn will give better appearance.
- **YELLOWNESS:** When value of yellowness is more, the grade becomes lower and lower grades produce weaker & inferior yarns.
- **NEPPINESS:** Neppiness may be due to entanglement of fiber in ginning process or immature fiber. Entangled fiber can be sorted out by careful processing But, Neps due to immature fibers will stay on in the end product and cause the level of yarn defects to go higher.

An analysis can be made of yarn properties which can be directly attributed to cotton quality.

1. **YARN COUNT:** Higher count of yarn can be produced by longer, finer and stronger fiber.

2. **C.V. OF COUNT:** Higher fiber uniformity and lower level of short fibers percentage will be beneficial to keep C.V (Co-efficient of Variation) at lowest.

3. **TENSILE STRENGTH:** This is directly related to fibers strength. Longer length of fibers will also help to produce stronger yarns.

4. **C.V. OF STRENGTH:** Yarn is directly related CV of fibers strength.

5. **ELONGATION:** Yarn elongation will be beneficial for weaving efficiently. Fibers with better elongation have positive co-relation with yarn elongation.

6. **C.V. OF ELONGATION:** C.V. of yarn elongation can be low when C.V. of fibres elongation is also low.

7. **MARS VARIATION:** This property directly related to fibres maturity and fibres uniformity.

8. **HAIRINESS:** Faster processing speeds and high level of very short fiber.

9. **DYEING QUALITY:** Yarn dyeing quality will defend on evenness of yarn and marketing of cotton fiber.

10. **BRIGHTNESS:** Yarn will give brighter appearance if cotton grade is higher.

1.3.1 COTTON QUALITY SPECIFICATIONS

The most important fibres quality is fibres length. Classification of fiber length is given in table 1.2

LENGTH

Staple classification	Length mm	Length inches	Spinning Count
Short	Less than 24	15/16 -1	Coarse Below 20
Medium	24- 28	1.1/132-1.3/32	Medium Count 20s-34s
Long	28 -34	1.3/32 -1.3/8	Fine Count 34s – 60s
Extra Long	34- 40	1.3/8 -1.9/16	Superfine Count 80s - 140s

Table: 1.2. Classification of fiber length

Notes:

- Spinning Count does not depend on staple length only. It also depends on fineness and processing machinery.
- Length is measured by hand stapling or Fibro graph for 2.5% Span length
- 2.5%SL (Spun Length) means at least 2.5% of total fiber has length exceeding this value.
- 50% SL means at least 50% of total fiber has length exceeding this value.

LENGTH UNIFORMITY

Length Uniformity is calculated by 50SL x 100 / 2.5 SL

Significance of UR (Uniformity ratio) is given below:

UR% Classification 50-55
Very Good 45-50 , Good 40-45
Satisfactory 35-40
Poor Below 30 Unusable
M= 50% SL
UHM SL - Average value of length of longest of 50% of fiber
UHM means Uniform hairiness.

UI Uniformity Index
UI M/UHM

Length uniformity for different type of fiber is given table 1.3

U.INDEX	CLASSIFICATION	UHM	CLASSIFICATION
Below 77	Very low	Below 0.99	Short
77-99	Low	0.99-1.10	Medium
80-82	Average	1.11-1.26	Long
83-85	High	Above 1.26	Extra Long
Above 85	Very High		

Table.1.3 Length uniformity for different type of fiber.

Now Uniformity is measured by HVI

HVI means High Value Instrument

FIBERS STRENGTH

Fibers strength, next important quality is tested using Presley instrument and the value is given in thousands of pounds per square inch. (1000 psi) For better accuracy, Stelometer is used and results are given in grams / Tex.

Lately, strength is measured in HVI (High Value Instrument) and result is given in terms of grams/tex.

Interpretation of Strength value is given below in table 1.4

G/tex	Classification
Below 23	Weak
24-25	Medium
26-28	Average
29-30	Strong
Above 31	Very Strong

Table 1.4 Fiber strength

Strength is essential for stronger yarns and higher processing speeds.

- Fibers fineness and maturity are tested in a conjunction using Micronaire Instrument.
- Finer fiber give stronger yarns but amenable for more neppiness of yarn due to lower maturity.
- Micronaire values vary from 2.6 to 7.5 in various varieties.

FINENESS AND MATURITY

Micronaire value is referred to evaluate fineness of cotton and its suitability for spinning particular count of yarn. The value is a combined result of fineness and maturity of cotton fibers, it cannot be interpreted, property for ascertaining its spinning value. This value should be taken in conjunction with standard value of calibrated cotton value.

The following table will explain that micronaire value goes up along with maturity but declines with thickness of fibers. An Egyptian variety of cotton, three samples of High maturity. Low maturity and medium maturity were taken and tested. Test results are given below in table 1.5

Maturity	Micronaire	Perimeter	Maturity	Maturity Ratio
High	4.3	52.9	85.1	1.02
Medium	4.0	54.4	80.1	0.96
Low	3.9	54.7	79.3	0.95

Table 1.5 Maturity of fibers

Here, Micronaire Value of 4.3 is higher than 3.9 of low maturity cotton. Greek cotton was tested and results are given below in table 1.6

High	3.8	57.0	75.1	0.88
Medium	3.5	54.9	70.7	0.84
Low	3.2	55.2	65.8	0.80

Table 1.6 Micronaire Value (Greek Value)

Micronaire Value of 3.8 is higher than 3.2 of low maturity cotton. American cotton was tested and results are as follows in table 1.7

High	4.1	64.4	75.9	0.87
Medium	3.4	62.1	68.0	0.80
Low	2.7	59.8	56.1	0.67

Table 1.7 Micronaire Value (American Value)

It is essential to know what Micronaire value is good for each variety of cotton. Micronaire value is good for each variety of cotton is given below table 1.8

Maturity Ratio	Classification
1.00 and above	Very Mature
0.95 - 1.0	Above Average
0.85 - 0.95	Mature
0.80 - 0.85	Below Average
Less than 0.80	Immature

Table 1.8 Micronaire value is good for each variety of cotton

COTTON GRADE

Cotton grade is determined by evaluating colour, leaf and ginning preparation. Higher grade cottons provide better yarn appearance and reduced process waste.

Colour is determined by using Nickerson-Hunter Calorimeter. This gives values Rd (Light or Dark) and +b (Yellowness).

American upland cottons are classified according to grades as given as below in table 1.9

WHITE COLOUR

S.NO	GRADE	SYMBOL	CODE
1	GOOD MIDDLING	GM	11
2	STRICT MIDDLING	SM	21
3	MIDDLING	M	31
4	STRICT LOW MIDDLING	SLM	41
5	LOW MIDDLING	LM	51
6	STRICT GOOD ORDINARY	SGO	61
7	GOOD ORDINARY	GO	71
8	BELOW GRADE		

Table 1.9 Colour grade

1.3.2 CHOOSING QUALITY

It is better if quality bench marks are established for different varieties so that buying decisions are easy for buyers following standards have been found to be appropriate for Strict Middling Grade cotton of staple 1.3/32".

1. Staple Length (2.5% Spun Length) - Minimum 1.08" or 27.4 mm
2. Micronaire : Minimum 3.8, Maximum-4.6 Variation within bulk sample should not be more than _ 0.1
3. Colour : Rd not less than 75 not more than 10
4. Nep Content: Less than 150 per gram
5. Strength : More than 30 grams/tex
6. Length Uniformity Ratio: Not less than 85%
7. Elongation : More than 8%

Commercial benchmarks can be given as follows:

1. Price Competitiveness
2. Price Stability
3. Easy Availability throughout year
4. Uniform Classing and Grading system
5. Even- running cotton in all Characteristics
6. Reliable deliveries or Respect for sanctity of contract.

Characteristics co-relation to yarn is given below in table 2.0

QUALITY EVALUATION	CHARACTERISTICS CO-RELATION TO YARN
1. Staple Length	Spinning Potential
2. Fibers Strength	Yarn strength, less Breakages
3. Fineness	Finer Spinning Potential
4. Maturity	Yarn Strength and even ness, better dyeing
5.Uniformity Ratio	Better productivity and Evenness
6. Elongation	Less end Breakages
7. Class	Yarn Appearance
8.Grey Value	Yarn luster
9.Yellowness	Yarn Appearance
10.Neppiness	Yarn neppiness
11. Moisture Content	8.5% moisture content optimum for spinning at 65%

Table 2.0 Characteristics co-relation to yarn

1.4 APPLICATION

The major end-uses of cotton include:

- Apparel - in a wide range of wearing apparel: blouses, shirts, dresses, children wear, active wear, separates, swimwear, suits, jackets, skirts, pants, sweaters, hosiery, neckwear.
- Home fashion - curtains, draperies, bedspreads, comforters, throws, sheets, towels, table cloths, table mats, napkins
- Medical and cosmetic applications - bandages, wound plasters
- Technical applications -

White cotton articles should be washed in the washing machine at 60° C, whilst colored cloths, especially if dark, should be washed at lower temperatures. Normally it should be ironed on the right side. Dark articles should be first ironed on the inside and then on the outside, with a cloth, to avoid that the heat of the iron shine the cloth. White articles can be starched to give more consistency to the cloth and avoid it creasing easily.

1.5 MAJOR PARAMETERS IN YARN PROCESSING

Padma textile mills ltd (PTML) major yarn manufacturer for export-oriented industries. PTML has to be very serious on the quality of its yarn. Presently the mill controls the process parameter according to the manufacturer suggestion or by the experience gained by the operating personnel. It is strongly felt that the yarn quality can be improved by the process parameters thorough scientific observation like factorial experiments. There are three sections here back section, ring section and finishing section. Mainly three process parameters are considered in back section. They are carding delivery speed, cylinder speed and flat speed. Two parameters are identified in ring section; they are ring speed and twist per inch. In finishing section, only the winding speed is considered as a process parameter.

The quality output parameters in the back section are sliver neps, sliver length, unevenness of mass, co-efficient of variation of mass, relevant count. Among them sliver neps is the most important quality parameter. Therefore, in this study only the sliver neps is considered as output parameter for factorial analysis. The quality output parameters in the ring section are yarn neps, yarn count, tenacity and elongation ,unevenness of mass , co- efficient of variation of mass, thick place, hairiness. Among them, yarn neps is the most important quality parameter. Therefore, in the study the yarn neps is considered as an output parameter. The quality output parameter in the finishing section is yarn neps, yarn short cut, long cut, thick cut, tenacity and elongation. Only the yarn neps is the most important quality parameter. So, in this study yarn neps is considered as an output quality parameter for factorial analysis.

1.7 AIMS AND OBJECTIVES OF THE STUDY

Productivity is affected by the operating parameters, machine availability, raw material condition, weather, operator's alertness etc. Experiment may be conducted by controlling input level of the parameter to optimize the yarn quality. Some selected significant parameter of Carding, Ring Frame and Winding were varied while all other factors were kept constant. Following design of experiment methodology.

The specific objectives of the study are as follows:

a) To study the acquisition process of the yarn manufacturing.
b) To identify the significant process parameter.
c) To evaluate the optimum input level of the parameters.
d) To determine the main and interactive effect on the input parameters on the yarn quality by design of Experiment.

1.8 ORIENTATION OF THE THESIS

In the introductory chapter of cotton and yarn quality co-relation, cotton quality specifications, choosing quality, major parameter in yarn processing, orientation of the thesis, aims and objectives of the study.

The second chapter "Background study and literature search" contains introduction, processing of yarn and manufacturer's target, design of experiment, advantage of factorial design and application of factorial design.

In third chapter "State-of-art technology of yarn manufacturing" brief description of technology used in yarn manufacturing is described. This chapter consists of the description of some major yarn processing machines as well as their operating and production process.

The fourth chapter titled" Experimental procedure and data collection" consists of planning of experiments, procedure of experiment, screening of data, randomization, specification etc.

The fifth chapter analysis and observation of experiments are described. This chapter consists of main and interactive effect of different factors, observation of experiments, effect of result on yarn quality etc.

Finally, in the last sixth chapter results and conclusions found from experiments are described. Recommendations for future works are also mentioned in this chapter.

Chapter 2

BACKGROUND STUDY AND LITERATURE SEARCH

2.1 INTRODUCTION

Industry has become increasingly aware of the importance of quality. It is being used as a business strategy to increase market share. Organization is achieving world class quality by using design of experiments. Therefore every company wants to lower the cost, improve quality and become more responsive to customers.

The Textile industries are among the most competitive in the world , driven as they are by the pressures of global supply lower price and improve quality . Meeting global standards is difficult due differences in operating practices in different countries. Their specification go behind the measurement , and define how process should be essential to optimizing the quality . The textile manufacturers improve the quality by maintaining of their different parameter in the manufacturing process. The organization culture can motivates and enables the worker to do what is necessary to deliver quality service.

2.2 PROCESSING OF YARN AND MANUFACTURER'S TARGET

In yarn manufacturing industry, the quality yarn produced is important. Therefore every company wants to lower the price, optimize the quality and become more responsive to customers.

There are varieties of application of optimizing technique. These techniques are helpful in sustaining in business, keeping the production price stable in the situation of increasing fixed cost, raw material cost, labor cost, taxes etc. Moreover, through these techniques it is possible to maintain feasible price rate of product for customer. Thus it checks consumer's grievances due to price rise and maintains customer satisfaction.

In the production line of an industrial organization it is always a matter of concern to determine the process variables which affect the certain areas of interest (popularly known as response). A logical next step is to optimize, that is to determine the region in the important factors that leads to the best possible outcome, also termed as response in the design of experiment. For example, if the response is yield, it would look for a region of maximum yield. Whereas if the response is the variability in a critical product dimension, it would seek a region of minimum variability.

2.3 COMMON METHODS OF OPTIMIZATION

There are many methods used to optimize the output and profit. These are linear programming, factorial design, response surface design, nested or hierarchical deign etc. Brief description of these design methods is given below:

a) **Linear programming**: In this method the objective function is determined in the form of a linear equation. The constrains to achieve this objective function are also expressed in form of algebraic equation. Optimizing can be achieved by solving these equations manually or with computer software.
b) **Factorial design**: factorial design involves the study of effects of two or more factors. It is one of the most efficient methods. it means that in each complete trial or replication of the experiment all possible combinations of the levels of the factors invested. For example, if there are ' a ' level of factors A and 'b' levels of factor B, then each replicate contains all 'ab' treatment combinations. When factors are arranged in a factorial design, they are said to be crossed.
c) **Response surface design:** Response surface methodology (RSM) is a collection of mathematical and statically techniques that are useful for modeling and analysis of problems in which response of interest is influenced by several variations and the objective is to optimize this response.

2.4 DESIGN OF EXPERIMENT

Experiments are performed by investigations in virtually all fields of inquiry, usually to discover something about a particular process or system. A deigned experiment is a test or series of tests in which purposeful changes are made to the input variables of a process or system so that we may observe and identify the reasons for changes in the output response.

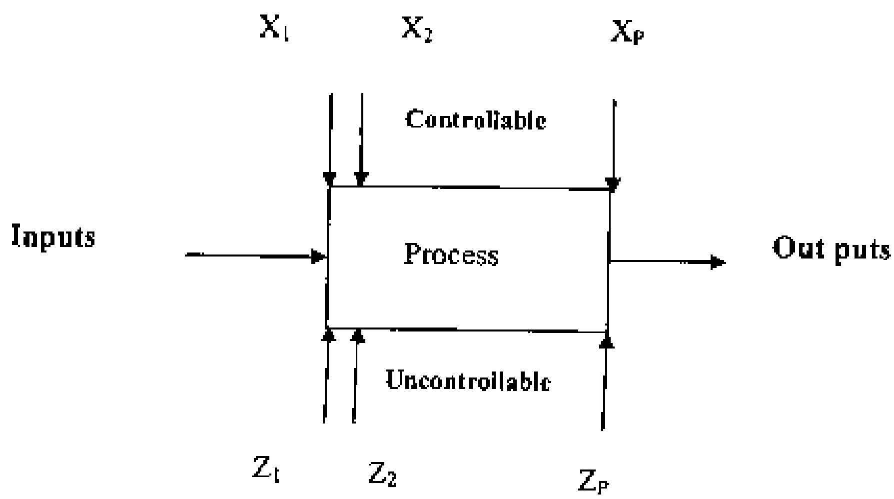


Fig2.1: General model of a process or system

The process or system can be represented by the model shown in fig: 2.1.We can usually visualize the process as a combination of machines, methods, people and other resources that transform some input (often a material) into an output that has one or more observable responses. Some of the process variables are controllable, whereas other variables are uncontrollable (though they may be controllable for purposes of a test). The objective of a process is to optimize output by considering all controllable and uncontrollable variables as much as possible.

Factorial design methods have found broad application in many disciplines. In fact, we may view experimentation as part of the scientific process and as one of the ways we learn about how system or processes work. Generally, we learn through a series of activities in which we make conjectures about a process, perform experiments to generate data from the process, and then use the information from the experiment to establish new conjectures which lead to new experiments, and so on.

Experimental design is a critically important tool in the engineering world for improving the performance of a manufacturing process. It also has extensive application in the development of new process. The application of experimental design technique early in process development can result in the following:

a) Improving process yield
b) Reduced variability and closer conformance to nominal or target requirement
c) Reduced development time.
d) Reduce overall costs.

Experiment design methods also play a major role in engineering design activities, where new products are developed and existing ones improved. Some applications of experimental design in engineering design include

a) Evaluation and comparison of basic design configuration.
b) Evaluation of material alterations.
c) Selection of design parameters that the product will work well under a wide variety of field conditions, that is, so that the product is robust.
d) Determination of key product design parameters that impact product performance.

The use of experimental deign in these areas can result in products that are easier to manufacturer, product that have enhanced field performance and reliability, lower product cost and shorter product design and develop time.

2.5 ADVANTAGE OF FACTORIAL DESIGN

Factorial designs have the several advantages. They are more efficient than one factor at a time experiments. Furthermore, a factorial design is necessary when interaction may be present to avoid misleading conclusions. Finally a factorial designs allow the effects of a factor to be established at several levels of the other factors, yielding conclusions that are valid over a range of experimental conditions. Relative efficiency of a factorial design to one at a time experiments is shown in fig.2.2

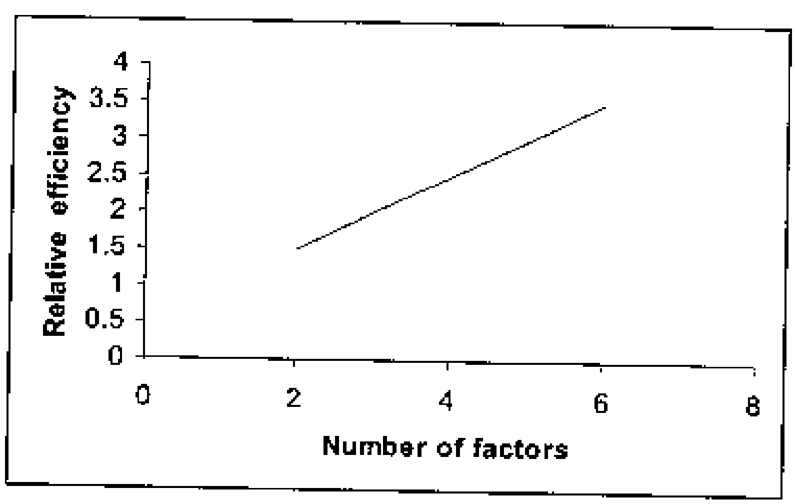


Fig2.2: Relative efficiency of factorial design to a one factor at a time experiments (two factor levels)

The advantage of factorial deign can be easily illustrated. Suppose we have factors A and B, each at two levels. Denote the levels of the factors by A_1, A_2, B_1 , B_2 Information on both factors could be obtained by varying the factors one at a time. The effect of changing factor A is given by $A_2 B_1$, - A_1B_1. Since experimental errors are present, it is desirable to take two observation, say, at each treatment combination and estimate the effect of the factors using average response. Thus, a total of six observations are required.

One factor at a time methods

Factor B

Factor A	B_1	B_2
	A_1 B_1	A_1 B_2
	A_2 B_1	Nil

Figure: 2.3 One factor at a time method

If a factorial experiment had been performed, an additional treatment combination, A_2B_2, would have taken. Now, using just four observations, two estimates of the A effect can be made: A_2B_1 - A_1B_1 and A_2 B_2 - A_1B_2. Similarly, two estimates of the b effect can be made. These two estimates of each main effect could be averaged to produce average main effects that are just as precise as those from the single factor experiment., but only four total observations are required and we would say that the relative efficiency of the factorial design to the one-factor-at-a-time experiment is $6/4 = 1.5$ .Generally, this relative efficiency will increase as the number of factors increases.

Now suppose, interaction is present. If the one-factor-at-a-time design indicated that A_1B_2 and A_2B_1 gave better response than A_2 B_2 , a logical conclusion would be that A_2B_2 would be better. However, if interaction is not present, this conclusion may be seriously in error.

2.6 APPLICATION OF FACTORIAL DESIGN

There are various parameters in a process industry and to optimize the process; the study of the effects of two or more factors is needed. Factorial design is one of the most efficient convenient methods for this type of experiment. Factorial design means that in each complete trial or replication of the experiment all possible combinations of the levels of the factors are investigated. For example, if there are 'a' levels of factor A and 'b' levels of factor B, then each replicate contains all 'ab' treatment combinations. When factors are arranged in a factorial design, they are said to be crossed.

The effect of a factor is defined to be the change in response produced by change in the level of the factor. This is frequently called a main effect because it refers to the primary factors of interest in the experiment. In some experiment, we find that the difference in response between the levels of one factor is not the same at all levels of the other factors. When this occurs, there is an interaction between the factors.

		Factor B	
		B_1	B_2
Factor A	A_1	$A_1 B_1$ 20	$A_1 B_2$ 30
	A_2	$A_2 B_1$ 40	$A_2 B_2$ 52

Figure: 2.4 factorial experiments (a)

Consider the above data of experiment. The main effect of factor A could be through of as the difference between the average response at the first level of A and the average response at the second level of A. Numerically, this is

$$A = (A_2 B_1 + A_2 B_2)/2 - (A_1 B_1 + A_1 B_2)/2 = (40+50)/2 - (20+30)/2 = 21$$

That is, increase factor a from level 1 to level 2 causes an average response increase of 21 units. Similarly, the main effect of B is

$$B = (A_1 B_1 + A_2 B_2)/2 - (A_1 B_1 + A_2 B_1)/2 = (30+52)/2 - (20+40)/2 = 11$$

If the factors appear at more than two levels, the above procedure must be modified since there are many ways to express the differences between the average responses.

In some experiments, we may find that the difference in response between the levels of one factor is not the same at the other entire factor. When this occurs, there is an interaction between the factors. For example, consider the data below.

Factor B

		B_1	B_2	
Factor A	A_1	A_1 B_1 20	A_1 B_2 40	
		A_2 B_1 50	A_2 B_2 12	A_2

Figure: 2.5 Factorial experiments (b)

At the first level of factor B, the A effect is $A = A_2B_1 - A_1B_1 = 50\text{-}20 = 30$

And at the second level of factor B, the effect is $A = A_2B_2 - A_1B_2 = 12\text{-}40 = -28$

Since the effect of a depends on the level chosen for factor b, we see there is interaction between A and B.

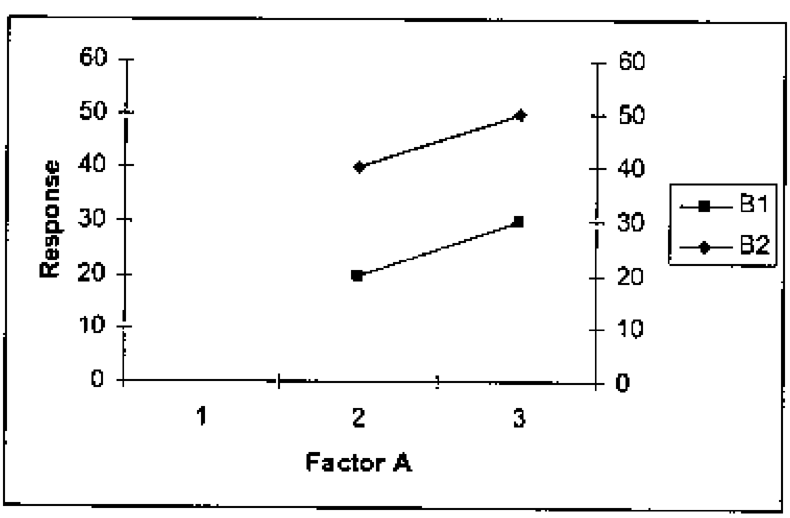


Figure 2.6: No interaction present between the factors of experiments (a)

There idea may be illustrated graphically. Figure2.6 plots the response data of experiments (a) of figure 2.4 against factor A for both levels of factor B. Note that the B1 and B2 lines are approximately parallel , indicating a lack of interaction between factor A and B. figure 2.7 plots the response data of experiment (b) of figure 2.5 .Here we see that B1 and B2 lines are not parallel , this indicate an interaction between factors A and B. Graphs such as there are frequently very useful in interpreting significant interactions and in reporting results to nonstatistically trained management. However, they should not be utilized as the sole technique of data analysis because their interpretation is subjective and their appearance is often misleading.

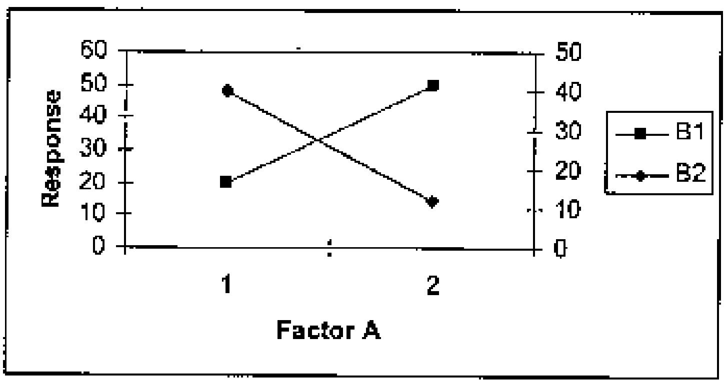


Figure 2.7: Strong interaction present between the factors of experiment (b)

Note that when an interaction ids large, the corresponding main effects have been little practical meaning .For the data of second experiment, we would estimate the main effect of A to be

$$A = (A_2B_1 + A_2B_2)/2 - (A_1B_1 + A_1B_2)/2 = (50+12)/2 - (20+40)/2 = 1$$

Which is very small, and we are tempted to conclude that there is no effect due to A. However, when we examine the effects of A at different levels of factor B i.e. see that this is not the case. Factor A has an effect, but it depends on the level of factor B. That is, knowledge of the AB interaction is more useful than knowledge of the main effect. A significant interaction will often mask the significant of main effects. This is clearly indicated by the data of second experiment. In the presence of significant interaction, the experiment must usually examine the levels of one factor, say A, with levels of the other factors fixed to draw conclusions about the main effect of A.

2.7 TAGUCHI'S CONTRIBUTIONS TO EXPERIMENTTAL DESIGN AND QUALITY ENGINEERING

Design of experiment is used for product and process improvement. One important goal of quality improvement is to design quality into every product and process that build them. Statistically design of experiments are a major element of this activity.

Professor Taguchi advocates a philosophy of quality engineering that is broadly applicable. His philosophy is based on three stages in a process.
These are:

- System deign
- Parameter design
- Tolerance design.

Unfortunately, the principles of experimental design (and statistically methods in general) have not been as widely used in the West as in Japan. Japanese engineers have had much greater exposure to these concepts and consequently, experimental design methods have become more of an engineering tool in Japan than they have in the United States. Taguchi methods have been adopted by many leading Japanese companies. One of these is Nippon Deno. The company conducts 2,500 Taguchi experiments each year, probably more than the total of D.O.E experiments of all kinds in the entire United States .Recently AT & T, Ford, Xerox, I.T.T, United technologies have started to use the orthogonal array approach. In the early 1980s Professor Genechi Taguchi introduced his approach to using experimental design for

- Design products or process so that they are robust to environmental conditions.
- Designing/developing products so that they are robust to component variation
- Minimizing variation around a target value.

The philosophy that Taguchi recommends is sound and should be included in improving quality of any process. However, he has advocated some novel methods of statistically data analysis and some approaches to the design of experiments that are complicated, insufficient and sometimes inefficient. It is possible to combine his sound engineering concepts to more efficient and effective experimental design and statistical data analysis methods.

2.8 QUALITY ACHIEVING TECHNIQUES

There are three techniques for achieving quality – the traditional approach, SPC and the design of experiment (DOE). The traditional quality control consists of ineffective methods such as brute-force inspection, delegation of quality control responsibility to a detached quality control department and even sampling plans.

Statistically process control (SPC) is a popular quality control tool. It is used to prevent defective work being produced by focusing on the producing process rather than on the final product. It is superior to sampling inspection plans whose only aim is to trap the defects after they have been produced a feature which makes this types of quality control an appraisal procedure rather than a quality improvement effort. It provides the operator with an opportunity of correction or appropriate tuning the production process in time to avoid whole batches being rejected later. It is also encourages continual process improvement, with this improvement being reflected in the product as well as in the production equipment. It helps to avoid unnecessary blame and recrimination by assigning the appropriate responsibilities to the appropriate people. SPC is a step forward in the evolution of quality control system but, in term of effort concentration, it is actually a step backwards from full inspection of the final product process. Furthermore, SPC cannot provide success in case of major problem in machine setting. It is only monitor if the process in within tolerance or specification limit. But there may be major defect in machine setting. These major problems cannot be removed or detected by SPC. In this case DOE tools are more effective.

The central thrust and secret weapon, on Japanese quality is its widespread use of design of experiment (DOE). The objective of DOE is to discover key variables in product and process design, to drastically reduce the variation they cause, and to open up the tolerance on the lesser variables so as to reduce costs. Relation between SPC and DOE is presented below in table 2.1

PROPERTY	SPC	DOE
1. Function	Monitor if the process is with in the tolerance/specification limit	Solve major problem in process design
2. Process type	On line process	Off line process
3. Uses	Used to control a process	Used to design a process or a product.
4. Typical uses	Universal quality control tool	Universal quality control tool
5. When to use	All times	All times
6.Analysis	Analyze data	Analyze data
7.Cost	Required low cost.	Easier and more cost effective than SPC

Table 2.1 Difference between SPC and DOE

Chapter – 3

STATE –OF – THE ART TECHNOLOGY OF YARN MANUFACTURING

3.1 INTRODUCTION:

BEXIMCO, a leading group of industries installed its spinning mill, Padma Textile Mills Ltd. to meet yarn requirement of Beximco Textile Ltd., Beximco Knitting Ltd. Beximco Denim Ltd. and to sell to other export oriented textile industries.

Manufacturing Products

1. Producing 100% export oriented spun yarn.
2. Manufacturing 100% cotton, Polyester yarn and several blends with polyester, viscose & Tencel.
3. Manufacturing diversified spun yarn like Polyester core yarn, Lycra core yarn & Fancy (Slub) yarn.

3.2 MANUFACTURING PROCESS:

Padma Textile Mills Ltd (PTML) major yarn manufacturer for export-oriented industries. PTML has to be very serious on the quality of its yarn. Presently the mill controls the process parameter according to the manufacturer suggestion or by the experience gained by the operating personnel. It is strongly felt that the yarn quality can be improved by the process parameters thorough scientific observation like factorial experiments. There are three sections here back section, ring section and finishing section. Mainly three process parameter are considered in back section. They are carding delivery speed, cylinder speed and flat speed. Two parameters are identified in ring section, they are ring speed and ring twist per inch. In finishing section, only the winding speed is considered as a process parameter.

3.2.1 PROCESS FLOW DIAGRAM:

There are two types flow diagram. They are

1) Karded Yarn
2) Combed Yarn

Spinning process (Karded) flow diagram is given blow in figure 3.1

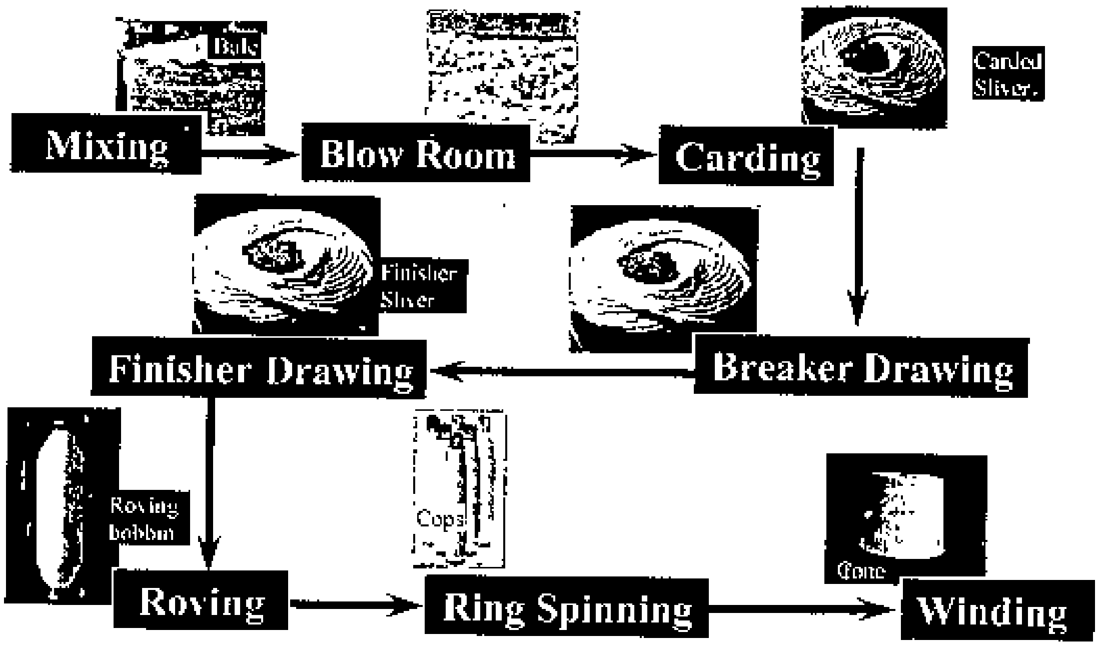


Fig 3.1 Spinning Process (Karded) Flow

Spinning process (Combed) flow diagram is given blow in figure 3.2

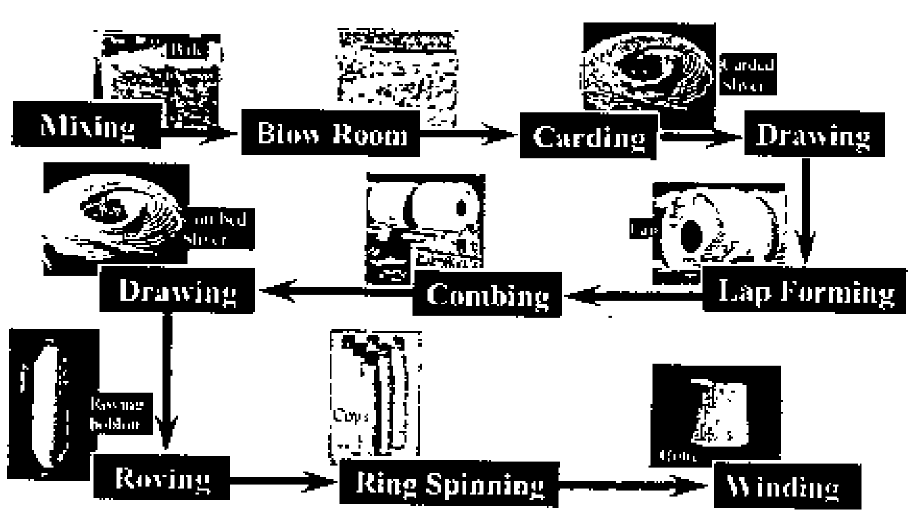


Fig 3.2 Spinning Process (Combed) Flow

There are many type of machineries used during yarn manufacturing process. The entire machines are shown below in figure 3.3

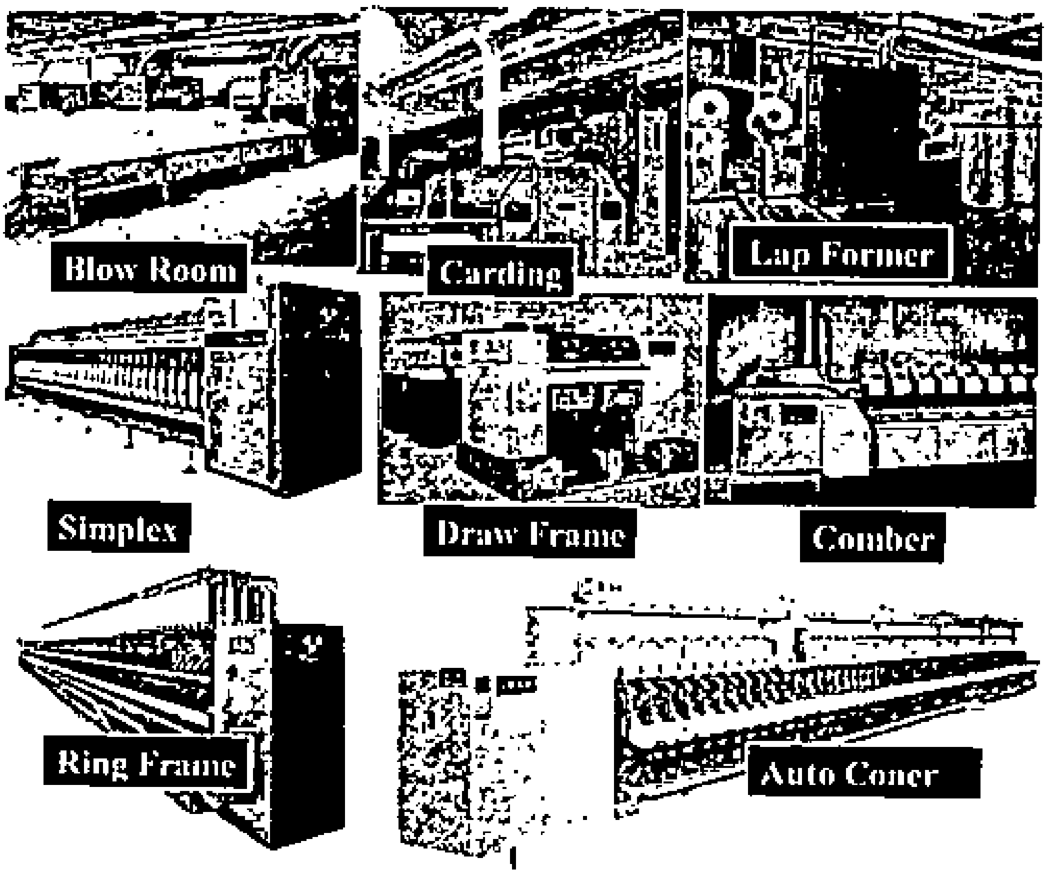


Fig 3.3 Different types of process machinery.

BLOW ROOM

3.2.2 INTRODUCTION:

The machines are arranged according to the kard process & combed process flow. Machine description and function are given below.

Basic operations in the blow room: opening

1. cleaning
2. mixing or blending
3. micro dust removal
4. uniform feed to the carding machine
5. Recycling the waste

A blow room installation consists of a sequence of different machines to carry out the above said operations. The tuft size of cotton becomes smaller and smaller, the required intensities of processing necessitates different machine configuration. The blow room machinery is shown in fig.3.4

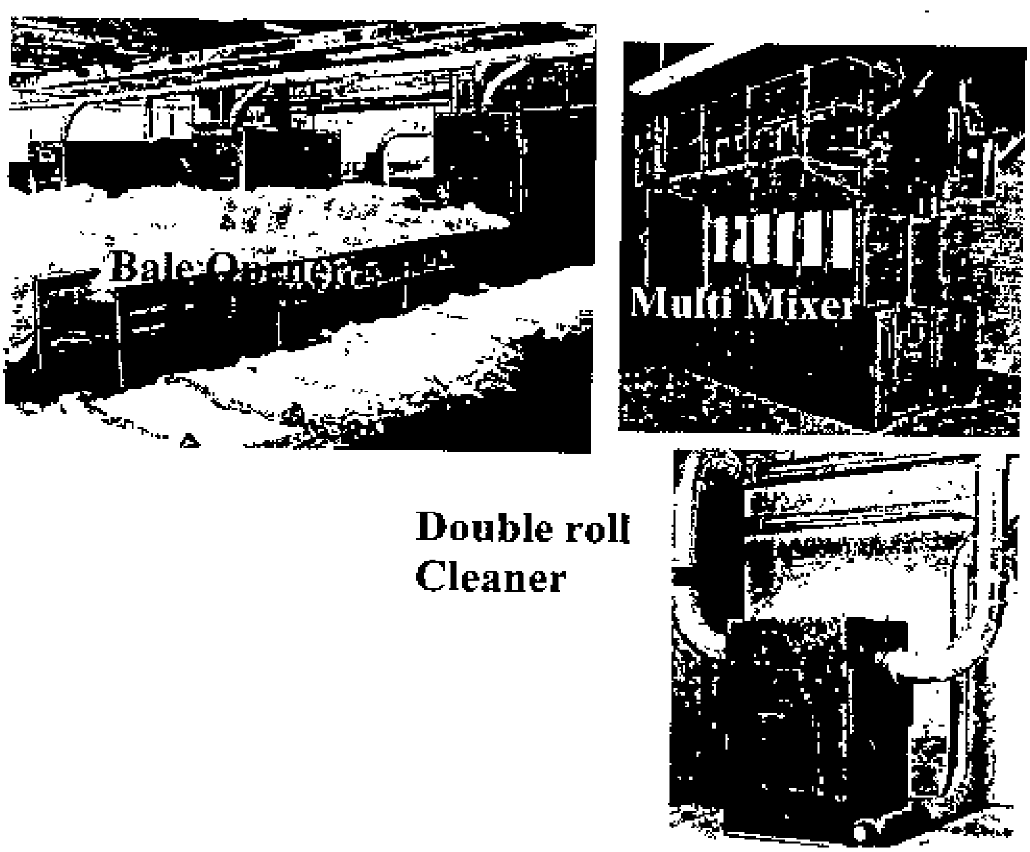


Fig 3.4 Blow room machinery

TECHNOLOGICAL POINTS IN BLOWROOM

•opening in blow room means opening into small flocks. Technological operation of opening means the volume of the flock is increased while the number of fibres remains constant. i.e. the specific density of the material is reduced.

•The larger the dirt particle, the better they can be removed.

• Cleaning is made more difficult if the impurities of dirty cotton are distributed through a larger quantity of material by mixing with clean cotton.

•If cotton is opened well in the opening process, cleaning becomes easier because opened cotton has more surface area, therefore cleaning is more efficient.

•If automatic bale opener is used, the tuft size should be as small as possible and the machine stop time should be reduced to the minimum level possible

•Due to machine harvesting, cotton contains more and more impurities, which furthermore are shattered by hard ginning. Therefore cleaning is always an important basic operation.

• Traditional methods use more number of machines to open and clean natural fibres.

• Mechanical action on fibres causes some deterioration on yarn quality, particularly in terms of neps. Moreover it is true that the staple length of cotton can be significantly shortened.

• Air streams are often used in the latest machine sequence, to separate fibres from trash particles by buoyancy differences rather than beating the material against a series of grid

• General factors which affect the degree of opening, cleaning and fibre loss are given blow

1. fiber alignment
2. Size of the flocks in the feed.
3. the type of opening device
4. speed of the opening device
5. type of feed (loose or clamped)
6. distance between feed and opening device
7. speeds of the opening devices
8. throughput speed of material
9. airflow through the grid
10. condition of pre-opening
11. quantity of material processed
12. position of the machine in the machine sequence
13. feeding quantity variation to the beater
14. ambient R.H.%
15. ambient temperature

MIXING

3.2.3 MIXING (COTTON)

Cotton is a hygroscopic material, hence it easily adapts to the atmospheric air-conditions. Air temperature inside the mixing and blow room area should be more than 25 degree centigrade and the relative humidity(RH%) should be around 45 to 60 %, because high moisture in the fibre leads to poor cleaning and dryness in the fibre leads to fibre damages which ultimately reduces the spin ability of cotton.

Cotton is a natural fibre. The following properties vary very much between bales (between fibres) fibre micronaire fibre length , fibre strength, fibre color, fibre maturity , fibre micronaire, color, maturity and the origin of growth results in dye absorption variation. There fore it is a good practice to check the maturity, color and micronaire of all the bales and to maintain the following to avoid dye pick up variation and barre the finished fabric.

BALE MANAGEMENT:

In a particular lot

- Micronaire range of the cotton bales used should be same for all the mixings of a lot.
- Micronaire average of the cotton bales used should be same for all the mixings of a lot.
- Range of color of cotton bales used should be same for all the mixings of a lot.
- Average of color of cotton bales used should be same for all the mixings of a lot.
- Range of maturity coefficient of cotton bales used should be same for all mixings of a lot.
- Average of maturity coefficient of cotton bales used should be same for all mixings of a lot.

- Mixing is the best way of doing the mixing compared to using automatic bale openers which picks up the material from 40 to 70 bales depending on the length of the machine and bale size, provided stack mixing is done perfectly. Improper stack mixing will lead to barre or shade variation problem. Stack mixing with bale opener takes care of short term blending and two mixers in series takes care of long term blending.

The raw cotton is shown below in fig3.5

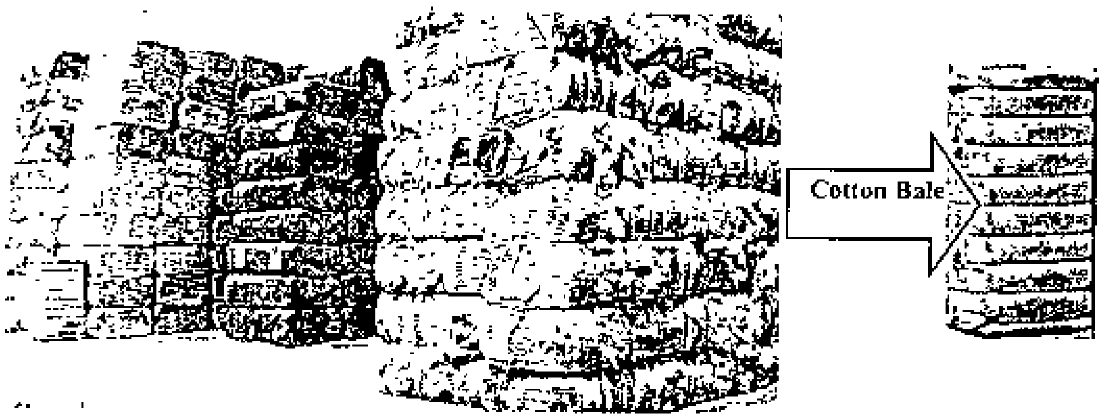


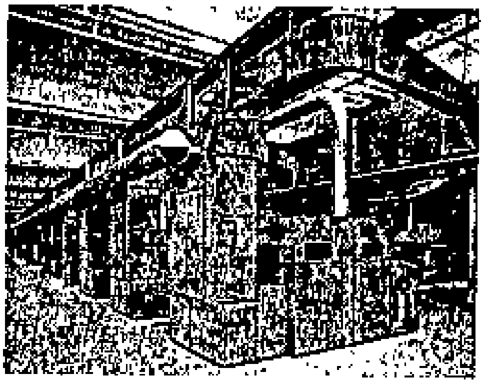
Fig3.5 Raw Cotton

CARDING

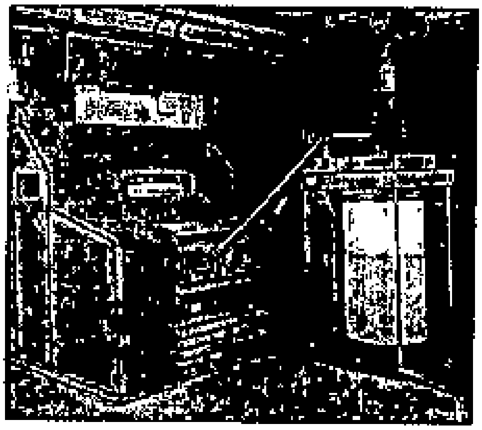
3.3 INTRODUCTION

"Card is the heart of the spinning mill" and "Well carded is half spun" are two proverbs of the experts. These proverbs inform the immense significance of carding in the spinning process. High production in carding to economize the process leads to reduction in yarn quality. Higher the production, the more sensitive becomes the carding operation and the greater danger of a negative influence on quality. Carding machine is shown in fig3.6

Tuft Feeder



Chut feed Cards



Trutzschler
DK 903

Fig3.6 Carding machine

FUNCTION OF CARDING:

1) Opening 2) Cleaning 3)Delivery sliver

THE PURPOSE OF CARDING:

1. Cleaning or elimination of impurities
2. Reduction of neps
3. Elimination of dust
4. Elimination of short fibres
5. Fibre blending
6. Fibre orientation or alignment
7. Sliver formation

PROCESS PARAMETERS IN CARDING

Carding is the most important process in spinning. It contributes a lot to the yarn quality. The following process parameters and specifications are to be selected properly to produce a good quality yarn with a lower manufacturing cost.

CYLINDER SPEED

Cylinder wire selection is very important, it depends upon cylinder speed ,the raw material to be processed and the production rate. The following characteristics of cylinder speed should be considered.

- Higher cylinder speed helps fibre transfer. Higher the production, higher should be the cylinder speed.
- Higher cylinder speed improves carding action, thereby imperfections are reduced.
- Cylinder wire front angle depends on mainly cylinder speed and coefficient of friction of raw material. Higher the cylinder speed, lower the angle for a given fibre. The cylinder speed in turn depends upon the production rate.
- Higher production means more working space for the fibre is required. It is the wire that keeps the fibre under its influence during carding operation. Therefore the space within the wire should also be more for higher production. Higher cylinder speeds also increase the space for the fibre. Therefore higher cylinder speed is required for higher production.
- Higher the cylinder speed, higher the centrifugal force created by the cylinder, this tries to eject the fibre from the cylinder, along with the trash. It is the cylinder wire's front angle which overcomes the effect of this force. Low front angle with too low cylinder speed and with high frictional force will result in bad quality, because the fibre transfer from cylinder to doffer will be less. Hence recycling of fibres will take place, which result in more neps and entanglements.

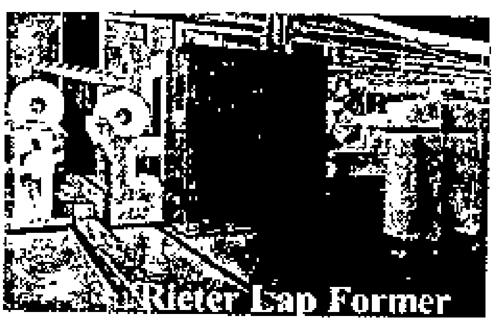
DELIVERY SPEED AND FLAT SPEED:

- The setting between cylinder and doffer is the closest setting in the card. This setting mainly depends upon the cylinder speed, hank of the delivery speed of sliver and the type of wire. Cylinder speed up to 360, the setting should be 0.1mm. For cylinder speeds more than 450, the setting ranges from 0.125 to 0.15.
- Higher flat speed improves yarn quality and at the same time increases the flat waste.
- With the same flat speed, higher the carding production, lower the flat waste and vice-versa.
- The most critical setting in a carding machine is between cylinders and flat speed. While processing cotton, it can be as close as 0.175 mm provided the mechanical accuracy of flat speed is good.

- Closer the setting between cylinder and flats, better the yarn quality. Neps are directly affected by this setting. Of course, very close setting increase the flat speed.
- These stationary flats open the material so that, the setting between cylinder and flats can be as close as possible.
- For cotton processing, the stationary flats are fixed with a knife attachment. The setting should be as close as possible, i.e. around 0.15mm. This helps to remove the trash particles of very small size.
- The setting between cylinder and cylinder under casing should be as per the manufacturer's recommendation. The design of under casing is different for different manufacturers. This setting is very important, as wrong settings will affect the fibre transfer and can also create air turbulence.

3.4 LAP FORMER & COBBER:

The function of lap former is to make cotton lap from doubling of slivers for combing. Comber extracts the short fibers to make a clean sliver with more parallel longer fibers. The lap former & comber are shown below in fig 3.7



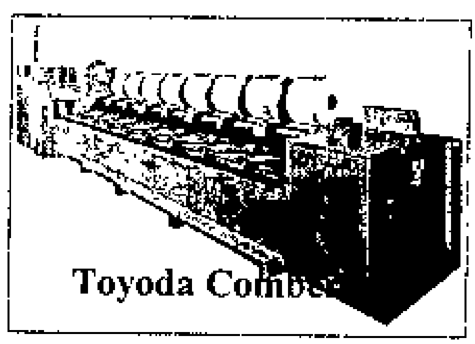


Fig3.7 Lap former & Comber

3·5 **SIMPLEX:** The functions of simplex are drafting and twisted roving formation. The simplex figure is shown below in fig 3.8

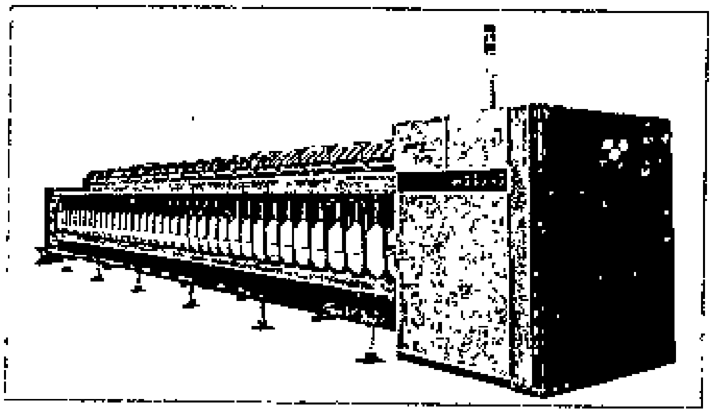


Fig 3.8 Simplex machine

RING FRAME

3.6 INTRODUCTION:

The ring spinning will continue to be the most widely used form of spinning machine in the near future, because it exhibits significant advantages in comparison with the new spinning processes. Following are the advantages of ring spinning frame

- It is universal applicable, i.e. any material can be spun to any required count
- It delivers a material with optimum characteristics, especially with regard to structure and strength.
- the know-how is well established and accessible for everyone

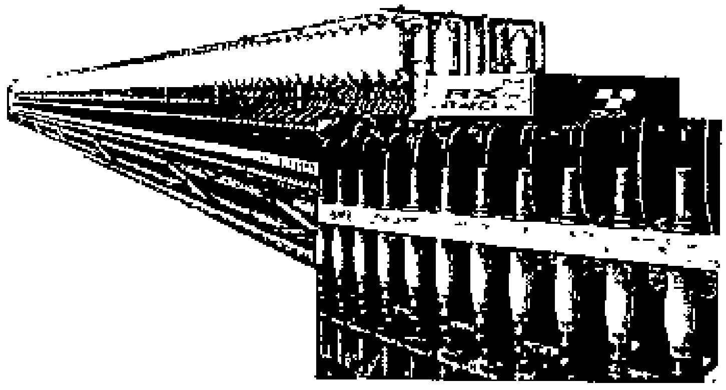


Fig 3.9 Ring frame

FUNCTION OF RING FRAME

- to draft the roving until the required fineness is achieved

- to impart strength to the fibre, by inserting twist
- to wind up the twisted strand (yarn) in a form suitable for storage, transportation and further processing.

DRAFTING

• Drafting arrangement is the most important part of the machine. It influences mainly evenness and strength.
The following points are therefore very important

- drafting type
- design of drafting system
- drafting settings
- selection of drafting elements like cots, apron, traveller etc
- choice of appropriate draft
- service and maintenance

• Drafting arrangement influence the economics of the machine - directly by affecting the end break rate and indirectly by the maximum draft possible.

• If higher drafts can be used with a drafting arrangement, then coarser roving can be used as a feeding material. This results in higher production rate at the roving frame and thus reducing the number roving machines required, space, personnel and so on.

• In fact increase in draft affects the yarn quality beyond certain limit. Within the limit some studies show that increase in draft improves yarn quality. The following draft limits have been established for practical operation:

- carded cotton- up to 35
- carded blends – up to 40
- combed cotton and blends(medium counts) – up to 40
- combed cotton and blends(fine counts) – up to 45
- synthetic fibres – up to 50

• The break draft must be adapted to the total draft in each case since the main draft should not exceed 25 to 30. It should be noted that higher the break draft, more critical is the break draft setting

• The front top roller is set slightly forward by a distance of 2 to 4mm relative to the front bottom roller, while the middle top roller is arranged a short distance of 2mm behind the middle bottom roller.

• Overhang of the front top roller gives smooth running of the top rollers and shortens the spinning triangle. This has a correspondingly favorable influence on the end break rate.

• Rubber cots with hardness less than 60 degrees shore are normally unsuitable because they can not recover from the deformation caused by the pressure on the top roller while running.

• Soft rubber cots for top rollers have a greater area of contact, enclose the fibre strand more completely and therefore provide better guidance for the fibres. However softer cots wear out significantly faster and tend to form more laps.

• Normally harder rubber cots are used for back top rollers, because the roving which enters the back roller is compact , little twisted and it does not require any additional guidance for better fibre control.

• In the front top roller, only few fibres remain in the strand and these exhibit a tendency to slide apart. Additional fibre guidance is therefore necessary. Therefore rubber cots with hardness levels of the order 80 degrees to 85 degrees shore are mostly used at the back roller and 63 degrees and 65 degrees at the front roller.

• If coarse yarns and synthetic yarns are being spun, harder rubber cots are used at the front roller because of increased wear and in the case of synthetic yarns to reduce lapups.

• Three kinds of top roller weighting(loading) are presently in use

- spring loading
- pneumatic loading
- magnetic weighting

• With pneumatic loading system, the total pressure applied to all top rollers is obtained by simple adjustment of the pressure in the hose using pressure reducing valve. Moreover the rubber cots will not get deformed if the machine is stopped for a longer duration, because the pressure on top rollers can be released to the minimum level.

• The fibre strand in the main drafting field consists of only a few remaining fibres. There is hardly any friction field and fibre guidance provided by the rollers alone is inadequate. Special fibre guiding devices are therefore needed to carry out a satisfactory drafting operation. Double apron drafting arrangements with longer bottom aprons is the most widely used guiding system in all the modern ring frames.

• In double apron drafting system two revolving aprons driven by the middle rollers form a fibre guiding assembly. In order to be able to guide the fibres, the upper apron must be pressed with controlled force against the lower apron. For this purpose, a controlled spacing (exit opening), precisely adapted to the fibre volume is needed between the two aprons at the delivery. This spacing is set by "spacer" or "distance clips". Long bottom aprons have the advantage in comparison with short ones that they can be easily replaced in the event of damage and there is less danger of choking with fluff.

• Spindles and their drive have a great influence on power consumption and noise level in the machine The running characteristics of a spindle, especially imbalance and eccentricity relative to the ring flange, also affect yarn quality and of course the number of end breakage. Almost all yarn parameters are affected by poorly running spindles. Hence it should be ensured that the centering of the spindles relative to the rings is as accurate as possible. Since the ring and spindle form independent units and are able to shift relative to each other in operation, these two parts must be re-centered from time to time. Previously, this was done by shifting the spindle relative to the ring, but now it is usually carried out by adjusting the ring.

• In comparison with tangential belt drive, the 4-spindle drive has the advantages of lower noise level and energy consumption, and tapes are easier to replace.

• Lappet guide performs the same sequence of movements as the ring rail, but with a shorter stroke, this movement of the guide ensures that differences in the balloon height caused by changes in the ring rail positions do not become too large. This helps to control the yarn tension variation with in control, so that ends down rate and yarn characteristics are under control.

• Spindles used today are relatively long. The spacing between the ring and the thread guide is correspondingly long, thus giving a high balloon. This has two negative influence

- A high balloon results in large bobbin diameter leading to space problems
- Larger the balloon diameter, higher the air drag on the yarn. This intern causes increased deformation
  of the balloon curve out of the plane intersecting the spindle axis. This deformation can lead to balloon stability,
  there is increase danger of collapse.

Both these disadvantages result in higher yarn tension, thereby higher end breaks. In order to avoid this, balloon control rings are used. It divides the balloon into two smaller sub-balloons. Inspire of its large overall height, the double-balloon created in this way is thoroughly stable even at relatively low yarn tension.

• Balloon control rings therefore help to run the machine with long spindles(longer lift) and at high spindle speed, but with lower yarn tension. Since the yarn rubs against the control ring, it may cause roughening of the yarn.

• Most ends down arise from breaks in the spinning triangle, because very high forces are exerted on a strand consisting of fibres which have not yet been fully bound together in the spinning triangle.

WINDING

3.7 INTRODUCTION:

Ring spinning produces yarn in a package form called cops. Since cops from ring frames are not suitable for further processing, the winding process serves to achieve additional objectives made necessary by the requirements of the subsequent processing stages.

Following are the tasks of winding process

- Extraction of all disturbing yarn faults such as the short, long thick, long thin, spinner's doubles, etc.
- Manufacture of cones having good drawing - off properties and with as long a length of yarn as possible.
- introduction into the yarn of a minimum number of knots.
- achievement of a high machine efficiency i.e. high production level.

Practical experience has proven that winding alters the yarn structure. This phenomenon does not affect yarn evenness, but affect the following yarn properties

- neps
- thick places
- thin places
- hairiness
- standard deviation of hairiness

If winding tension is selected properly, the following tensile properties are not affected

- tenacity
- elongation
- work- to- break

But excessive tensions in winding will deteriorate the above said tensile properties.

Changes in the yarn surface structure due to winding cannot be avoided. Since the yarn is accelerated from zero speed to 1200 or 1350 meters per min in a few milli seconds while being pulled off the bobbin, dragged across several deflection bars and eyelets, forced into a traverse motion at speed that make it invisible, and finally rolled up into a firm construction called package or cone which also related to the yarn quality.

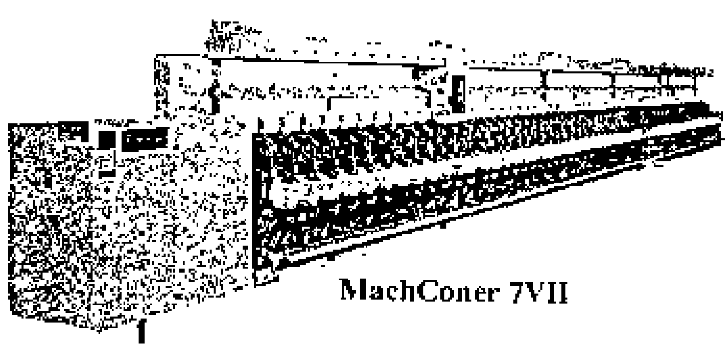


Fig3.9.1 Winding machine

High speed automatic winders have frequently been blamed for causing higher nep counts .The bobbin unwinding behavior is the major limiting factor for winding speed which also is the main reason for the above said changes in yarn quality. Most of the damage occurs at the moment when the end is detached and removed from the tight assembly of yarn layers on the bobbin and dragged along the tube at very high speeds.

The factors that affect the yarn structure during winding include the frictional properties of the yarn itself, winding speed, the bobbin geometry and the bobbin unwinding behavior, winding geometry as well as the number and design of the yarn / machine contact points.

YARN CLEARER FUNCTION PRINCIPLE

The yarn is measured in a measuring field constituted by a set of parallely placed capacitor plates. When the yarn passes through this measuring field (between the capacitor plates), an electrical signal is produced which is proportional to the change in mass per unit length of the yarn. This signal is amplified and fed to the evaluation channels of the yarn clearing installation. The number and type of evaluation channels available are dependent on the sophistication and features of the model of the clearer in use. Each of the channels reacts to the signals for the corresponding type of yarn fault. When the mass per unit length of the yarn exceeds the threshold limit set for the channel, the cutting device of the yarn clearer cuts the yarn.

Yarn Clearer Settings

The yarn clearer has to be provided with certain basic information in order to obtain the expected results in terms of clearing objectionable faults. The following are some of them

a. Winding Speed:

The setting of the winding speed is also very critical for accurate removal of faults. It is recommended that, instead of the machine speed, the delivery speed be set by actual calculation after running the yarn for 2-3 minutes and checking the length of yarn delivered. Setting a higher speed than the actual is likely to result in higher number of cuts. Similarly a lower speed setting relative to the actual causes less cuts with some faults escaping without being cut. In most of the modern day clearers, the count, material number and speeds are monitored and automatically corrected during actual running of the yarn.

b. Clearing Limit:

The clearing limit defines the threshold level for the yarn faults, beyond which the cutter is activated to remove the yarn fault. The clearing limit consists of two setting parameters - Sensitivity and Reference Length.

i. **Sensitivity** - This determines the activating limit for the fault cross sectional size.

ii. **Reference Length** – This defines the length of the yarn over which the faults cross – section is to be measured. Both the above parameters can be set within a wide range of limits depending on specific yarn clearing requirements. Here, it is worth mentioning that the ' reference length' may be lower or higher than the actual ' fault length'. For a yarn fault to be cut, the mean value of the yarn fault cross-section has to overstep the set sensitivity for the set reference length.

c. Yarn Count :

The setting of the yarn count provides a clearer with the basic information on the mean value of the material being processed to which the clearer compares the instantaneous yarn signals for identifying the seriousness of a fault.

Fault Channels:

The various fault channels available in a latest generation yarn clearer are as follows:

1. Neps
2. Short Thick places
3. Long Thick Places
4. Long Thin Places
5. Count
6. Splice

The availability of one or more of the above channels is dependent on the type of the yarn clearer. Most of the modern clearers have the above channels. Besides detection of the various types of faults, with latest clearers, it is also possible to detect concentration of faults in a specific length of yarn by means of alarms(cluster faults).

WINDING PRODUCTION:

It depends upon the following factors

- winding speed
- time required by the machine to carry out one splicing operation
- bobbin length per bobbin (both bobbin weight and tpi (twist per inch) to be considered, because TPI will affect the bobbin length). This decides the number of bobbin changes
- the number of faults in the yarn and the clearer settings, this decides the clearer cuts.
- count
- the time taken for each doff either by the doffer or by an operator
- bobbin rejections, it depends on weak yarn, wrong gaiting, double gaiting, bobbin characteristics etc.

Chapter - 4

EXPERIMENTAL POCEDURE AND DATA COLLECTION

4.1 INTRODUCTION:

To draw a precise decision, several experiments were conducted. The experiments were conducted in a planned way. During these experiments some factors were considered as constant and some were considered as variables. All constant factors were kept unchanged during experiments.

Besides these, some significant factors were selected whose best setting were determined according to the optimize. The data of the experiments were recorded carefully.

4.2 PLANNING OF EXPERIMENT:

In order to optimize the yarn quality, first effective factors and their levels for carding were determined. With the selected two levels of three parameters a 2^3 experimental factorial design of experiment was conducted in the back section. Eight set of test were designed and for a particular set, test was replicated for three times. So the value of the response was actually the mean of three replicated tests resulting in a total number of twenty four tests. Each of the tests was conducted randomly to eliminate error.

In case of ring frame, the first effective factors and their levels were determined. With the selected ~~two~~ three levels of two parameters a 3^2 experimental designed was conducted .Nine sets test were designed, where each set was the mean of three similar tests. These require number of tests was twenty seven. Each of the tests was conducted randomly to eliminate error.

In case of winding, the first effective factors and their levels were determined .With the selected level of one parameter experimental factorial design of experiment was conducted in finishing section.

4.3 SCREENING OF DATA

Experiments conducted with the desired combination of parameter exceeded the estimated number. In some experiments, it was not possible to maintain the desired condition properly. Not only that, inconsistent data was obtained under some set of condition. In both case the data collected were ignored. So to compensate those cases, experiments with required set conditions were performed again.

4.4 RANDOMIZATION

All the tests were conducted randomly to eliminate error. 40C yarn was selected for carding, ring frame and winding respectively. Actually scheduling of lot was conducted according to the requirement of the company. From this schedule experiment were selected for test considering the availability of concerned manpower, material and time. Special care was taken for these tests

4.5 EXPERIMENT CARIED OUT WITH CARDING

As mentioned earlier "40C" type yarn was selected for the experiments in carding. Two levels are selected against three factors. Eight groups of experiment were conducted for this purpose. Each group consists of three sets of similar experiment. The individual section was not synchronized because a test or series of test in which purposeful changes were made to the input variables of a process or system so that one may observe and identify the reasons for change in the output.

4.6.1 SPECIFICATIONS OF CARDING

Carding may be operated under some limitation of parameter setting. The carding has some range of operating parameter. The carding may be operated maintaining these rated set conditions. But actually this carding is operated as per company's convenient maintaining some standard operating set conditions. It is risky to operate the machine beyond any limit. Specification, rated set conditions and standard operating set conditions of carding are given in table 4.1

Table: 4.1 Specification and standard operating set conditions of carding

Delivery Speed		Up to 300 (m/min)
Flat Speed		153 m/min
Cylinder Speed		(369-451) rpm
Machine efficiency		96%
Diameter	Feed roller	100 mm
	Taker-in	250 mm
	Cylinder	1290 mm
	Doffer	700 mm
Mat width		995 mm
Type of Autoleveller		Long term electronic
Can size		24" x 48" inch
Silver length in Can		Up to 7000 meter
No of flat		84
Pressure(P_a)		200-300 P_a
Draft		60-130 mm
Card clothing		Metallic
Doffer Speed		96 rpm
Taker -in- Speed		786-1018 pm
Deflection angle		15° degree
Cylinder to take-in wire (Number.)		7

4.6.2 PROCEDURE OF EXPERIMENT WITH CARDING

The factors selected on experience and engineering judgment were delivery speed, cylinder speed and flat speed

Two levels for each factor were selected. The levels for delivery speed were 80m/min, 100 m/min. and cylinder speed were 375 rpm , 426 rpm and flat speed 135m/min and 153m/min.A 2^3 matrix, requiring eight combinations, was made and were tested accordingly.

Table 4.2 Factorial deign for carding

Cylinder Speed rpm (A)	Flat Speed meter/min (B)	Delivery Speed meter/min (C)
375	135	80
375	135	100
375	153	80
375	153	100
426	135	80
426	135	100
426	153	80
426	153	100

4.6.3 CALCULATION OF NEPS REMOVAL EFFICIENCY

Neps are entangled fibers that creates thick or thin fault in the yarn. Nep removal efficiency greatly depends on delivery speed. Higher delivery speed is always desirable which leads to a greater production from raw cotton. But the lower the delivery speed (production) the higher the nep removal efficiency. The standard value of neps number in card is 70.

Nep's removal efficiency;

Nep's removal efficiency = (Input/Output)* 100

= (Neps in card/Neps in cars mat)*100

Experimental data on neps removal efficiency at different set condition are listed in Table 4.4.

Table 4.3 Experimental data on nep removal efficiency set conditions

Delivery Speed meter/min	Cylinder Speed rpm	Flat Speed meter/min	Neps in card (cnt/g)	Neps in card Mat(cnt/g)	Nep Removal Efficiency (%)
80	426	153	83	327	75.0
			78	341	77.0
			70	313	78.0
80	426	153	231	981	76.7
80	375	153	76	360	79.0
			71	361	80.0
			76	344	78.0
80	375	153	74	355	79.0
80	375	135	79	327	76.0
			77	317	76.0
			76	312	77.0
80	375	135	232	956	75.7
80	426	135	60	339	82.0
			66	395	83.0
			73	346	80.0
80	426	135	66	360	81.7
100	426	153	79	327	77.0
			77	317	75.0
			89	351	72.0
100	426	153	82	332	74.7
100	375	153	113	387	71.0
			114	351	68.0
			116	383	70.0
100	375	153	114	374	69.7
100	375	135	108	330	67.0
			105	540	82.0
			120	400	70.0
100	375	135	333	1270	73.0
100	426	135	108	381	73.0
			115	405	71.0
			111	400	72.0
100	426	135	111	395	72.0

4.6.4 CHECKING OF QUALITY

Table 4.4 Quality data on nep removal efficiency set conditions

Cylinder Speed rpm (A)	Flat Speed meter/min (B)	Delivery Speed meter/min (C)	Nep Removal Efficiency %
375	135	80	75.7
375	135	100	73.0
375	153	80	79.0
375	153	100	69.7
426	135	80	81.7
426	135	100	72.0
426	153	80	76.7
426	153	100	74.7

4.7 EXPERIMENT CARRIED OUT WITH RING FRAME

Experiment has been conducted to find the best combination of different factors like ring speed and twist per inch. These two factors have been varied in three levels (3^2 experiment). The objective of this experiment is to optimize the yarn quality by decreasing the yarn neps. For this purpose nine groups of experiment has been conducted. Each group is the average of three similar experiments. Besides this interaction has been determined graphically. Further significance of factors are also determined.

4.6.1 SPECIFICATIONS OF RING FRAME

Some factors were considered as constant during investigation. These factors are listed in table 4.5.

Table 4.5 Ring Frame specification

Ring speed	Up to 20,000 rpm
Twist range	7.13 – 54.7 TPI
No. of spindle /machine (Number)	504
Spindle gauge	70 mm
Lift bobbin	6" , 7" inch
Machine efficiency	90-97 %

Twist direction		"Z" type (Rotation anti clock wise)
Draft range		20-60
Break draft		1.25-1.52 mm
Roller dia	Front	27 mm
	Middle	25 mm
	Back	27 mm
Creeling system		Umbrella type

4.6.2 PROCEDURE OF EXPERIMENT WITH RING FRAME

There are various parameters in ring frame of which two factors, ring speed and twist per inch were selected for investigation. The individual section was not synchronized because a test or series of test in which purposeful changes were made to the input variables of a process or system so that one may observe and identify the reasons for change in the output.The factors were selected on the basis of previous experience and engineering judgment.

Three levels for each factor were selected. The levels for ring speed 18100 rpm, 18600rpm, 19000 rpm and twist per inch 25.18, 25.48, and 25.78.A 3^2 matrix, requiring nine combinations, was made and were tested accordingly.

Table 4.6 Factorial deign for ring frame

Ring Speed rpm (A)	Twist per inch (B)
18100	25.18
18600	25.18
19000	25.18
18100	25.48
18600	25.48
19000	25.48
18100	25.78
18600	25.78
19000	25.78

4.6.3 CALCULATION OF NEPS REMOVAL EFFICIENCY

Neps are entangled fibers that creates thick or thin fault in the yarn. Nep removal efficiency greatly depends on ring speed speed. Higher ring speed is always desirable (production) the higher the nep removal efficiency. The standard value of neps number in ring is 48. Experimental data on neps removal efficiency at different set condition are listed in Table 4.7

Table 4.8 Experimental data on neps

Experiment No	Input parameter		Neps/km
	Ring speed	Twist per inch	
1	18100	25.18	110
2	18600	25.18	116
3	1900	25.18	90
4	18100	25.48	50
5	18600	25.48	48
6	1900	25.48	50
7	18100	25.78	96
8	18600	25.78	83
9	19000	25.78	92

4.7 EXPERIMENT CARRIED OUT WITH WINDING

Experiments were conducted to find the optimized combination of levels of different factors. Ten levels against one factor. Each group contains four sets similar experiment.

4.7.1 SPECIFICATIONS OF WINDING

Winding may be operated under some limitation of parameter setting. The winding has some st condition of operating parameter. The winding may be operated maintaining these rated set conditions. But actually this winding is operated as per company's convenient maintaining some standard operating set conditions. It is risky to operate the machine beyond any limit. Specifications, rated set conditions and standard operating set conditions of winding are given in Table. 4.8

Table 4.9 Specification of Winding

Drum speed(m/min)	1100-1450 rpm
Winding position (Number)	60
Splicing system	Auto splicing
Drum dia	9cm(cir)
Tensioner	Disc

4.7.2 PROCEDURE OF EXPERIMENT WITH WINDING

The factor selected on experienced and engineering judgment was winding speed. Five levels for each factor were selected The levels for winding speed were 1250 m/min, 1300m/min, 1350m/min, 1400m/min, and 1450m/min.

Table 4.10 Experimental data on neps

Winding Speed (meter/min)	Neps/ km
1250	32
	38
	38
	38
1250	91
1300	42
	35
	48
	34
1300	99
1350	35
	29
	46
	51
1350	101
1400	65
	50
	54
	51
1400	138
1450	65
	45
	69
	52
1450	144

Chapter -5

ANALYSIS AND OBSERVATIONS

5.1 INTRODUCTION

It is necessary to arrange the collected data in a planned for proper analysis and correct decision making. Analyses are based on these data and decisions are mad from the analysis outcome. Besides these, some observations are made during the experiments, which are helpful in making comprehensive idea about the overall process.

5.2 EXPERIMENT CARRIED OUT WITH CARDING

Experiments were conducted with carding to identify the optimized combination of levels of the selected three factors. Two levels were selected against three factors. The first factor is the delivery speed, a second factor is cylinder speed and third factor is flat speed. The levels of delivery speed are 80 and 100 m/min, cylinder speed are 375 and 426 rpm and flat speed are 135 and 153m/min. Thus eight sets of experiments were conducted for this purpose, each consisting of three sets of experiments under same conditions. The data on the neps removal efficiency and the quality ratio along with their standard deviations corresponding to each set point are represented in Table 5.1

The sequence of testing each combination was randomly chosen to fulfill the requirement of randomization. The average of the reading under a particular set condition was taken. The difference between the summation of one level from summation of another level of the same factor was due factor alone, as all other factors balance one another. The best/optimum level corresponding to the maximum of average response value (min neps) under each factor was evaluated. The interactive effects among the factors were also evaluated according to the standard procedure.

Table 5.1 Quality data on neps removal efficiency set conditions

SL. No	Cylinder Speed RPM (A)	Flat Speed meter/min (B)	Delivery Speed meter/min (C)	Nep Removal Efficiency %
1	375	135	80	75.7
2	375	135	100	73.0
3	375	153	80	79.0
4	375	153	100	69.7
5	426	135	80	81.7
6	426	135	100	72.0
7	426	153	80	76.7
8	426	153	100	74.7

5.2.1 FACTORIAL ANALYSIS FOR NEPS REMOVAL EFFICIENCY:

As mentioned earlier, three factors such as delivery speed 80 and 100 m/min , cylinder speed 375 and 426 rpm and flat speed 135 and 153m/min were considered for factorial analysis. The effects of the variables on neps removal efficiency are presented on Table 5.2

5.2.2 ASSESSMENT OF THE MAIN EFFECT

From the table 5.7, it is observed that all the three factors had main effects on the neps generation. The Little interaction between cylinder speed & flat speed and Very little interaction between flat speed & delivery speed.

Table.5.2 The data for neps removal efficiency in carding

				Cylinder Speed (A)		
				A- (375)	+ (426)	
Delivery Speed	C- (80)	Flat speed	B- (135)	75.7	81.7	157.4
			B+ (153)	79.0	76.7	155.7
	C+ (100)	Flat speed	B- (135)	73.0	72.0	145.0
			B+ (153)	69.7	74.7	144.4
				297.4	305.1	

A-		297.4
A+		305.1
B-	=157.4+145	302.4
B+	=155.7+144.4	300.1
C-	=157.4+155.7	313.1
C+	=145.0+144.4	289.4

A = Cylinder Speed — A(-) = 375, A(+) = 426
B = Delivery Speed — B(-) = 135 , B(+) = 153
C = Flat Speed — C(-) = 80 , C(+) = 100

Among total two reading A(+) is better than A(-) by (305.1-297.4) = 7.7 unit.
On average A(+) is better than A(-) by (7.7/4)= 1.925 per operation.

Among total two reading B(-) is better than B(+) by (302.4-300.1) = 2.3 unit.
On average B(-) is better than B(+) by (2.3/4)= 1.15 per operation.

Among total two reading C(-) is better than C(+) by (313.1-289.4) = 23.7 unit.
On average C(-) is better than C(+) by (23.7/4)= 11.85 per operation.

5.3.2 ASSESSEMENT OF THE INTERACTION EFFECT:

For AB interaction the values A(-) are selected and all the values corresponding to B(-) are added.
Example:

Combination	Neps removal efficiency
A(-) B(-)C(-)	75.7
A(-) B(-)C(+)	73.0
Total	148.7

The values of A(-) are selected and all the values corresponding to B(+) are added.

Example:

Combination	Neps removal efficiency
A(-) B(+)C(-)	79.0
A(-) B(+)C(+)	69.7
Total	148.7

The values of A(+) are selected and all the values corresponding to B(-) are added.

Example:

Combination	Neps removal efficiency
A(+) B(-)C(-)	81.7
A(+) B(-)C(+)	72.0
Total	153.7

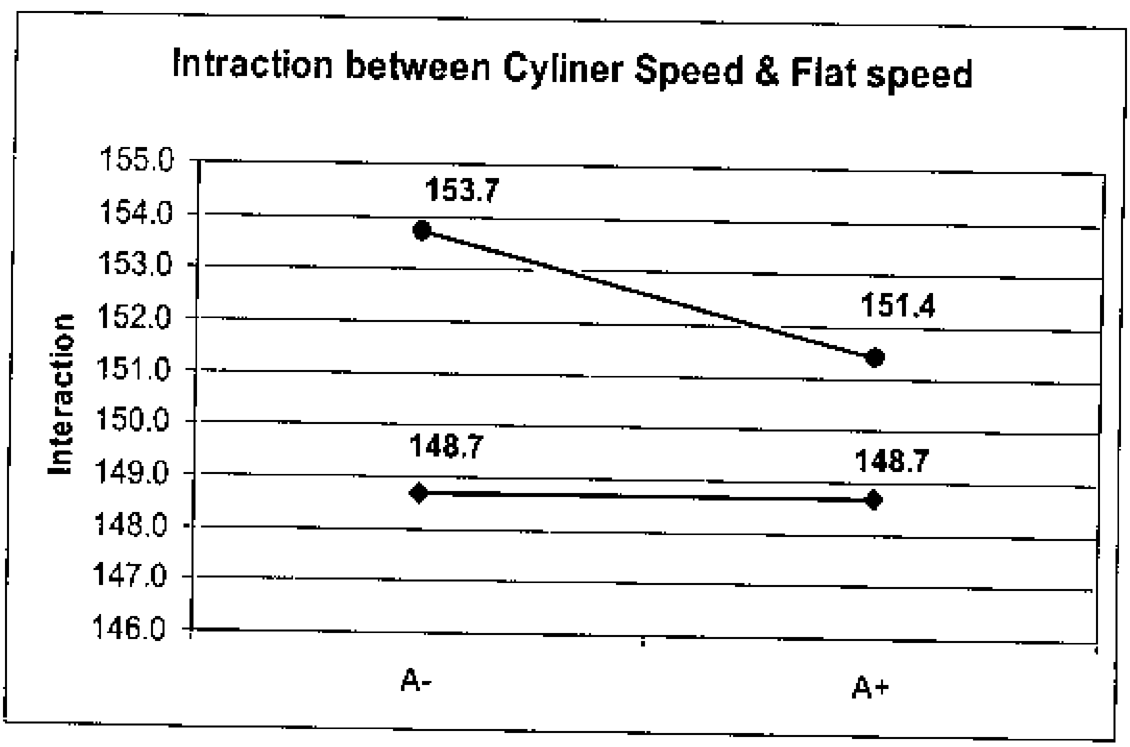
The values of A(+) are selected and all the values corresponding to B(+) are added.

Example:

Combination	Neps removal efficiency
A(+) B(+)C(-)	76.7
A(+) B(+)C(+)	74.7
Total	151.4

Graph with these points is plotted to find interaction. The interaction of different factors of CARDING is shown in figure 5.2 . As evident in the figure there is little interaction between factor A and factor B.

		B(-)	B(+)
A(-)	375	148.7	148.7
A(+)	426	153.7	151.4

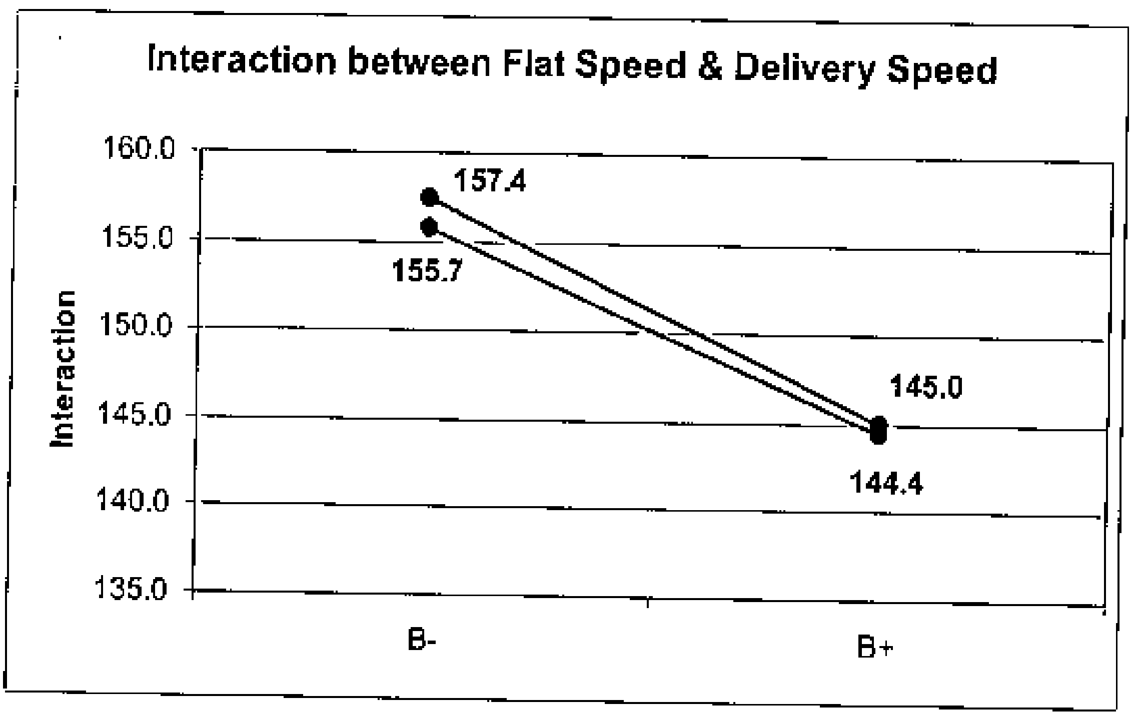


Little interaction between cylinder speed & flat speed

Fig: 5.1 Interaction between factor A and factor B

Similarly graphs are plotted with BC and CA combinations and shown in fig5.3 and fig 5.4.

		C(-)	C(+)
B(-)	135	155.7	157.4
B(+)	153	144.4	145.0



Little interaction between cylinder speed & flat speed

Fig 5.2 Interaction between factor B and factor C

From the figure it is evidence that there is little interaction between factor B and C.

		C(-)	C(+)
A(-)	375	142.7	154.7
A(+)	426	146.7	158.4

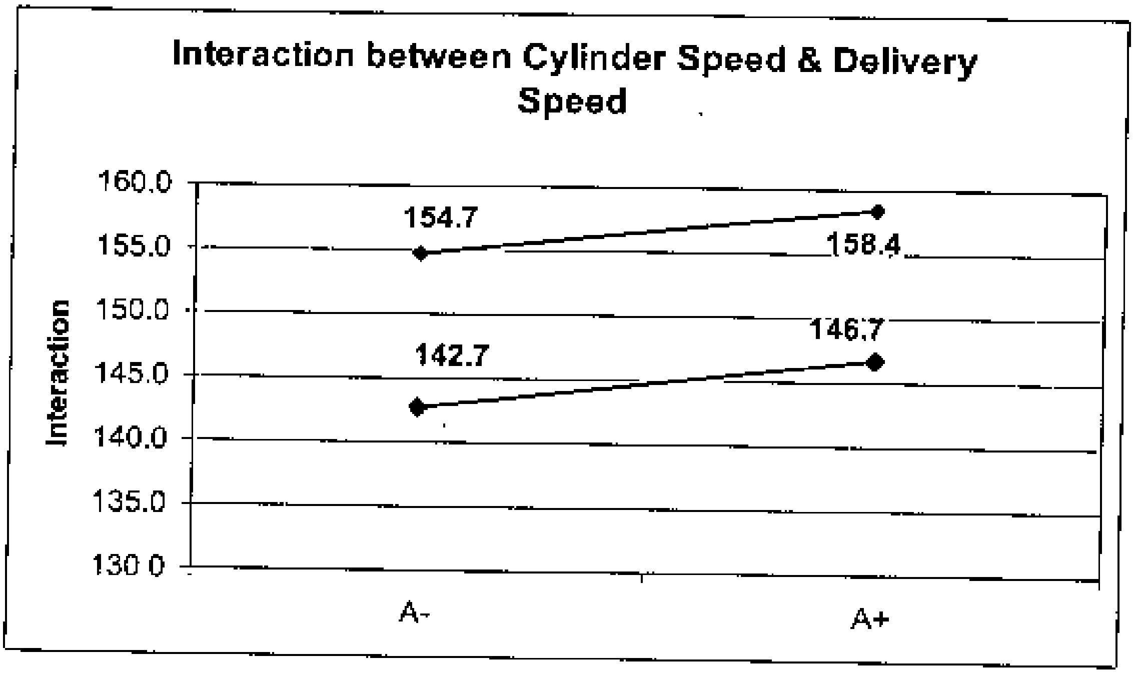


Figure 5.3 Interaction between factor A and factor C

5.2.4 CONTRUCTING AN ANOVA TABLE:

In the "cell group" column, the cell number is entered from 2^3 matrix.

The "factors "column, the appropriate (-) and (+) signs for factor A,B,C in cell no1.are entered. Here A,B,C are (-).The (-) and (+) signs merely indicate the levels of the factors used. Similarly, the appropriate (-) and (+) signs for A,B,C in the remaining seven cell are entered.

In the "output" column, the averages of the outputs record in each cell are entered from 2^3 matrix table.

In the two factor interaction columns, the signs of the product in the AB column are multiplied algebraically. Here ,since A and B are both(-),the product sign for AB is (+).Similarly , the algebraic product of A and C,B and C etc are determined and are recorded in the appropriate two factor interaction column.

The algebraic multiplication of A, Band C repeated and signs in the appropriate three factor interaction column are recorded.

Foe all remaining seven cells steps 4 and 5 are repeated.

In column a, all the outputs where A is (-) are added and all the outputs where A is (+) are added. Note the difference between these two sums in the last row labeled "main and Interaction effects contribution." A (-) sign above this entry is placed if A (-) sum is worse than the A(+) sum or A(+) sign if the reverse is the case.

Similarly, all the (+) and (-) outputs for each column B and C, AB through CA, Abc are added and the difference in the last row are noted as in step7.

The row now displays, in precise quantified form, the contribution of each main factor as well as each two factors, Three factors interaction to the total variation.
An ANOVA Table is constructed with average data and is presented in Table 5.8.

Table 5.3 ANOVA Table

Cell Group	Factors			2 Factors interactions			3 Factors interactions	Output
	A	B	C	AB	AC	BC	ABC	Nep removal Efficiency
1	-	-	-	+	+	+	-	75.7
2	-	-	+	+	-	-	+	73.0
3	-	+	-	-	+	-	+	79.0
4	-	+	+	-	-	+	-	69.7
5	+	-	-	-	-	+	+	81.7
6	+	-	+	-	+	-	-	72.0
7	+	+	-	+	-	-	-	76.7
8	+	+	+	+	+	+	+	74.7
	7.7	-2.3	-23.7	-2.3	0.3	1.1	14.3	
			Red				Pink	

Red X

This is the smallest point (absolute smallest value) in the main an interactive effects cell. This cell indicates the worst condition. Therefore, the setting of delivery speed 100 m/min provides worst result. This setting is forbidden to use.

5.2.5 RESULT OF SIGNIFICANCE TEST:

Analysis f variance is performed o test significance of different factors .The calculation of significance test is shown in Appendix A and result of the test is shown in table 5.4 The main and interactive effects are presented in table 5.5.For the main effects, the computed values of f for (4.99 , 16.25, 18.87) for factors cylinder, flat speed and delivery speed are less than the tabulate value (f = 4.15) .Therefore ,for the significance .05,the main effects are significant for the all three factors.

For the same level of significance, the computed value of f(4.34) for the interaction of cylinder values and flat speed are more than the tabulated value (f = 4.15) .So the interaction effect of flat speed and delivery speed rate are significance for a level of significanc,.05.

Furthermore, for the same level of significance, the computed value of f (4.19) for the interaction of cylinder values and delivery speed are more than the tabulated value (f = 4.15) and the computed value of f (20.44) for the interaction of delivery speed and flat speed are more than the tabulated value (f = 4.15). So the interaction effect and the interactive and are not significant for a level of significance.05.

Table5.4 Analysis of variance.

Source of Variation	Sum of square	Degree of freedom	Mean square	Computed f
Cylinder speed (A)	2.47	1	2.47	4.99
Flat speed (B)	20.148	1	20.148	16.25
Delivery speed (C)	23.4	1	23.4	18.87
AB	5.387	1	5.387	4.34
BC	25.10	1	25.10	20.24
CA	5.2	1	5.2	4.19
ABC	2.765	1	2.765	2.23
Error	39.695	32	1.24	
Total	121.4	39		

$f_{05}(1,20) = 4.34$

$f_{.05}(1,22) = 4.30$

$f_{05}(1,32) = 4.15$

Therefore, Factor C(Delivery speed),the interaction of AB and BC significantly affect the neps removal efficiency.

Therefore , factor A(cylinder speed),factor B(flat speed), factor C(delivery speed) and interaction of factor and significantly affect the neps removal efficiency.

Table5.5 Main and interactive effect the neps removal efficiency.

Effects	Values
Cylinder speed(A)	2.47
Flat speed(B)	20.148
Delivery speed(C)	23.4
Interaction AB	5.387
Interaction BC	25.10
Interaction CA	5.2
Interaction ABC	2.765

5.2.6 OBSERVATION:

All the three factors had main effects on the neps removal efficiency. Nep removal efficiency greatly depends on delivery speed is 80m/min. The lower the delivery speed (production) the higher the nep removal efficiency.

5.2.7 IMPACT ON THE YARN PRODUCTOIN

The impact of reps removal efficiency per lb weight of cotton is negligible an unnoticeable by the customer. But the total increase the production per operation is significant. More profit can b obtained from the additional production. Furthermore, this development will be helpful to maintaining production price in case of increase the raw material cost, labor cost,tax,fixed cost etc. Although this development is negligible in front o the total extend of the company. This king of research and development works is helpful in the implementation of one of the major marketing policy of the company to monopoly in market by maintaining relationship with government, introducing tax stamp and increasing tax without increasing production price. The impact on yarn production is shown in Table 5.11,sa mention earlier delivery speed 80m/min is used. Efforts are taken continuously to produce more yarn than minimum tolerance limit.

Table 5.6 Impact on Yarn production.

Sl.no	Input parameter			Neps removal efficiency	No. of production per day	More than lower limit 472 lbs
	Cylinder speed(A)	Flat speed(B)	Delivery Speed(C)			
1	375	135	80	75.7	953.6892	4.8%
2	375	135	100	73.0	1149.592	6.7%
3	375	153	80	79.0	995.2635	5.2%
4	375	153	100	69.7	1097.624	6.2%
5	426	135	80	81.7	1029.279	5.5%
6	426	135	100	72.0	1133.844	6 6%
7	426	153	80	76.7	966.2875	4.9%
8	426	153	100	74.7	1176.364	7 04%

5.3 EXPERIMENT CARRIED OUT WITH RING FRAME

Experiments were conducted with RING FRAME to identify the optimized combination of levels of the selected two factors. Three levels were selected against two factors. The first factor is the ring speed and twist per inch. The levels of ring speed are 18100, 18600 and 19000 while those are twist per inch are 25.18,25.48 and 25.78.Thus nine sets of experiment are conducted for this purpose, each consisting of three sets of experiment under same conditions. The data on the neps and quality ratio along with their standard deviations corresponding to each set point are presented in Table 5.10

The sequence of testing for each combination was randomly chosen to fulfill the requirement f randomization. The average of the readings under a particular set condition was taken. The difference between the summations of one level from summation of another level of the same factor was due to factor alone, as all other factors balance one another. The best/optimum level corresponding to the maximum of average response values under each factor was evaluated. The interactive effects among the factors were alone evaluated according to the standard procedure.

Table 5.7 Production and Neps of different experiment.

Experi ment No	Input parameter		Prod mean (ops)	Neps/Km	Neps (Imperfection)
	Ring speed	Twist per inch			
1	18100	25.18	4.25	110	146
2	18600	25.18	4.34	116	153
3	1900	25.18	4.34	132	119
4	18100	25.48	4.2	50	71
5	18600	25 48	4.28	48	68
6	1900	25.48	4 29	50	70
7	18100	25.78	4.21	96	133
8	18600	25.78	4.30	83	108
9	19000	25.78	4.28	92	126

Two factors such as ring speed with three positions 18100, 18600 and 19000 rpm and twist per inch 25.18, 25.48 and 25.78 were consider for fractional analysis. The effects of the variables on neps generation are presented on Table 5.11.

5.3.1 ASSESSMENT OF THE MAIN EFFECT

For both the ring speed and twist per inch had their individual main effects on the neps. On the average the higher the ring speed, the better is the neps. This trend holds good for the set point of the ring speed 18600 rpm and 25.48 twist per inch. But it does not occur while the ring speed is set either at 18100 rpm or at 19000rpm. In case of ring speed "18600rpm" and 25.18 twist per inch , there is an increase the neps and then decrease, where as for ring speed" 18600rpm and 25.48 twist per inch". Maximum production and minimum neps is obtained at ring speed"18600 rpm" and 25.48 twist per inch.

Table 5.8 The data for production with different parameter for ring frame

Ring speed	Twist per inch			Total
	25.18	25.48	25.78	
18100	110	50	96	256
18600	116	48	83	247
19000	132	50	92	274
Total	358	148	271	

In the context min neps on the twist pr inch is 25.48. The min neps on the yarn the twist per inch 25.48 is superior compared to 25.78 and total gain is (148-358) 210 per km(negative value). This gain is achieved as the cumulative effect of three ring speed positions. So the average gained by min neps twist per inch is (210/3)i.e.70 per km.

Similarly, twist per inch of 25.48 is superior compared to 25.18 and the gain is (148-271) 41per km (negative value). This gain is achieved as the cumulative effect of three ring speed positions. So the average gained by min neps twist per inch is (41/3)i.e.14 per km.

The Ring speed the min neps '18600 rpm' is superior compared to that of '19000rpm' and total gain is (247-274) 27 per km (negative value). The gain is achieved as the cumulative effect of three twist per inch. So the average gain by min neps Ring speed is (27/3) i.e.9 units per km.

The Ring speed '18600 rpm' is superior compared to that of 18100 rpm' and total gain is (247-256) 9 per km (negative value) units. The gain is achieved as the cumulative effect of three twist per inch. So the average gain by min neps Ring speed is (9/3) i.e.3 per km.

It is observed for Twist per inch 25.48 and Ring speed 18600rpm, the neps is minimum. So the condition (Twist per inch 25.48 and Ring speed 18600rpm) is the most desirable set condition for the operation of Ring frame.

Now we consider the data optimum production with different input parameter for ring frame.

Table 5.9 The data for production with different parameter for RING FRAME

	Twist per inch			
Ring speed	25.78	25.48	25.18	**Total**
18100	398.1374	398.5624	403.3109	1200.011
18600	406.971	405.1919	410.0195	1222.182
19000	402.4553	407.1938	409.4311	1219.08
Total	1207.564	1210.948	1222.761	

In the context production of yarn the twist per inch 25.18 is superior compared to 25.78 and total gain is (1222.761-1207.564) 15.197 units. This gain is achieved as the cumulative effect of three ring speed positions. So the average gained by twist per inch is (15.197/3)i.e.5.066 per operation.

Similarly, twist per inch of 25.18 is superior compared to 25.48 and the gain is (1210.948-1207.564)11.813 units. This gain is achieved as the cumulative effect of three ring speed positions. So the average gained by twist per inch is (11.813/3)i.e.3.94 per operation.

The Ring speed '18600 rpm' is superior compared to that of '18100rpm' and total gain is (1222.182- 1200.011) 22.171 units. The gain is achieved as the cumulative effect of three twist per inch. So the average gain by Ring speed is (22.171/3) i.e.7.39 units per operation.

The Ring speed '18600 rpm' is superior compared to that of 19000 rpm' and total gain is (1222.182- 1219.08) 3.112 units. The gain is achieved as the cumulative effect of three twist per inch. So the average gain by Ring speed is (3.112/3) i.e.1.037 units per operation.

It is observed for Twist per inch 25.18 and Ring speed 18600rpm,the production is maximum. So the condition (Twist per inch 25.18 and Ring speed 18600rpm) is the most desirable set condition for the operation of Ring frame.

5.3.2 ASSESSMENT OF THE INTERACTIVE EFFECT

Ring speed '18100 rpm' is selected and the average values of neps for the twist per inch of 25.18, 25.48 and 25.78 are plotted against this ring sped.

Similarly the average value of neps for the twist per inch of 25.18, 25.48 and 25.78 are plotted against the ring speed"18600" and "19000" respectively.

Joint all the points of 25.18 with straight lines. Similarly joint all points of 25.48 and 25.78 with straight lines respectively.

Interaction between the two factors namely the ring speed and twist per inch can be determined according to the following rules.

If the two lines are parallel, there is not any interaction between them.

If the two lines cross each other in the middle point, there is strong interaction between the two factors. If the lines cross in one side, there is little interaction.

Interaction between the ring speed and twist per inch are shown in Fig.5.4

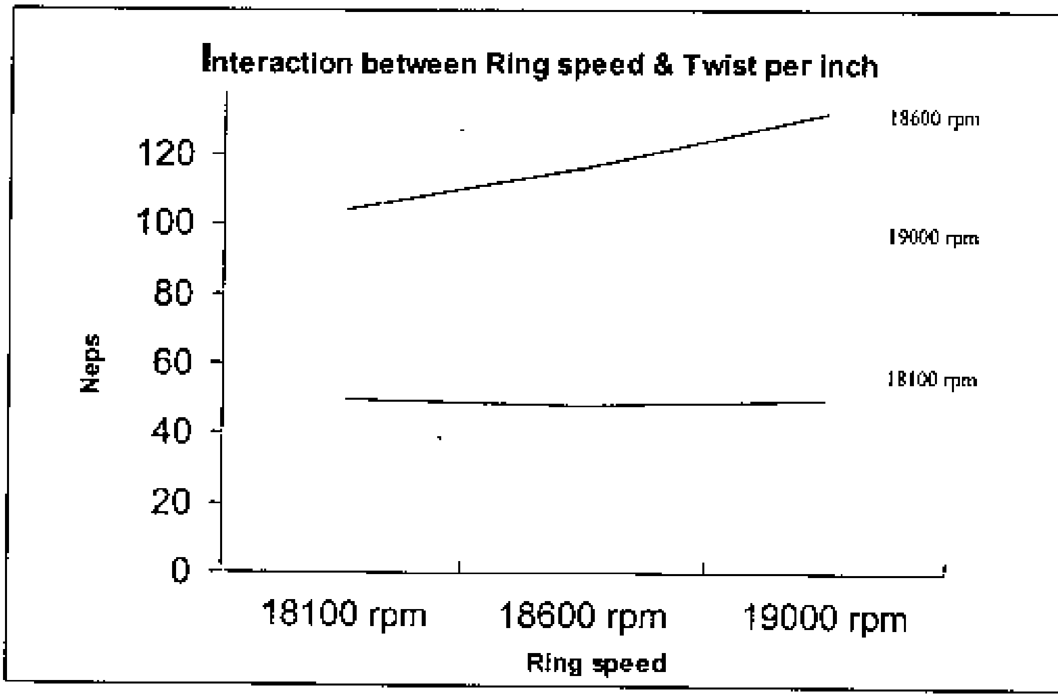


Fig5.4 Interaction between ring speed and twist per inch

5.3.3 RESULT OF SIGNIFICANT TEST

Analysis of variance is performed to test significance of different factor. The calculation of significance test is shown in Appendix A and result of the test is shown in table 5.10 The main and interactive effect is shown in Table5.14.For the main effects, the computed values(1.42and 1.032)are less tabulated value($f_{05}(2,18)$) = .0920.or the levels of significance .05,th main effects are not significance for the both actors.

For the level of significance, the computed values of f is more than the tabulated values ($f_{.05}(2,18) = 2.93$) .So the interactive effect is significant for a level of significance.05.

However, for ($\infty = .25$) the level of significance, the tabulated value of f($f_{05}(2,18) = 1.5$) is more than the computed value of f(1.42 and 1.032).So, for the level significance .025,the main effects not significant for the both factors.

Furthermore, for ($\infty = .01$) the level of significance, the tabulated value (f($f_{05}(2,18) = 1.5$) Is more than the computed value(.092).So, with .01 level of significance the interaction is not significance.

RESULT OF SIGNIFICANCE TEST

Table.5.10 Analysis of variance

Source of Variation	Sum of square	Degree of freedom	Mean square	Computed f
Twist per inch (A)	24.74	2	12.37	1.42
Ring speed (B)	17.93	2	8.965	1.032
Interaction	3.17	4	.7925	.092
Error	156.39618	18	8.69	
Total	202.236	26		

$f_{.05}(2,18) = .092$

$f_{.05}(4,18) = 2.93$

Therefore, the interaction between Factor A (Twist per inch) and factor B (Ring speed) significantly affect to minimize the neps.

Table5.11 Main and interactive effect the neps .

Effects	Values
Twist per inch(A)	1.42
Ring speed(B)	1.032
Interaction AB	.092

5.3.4 RESULT AND OBSERVATION

Both the Ring speed and twist per inch had main effects on the neps. The higher ring speed, the more neps, where as, ~~increase~~ min neps is obtained at ring speed 18600 and twist per inch 25.48. The interaction between the two parameters is also significance. Higher ring speed has two benefits without breakage. Productivity is increased and minimum neps is obtained.

5.3.5 IMPACT ON THE YARN PRODUCTOIN

The impact of reps removal efficiency per lb weight of cotton is negligible an unnoticeable by the customer. But the total increase the production per operation is significant. More profit can b obtained from the additional production. Furthermore, this development will be helpful to maintaining production price in case of increase the raw material cost, labor cost, tax, fixed cost etc. Although this development is negligible in front o the totals extend of the company. This king of research and development works is helpful in the implementation of one of the major marketing policy of the company to monopoly in market by maintaining relationship with government, introducing tax stamp and increasing tax without increasing production price. The impact on yarn production is shown in Table 5.16.sa mention earlier ring speed 18600rpm is used. Efforts are taken continuously to produce more yarn than minimum tolerance limit.

Table 5.12 Impact on yarn production.

Sl. no.	Input parameter		Number of neps	No. of production per day	More than lower limit 447 lbs
	Twist per inch	Ring speed			
1	25.18	18100	110	403.310	10.92%
2	25.48	18100	116	410.0195	9.43%
3	25.78	18100	132	409.4311	9.56%
4	25.18	18600	50	398.5624	11.97%
5	25.48	18600	48	405.1919	10.50%
6	25.78	18600	50	407.1938	10.06%
7	25.18	19000	96	398.1374	12.06%
8	25.48	19000	83	406.971	10.12%
9	25.78	19000	92	402.4553	11.11%

5.4 EXPERIMENT CARRIEDOUT WITH WINDING

Experiment has been conducted to find the best factor winding speed. Five levels of the single parameter will be considered for the design of experiment in finishing section. Each group is the average of four similar experiments. The sequence of testing for each combination was randomly chosen. The average of the reading under each level of factor was taken. The best/optimum level corresponding to the maximum of average values under factor was evaluated. In Table 15.50,the data of neps with the standard deviations corresponding to each set point are represented.

Furthermore, significance test and interactive effects among the factor was also evaluated.

5.4.1 FACTORIAL DESIGN ANALYSIS NEPS

The individual section was not synchronized because a test or series of test in which purposeful changes were made to the input variables of a process or system so that one may observe and identify the reasons for change in the output as mentioned earlier, the factor was winding speed 1250m/min, 1300m/min,1350m/min ,1400m/min and 1450m/min.The effects of variable on neps are represented on Table.5.50

Table 5.13 Production and Neps of different experiment.

Experiment No	Winding speed	Neps/Km
1	1250	91
2	1300	99
3	1350	101
4	1400	138
5	1450	144

5.4.2 ASSESSMENT OF THE WINDING SPEED EFFECT

The generation of neps on different speed is represented the following figure5.6

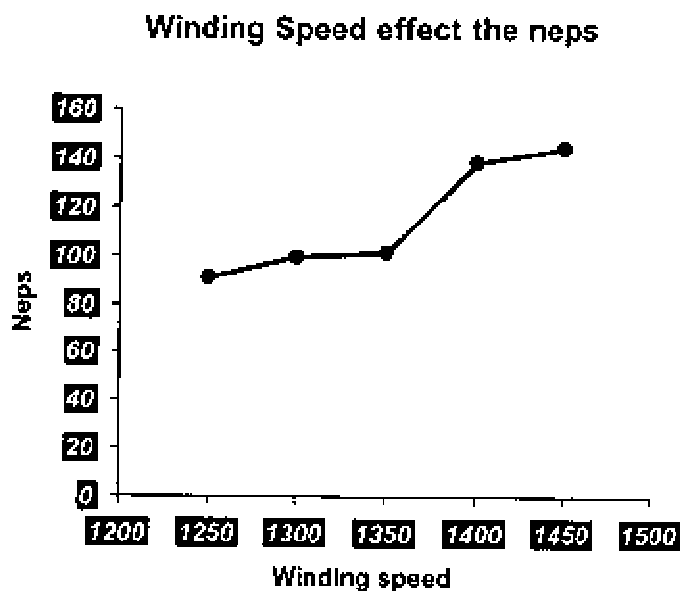


Fig.5.5 Winding speed effects on neps

5.4.3 RESULT AND OBSERVATION

The higher winding speed, the more neps, where as, increased production is obtained at winding speed 1450m/min. But the winding speed 1350 m/min is satisfying the quality standard. In most of the experiment quality ratio was more than tolerance limit.

Chapter – 6

CONCLUSION AND RECOMENDAIONS

6.1 INTRODUCTION

The concluding remarks outlined here are based on the findings of the study conducted under specified experimental condition. Experiments were conducted on three machines, namely the carding, ring frame and the winding machine.

6.2 CONCLUSION FOR CARDING MACHINE

In case of carding there are a number of parameters can be changed. These are auto leveler, process air temperature, Pressure (P_a), Deflection angle, delivery speed, flat speed and cylinder speed. However, depending on the set values of auto leveler, process air temperature, FBK Pressure (P_a) are controlled by PLC. The remaining three parameter – delivery speed, flat speed and cylinder speed can be regulated manually The control values of delivery speed, flat speed and cylinder speed are 80 ~ 100 m/min, 135~153 m/min and 375~ 426 rpm respectively.

The following concluding remarks made with CARDING machine:

- All the three parameters such as the delivery speed, flat speed and cylinder speed were found to have individual effect on the neps. The maximum was found for delivery speed than for flat speed and the minimum for cylinder speed.
- Small interactive effect on the parameters on nep was also observed.
- Delivery speed 80m/min, flat speed 135 m/min and 426 rpm were found to lead to maximum neps removal efficiency.
- Among the experimental conditions variability was found to differ significantly.
- From the ANOVA table5.3 it is found that the combination [illegible]
- From the significance test it has been found that delivery speed, flat speed and cylinder – all these three parameters have significant effect on nep removal efficiency. Interaction between flat speed and delivery speed and cylinder speed and flat speed was found to be significant by the test.
- In all cases of quality was more than standard indicating the fulfillment of the minimum requirement of material utilization set by the company.

6.3 RECOMMENDATIONS FOR CARDING

- It is recommended to ensure minimum variation in those steps of processing operations and input variables to perform the experiment on carding.
- Response surface methodology can be applied to develop a functional relationship.

- Experiment may be conducted with wider range and greater number of levels.
- To get accurate result every test must be repeated several times(more than 5 times) as the average of large number of tests can give more reliable result.

6.4 CONCLUSIONS FOR RING FRAME

In case of RING FRAME, there are a number of parameters can be changed. These are Drafting system, process air temperature, Twist direction, ring speed and twist per inch. However, depending on the set values of drafting system, process air temperature, twist direction are controlled by PLC. The remaining two parameters – twist per inch, ring speed can be regulated manually. The control values of ring speed and twist per inch are respectively 18100 rpm, 18600 and 19000 add 25.18, 25.48 and 25.78

It may be mentioned here that each set condition, experiment was replicated for three times.. With three values standard deviation was calculated to check the variability. Quality standard, a parameter to measure the retained material, was checked individually with very experiment to confirm the minimum acceptable level.

The following concluding remarks can be made for ring frame

- Both the ring frame speed and twist per inch were found to have significant effects on the neps.
- A strong interactive effect of the parameters was also observed.
- With the experiment limits, the minimum neps and maximum productivity was observed for 18600 rpm ring speed and 25.48 twist per inch.
- Among the nine experimental conditions variability (standard deviation) was found to differ significantly.
- At ring speed 19000 and 25.78 twist per inch, the variability was the lowest leading to the consistency and customer satisfaction.
- Maximum quality standard was observed to occur at 18600 rpm and twist per inch 25.48.
- A significance test was conducted by analysis of variance and it has been found that there is significant interactive effect of the ring speed and twist per inch on neps.

6.5 RECOMMENDATIONS FOR RING FRAME

- Greater number of parameters may be selected for experiment with ring frame.
- To get accurate result every test must be repeated several times. The average of these tests can ensure more reliable results.
- There are several prior operations conducted in the processing of yarn before the operation performed in ring frame. So, It is recommended to secure

minimum variation in those steps of processing operations and input variable to perform the experiment on ring frame.

- Response Surface Methodology can be applied to obtain a functional relationship.
- Experiment may be conducted with wider range and greater number of levels.

6.6 CONCLUSIONS FOR WINDING

In case of winding, there are a number of parameters can be changed. These are splicing system, process air temperature, tensioner, winding speed. However, depending on the set values of splicing system, process air temperature, and tensioner are controlled by PLC. The winding speed can be regulated manually. The control values of winding speed are respectively 1250,1300,1350,1400 and 1450 rpm.

It may be mentioned here that each set condition, experiment was replicated for three times. With three values standard deviation was calculated to check the variability. Quality standard, a parameter to measure the retained material, was checked individually with very experiment to confirm the minimum acceptable level.

The following concluding remarks can be made for winding.

- Winding speed was found to have significant effects on the neps.
- With the experiment limits, the minimum neps and maximum productivity was observed for 1350m/min winding speed.
- Among the nine experimental conditions variability (standard deviation) was found to differ significantly.
- At winding speed 1450 m/min, the variability was the lowest leading to the consistency and customer satisfaction.
- Maximum quality standard was observed to occur at 1350m/min.
- A significance test was conducted by analysis of variance and it has been found that there is significant interactive effect of the winding speed to generate neps.

6.7 RECOMMENDATIONS FOR WINDING

The following recommendations are made for future work and optimized operation of winding.

- It is recommended to ensure minimum variation in those steps of processing operations and input variables to perform the experiment on WINDING.
- To get accurate result every test must be repeated several times. The average of these tests can ensure more reliable results.
- Response Surface Methodology can be applied to obtain a functional relationship.
- Experiment may be conducted with wider range and greater number of levels.

BIBLIOGHAPHY

1) Annual Report of Beximco Textile Limited.

2) "Design and Analysis of experiment" Douglas C. Montgomery, john Wiles & sons ,1991

3) Taguchi methods: hands- on approach/ Glen Stuart Peace.

4) "Production and Operation Management "- manufacturing and service / Richard B. Chase , Nicholas J.Aquilano, F. Robert Jacobs

5) "Total Quality Management " by Dale Bester field , Carol Besterfield-Michina, Glen H.Besterfield & Mary Besterfield-Sacre.

6) Belt Wide cotton Conference Report of "National Cotton Council, Memphis TN".

7) Information from internet

8) Cotton http//www.swicofil.com

9) Information from internet
   Textile technology http//www. Textile technology.com

10) Information from internet

    http//www.design& technology.com

Appendix A

CALCULATION OF SIGNIFICANCE TEST FOR CARDING

Nep removal efficiency (%) = (Nep in card) x 100 / Nep in card material

83	327	0.253823	0.746177	74.61774
78	341	0 228739	0 771261	77.1261
70	313	0.223642	0.776358	77.63578
231	**981**	**0.235474**	**0.764526**	**76.7**

Delivery speed	Flat speed	Cylinder speed		Total
		A(-) 375 rpm	A(+) 426rpm	
C(-) 80m/min	B(-) 135m/min	76.0 76.0 75.0 **75.7**	82.0 83.0 80.0 **81.7**	**157.4**
	B(+) 153 m/min	79.0 80.0 78.0 **79. 0**	75.0 77.0 78.0 **76.7**	**155.7**
C(+) 100m/min	B(-) 135m/min	67.0 82.0 70.0 **73. 0**	73.0 71.0 72.0 **72. 0**	**145.0**
	B(+) 153m/min	71.0 68.0 70.0 **69.7**	77.0 75.0 72.0 **74.7**	**144.4**
Total		**297.4**	**305.1**	**602**

The sum of squares are computed as follows

Here

a = level o factor A; b = level of factor B; c = level of factor C; n = number of replicate
$i = 1,2 - - -a$; $j=1,2 - - b$; $k=1,2 - - c$ and $l = 1,2 - - n$.
y^2 = Average of the square of the observation of all abcn observation.

y_i^2 /bcn = Average of the square of the observation for the i th level of factor A.

y_j^2 /acn = Average of the square of the observation for the j th level of factor B

y_k^2 /abn = Average of the square of the observation for the k th level of factor C

y_{ij}^2 /cn = Average of the square of the observation for the i th level of factor A and j th level of factor C

y_{ik}^2 /bn = Average of the square of the observation for the i th level of factor A and k th level of factor C

y_{jk}^2 /bn = Average of the square of the observation for the j th level of factor A and k th level of factor C

y_{ijk}^2 /n = Average of the square of the observation for the i th level of factor A and j th level of factor B and k th level o factor C.

y_{ijkl}^2 = Average of the square of the observation for the i th level of factor A and j th level of factor B and k th level o factor C.

$$SS_T = \sum_{i=1}^{a} \sum_{j=1}^{b} \sum_{k=1}^{c} \sum_{l=1}^{n} y_{ijkl}^2 - y^2/abcn$$

$= (76)^2 + (76)^2+(75)^2+$-------$(75)^2+(72)^2 - (602)^2/(2.2.2.*3)$

= 121.4

a

$$SS_A = \sum_{i=1} y_i^2/bcn - y^2/abcn$$

$= \{(297.4)^2 + (305.1)^2\}/(2*2*3) - (602)^2/(2*2*2*3)$

$= 2.47$

$$SS_B = \sum_{j=1}^{b} y_j^2/acn - y^2/abcn$$

$= \{(157.4)^2 + (145.7)^2 + (155.7)^2 + (144.4)^2\}/(2*2*3) - (602)^2/(2*2*2*3)$

$= 20.148$

$$SS_C = \sum_{k=1}^{c} y_k^2/abn - y^2/abcn$$

$= \{(157.4)^2 + (155.7)^2 + (145)^2 + (144.5)^2\}/(2*2*3) - (602)^2/(2*2*2*3)$

$= 23.4$

$$SS_{AB} = \sum_{i=1}^{a} \sum_{j=1}^{b} y_{ij}^2/cn - y^2/abcn - SS_A - SS_B$$

$= \{(148.7)^2 + (148.7)^2 + (153.7)^2 + (151.4)^2\}/(2*3) - (602)^2/(2*2*2*3) - 2.47 - 20.148$

$= 5.387$

$$SS_{AC} = \sum_{i=1}^{a} \sum_{k=1}^{c} y_{ik}^2/bn - y^2/abcn - SS_A - SS_C$$

$= \{(154.7)^2 + (142.7)^2 + (158.4)^2 + (146.7)^2\}/(2*3) - (602)^2/(2*2*2*3) - 2.47 - 23.4$

$= 25.10$

$$SS_{BC} = \sum_{j=1}^{b} \sum_{k=1}^{c} y_{jk}^2/bn - y^2/abcn - SS_B - SS_C$$

$= \{(157.4)^2 + (155.7)^2 + (145)^2 + (144.4)^2\}/(2*3) - (602)^2/(2*2*2*3) - 20.148 - 23.4$

= 5.2

$$SS_{ABC} = \sum_{i=1}^{a} \sum_{j=1}^{b} \sum_{k=1}^{c} y_{ijk}^2/n - y^2/abcn - SS_A - SS_B - SS_C - SS_{AB} - SS_{AC} - SS_{BC}$$

$= \{(75.7)^2 + (81.7)^2 + (79)^2 + (76.7)^2 + \cdots + (74.7)^2 - (602)^2/(2*2*2*3) - 2.47 - 20.148 - 23.4 - 5.387 - 25.10 - 5.2$

= 2.765

$SS_E = SS_T - SS_A - SS_B - SS_C - SS_{AB} - SS_{AC} - SS_{BC}$

= 121.4 – 2.47 – 20.148 – 23.4 – 5.387 - 25.10 – 5.2

= 39.695

Formulas of Analysis of variance

Source of Variation	Sum of square	Degree of freedom	Mean square	Computed f
Cylinder speed (A)	SS_A	a-1	$MS_A = SS_A/(a-1)$	MS_A/MS_E
Flat speed (B)	SS_B	b-1	$MS_B = SS_B/(b-1)$	MS_B/MS_E
Delivery speed (C)	SS_C	c-1	$MS_C = SS_C/(c-1)$	MS_C/MS_E
AB	SS_{AB}	(a-1)(b-1)	$MS_{AB} = SS_{AB}/(a-1)(b-1)$	MS_{AB}/MS_E
BC	SS_{AC}	(a-1)(c-1)	$MS_{AC} = SS_{AC}/(a-1)(c-1)$	MS_{AC}/MS_E
CA	SS_{BC}	(a-1)(b-1)	$MS_{BC} = SS_{BC}/(b-1)(c-1)$	MS_{BC}/MS_E
ABC	SS_{ABC}	(a-1)(b-1)(c-1)	$MS_{ABC}=SS_{ABC}/(a-1)(b-1)(c-1)$	MS_{ABC}/MS_E
Error	SS_E	abc(n-1)	$MS_E = SS_E/abc(n-1)$	
Total	SS_T	abn-1		

RESULT OF SIGNIFICANCE TEST

Analysis of variance

Source of Variation	Sum of square	Degree of freedom	Mean square	Computed f
Cylinder speed (A)	2.47	1	2.47	4.99
Flat speed (B)	20.148	1	20.148	16.25
Delivery speed (C)	23.4	1	23.4	18.87
AB	5.387	1	5.387	4.34
BC	25 10	1	25.10	20 24
CA	5.2	1	5.2	4.19
ABC	2.765	1	2.765	2.23
Error	39.695	32	1.24	
Total	121.4	39		

$f_{.05}(1,20) = 4.34$

$f_{.05}(1,22) = 4.30$

$f_{.05}(1,32) = 4.15$

Therefore, Factor C(Delivery speed),the interaction of AB and BC significantly affect the nps removal efficiency.

CALCULATION OF SIGNIFICANCE TEST

	Twist per inch	B Ring speed			Total
		18100 rpm	18600 rpm	19000 rpm	
A	25.18	108 110 112 110	115 116 117 116	125 129 142 132	358
	25.48	47 51 52 50	46 46 52 48	48 50 52 50	148
	25.78	94 96 97 96	81 83 85 83	91 92 93 92	271
Total		256	247	274	777

The sum of squares are computed as follows

Here

a = level o factor A; b = level of factor B; c = level of factor C; n = number of replicate
i = 1,2- - -a; j=1,2 - - b; k=1,2- - c and l = 1,2- - n.
y^2 /abn= Average of the square of the summation of all abcn observation.

y_i^2 /bn = Average of the square of the observation for the i th level of factor A.

y_j^2 /an = Average of the square of the observation for the j th level of factor B

y_{ij}^2 /n = Average of the square of the observation for the i th level of factor A and j th level of factor B

y_{ijk}^2 = Square of the observation for the ijk th treatment..

$$SS_T = \sum_{i=1}^{a} \sum_{j=1}^{b} \sum_{k=1}^{n} y_{ijkl}^2 - y^2/abn$$

$= (80)^2 + (110)^2 + (112)^2 + \text{-----------} (92)^2 + (93)^2 - (777)^2/(3*3*3)$

$= 202\ 236$

$$SS_A = \sum_{i=1}^{a} y_i^2/bn - y^2/abn$$

$= \{(358)^2 + (148)^2 + (271)^2\}/(3*3) - (777)^2/(3*3*3)$

$= 24.74$

$$SS_B = \sum_{j=1}^{b} y_j^2/an - y^2/abn$$

$= \{(256)^2 + (247)^2 + (274)^2\}/(3*3) - (777)^2/(3*3*3)$

$= 17.93$

$$SS_{AB} = \sum_{i=1}^{a} \sum_{j=1}^{b} y_{ij}^2/n - y^2/abn - SS_A \,.\, SS_B$$

$= \{(110)^2 + (116)^2 + \text{- - - -} + (83)^2 + (92)^2\}/(3) - (777)^2/(2*2*2*3) - 24.74 - 17.93$

$= 3.17$

$$SS_E = SS_T \,.\, SS_A \,.\, SS_B - SS_C \,.\, SS_{AB} - SS_{AC} \,.\, SS_{BC}$$

$= 202.236 - 3.17 - 24.74 - 17\ 93$

$= 156.396$

Formulas of Analysis of variance

Source of Variation	Sum of square	Degree of freedom	Mean square	Computed f
Twist per inch (A)	SS_A	a-1	$MS_A = SS_A/(a-1)$	MS_A/ MS_E
Ring speed (B)	SS_B	b-1	$MS_B = SS_B/(b-1)$	MS_B/MS_E
Interaction	SS_{AB}	(a-1)(b-1)	$MS_{AB} = SS_{AB}/(a-1)(b-1)$	MS_{AB}/ MS_E
Error	SS_E	ab(n-1)	$MS_E = SS_E/ab(n-1)$	
Total	SS_T	abn-1		

RESULT OF SIGNIFICANCE TEST

Analysis of variance

Source of Variation	Sum of square	Degree of freedom	Mean square	Computed f
Twist per inch (A)	24.74	2	12.37	1.42
Ring speed (B)	17.93	2	8.965	1.032
Interaction	3.17	4	.7925	<u>.092</u>
Error	156.39618	18	8.69	
Total	202.236	26		

$f_{05}(2,18) = .092$

$f_{05}(4,18) = 2.93$

Therefore, the interaction between Factor A (Twist per inch) and factor B (Ring speed) significantly affect to minimize the neps.