A COMPARITIVE STUDY ON SURFACE ACTION OF ALKALI ON VARIOUS BLEND PROPORTION OF POLYESTER COTTON YARN

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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ABSTRACT

Polyester is the most widely used manufactured fiber. Polyester/cotton fabrics are used for apparel and home furnishings. These include bed sheets, bedspreads, curtains and draperies. Polyester used in knitted fabrics includes shirts and blouses. Fiberfill is also used to stuff pillows, comforters and cushion padding.

The main aim behind this project is to develop more comfortable poly- cotton yarn and hence improving the usage of Polyester/cotton yarns in day to day life. The drawback of the yarn is poor handle property. By the alkali treatment, we can improve the handle and comfort properties.

There are large availability of alkalies such as Potassium Hydroxide, Sodium carbonate. But we chose Sodium Hydroxide because it will not undergo harsh action against the yarn and also it produces better appearance of the yarn compared to other alkalies. As the yarn is treated with Sodium Hydroxide the cotton fibers will undergo swelling that is it will get bulged and it causes mercerization. But in the polyester the Hydrolysis reaction takes place and the surface of the fiber get ruptured.

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1.INTRODUCTION

1.1 GENERAL

Polyester is the most widely used manufactured fiber .Woven fabrics are used for apparel and home furnishings. These include bed sheets, bedspreads, curtains and draperies. Polyester used in knitted fabrics includes shirts and blouses. Fiberfill is also used to stuff pillows, comforters and cushion padding. Synthesis of polyesters is generally achieved by a poly-condensation reaction. In this project mainly deals with polyester / cotton khadi yarn and their behavior with alkali solution viz. sodium hydroxide in order to increase their comfort and aesthetic properties. There is a drop in the yarn strength and yarn weight and increase in the wearability.

1.2 ALKALI TREATMENT

Alkali treatment is nothing but treating yarns with chemicals such as sodium hydroxide, potassium hydroxide, etc. The main thing behind the use of sodium hydroxide is that weight loss will be less compared to other alkalis. Hydrolysis of polyester with Sodium Hydroxide is a saponification reaction through elimination of -OH groups, as a result of which polyester losses its weight. During the alkali treatment, the molecular chains in the cotton fiber get broken down due to this the fiber get swelled and mercerization takes place. Caustic hydrolysis initially proceeds over the whole fiber surface and then continues through enlarged surface cavitations causing higher weight loss

2.LITERATURE REVIEW

2.1. COTTON

Cotton is the oldest fiber used for textile purposes. In the tropical countries, it is the most important fiber. India was the centre for world's cotton industry as well as variety of fine yarns till 1600 A.D. the date of origin of cotton is unknown.

2.1.1. CHEMICAL PROPERTIES

The cotton fiber is elongated cell, constructed from millions of cellulose molecules. Small amount of moisture, fatty materials, minerals are other constituents of cotton. So the chemical properties of cotton are mostly influenced by the chemical characteristics of cellulose.

ACTION OF HEAT

Cotton fiber ignites easily and it burns with a bright flame, which continues even after the fibre is removed from fire. Cotton can be heated in a dry state to 150°C without any decomposition. But if heating continues, a brown colour on cotton develops gradually. A slight brown discoloration can occur at temperatures lower than 150°C, which does not deteriorate the fiber. However, it is sufficient to spoil the effects of bleaching.

ACTION OF LIGHT

Exposure to air in presence of sunlight for a long period will have an effect on cotton like that of heat. Oxycellulose is gradually formed accompanied by tendering because of atmospheric oxygen. The tendering effect by light and air is accelerated by traces of metals like copper.

ACTION OF WATER

Raw cotton is very hard to wet because the wax is present on the surface of the fiber. Cold water swells cotton without any chemical damage. Swelling is accompanied by the disappearance of the natural twist i.e., deconvolution. The irregular cross section becomes more circular, which reappears on drying. Structurally, swelling is due to the intercrystalline areas, which means only amorphous regions are affected by swelling.

ACTION OF ACIDS

Cold dilute solutions of mineral acids at boil have no effect on cotton cellulose, provided the acid are neutralised or washed out completely before drying. Cold concentrated sulphuric acid dissolves cellulose and forms cellulose hydrate. Hydrochloric acid affects cotton much more severely than sulphuric acid.

ACTION OF ALKALI

One of the main advantages of cotton is its resistance to alkali solutions. Mild alkalies like sodium carbonate have no action on cotton in the absence of air either at low temperature or at high temperature. However, in presence of oxygen or air, oxycellulose is formed with gradual tendering of cotton.

Generally, dilute solution of sodium hydroxide is used for scouring. Strong alkalies with higher concentration induce structural and physical changes in cotton fiber.. The diameter of these hydrated forms depend on the concentration of the alkali used. As the concentration of alkali increases, the number of water molecules per molecule of alkali decreases for the formation of smaller hydrates. Thus the diameter of the hydrated form of alkali

2.1.2. PHYSICAL PROPERTIES

FIBER FINENESS

The wall thickness of different types of cotton ranges from 3.5 micron to 10 micron. Ribbon width is said to range from 12 micron to 25 micron. The thickness part of a fiber is not at the base but it is at the middle. The tip end is usually gently tapered. The base end is slightly finer than the middle portion.

FIBER UNIFORMITY

There are considerable differences between cotton grown from the same seed in the same location from time to time. Unless like other fibers will not possess same fiber properties because the cotton properties will change periodically according to the monsoon changes.

POROSITY

Cotton fibers is porous and exhibits capillary effects to a higher degree. The fibrils themselves are dense as a result of the higher packing density of the molecules and so non porus. This part of the structure constitute approximately 70% or more of the fiber.

LUSTRE

The natural lustre of cotton fiber is determined by two factor s i.e., fiber shape and fiber polish. The lustre does not depend upon hair weight , length, diameter, fineness or convolutions. It depends upon the ratio of semi-major and semi-minor axes of the elliptical fibre cross section. If the ratio is be low, the lustre will be high. The highest lustre is noticed in the fiber with circular cross section. So the dominating influence in lustre is the external fiber

DENSITY & STRENGTH

Cotton fiber has a density of 1.54 gm/cc, which corresponds to a specific volume of 0.64 cc/gm.

The load required tom break i.e., tensile strength of single cotton fiber varies widely. It depends upon the thickness of the wall, prior damage to the fiber and cellulose degradation. Matured fibers with coarse and heavy wall are the strongest fibers. Their strength ranges from 9 gm to 13 gm per fiber. The strength of fiber increases at higher humidity or at higher moisture. In general, the tensile strength increases up to a relative humidity of 60% and then remains mostly constant.

ELONGATION

When load is applied, the length increases, the change in length with respect to the original length is defined as extension or elongation or strain. Average fiber elongation at break is about 5% to 10%, exactly around 6% to 8%. In the structure of cotton fibers, the fibrils spiral round at an angle of about 20° to 30° to the fiber axis. In general, increasing the helix angle reduces the resistance for extension.

TORSIONAL RIGIDITY

The mean rigidity of cotton fiber is about 7.9×10^{-4} g.wt.sq.cm.sq.tex. rigidity varies with the shape, conditions of growth and wall thickness of the fiber. The high rigidity of thick walled fibers suggests why coarse cottons must be more highly twisted than fine cottons to produce yarns of the same size.

2.1.3. MODIFICATIONS OF COTTON WITH ALKALI

The cotton yarn immersed in aqueous solutions of caustic soda (NaOH) exhibited swelling and shrinkage. Changes in fine structure, morphology and conformation of the cellulose chains occur with mercerization. More specifically, treatment of cellulosic fibers with aqueous solutions of sodium hydroxide at various temperatures produces a polymeric change in the cellulose (known as cellulose II).

Sarko and co-authors have proposed elaborate pathways by which native cellulose is converted to each of the soda celluloses that ultimately lead to the thermodynamically stable and irreversible cellulose II structure. The most popular view that has been held for the past fifty years is that cellulose I exists in a parallel chain conformation while cellulose II exists in an antiparallel chain conformation. A more recent and simpler explanation of how cellulose I is converted into cellulose II and what the arrangements of the cellulose chains are in the unit cell is given by Turbak et al. computer- generated models (consistent with x-ray diffraction and other experimental data) indicate that cellulose II exists in a parallel-up chain conformation that can be achieved by initially breaking intramolecular hydrogen bonds between 6-OH and 2-OH on the adjacent glucose residue (trans/gauche or "tg" conformation). The formation of new and stronger intermolecular hydrogen bonds occurs on conversion to cellulose II.

Although these investigators have not specifically discussed " soda cellulose intermediates", their cellulose II structural model is consistent with the presence of different degrees of salvation/hydration of sodium hydroxide between cellulose chains at various degrees of chain separation, swelling and deswelling as well as equilibria in the conversion of cellulose to cellulosate ions.

2.2. POLYESTER

The work of W.H.Carothers, on linear fiber forming polymers put this initial foots on polyesters by polycondensation method. The polyester were aliphatic polyesters, made from dibasic acids like adipic acids and glycols. The melting point of the polyester were below 100°C having molecular weights in the range of 2500-5000. it is only a short step onward from him to J.R.Whinfield and J.T.Dickson, who prepared the first high molecular weight, high melting polyester in 1940. This polymer is poly(ethylene terephthalate) or poly(oxyethylene oxy terephthaloyl) or simply PET. Polyester fiber is defined as " a manufactured fiber in which the fiber forming substance is any long chain synthetic polymer composed of at least 85 % weight of an ester of dihydric alcohol and terephthalic acid. So this may include pure polyester or polyester–ether fiber. Generally polyester fibers are produced from spinnerets. Polyester polymer is produced commercially in a two step polymerization process, i.e., monomer formation by ester interchange of dimethyl terephthalate with glycol or esterification of terephthalic acid with glycol followed by polycondensation by removing excess glycol.

An alternative monomer formation system involves terephthalicphthalate and an catalysed direct esterification rather than ester interchange. The monomer which is the same from both methods expect for some end groups, usually is polymerized in the presence of antimony catalyst. Chain extension is promoted by removal of excess glycol from the various viscous melt at about 280°C,with carefully controlled agitation and a progressive reduction of pressure to about 200 Pa. heating is continued about 280°C until the desired degree of condensation is obtained.

2.2.1. STRUCTURE OF POLYESTER

The length of the repeated unit in poly (ethylene terephthalate) along the chain is 10.75°A, a value only slightly less the expected for a fully extended chain with one chemical unit to the geometric repeating unit, and successive ester groups in the trans configuration to each other (10.9°A). The chains are therefore nearly planar. The unit cell is triclinic, the atomic positions in the crystalline indicate that no special forces of attraction exist between the molecules. The spacing between atoms of neighboring molecules is of order expect if Van der Waals forces operate.

Drawn polyester fibers may be considered to be composed of crystalline and non crystalline regions. The theoretical density of pure crystalline material can be determined mathematically from the dimensions of the unit cell. Percentage crystallinity and molecular orientation relate to tensile strength and shrinkage; however the various methods of measurement are problematic.

Polyester fibers have many favorable properties, such as high strength and resilience, resistance to many chemicals and resistance to abrasion, stretching, shrinking and wrinkling.

It has certain disadvantages, such as tendency to pill, static charges, and high luster, as well as being unbreathable difficult to dye and resistant to oily stain removal, due to its hydrophobic nature and inactive surface. improving the undesirable properties of polyester fibers is done under harsh conditions, since the fibers are resistant to most chemicals.

In order to modify the surface of the polyester enzymes are used. The enzyme, polyesterase, is a serine esterase that acts by cleaving the polymer chain through hydrolysis of ester bonds of the polyester fibers

2.2.2 CHEMICAL PROPERTIES:

EFFECT OF ALKALIES:

Polyester fibers have good resistance to weak alkalis at high temperatures. It exhibits only moderate resistance to strong alkalis at room temperature and degraded at elevated temperature.

EFFECT OF ACIDS:

Weak acids, even at the boiling point, have no effect on the polyester fibers are exposed for several days. Polyester fibers have good resistance to strong acids at room temperature. Prolonged exposure to boiling hydrochloric acid destroys the fibers and 96% sulphuric acid and causes disintegration of the fibers.

EFFECT OF SOLVENTS:

Polyester fibers are generally resistant to organic solvents. Chemical used in cleaning and stain removal do not damage it, but hot m-cresol destroys the fibers, and certain mixtures of phenol with trichloromethane dissolve polyester fibers. Oxidizing agents and bleachers do not damage polyester fibers.

MECHANICAL PROPERTIES:

Polyester fibers exhibit good resistance to sunlight, and it also resists abrasion very well. Soaps, synthetic detergents, and other laundry aids do not damage it. One of the most serious faults with polyester is its oleophilic quality. It absorbs oily materials easily and holds the oil tenaciously.

2.2.3 MISCELLANEOUS PROPERTIES:

Poly (ethylene-terephthalate) shows non linear and time – dependent elastic behavior. Creep occurs under the load with subsequent delay in recovery on removal of the load, but compared to that of other melt-spun fibers, creep is small.

2.2.4 PHYSICAL PROPERTIES:

MOISTURE REGAIN:

The moisture regain of polyester is low, ranges between 0.2 to0.8 percent. Although polyesters are non absorbent, they do not have wicking ability. In wicking, moisture can be carried on the surface of the fiber without absorption.

SPECIFIC GRAVITY:

The specific gravity 1.38 or 1.22 depending on the type of polyester fibers is moderate. Polyester fibers have a density greater than polyamide fibers and lower than rayon. Yarns made from polyester fibers are medium in weight.

HEAT EFFECT:

The melting point of polyester is close to polyamide, ranging from 250 to 300°C. Polyester fibers shrink from flame and melt, leaving a hard black residue. The yarn burns with strong, pungent odour. Heat setting of polyester fibers, not only stabilizes size and shape, but also enhances wrinkle resistance of the fibers.

2.2.5 CHEMICAL MODIFICATION OF POLYESTER FIBERS:

Polyester fibers have taken the major position I textiles all over the world although they have many drawbacks e.g., (a) low moisture regain (0.4%), (b) the fibers has a tendancy to accumulate static electricity, (c) the cloth made up of polyester fibers pick up more soil during wear and it also difficult to clean during washing, (d) the polyester garments from pills and thus, the appearance of a garment is spoiled, (e) the polyester fiber is flammable. Thus, it has been suggested that surface modifications can have an effect on hand, thermal properties, permeability, and hydrophilicity.

Numerous research papers and patents are available and considerable amount of research works is in progress on the hydrolysis and aminolysis of polyester fibers to overcome their disadvantages.

Namboodri and Haith carried out a comparative study by treating the polyester fibers with alkalies and various alkoxides (e.g. sodium hydroxide with water, sodium methoxide in methanol, sodium ethoxide in ethanol, sodium isopropoxide in isoproponal, and potassium tertiary butoxide in tertiary butanol) at 60°C and at different concentrations. It was found that the loss in weight of the polyester fiber was in the order sodium hydroxide< tertiary butoxide < secondary propoxide < methoxide and ethoxide. It was suggested that the observed order followed the nucleophilicity of the bases and the relatively lower reactivity of the secondary propoxide and tertiary butoxide was assumed to be due to the streric retardation during the equilibrium reactions. The hydrolysis of the polyester fiber was assumed to be taking place on the surface of the fiber. It was assumed that a random attack of the base on the carboxyl groups of the surface polymer molecules took place with removal of the shorter chains from the surface, which were further hydrolyzed by the base present in the solution.

Ko Sohk Won et al. have reported that the treatment of a polyester yarn with aqueous sodium hydroxide solution caused a decrease of weight and breaking strength and improved handle with increasing sodium hydroxide concentration, treatment time and temperature. It has been reported that these effects were further enhanced in the presence of a carrier, such as palanil carrier A. the molecular weight of the fiber was also decreased, but crystallinity was not affected by the alkali treatment.

Hydrolysis improved the smoothness of the yarn and decreased the electrostatic charge fro friction. Elisson et al. observed that untreated polyester fibers have relatively smooth surface, while NaOH treatment causes pitting of the fiber surface. The pits increase in number and depth as the time of hydrolysis was lengthened.

Song and kim found that the weight loss of poly(ethylene terephthalate) fibres by alkali treatment decreased in the order of KOH > NaOH > Na_2CO_3 and increased with increasing alkali concentration and treated temperature and time. With increasing weight loss, drape and flex stiffness and tear strength decreased, and tear strength retention at weight loss 17% was >70%. At the same weight loss, handle was affected by the treatment conditions. Zhang and co-workers observed that the addition of dodecyl-dimethybenzeneammonium bromide cationic surfactant reduced concentration of NaOH and thus lowered the degree of degradation of poly(ethylene terephthalate) fibers.

The hydroxyl ions in the solution of sodium Hydroxide attack the carboxyl group in the polymer which result in the formation of disodium terephthalate and ethylene glycol. Disodium terephthalate is soluble in alkaline solution (pH above 8) up to 13-14%. Free terephthalic acid is on the surface of the yarn which is to be washed out with alkaline water before neutralizing the yarn.

2.3. POLYESTER / COTTON BLENDS ON ALKALI

According to R.T.SHET, S.H.ZERONIAN, H.L.NEEDLES and S.A.SIDDIQUI, Alkali treatment of polyester by a continuous techniques pad-heat technique for a given length of time results in a much higher degree of hydrolysis, as indicated by weight loss, than a batch process employing a large liquor :solid ratio.The moisture related properties of polyester are essentially unaffected by the alkali treatment , and the tensile warp direction ,as indicated by yarn tests , are also not affected when the weight loss is kept below 14%.

Hot alkali treatment of polyester/cotton blend yarns serves a dual purposes subjectively, it imparts a silk like soft hand to the polyester and brings about mercerization of the cotton.The presence of cotton improves moisture related properties while the polyester imparts dimensional stability to alkali treated blend yarns.

The treatment of cotton with aqueous sodium hydroxide of mercerization strength is a well known process for enhancing its physical properties.It has recently been concluded that although low temperature is required to swell the cotton for mercerization,the treatment has been attributed to the limitation of the reaction mainly to the fiber surface. Cold industrial mercerization is therefore a topochemical reaction resulting in a more condensed skin around the unswollen core of the fiber.

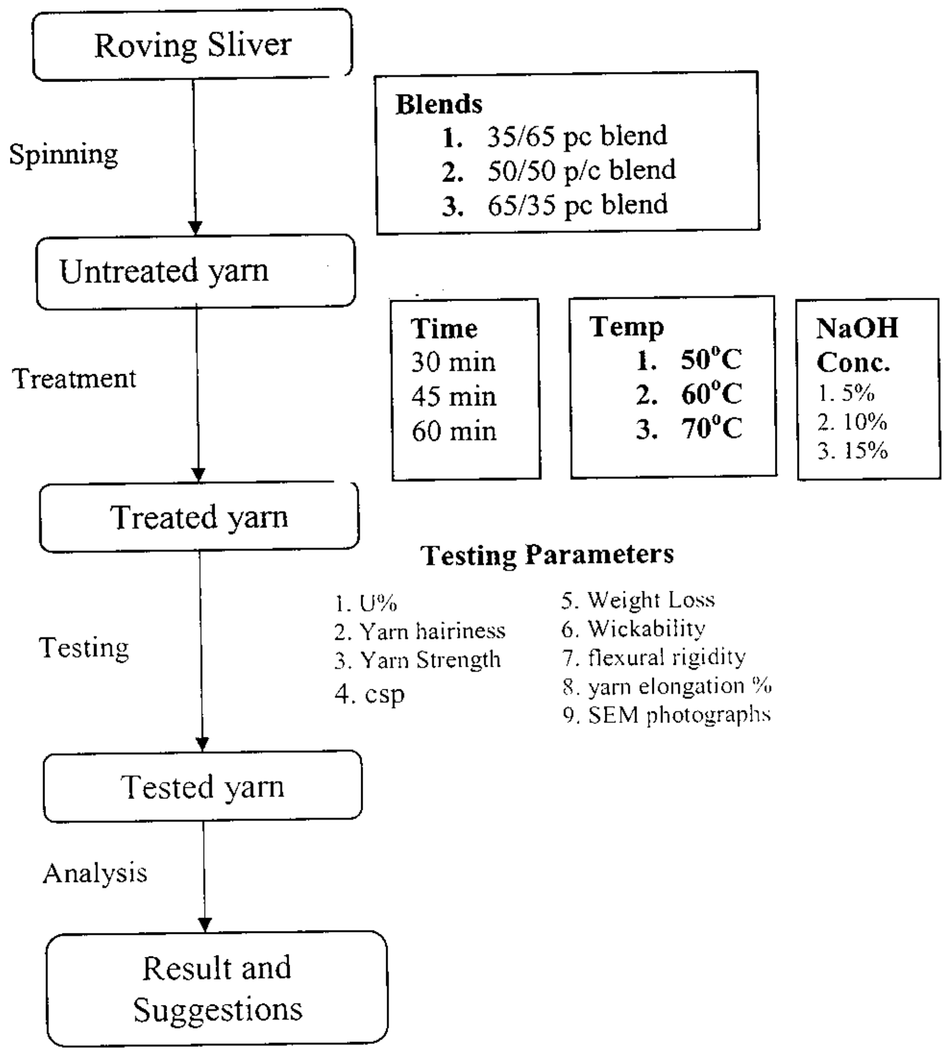
Warm sodium hydroxide on the other hand , penetrates cotton fibres rapidly, resulting in more uniform swelling of the fiber when the temperature is lowered. Hot alkali treatment of polyester/cotton blends could achieve the dual purpose of imparting a soft silky hand to the polyester fiber and improving the hydrophilicity and dyeability of the cotton fiber. The objective of this study was to examine the effect of hot alkali treatments on the physical properties of polyester and polyester/cotton blend yarns.

3. AIM

Scope of this treatment is to improve the polyester/cotton blended yarn and improve the performance of the yarn. The performance of this yarns of different blends (35/65, 50/50 and 65/35) by varying the concentration of NaOH(5%, 10 % and 15%), Temperature (50°C,60°C,70°C) and Time (30 minutes, 45 minutes and 60 minutes) are studied using Box-Behnken design of experiments .Only little work done on the effect of polyester / cotton blends since blends are widely used. Therefore this investigation has been undertaken. The treated samples will be investigated for Yarn Unevenness, Yarn Hairiness, Yarn strength, yarn elongation, Wick ability, flexural rigidity, CSP and Weight loss. Based on the results obtained suitable recommendation will be made.

4. METHODOLOGY

4.1PROCESS FLOW DIAGRAM



4.2 .PRE SPINNING OPERATIONS:

The roving used in spinning are processed in Karthikeya spinning mills. The various processes are

Sample 1 (35/65 P/C blend) :

Blend type : drawframe blend.

Polyester : 0.8 denier (32 mm cut length)

Cotton ; 29 mm , 3.8 mic, 21 g/tex.

Blow room :

Polyester :0.00164 HK

cotton : 0.00157 HK

Carding :

Polyester : 0.156 HK

Cotton : 0.172 HK

Drawing:

3 polyester slivers + 5 cotton slivers

Output hank = 0.140HK

Setting = 36/40.

Comber:

Hank = 0.208 HK

Noils = 17%

Simplex:

T.M = 0.8

1.2 HK; 1.24 B.draft.

Spinning:

40/1 Ne

1.24 B.draft; Spacer : 3.5 mm

T.M = 3.2

Sample 2 (50/50 P/C blend) :

Blend type : drawframe blend.

Polyester : 0.8 denier (32 mm cut length)

Cotton ; 29 mm , 3.8 mic, 21 g/tex.

Blow room :

Polyester :0.00164 HK

cotton : 0.00157 HK

Carding :

Polyester : 0.156 HK

Cotton : 0.172 HK

Drawing:

4 polyester slivers + 4 cotton slivers

Output hank = 0.140HK

Setting = 36/40.

Comber:

Hank = 0.208 HK

Noils = 17%

Simplex:

T.M = 0.8

1.2 HK; 1.24 B.draft.

Spinning:

40/1 Ne

1.24 B.draft; Spacer : 3.5 mm

T.M = 3.2

Ring diameter : 38 mm

Sample 3 (65/35 P/C blend) :

Blend type : drawframe blend.

Polyester : 0.8 denier (32 mm cut length)

Cotton ; 29 mm , 3.8 mic, 21 g/tex.

Blow room :

Polyester :0.00164 HK

cotton : 0.00157 HK

Carding :

Polyester : 0.156 HK

Cotton : 0.172 HK

Drawing:

5 polyester slivers + 3 cotton slivers

Output hank = 0.140HK

Setting = 36/40.

Comber:

Hank = 0.208 HK

Noils = 17%

Simplex:

T.M = 0.8

1.2 HK; 1.24 B.draft.

Spinning:

40/1 Ne

1.24 B.draft; Spacer : 3.5 mm

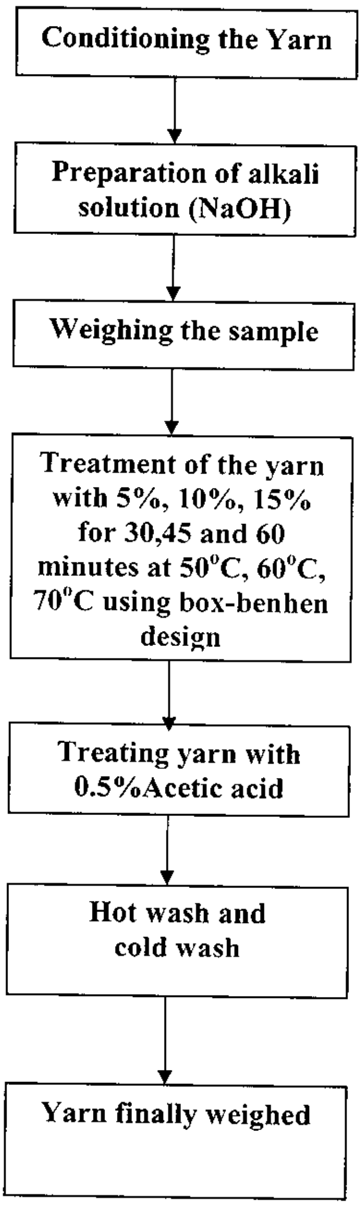
T.M = 3.2

Ring diameter : 38 mm

4.3 Reeling:

The yarns are then subjected to reeling operation. The yarns are converted into skein form and are weighed and packed.

4.4 TREATMENT PROCEDURE



4.5 PROCESS SPECIFICATION

4.5.1.TIME

Weight loss was found to be directly proportional to the time of hydrolysis as the time of hydrolysis increased, weight loss also increased. Generally the time taken for the alkaline hydrolysis is 30 minutes, 45 minutes and 60 minutes. The percentage loss in weight of polyester / cotton blend yarns for the first five minutes was very small. The loss in weight was highest during the next increment of time. The reaction appears to slow down with further increases in time of heating.

4.5.2 TEMPERATURE

When a yarn saturated with aqueous alkali is heated at constant external temperature there will be an increase in the concentration of sorbed alkali due to the evaporation of water from the yarn phase. The temperature of sorbed alkali in the yarn phase, after an initial increase with time will attain an equilibrium value once the loosely bound water is evaporated. For the improvement of luster property and comfort property of cotton hot alkali treatment is necessary for the 50°C, 60°C and 70°C is preferred.

4.5.3. CONCENTRATION

At the higher concentration, the surface of the fiber get ruptured and the weight loss of the yarn is increased about 25%. At lower concentration the rate of hydrolysis taken more time to attain its equilibrium so that the concentration that are selected are 5%,10%,15%.

4.5.4. LIQUOR RATIO

It is observed that at lower bath ratio (w/w), the yarn exhibits an excellent handle value as compared at those at higher bath ratio, thus confirming the potential of low liquor dyeing principles. The effect depends on several factors and the bath ratio is one among them influencing the mechanical properties of the yarn to a greater extent. Lower bath ratio will exhibit the properties favourable to a soft yarn so finally the liquor ratio of 1:10 is selected.

4.6YARN CONDITIONING:

Yarn conditioning is done to remove the stresses in the yarn and make ready for alkali treatment. For the conditioning treatment the yarn is subjected to treatment with 0.5% soap oil with M: L ratio of 1:20 for 30 minutes under room temperature. Then the skein is taken out and subjected to washing and then the yarn skein is dried for 24 hours with some tension.

4.7. VESSEL SPECIFICATION

4.7.1. CONSTRUCTION

The Vessel is especially suitable for dyeing yarns. Water is poured into the vessel about two third of its volume. The water is heated by means of Electrical coil controlled by an electronic circuit. The vessel is covered by a tray with 6 openings to fit six beakers. Yarn with necessary amount of water and chemicals are added and placed in the tray so that the beaker lies on the surface of the water. The temperature of the water inside the vessel is set by means of an digital dial.

- **Material of construction** : Stainless steel 304 quality
- **Heating medium** : Through water
- **Temperature Control** : digital temperature indicator cum controller DTIC - 200
- **Temperature indication** : By dial thermometer 0 – 150°C

4.7.2. CHEMICAL TREATMENT

The beakers are cleaned and washed with water. The vessel for placing the samples is filled with water and the water bath is set at 50°C, 60°C and 70°C. The M:L ratio is 1:10.The yarn skein is weighed and the amount of Sodium hydroxide(5% (or)10% (or) 15%) and water required are calculated.

Water is poured into the beaker and the calculated amount of sodium hydroxide is added to water and stirred well. Now the yarn skein is added to the beaker and the beaker is placed in the holes in the tray placed over the vessel. Similarly all the holes in the tray are filled with beakers.

The reaction time is 30, 45 , 60 minutes. After the specific time the yarn skein are taken out and subjected to 0.5% acetic acid with M:L ratio of 1:10 to remove alkali present. Then the samples are subjected to hot and cold wash with water. The yarn samples are dried and weighed.

4.8 Re-reeling:

After the yarn skein is subjected to Sodium hydroxide treatment it converted to cone form by the process of re-reeling. It was the most tedious process and it needed lot of time as the process consists of two stages. At first the yarn skein is converted into Pony forms. Then these ponies are converted to cone in the re-reeling machine.

4.9 BOX-BEHNKEN

The Box-Behnken design is an independent quadratic design in that it does not contain an embedded factorial or fractional factorial design. In this design the treatment combinations are at the midpoints of edges of the process space and at the center. These designs are rotatable (or near rotatable) and require 3 levels of each factor. The designs have limited capability for orthogonal blocking compared to the central composite designs.

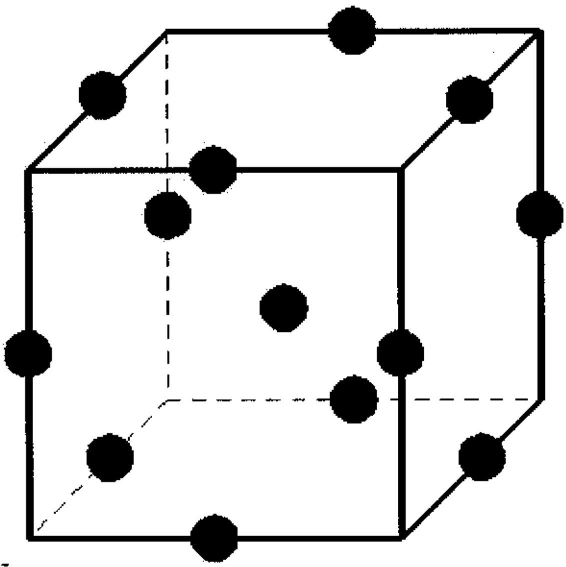


Figure 1. Box-behnken design

The geometry of this design suggests a sphere within the process space such that the surface of the sphere protrudes through each face with the surface of the sphere tangential to the midpoint of each edge of the space.

Table 1 Box-Behnken design of experiment.

TRIAL	X1	X2	X3
1	-1	-1	0
2	+1	-1	0
3	-1	+1	0
4	+1	+1	0
5	-1	0	-1
6	+1	0	-1
7	-1	0	+1
8	+1	0	+1
9	0	-1	-1
10	0	+1	-1
11	0	-1	+1
12	0	+1	+1
13	0	0	0
14	0	0	0
15	0	0	0

where +1 is the high value, – 1 is the low value and 0 is the center value. Designs exist for other numbers of factors.

Table 2 Range of variables

Variables	-1	0	+1
Concentration of NaOH (in %), X1	5	10	15
Temperature (in °C) ,X2	50	60	70
Time (in Minutes),X3	30	45	60

4.10 TESTING

In order to carried out the test the following testing conditions are required which is 21 ± 1°C (70 ± 2°F) and 65 ± 2 % relative humidity.

4.10.1. TESTS PERFORMED

The yarn samples are tested for the following

1. U%
2. Single yarn strength
3. yarn elongation %
4. Hairiness
5. Wickability
6. Weight loss
7. Flexural rigidity
8. CSP
9. SEM photograph

4.10.2. TESTING PROCEDURE:

4.10.2.1U%:

This analysis is mainly done to determine the imperfection level in the yarn. Along with U%,

1. CVm (%) 2. CVm (1m)3. Index4. Thin (-50%) 5. Thick (50%)
6. Neps (+200%)7. Thin (-30%) 8. Thin (-40%)9. Dust Count.

are also been done to assess the imperfection levels ie., mass per unit length variations in the yarn. This test is conducted on **USTER TESTER 4.**

Figure 2 USTER TESTER 4

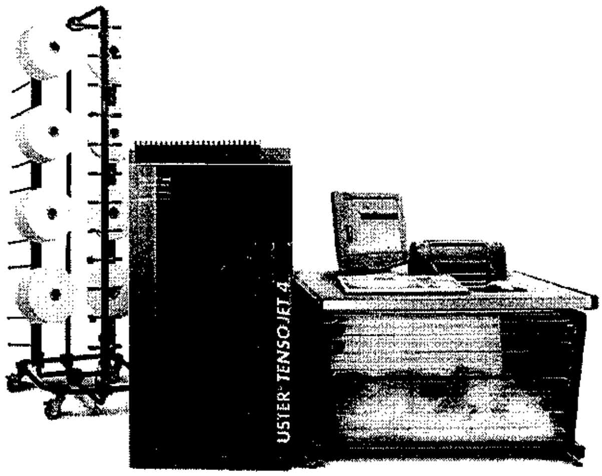
In this test, the test sample is fed to the machine. The machine is made to run at 400m/min. The testing time for each sample is 1 minute. The instrument analyses the yarn and gives the U%, thick place, thin place and no. of neps values in the computer.

4.10.2.2 SINGLE YARN STRENGTH:

This is mainly analyzed to check whether the strength of the yarn has decreased after the alkali treatment.Along with single yarn strength, Elongation tenacity and B-work is tested.

Breaking force(Single yarn strength): Maximum force value measured during the tensile test.

Tenacity: Breaking force in relation to the yarn count of the sample.



Breaking work: Work done to break (enclosed area below the force/elongation characteristic curve up to the point of breaking force).

Figure 3 USTER TENSOJET 4

The yarn is tested for the above parameters using **USTER TENSOJET 4**. It works on the principle of **CONSTANT RATE OF EXTENSION**.The yarn in the package is fed to the machine and is automatically hold by the clamps. The test length of the yarn is 500 mm.The clamp/testing speed is 400 m/min.The reading are noted and assessed.

4.10.2.3HAIRINESS:

It refers to the number of protruding hairs on the unit surface of the spun yarn.

The S3 value and Hairiness index of the yarn samples before and after the treatment are tested.

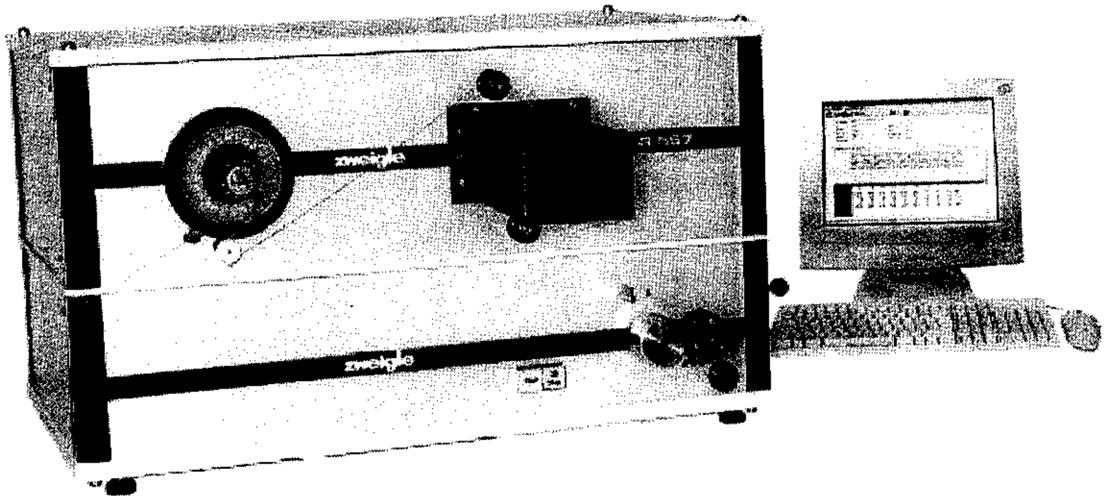


Figure 4 Zweigle G567

This testing is done in Zweigle G567 machine. Measurement is performed by a newly developed optical measuring head with laser light source having extremely long working life at constant light output.· G 567 covers 9 length zones from 1 mm to 15 mm fibre length in one pass, producing objective reproducible data.· G 567 is controlled by a PC that also undertakes analysis of the test results. Any desired number of measurements can be made on a bobbin. The pretension is set at 5cN. Each yarn sample tested is of 100 m each and 10 readings are taken per cone.

4.10.2.4 Elongation %

Breaking elongation: Elongation at maximum breaking force value

The yarn is tested for the above parameters using **USTER TENSOJET 4**. It works on the principle of **CONSTANT RATE OF EXTENSION**.The yarn in the package is fed to the machine and is automatically hold by the clamps. The test length of the yarn is 500 mm.The clamp/testing speed is 400 m/min.The reading are noted and assessed.

4.10.2.5 WICKABILITY:

The ability of a material to not only absorb sweat but to actually move it away from our bodies.

1.For this test, the yarn is tied at one end to a scale and the other end is placed on the surface of colored water

2. The distance the water travels up the material is measured at various intervals over thirty minutes.

3. The distance is measured in centimeters.

4. A good "wickable" yarn will transport all the water straight up.

4.10.2.6 WEIGHT LOSS %

1. Weight loss is the Amount weight lost by the yarn after the yarn is treated with the alkali treatment.
2. Initial weight of the yarn in skein form is noted.
3. Yarn is treated with a alkali solution
4. Final weight of the yarn skein is noted before rereeling.
5. Weight Loss is calculated in percentage.

4.10.2.7 Flexural Rigidity

1. **Flexural rigidity** is defined as the force couple required to bend a rigid structure to a unit curvature.

2. The yarn is made into a circular form and its hanged on the nail.

3. A known weight is made to be hanged on the yarn.

4. Now the circular ring gets deflected due to the load.

5. The deflection of lower end of the ring under the action of weight is noted down.

6. The flexural rigidity of the yarn is calculated using the below formula

$$G = KWL^2 (\cos\theta/\tan\theta)$$

$$\theta = 493D/L$$

Where,

G = Flexural rigidity in $mg.cm^2$

K = constant = 0.0047

W = weight applied in mg.

L = circumferential length of undistorted ring in cms

D = deflection of lower end of ring under the action of weight.

4.10.2.8 CSP

1. CSP is the product of count and the lea strength of the yarn.
2. The count of the yarn is first found by reeling a lea of yarn and weighing it.
3. Count = 64.8/ weight of the lea in grams.
4. Now the lea is fixed on the lea strength meter and the strength of the lea is found.
5. The product of count and lea strength will give the CSP of the yarn.

5. RESULTS AND DISCUSSIONS:

5.1 OPTIMISATION:

Table 3 Optimization of variables for 35/65 Polyester cotton Blended yarn

Concentration of NaOH	Temperature	Time	35/65 P/C Blend			Σ rank
			Tenacity	S3	Wickability	
5	50	30	1	27	23	51
5	50	45	4	24	21	49
5	50	60	5	23	22	50
5	60	30	3	26	24	53
5	60	45	6	22	20	48
5	60	60	9	20	18	47
5	70	30	2	25	26	53
5	70	45	7	21	19	47
5	70	60	10	19	17	46
10	50	30	8	18	25	51
10	50	45	11	16	14	41
10	50	60	13	14	14	41
10	60	30	12	17	16	45
10	60	45	18	12	13	43
10	60	60	21	8	11	40
10	70	30	14	13	15	42
10	70	45	20	7	10	37
10	70	60	25	3	6	34
15	50	30	15	15	12	42
15	50	45	17	10	9	36
15	50	60	16	11	8	35
15	60	30	19	9	7	35
15	60	45	23	5	4	32
15	60	60	24	4	3	31
15	70	30	22	6	5	33
15	70	45	26	2	2	30
15	70	60	27	1	1	29

Table 4 Optimization of variables for 50/50 Polyester cotton Blended yarn

Concentration Of NaOH	Temperature	Time	50/50 P/C Blend			Σ rank
			Tenacity	S3	Wickability	
5	50	30	2	25	26	53
5	50	45	4	26	23	53
5	50	60	5	21	24	50
5	60	30	3	27	25	55
5	60	45	6	24	19	49
5	60	60	8	20	20	48
5	70	30	1	23	26	50
5	70	45	7	22	22	51
5	70	60	12	19	21	52
10	50	30	10	17	18	45
10	50	45	9	18	14	41
10	50	60	11	13	16	40
10	60	30	13	16	15	44
10	60	45	18	15	10	43
10	60	60	23	8	11	42
10	70	30	14	11	17	42
10	70	45	21	9	12	42
10	70	60	26	5	9	40
15	50	30	17	12	13	42
15	50	45	15	14	6	35
15	50	60	16	10	8	34
15	60	30	19	6	5	30
15	60	45	22	7	3	32
15	60	60	24	4	4	32
15	70	30	20	3	7	30
15	70	45	25	2	2	29
15	70	60	27	1	1	29

Table 5 Optimization of variables for 65/35 Polyester cotton Blended yarn

Concentraion of NaOH	Temperature	Time	65/35 P/C Blend			Σ rank
			Tenacity	S3	Wickability	
5	50	30	1	24	27	52
5	50	45	3	25	24	52
5	50	60	7	22	23	52
5	60	30	2	27	25	54
5	60	45	5	26	21	52
5	60	60	8	21	20	49
5	70	30	4	23	26	53
5	70	45	6	20	22	48
5	70	60	9	19	19	47
10	50	30	10	16	18	44
10	50	45	11	17	17	45
10	50	60	14	14	14	42
10	60	30	16	18	15	49
10	60	45	17	15	13	45
10	60	60	22	12	11	45
10	70	30	20	13	16	49
10	70	45	21	11	12	44
10	70	60	26	5	9	40
15	50	30	15	10	10	35
15	50	45	13	9	8	30
15	50	60	12	6	7	25
15	60	30	23	8	6	37
15	60	45	18	7	4	29
15	60	60	19	4	3	26
15	70	30	27	3	5	35
15	70	45	24	2	2	28
15	70	60	25	1	1	27

Optimization of the process was done on the basis of results of tenacity , Hairiness Index and wickability. These factors were considered to be important , as the alkaline treatment of PET directly influences the surface of polyester fibre resulting in a weight loss. The weight loss obtained has direct co-relation with loss in tensile strength. So the Tensile strength loss is considered as an important factor for the process of optimization. And also due to the action of alkali on the yarn , the protruding fibers are removed, which enhances the comfort properties of the yarn. Due to the alkaline treatment , polymers session at the surface of the fibre , resulting in increase in generation of hydrophilic groups such as - COOH and – OH groups. This enhances the wickabilility of the yarn. So hairiness and wickability are also considered as an important factor for optimization process.

For the results obtained for the above properties, ranks are assigned for each values, by ranking the best result as NO.1 and the ranks are given till 27 , for all 27 values as shown in Table 3, table 4 and Table 5 for the 3 blend proportions. And now the summation of the ranks of all the three properties is taken and the experimental conditions of the best rank are taken as the optimized condition for the three blends. And we consider the tenacity values only up to 16.5 cN/Tex, 17.5 cN/Tex and 20 cN/Tex for 35/65, 50/50 and 65/35 polyester cotton blended yarns respectively.

The optimized values and their corresponding response surface equations for the various properties on the different blend proportions are shown in table 6.

Table 6 Response surface equation of yarn properties.

Properties	**Blend proportion**	**Response surface equation**	**R^2**	**Optimized values**
Weight loss	35/65	-27.3275+1.9095* X1+0.766125* X2-0.11725* X3-0.08245* X1* X1-0.0071875* X2* X2-0.000461111* X3* X3+0.0044* X1* X2+0.00326667* X1* X3+0.00301667* X2* X3	0.980	X1=15 X2= 60 X3= 45
	50/50	-39.6225+1.949* X1+1.09275* X2-0.00316667* X3-0.1022* X1* X1-0.0101* X2* X2-0.00106667* X3* X3+0.0097* X1* X2+0.00406667* X1* X3+0.002* X2* X3	0.974	X1=15 X2= 60 X3= 30
	65/35	3.95125+1.0305* X1-0.1075* X2-0.213333* X3-0.05225* X1* X1+0.0005875* X2* X2+0.00179444* X3* X3+0.00485* X1* X2+0.00403333* X1* X3+0.00095* X2* X3	0.965	X1=15 X2= 50 X3= 60

S3 values	35/65	1868.37-152.125* X1+19.0875* X2-9.73333* X3+6.535* X1* X1-0.09625* X2* X2+0.153889* X3* X3-0.685* X1* X2+0.173333* X1* X3-0.176667* X2* X3	0.994	X1=15 X2= 60 X3= 45
	50/50	-134.125-145.1* X1+66.3625* X2+39.4417* X3+6.67* X1* X1-0.46* X2* X2-0.355556* X3* X3-1.185* X1* X2+0.256667* X1* X3-0.276667* X2* X3	0.958	X1=15 X2= 60 X3= 30
	65/35	-2849.12-56.5* X1+152.287* X2+38.6583* X3+2.36* X1* X1-1.1325* X2* X2-0.227778* X3* X3-1.315* X1* X2-0.143333* X1* X3-0.396667* X2* X3	0.944	X1=15 X2= 50 X3= 60
U %	35/65	11.67-0.04425* X1+0.009125* X2+0.00516667* X3+0.002* X1* X1+1.98372E-18* X2* X2+0.0001* X3* X3-0.0002* X1* X2-0.000166667* X1* X3-0.00025* X2* X3	0.986	X1=15 X2= 60 X3= 45
	50/50	9.67625-0.0525* X1+0.05775* X2+0.0301667* X3+0.00365* X1* X1-0.0003875* X2* X2-0.000238889* X3* X3-0.00085* X1* X2+0.0001* X1* X3-0.000216667* X2* X3	0.987	X1=15 X2= 60 X3= 30
	65/35	9.67625-0.0525* X1+0.05775* X2+0.0301667* X3+0.00365* X1* X1-0.0003875* X2* X2-0.000238889* X3* X3-0.00085* X1* X2+0.0001* X1* X3-0.000216667* X2* X3	0.980	X1=15 X2= 50 X3= 60
Elongation %	35/65	13.0562-0.1455* X1-0.081875* X2-0.01725* X3+0.0062* X1* X1+0.000875* X2* X2+0.000677778* X3* X3-0.00085* X1* X2-0.000566667* X1* X3-0.0008* X2* X3	0.980	X1=15 X2= 60 X3= 45
	50/50	7.755-0.07225* X1-0.0275* X2+0.130917* X3+0.00905* X1* X1+0.0008375* X2* X2-0.00035* X3* X3-0.0027* X1* X2-0.0017* X1* X3-0.0017* X2* X3	0.959	X1=15 X2= 60 X3= 30
	65/35	22.5238-0.711* X1-0.377875* X2+0.06225* X3+0.0244* X1* X1+0.003475* X2* X2-0.000211111* X3* X3-0.00105* X1* X2+0.000966667* X1* X3-0.00123333* X2* X3	0.960	X1=15 X2= 50 X3= 60

Tenacity (in cN/Tex)	35/65	30.9925-1.122* X1-0.176625* X2+0.0395833* X3+0.03905* X1* X1+0.0018875* X2* X2+0.000172222* X3* X3-0.0023* X1* X2+0.00233333* X1* X3-0.00201667* X2* X3	0.984	X1=15 X2= 60 X3= 45
	50/50	27.2688-0.874* X1-0.194875* X2+0.132417* X3+0.0399* X1* X1+0.0025* X2* X2-0.000222222* X3* X3-0.00435* X1* X2+0.0007* X1* X3-0.0026* X2* X3	0.979	X1=15 X2= 60 X3= 30
	65/35	32.24-0.91825* X1-0.226125* X2+0.0225* X3+0.0346* X1* X1+0.00195* X2* X2-0.000233333* X3* X3-0.0017* X1* X2+0.00183333* X1* X3-0.00065* X2* X3	0.987	X1=15 X2= 50 X3= 60
CSP	35/65	2983.75-73.375* X1-28.5625* X2+5* X3+3.2* X1* X1+0.275* X2* X2+0.0166667* X3* X3-0.2* X1* X2-0.116667* X1* X3-0.125* X2* X3	0.978	X1=15 X2= 60 X3= 45
	50/50	4999.38-130.625* X1-71.375* X2+1.04167* X3+6.8* X1* X1+0.6625* X2* X2+0.0666667* X3* X3-0.625* X1* X2-0.266667* X1* X3-0.141667* X2* X3	0.975	X1=15 X2= 60 X3= 30
	65/35	3.95125+1.0305* X1-0.1075* X2-0.213333* X3-0.05225* X1* X1+0.0005875* X2* X2+0.00179444* X3* X3+0.00485* X1* X2+0.00403333* X1* X3+0.00095* X2* X3	0.930	X1=15 X2= 50 X3= 60
Flexural Rigidity (In Mg.Cm²)	35/65	2.01+0.004375* X1+0.0021875* X2+0.00183333* X3-0.00005* X1* X1-0.0000125* X2* X2-0.0000111111* X3* X3-0.00005* X1* X2-0.00005* X1* X3-0.00000833333* X2* X3	0.905	X1=15 X2= 60 X3= 45
	50/50	2.07375+0.003875* X1+0.0006875* X2+0.002* X3-0.0001* X1* X1-1.65597E-18* X2* X2-0.0000166667* X3* X3-0.00005* X1* X2-0.0000166667* X1* X3-0.00000833333* X2* X3	0.904	X1=15 X2= 60 X3= 30

	65/35	2.05375+0.002* X1+0.00075* X2+0.00208333* X3-2.26647E-18* X1* X1+5.32177E-19* X2* X2-0.0000111111* X3* X3-0.00005* X1* X2-0.0000333333* X1* X3-0.0000166667* X2* X3	0.992	X1=15 X2= 50 X3= 60
Vertical Wicking Height (in Cms) in 1 minute.	35/65	2.425-0.0275* X1+0.01* X2-0.0075* X3-0.0005* X1* X1-0.000375* X2* X2-0.000277778* X3* X3+0.002* X1* X2+0.000333333* X1* X3+0.000666667* X2* X3	0.975	X1=15 X2= 60 X3= 45
	50/50	-6.4375+0.1425* X1+0.1875* X2+0.0625* X3-0.004* X1* X1-0.00175* X2* X2-0.000888889* X3* X3+0.0015* X1* X2-6.64885E-19* X1* X3+0.0005* X2* X3	0.972	X1=15 X2= 60 X3= 30
	65/35	-4.075+0.1675* X1+0.11625* X2+0.0333333* X3-0.004* X1* X1-0.001* X2* X2-0.000333333* X3* X3+0.001* X1* X2-0.000333333* X1* X3+0.000166667* X2* X3	0.981	X1=15 X2= 50 X3= 60

5.2 WEIGHT LOSS % :

Table 7 weight Loss %.

Concentration of NaOH	Temperature	Time	Weight Loss %		
			35/65	50/50	65/35
5	50	30	2.348756	1.934997	2.678756
5	50	45	2.182505	2.492494	2.908758
5	50	60	2.823753	2.569989	2.931261
5	60	30	2.447506	2.837497	3.558757
5	60	45	2.423755	3.694994	4.24126
5	60	60	3.207503	4.072489	4.716263
5	70	30	2.663756	1.719997	3.001258
5	70	45	2.782505	2.877494	4.136261
5	70	60	3.708753	3.554989	5.063765
10	50	30	5.400005	7.049998	7.632506
10	50	45	5.536255	7.912495	8.107509
10	50	60	6.480002	8.29499	8.375012
10	60	30	5.741255	8.437498	8.732507
10	60	45	6.020005	9.599995	9.660011
10	60	60	7.106252	10.28249	10.38001
10	70	30	6.200005	7.804998	8.395008
10	70	45	6.621255	9.267495	9.775012
10	70	60	7.850002	10.24999	10.94752
15	50	30	5.838755	7.054998	8.463757
15	50	45	6.277504	8.222495	9.18376
15	50	60	7.523751	8.909991	9.696263
15	60	30	6.422505	8.927498	9.783758
15	60	45	7.003754	10.395	10.95626
15	60	60	8.392501	11.38249	11.92127
15	70	30	7.123755	8.779998	9.666259
15	70	45	7.847504	10.5475	11.29126
15	70	60	9.378751	11.83499	12.70877

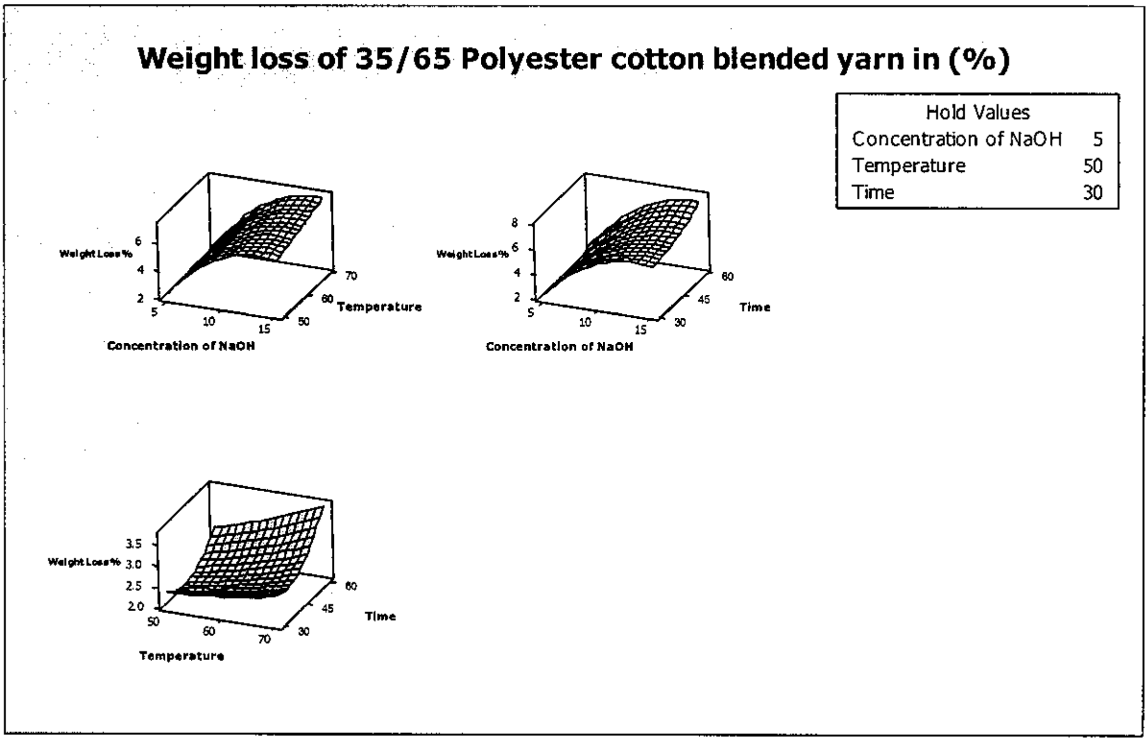


Figure 5 surface plots for weight loss(%) of 35/65 p/c yarn.

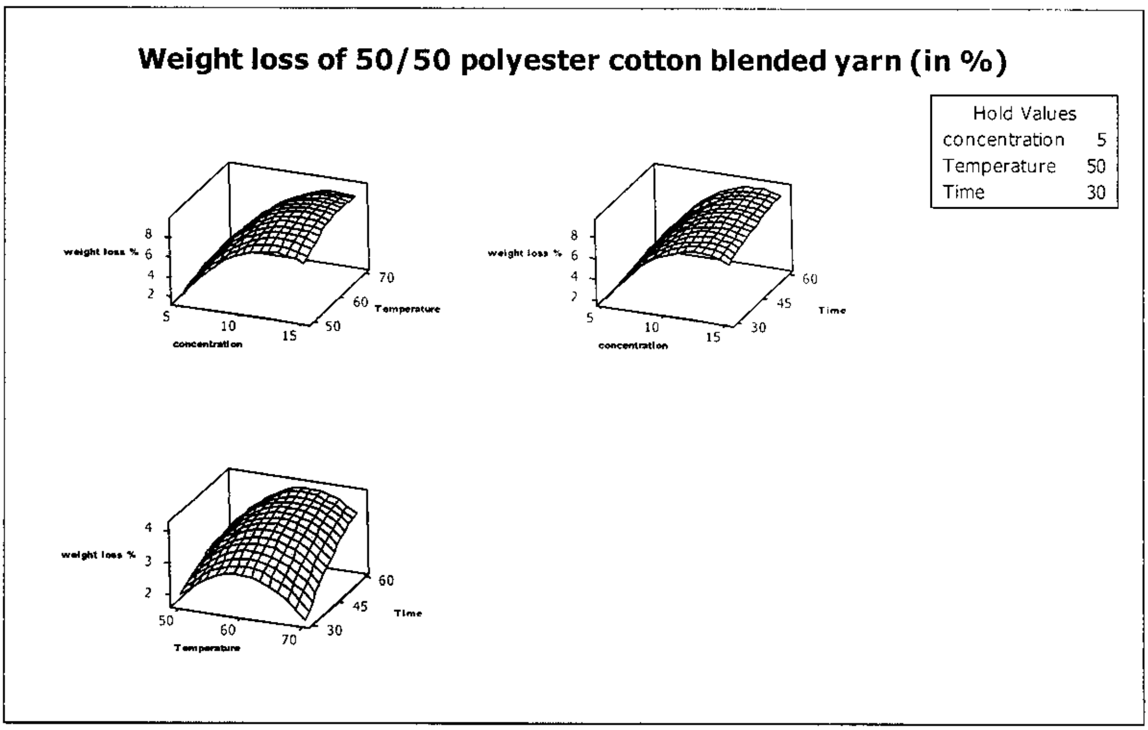


Figure 6 surface plots for weight loss(%) of 50/50 p/c yarn.

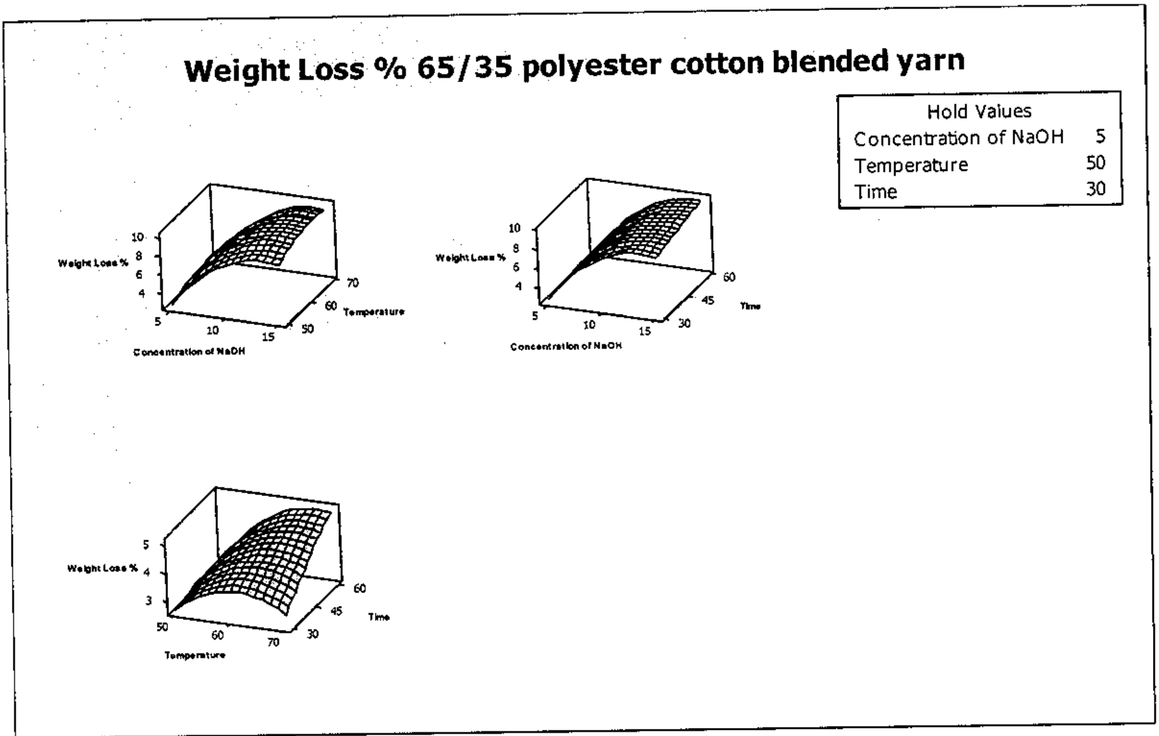


Figure 7 surface plots for weight loss(%) of 65/35 p/c yarn.

Weight loss is mainly due to the hydrolysis reaction took place in the fibers. When the time , temperature and concentration of the treatment increases, the weight loss is increases. So Strength of the yarn decreases.

The weight loss is due to the rupture of polyester fiber surface and the alkali absorbed by the fibers. The sample consists of polyester / cotton, the polyester surface of the fiber get ruptured due to the Hydrolysis reaction. In cotton, swelling takes place. Weight loss is more in the 15% concentration. There is a moderate weight loss 10% concentration and a less weight loss at 5% concentration.

The weight loss gets increased with increase in severity of the treatment as shown Figure 5 , Figure 6 and Figure 7. And also it is found that weight loss increases with increase in polyester content of the yarn as shown in Table 7.

5.3 Wickability:

Table 8. Wickability of yarn at various conditions

Concentration of NaOH	Temperature	Time	Wickability		
			35/65	50/50	65/35
5	50	30	2.9125	1.375	1.125
5	50	45	3.0125	1.6875	1.35
5	50	60	2.9875	1.6	1.425
5	60	30	2.9	1.55	1.2875
5	60	45	3.1	1.9375	1.5375
5	60	60	3.175	1.925	1.637501
5	70	30	2.8125	1.375	1.25
5	70	45	3.112501	1.8375	1.525
5	70	60	3.287501	1.9	1.650001
10	50	30	3.2875	2.1625	1.8625
10	50	45	3.4125	2.475	2.0625
10	50	60	3.4125	2.3875	2.1125
10	60	30	3.375	2.4125	2.075
10	60	45	3.6	2.8	2.3
10	60	60	3.7	2.7875	2.375001
10	70	30	3.3875	2.3125	2.0875
10	70	45	3.7125	2.775	2.3375
10	70	60	3.9125	2.8375	2.437501
15	50	30	3.6375	2.75	2.4
15	50	45	3.7875	3.0625	2.575
15	50	60	3.8125	2.975	2.600001
15	60	30	3.825	3.075	2.6625
15	60	45	4.075	3.4625	2.8625
15	60	60	4.2	3.45	2.912501
15	70	30	3.9375	3.05	2.725
15	70	45	4.2875	3.5125	2.95
15	70	60	4.5125	3.575	3.025001
Raw sample			2.7	1.4	1.1

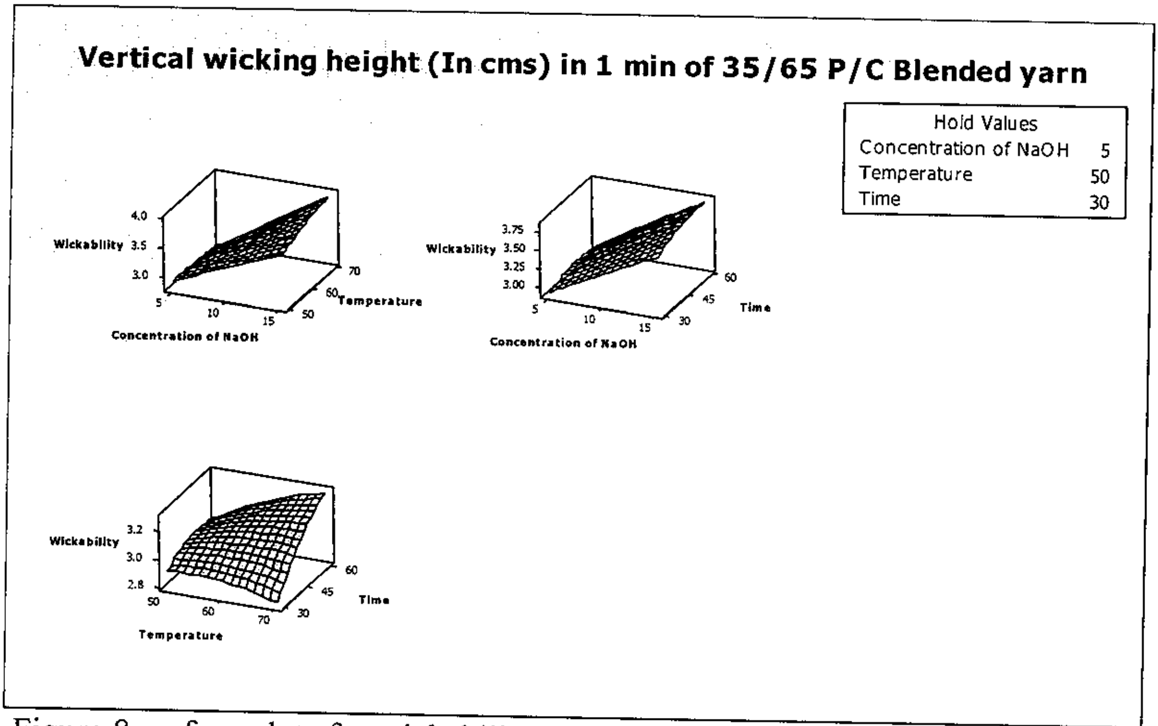


Figure 8 surface plots for wickability (in cms) of 35/65 p/c yarn.

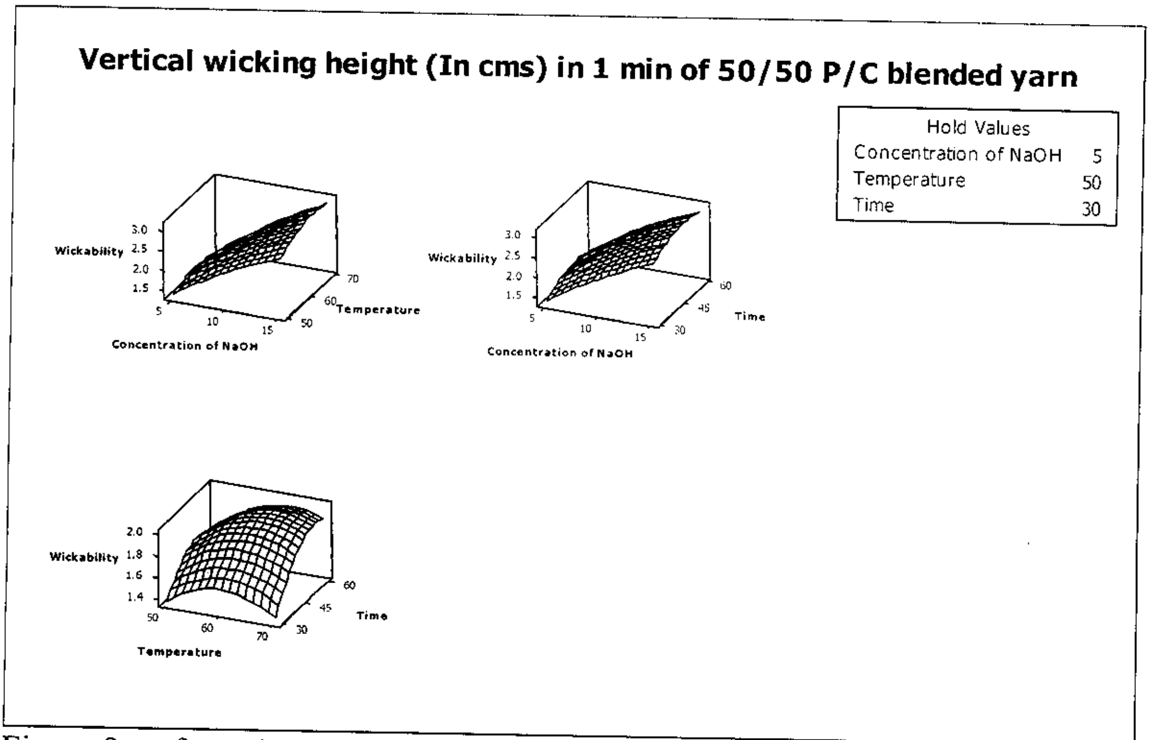


Figure 9 surface plots for wickability (in cms) of 50/50 p/c yarn.

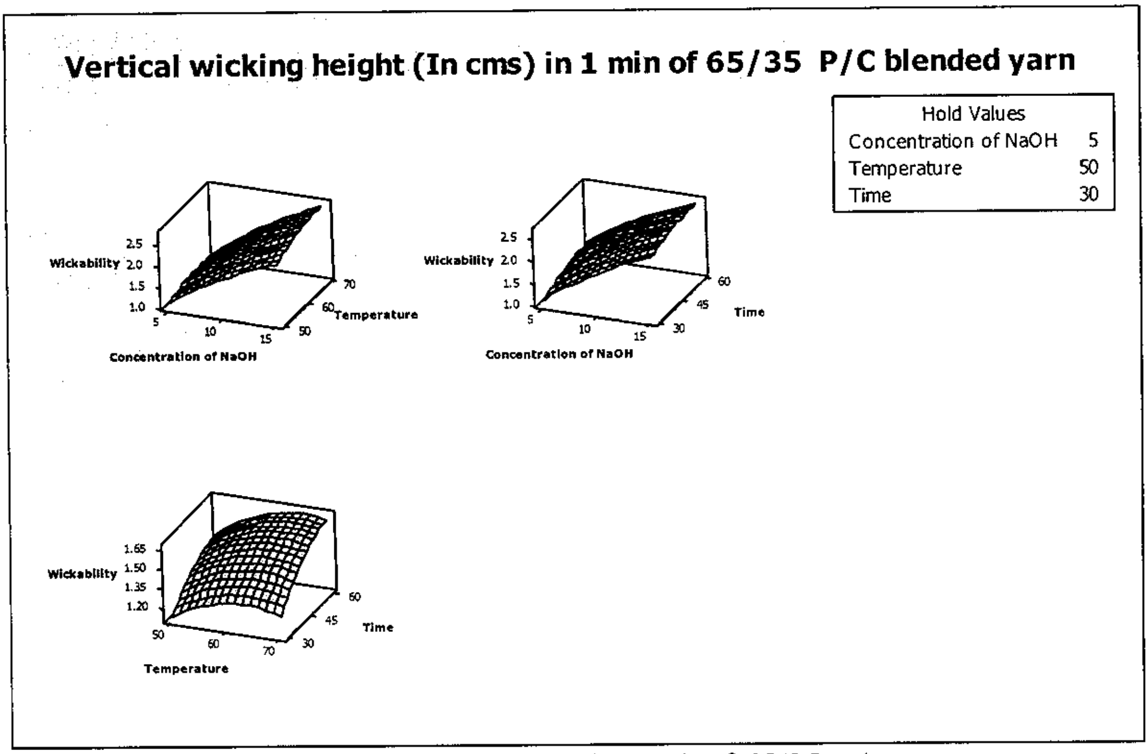


Figure 10 surface plots for wickability (in cms) of 65/35 p/c yarn.

The water drop absorbency time decreases after the treatment of yarn with NaOH. The polymer session at the surface of the fibre resulting in increase in hydrophilic groups such as COOH and OH which enhances the wickability of the yarn.

From the table 8 we can see that the wickability of the yarn increases with the severity of the treatment (i.e. with increase in time, temperature and concentration of alkali) within the same blend as shown in figure 8, figure 9 and figure 10. It is also found that the wickability of the yarn increases with the decrease in polyester content between the blends.

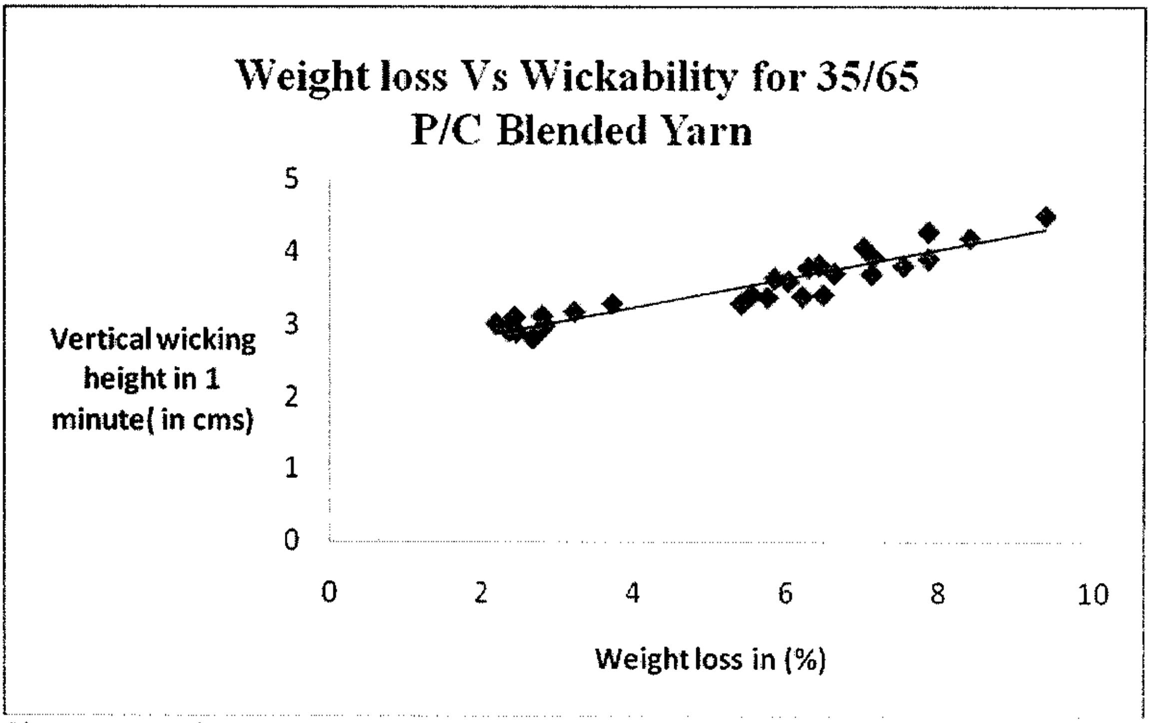


Figure 11 Weight loss Vs Wickability for 35/65 P/c Yarn.

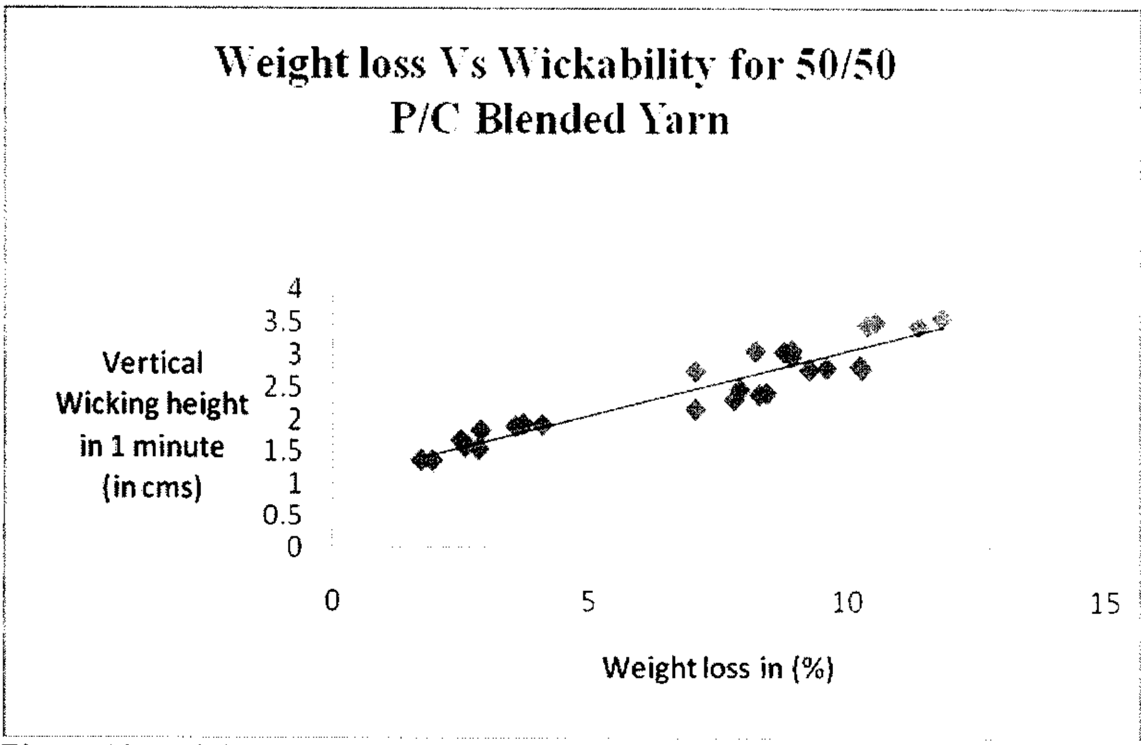


Figure 12 Weight loss Vs Wickability for 50/50 P/c Yarn.

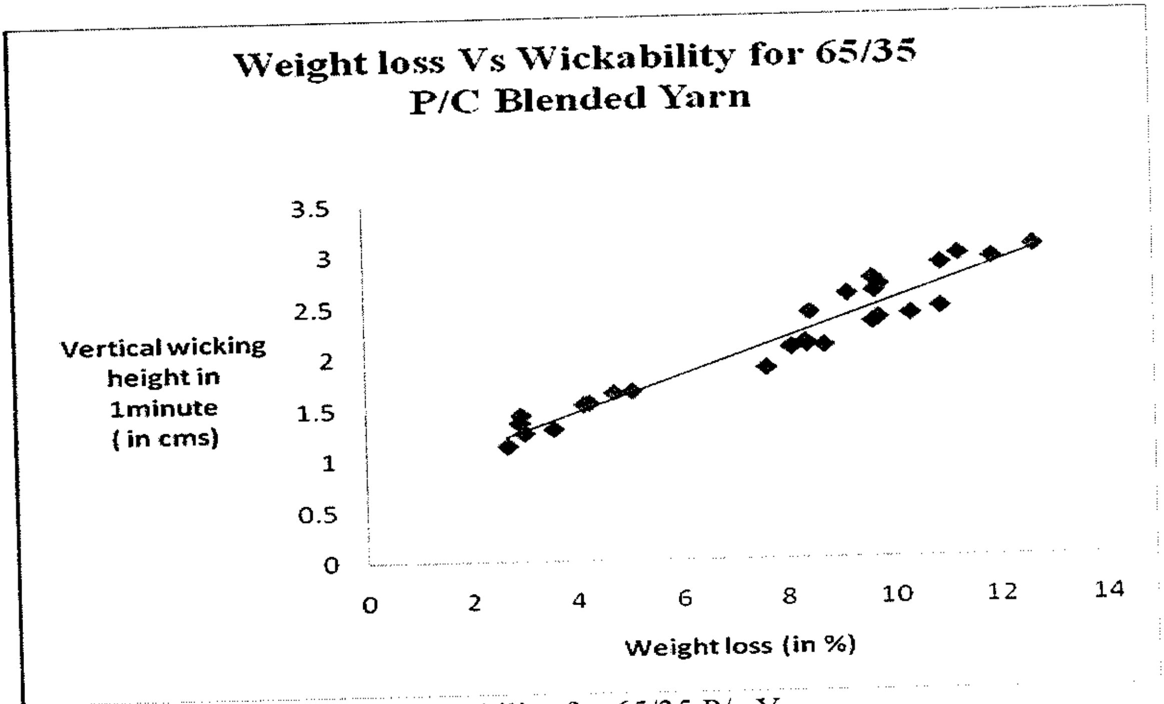


Figure 13 Weight loss Vs Wickability for 65/35 P/c Yarn.

And also from the figure 11, It is clear that wickability of the yarn is having a direct co-relation with weight loss%. And the similar trend is observed in other 2 blends as shown in figure 12 and figure 13.

5.4 CSP:

Table 9 CSP of different yarns at different conditions.

Concentration of NaOH	Temperature	Time	CSP		
			35/65	50/50	65/36
5	50	30	1866.25	2286.255	2994.376
5	50	45	1857.5	2250.629	3050.626
5	50	60	1856.25	2245.004	3025.625
5	60	30	1835.625	2227.504	2973.751
5	60	45	1808.125	2170.629	3020.001
5	60	60	1788.125	2143.754	2985
5	70	30	1860	2301.254	2969.376
5	70	45	1813.75	2223.129	3005.626
5	70	60	1775	2175.004	2960.625
10	50	30	1671.875	1946.88	2810.626
10	50	45	1654.375	1891.254	2823.126
10	50	60	1644.375	1865.629	2754.376
10	60	30	1631.25	1856.879	2772.501
10	60	45	1595	1780.004	2775.001
10	60	60	1566.25	1733.129	2695.25
10	70	30	1645.625	1899.379	2750.626
10	70	45	1590.625	1801.254	2743.126
10	70	60	1543.125	1733.129	2654.375
15	50	30	1637.5	1947.504	2800.626
15	50	45	1611.25	1871.879	2769.376
15	50	60	1592.5	1826.254	2656.876
15	60	30	1586.875	1826.254	2745.001
15	60	45	1541.875	1729.379	2703.751
15	60	60	1504.375	1662.504	2581.251
15	70	30	1591.25	1837.504	2705.626
15	70	45	1527.5	1719.379	2654.376
15	70	60	1471.25	1631.254	2521.876
Untreated sample			1975	2415	3220

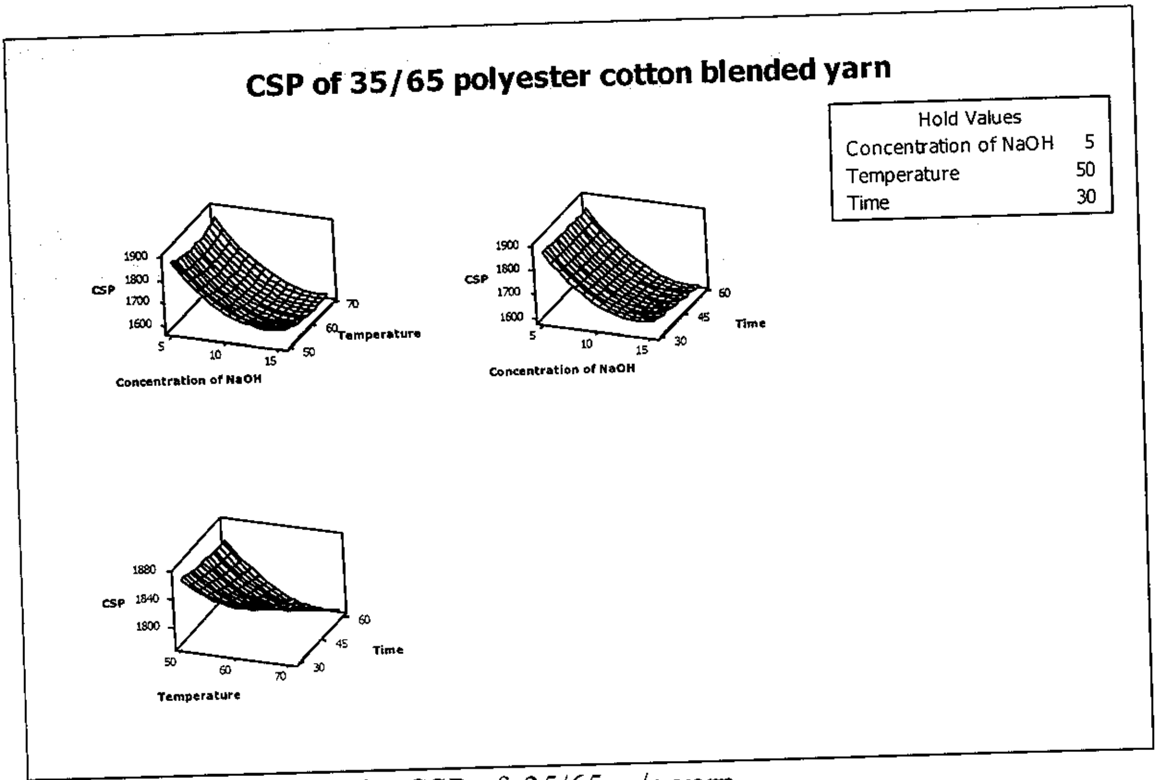


Figure 14 surface plots for CSP of 35/65 p/c yarn.

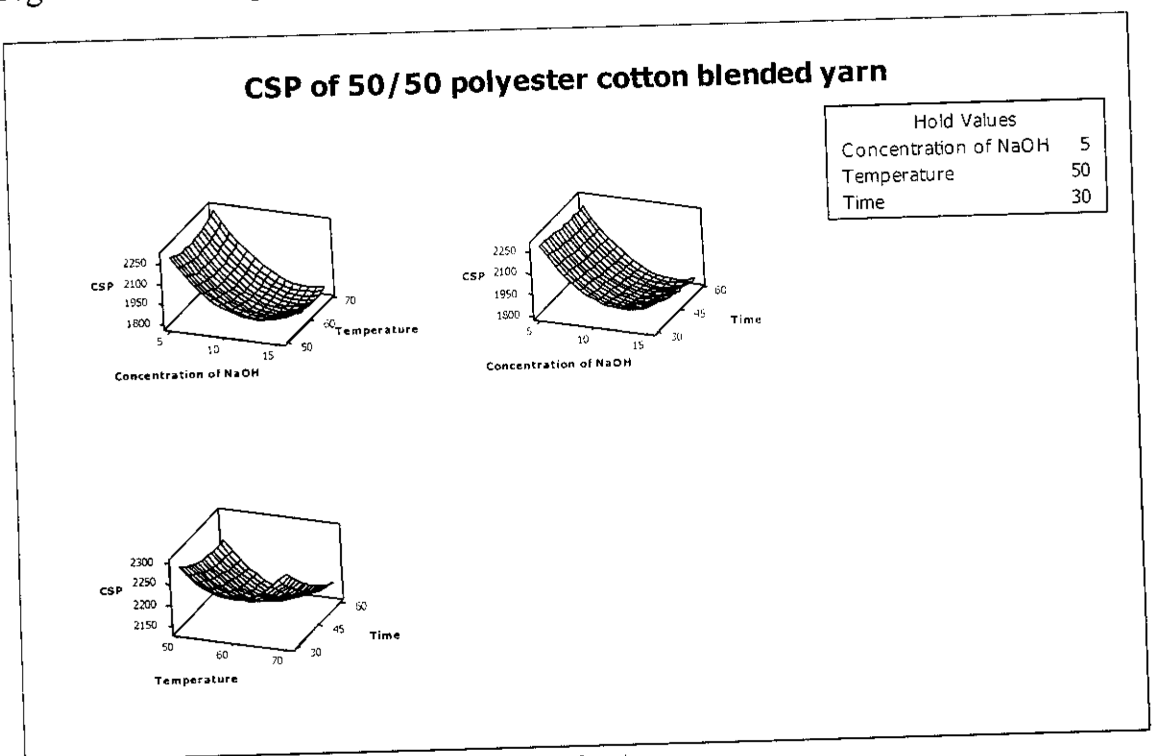


Figure 15 surface plots for CSP of 50/50 p/c yarn.

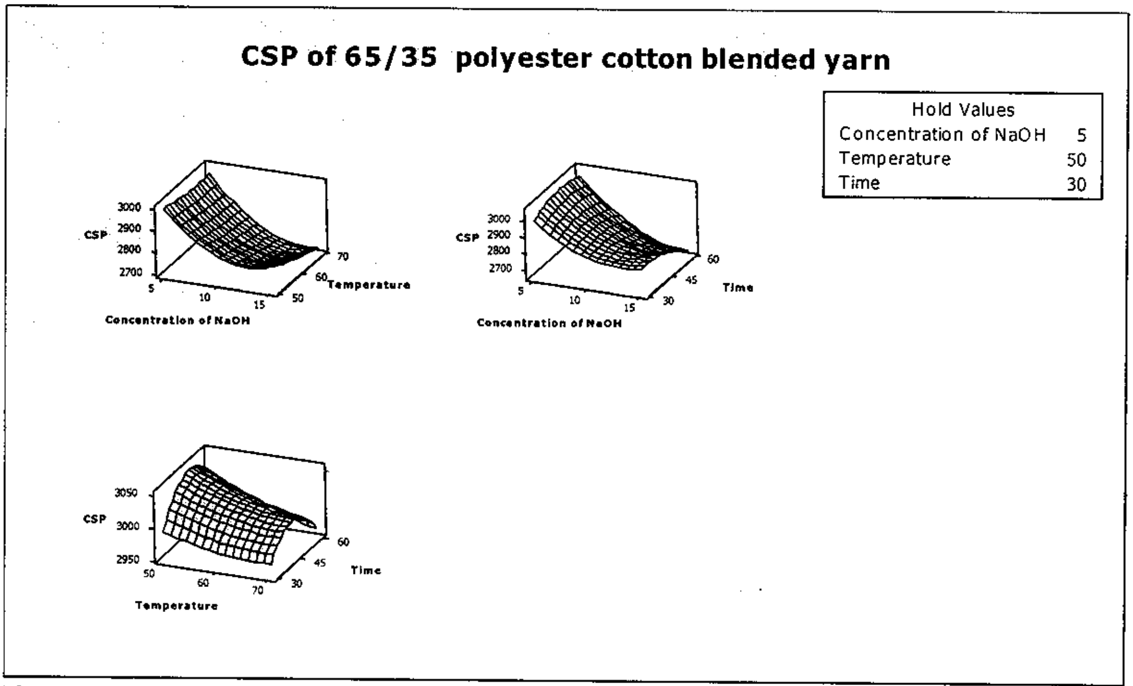


Figure 16 surface plots for CSP of 65/35 p/c yarn.

The results obtained from the experimental demonstrations shows that the CSP% after treatment varies in the range of 1866 – 1471 for 35/65, 2286 – 1631 in case of 50/50 and in the range of 2994 – 2521 in the case of 65/35 as shown in the table 9.

Due to alkaline treatment the yarn undergoes weight loss and hence the fineness of the yarn increases, which results in the increase of the English count of the yarn but at the same time the lea strength of the yarn decreases.

The CSP value decreases within the same blend with increase in severity of the treatment (i.e.with increase in time, temperature and concentration of the process) as shown in the figure 14, figure 15 and figure 16. But the CSP value increases at the same conditions with increase in polyester content.

On comparing the data in table 7 it shows that CSP is directly proportional to weight loss.

5.5 FLEXURAL RIGIDITY:

Table 10 Flexural Rigidity of different yarns at different conditions.

Concentration of NaOH	Temperature	Time	Flexural rigidity		
			35/65	50/50	65/35
5	50	30	2.12125	2.1425	2.11125
5	50	45	2.12625	2.14625	2.115
5	50	60	2.12625	2.1425	2.11375
5	60	30	2.124375	2.144375	2.11125
5	60	45	2.128125	2.146875	2.1125
5	60	60	2.126875	2.141875	2.10875
5	70	30	2.125	2.14625	2.11125
5	70	45	2.1275	2.1475	2.11
5	70	60	2.125	2.14125	2.10375
10	50	30	2.119375	2.139375	2.10375
10	50	45	2.120625	2.141875	2.105
10	50	60	2.116875	2.136875	2.10125
10	60	30	2.12	2.13875	2.10125
10	60	45	2.12	2.14	2.1
10	60	60	2.115	2.13375	2.09375
10	70	30	2.118125	2.138125	2.09875
10	70	45	2.116875	2.138125	2.095
10	70	60	2.110625	2.130625	2.08625
15	50	30	2.115	2.13125	2.09625
15	50	45	2.1125	2.1325	2.095
15	50	60	2.105	2.12625	2.08875
15	60	30	2.113125	2.128125	2.09125
15	60	45	2.109375	2.128125	2.0875
15	60	60	2.100625	2.120625	2.07875
15	70	30	2.10875	2.125	2.08625
15	70	45	2.10375	2.12375	2.08
15	70	60	2.09375	2.115	2.06875
Untreated sample			2.13	2.15	2.12

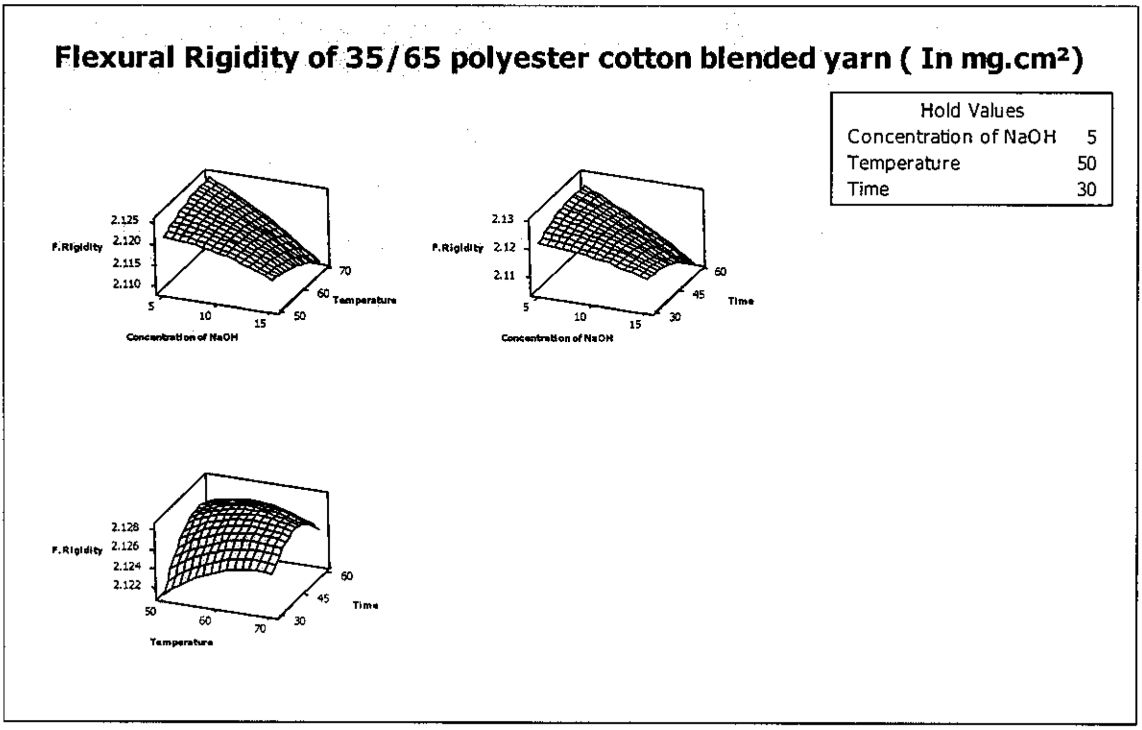


Figure 17 surface plots for Flexural rigidity (in mg.cm²) of 35/65 p/c yarn.

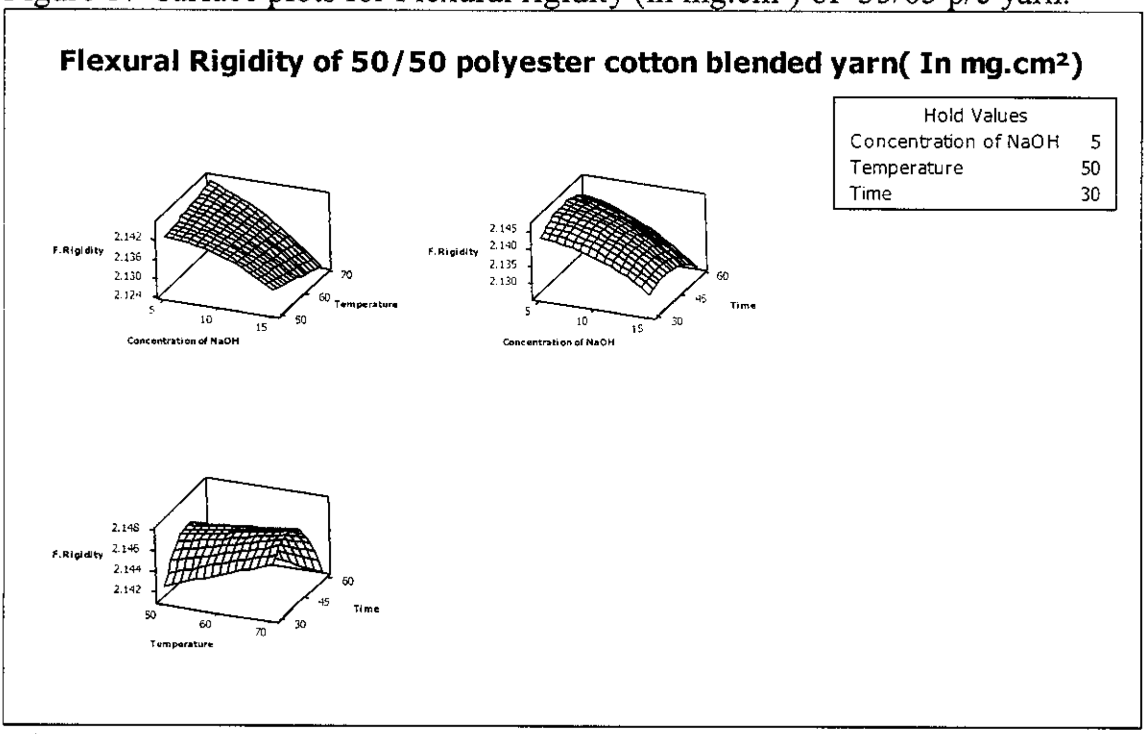


Figure 18 surface plots for Flexural rigidity (in mg.cm²) of 50/50 p/c yarn.

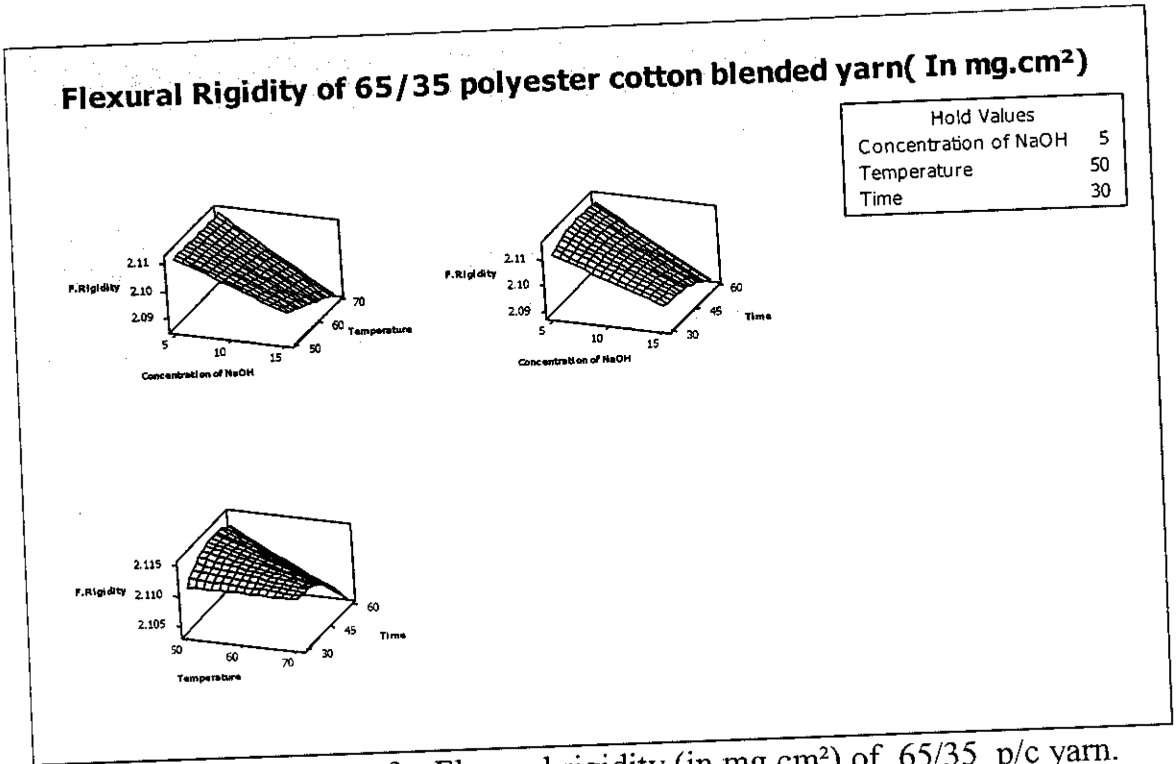


Figure 19 surface plots for Flexural rigidity (in mg.cm²) of 65/35 p/c yarn.

The results obtained from the experimental demonstrations shows that the Flexural Rigidity values after treatment varies in the range of 2.12 – 2.09 for 35/65, 2.14 – 2.11 in case of 50/50 and in the range of 2.11 – 2.06 in the case of 65/35 as shown in the table 10.

The results the table indicate that there is no significant difference in the flexural rigidity values with the change in the concentration of the alkali, the temperature and time of the treatment. In other words we can say that the effect of the 3 variables (time, temperature and concentration of alkali) within our experimental boundaries does not effect the flexural rigidity of the yarn and its values are similar for all the blends as shown in figure 17, figure 18 and figure 19.

5.6 UNEVENESS % :

Table 11 U % of different yarns at different conditions.

Concentration of NaOH	Temperature	Time	U%		
			35/65	50/50	65/35
5	50	30	11.75	11.59125	11.08755
5	50	45	11.74	11.62	11.0288
5	50	60	11.775	11.54125	10.95005
5	60	30	11.75625	11.635	11.0763
5	60	45	11.70875	11.63125	10.90255
5	60	60	11.70625	11.52	10.7088
5	70	30	11.7625	11.60125	11.12505
5	70	45	11.6775	11.565	10.8363
5	70	60	11.6375	11.42125	10.52755
10	50	30	11.60375	11.405	10.46505
10	50	45	11.58125	11.44125	10.4388
10	50	60	11.60375	11.37	10.39255
10	60	30	11.6	11.40625	10.4113
10	60	45	11.54	11.41	10.27005
10	60	60	11.525	11.30625	10.1088
10	70	30	11.59625	11.33	10.41755
10	70	45	11.49875	11.30125	10.1613
10	70	60	11.44625	11.165	9.885047
15	50	30	11.5575	11.40125	10.10755
15	50	45	11.5225	11.445	10.1138
15	50	60	11.5325	11.38125	10.10005
15	60	30	11.54375	11.36	10.0113
15	60	45	11.47125	11.37125	9.902547
15	60	60	11.44375	11.275	9.773797
15	70	30	11.53	11.24125	9.975048
15	70	45	11.42	11.22	9.751297
15	70	60	11.355	11.09125	9.507546
Untreated sample			11.77	11.66	11.32

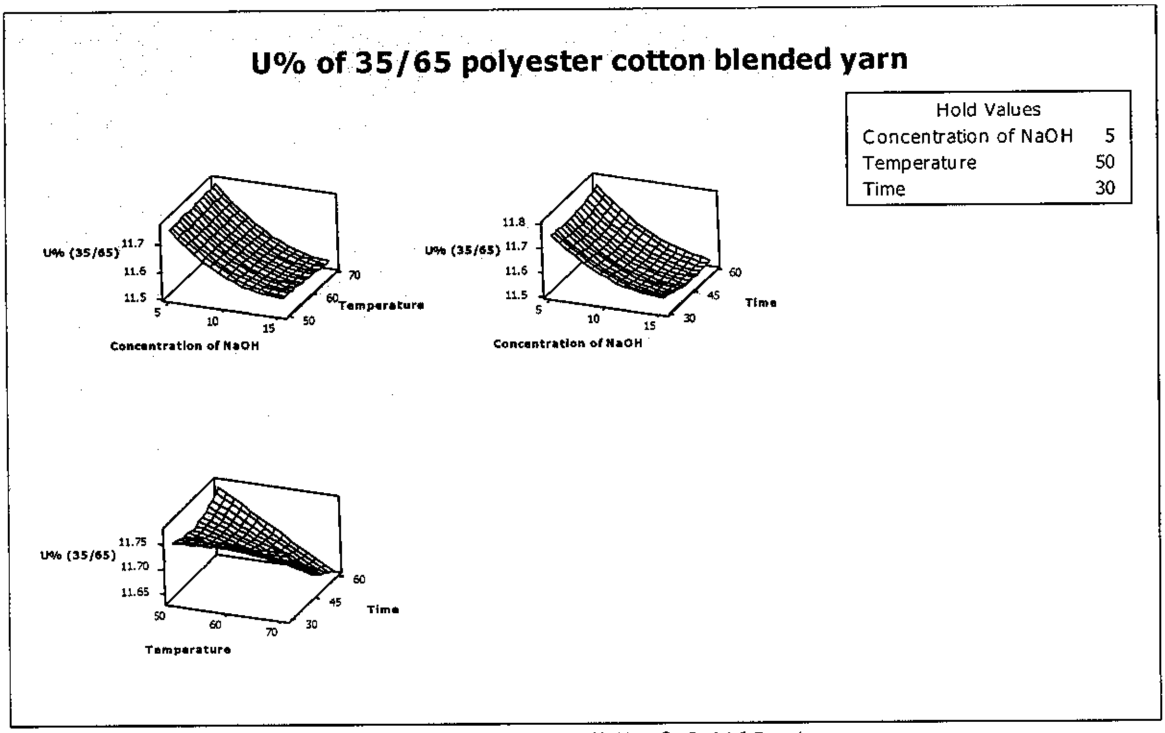


Figure 20 surface plots for unevenness (%)of 35/65 p/c yarn.

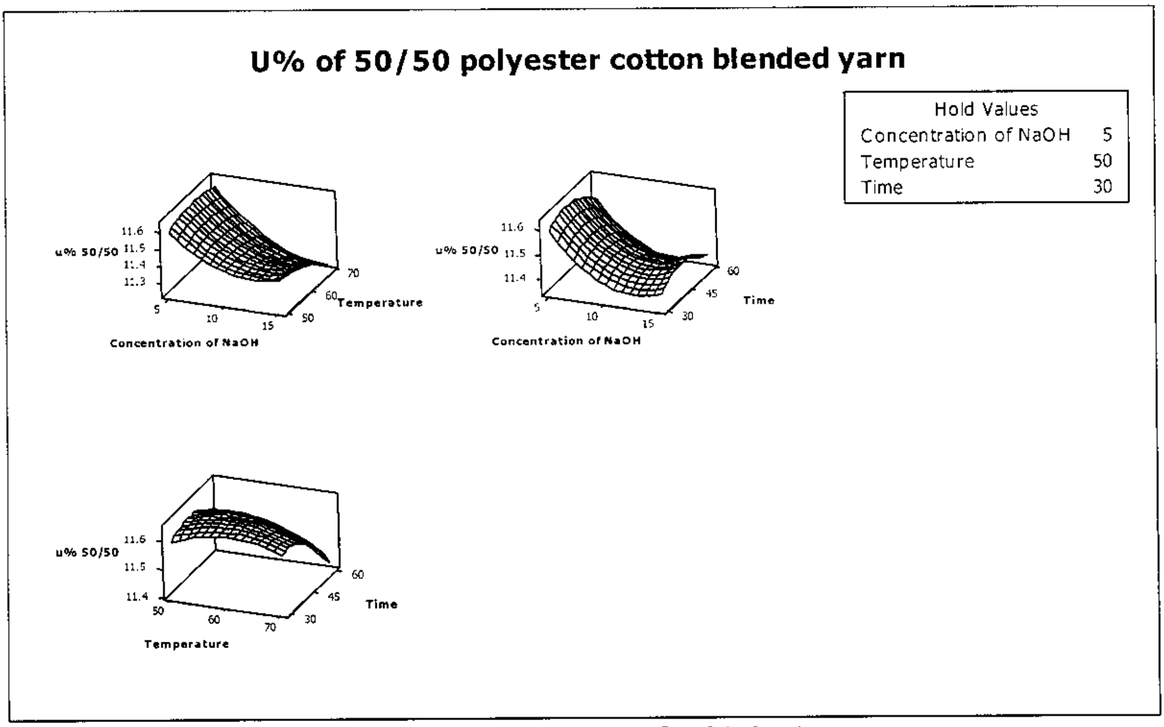


Figure 21 surface plots for unevenness (%)of 50/50 p/c yarn.

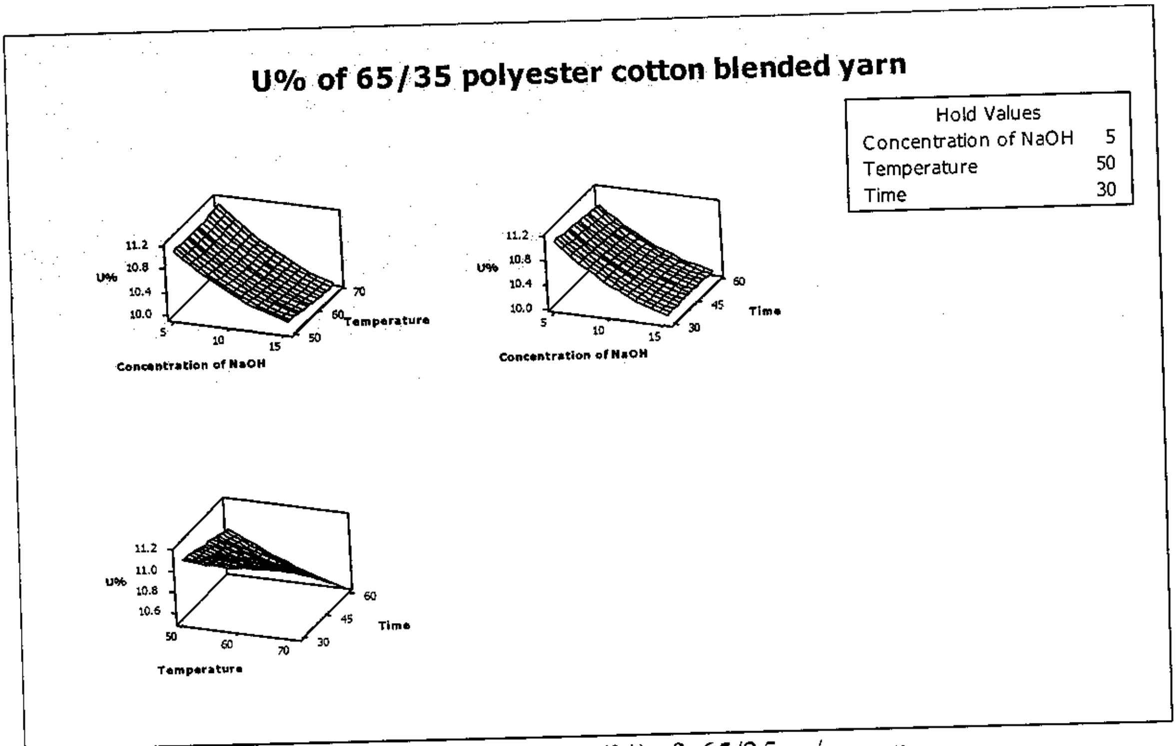


Figure 22 surface plots for unevenness (%)of 65/35 p/c yarn.

The results obtained from the experimental demonstrations shows that the CSP% after treatment varies in the range of 11.75 – 11.35 for 35/65,11.63 – 11.09 in case of 50/50 and in the range of 11.12 – 9.50 in the case of 65/35 as shown in the table 11.

This indicates that the unevenness of the yarn decreases with the increase in severity of the treatment (i.e.increase in time, temperature and concentration of the alkali) as shown in figure 20, figure 21 and figure 22. This can be attributed to the fact that the increase in NaOH concentration results in greater hydrolysis on the surface of the yarn.

5.7 S3 VALUE:

Table 12 S3 Value of different yarns at different conditions.

Concentration of NaOH	Temperature	Time	S3 Value		
			35/65	50/50	65/35
5	50	30	1421.12	1665.75	1719.978
5	50	45	1328.745	1669.125	1735.352
5	50	60	1305.62	1512.5	1648.226
5	60	30	1418.87	1681.125	1812.348
5	60	45	1299.994	1643	1768.222
5	60	60	1250.369	1444.874	1621.596
5	70	30	1397.369	1604.5	1678.218
5	70	45	1251.994	1524.875	1574.592
5	70	60	1175.869	1285.249	1368.466
10	50	30	1005.37	1182.75	1264.228
10	50	45	925.9945	1205.375	1268.852
10	50	60	915.8694	1068	1170.976
10	60	30	968.8695	1138.875	1290.848
10	60	45	862.9943	1120	1235.972
10	60	60	826.3692	941.1244	1078.596
10	70	30	913.1194	1003	1090.968
10	70	45	780.7442	942.6247	976.5922
10	70	60	717.619	722.2492	759.716
15	50	30	916.3696	1033.25	926.4785
15	50	45	849.9944	1075.125	920.3525
15	50	60	852.8693	956.9997	811.7265
15	60	30	845.6195	930.1252	887.3484
15	60	45	752.7443	930.4999	821.7224
15	60	60	729.1191	770.8745	653.5963
15	70	30	755.6194	735.0001	621.7183
15	70	45	636.2441	693.8748	496.5922
15	70	60	586.1189	492.7493	268.9661
Untreated sample			1875	2610	2609

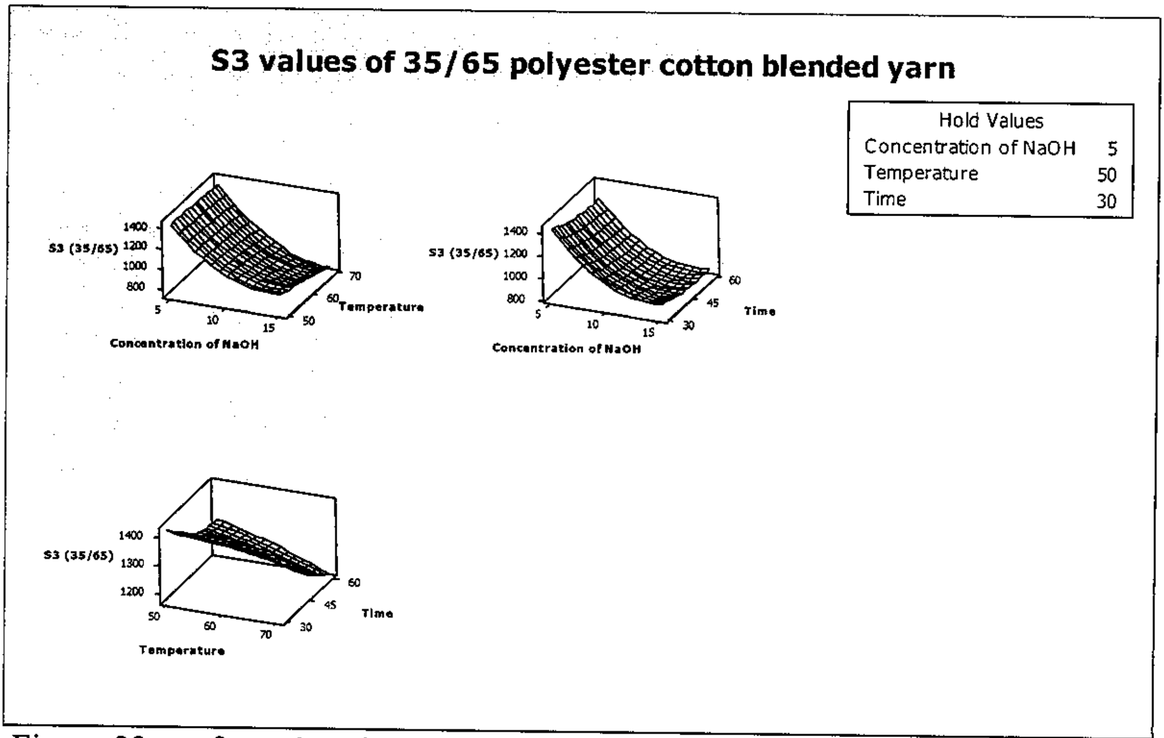


Figure 23 surface plots for S3value of 35/65 p/c yarn.

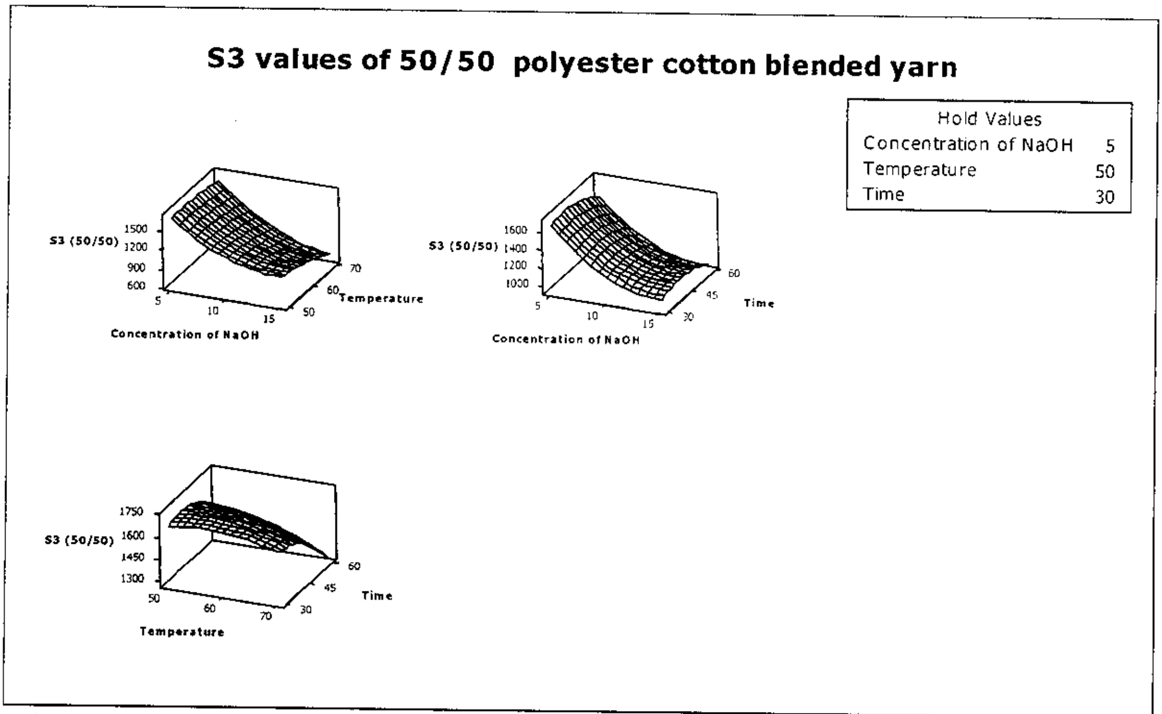


Figure 24 surface plots for S3value of 50/50 p/c yarn.

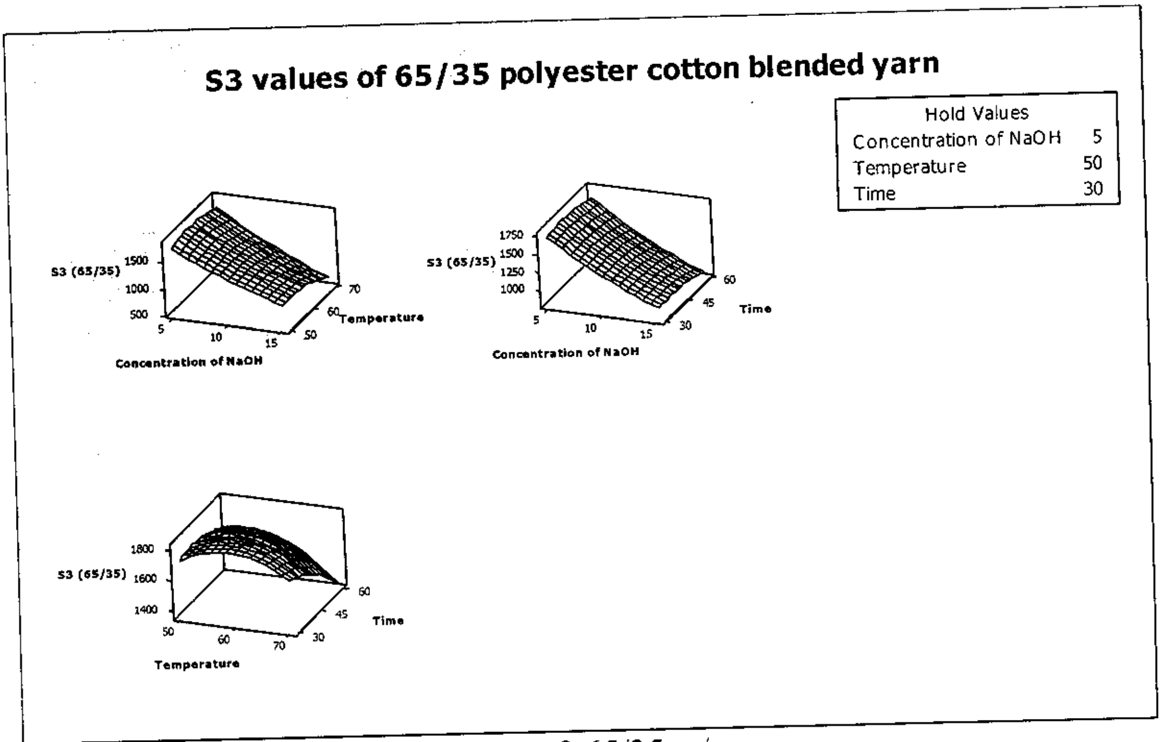


Figure 25 surface plots for S3value of 65/35 p/c yarn.

The results obtained from the experimental demonstrations shows that the S3 Value after treatment varies in the range of 1421 – 586 for 35/65, 1665 – 492 in case of 50/50 and in the range of 1719 – 268 in the case of 65/35 as shown in the table 12.

The results obtained shows that S3 value increases with the increase in severity of the treatment (i.e.increase in time, temperature and concentration of the alkali) as shown in figure 23 , figure 24 and figure 25. This is due to the fact that the action of alkali removes the protruding fibres of the yarn.

5.8 ELONGATION %:

Table 13 Elongation % of different yarns at different conditions.

Concentration of NaOH	Temperature	Time	ELONGATION %		
			35/65	50/50	65/35
5	50	30	9.1724502	8.47126	9.082555
5	50	45	9.0337004	8.638765	8.926308
5	50	60	9.1999507	8.64877	8.675061
5	60	30	9.0337002	8.47251	8.703806
5	60	45	8.7749504	8.385015	8.362559
5	60	60	8.8212007	8.14002	7.926313
5	70	30	9.0699502	8.64126	9.020057
5	70	45	8.6912004	8.298765	8.493811
5	70	60	8.6174507	7.79877	7.872565
10	50	30	8.6124501	7.85876	7.240055
10	50	45	8.4312003	7.898765	7.156308
10	50	60	8.5549506	7.78127	6.977561
10	60	30	8.4312001	7.72501	6.808806
10	60	45	8.1299503	7.510015	6.540059
10	60	60	8.1337006	7.13752	6.176313
10	70	30	8.4249501	7.75876	7.072557
10	70	45	8.0037003	7.288765	6.618811
10	70	60	7.8874506	6.66127	6.070065
15	50	30	8.3624501	7.69876	6.617555
15	50	45	8.1387002	7.611265	6.606308
15	50	60	8.2199505	7.36627	6.500061
15	60	30	8.1387001	7.43001	6.133806
15	60	45	7.7949502	7.087515	5.937559
15	60	60	7.7562005	6.58752	5.646313
15	70	30	8.0899501	7.32876	6.345057
15	70	45	7.6262002	6.731265	5.963811
15	70	60	7.4674505	5.97627	5.487565
Untreated sample			9.24	9.34	10.00

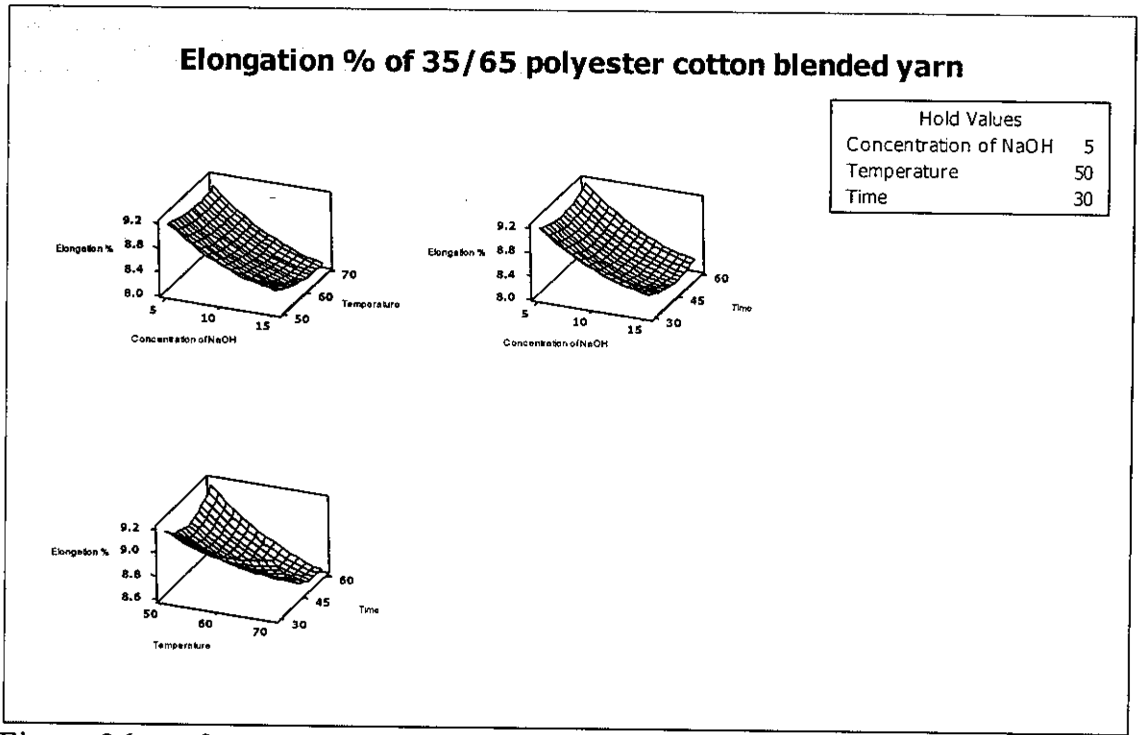


Figure 26 surface plots for Elongation % of 35/65 p/c yarn.

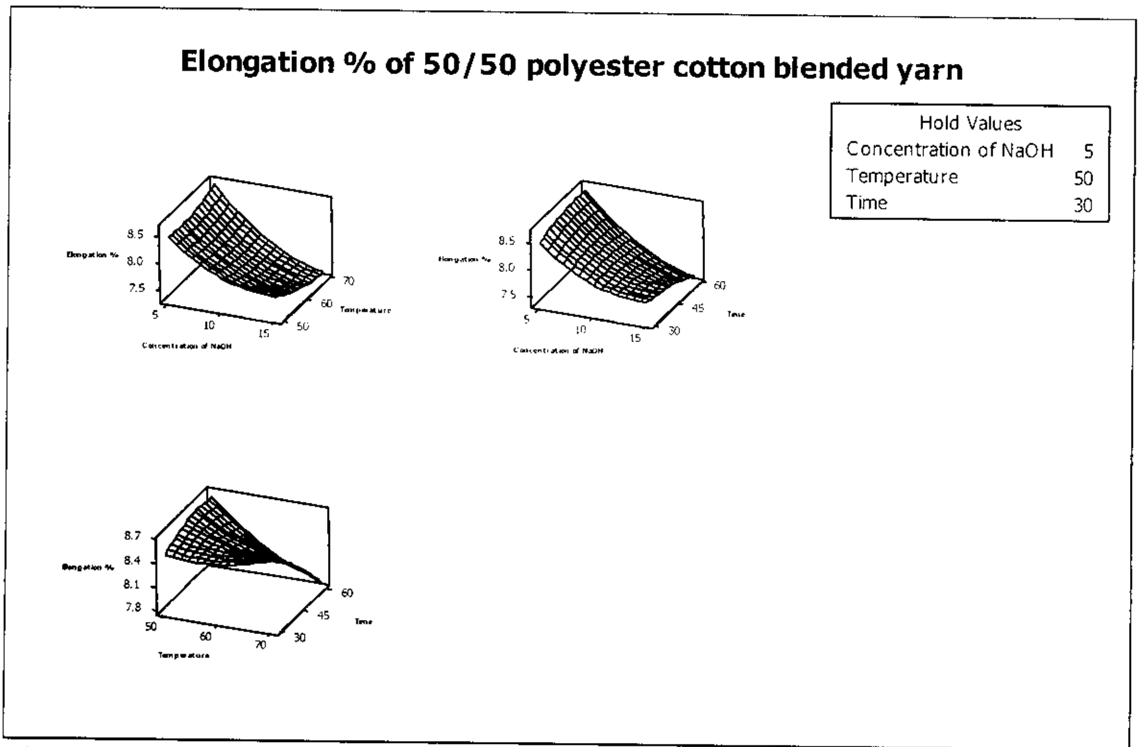


Figure 27 surface plots for Elongation % of 50/50 p/c yarn.

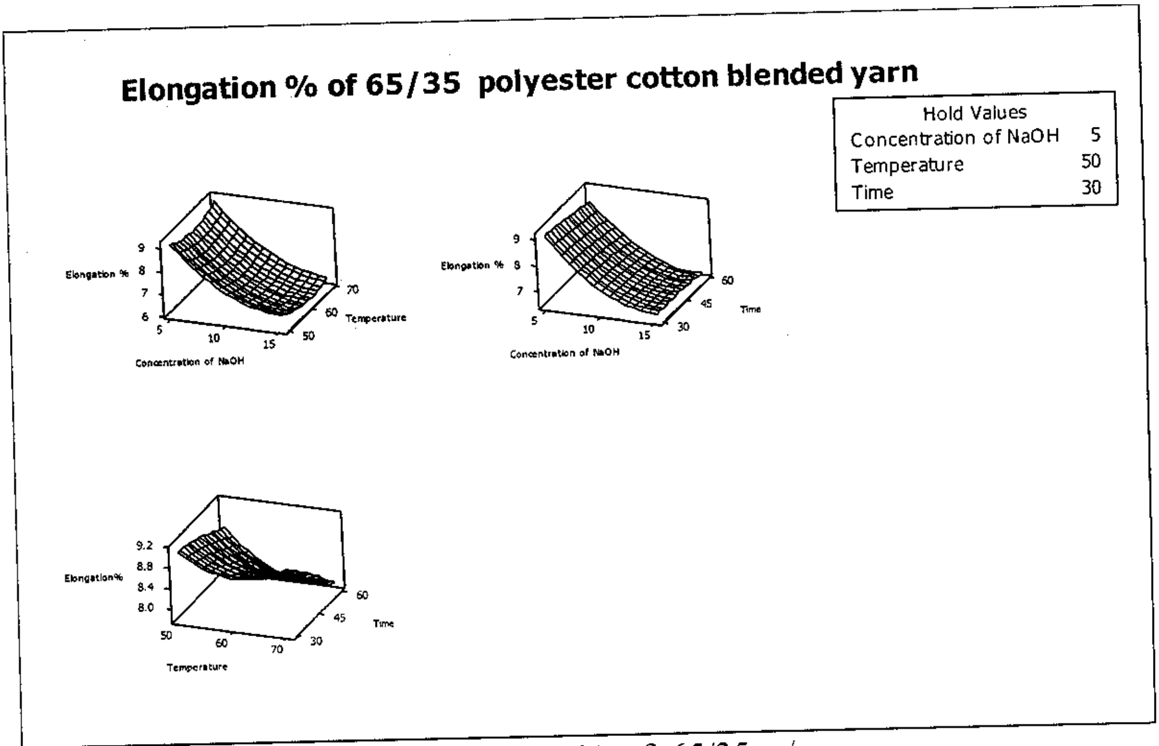


Figure 28 surface plots for Elongation % of 65/35 p/c yarn.

The results obtained from the experimental demonstrations shows that the Elongation% after treatment varies in the range of 9.2 – 7.5 for 35/65, 8.65 – 5.97 in case of 50/50 and in the range of 9.08 – 5.5 in the case of 65/35 as shown in the table 13.

The elongation% of the yarn decreases with the increase in severity of the treatment (i.e.increase in temperature, time and concentration of NaOH) within the blend as shown in figure 26, figure 27 and figure 28.

It is also found that the elongation% decreases between the blends with increase in polyester content for the same conditions predominantly within our experimental boundaries. This is because the yarn gets swelled and hence loses some of its crystalline regions which directly effects the elongation%

5.9 TENACITY:

Table 14 Tenacity of different yarns at different conditions.

Concentration of NaOH	Temperature	Time	Tenacity (in cN/Tex)		
			35/65	50/50	65/35
5	50	30	20.95376	19.79208	21.4781
5	50	45	20.35247	19.73887	21.25261
5	50	60	19.9976	19.48482	20.87556
5	60	30	20.55214	19.77272	21.27318
5	60	45	19.66818	19.37292	21.04524
5	60	60	19.02192	18.76616	20.66118
5	70	30	20.56421	19.85882	21.14462
5	70	45	19.39409	19.12051	20.91659
5	70	60	18.45488	18.16868	20.52996
10	50	30	18.5389	18.32689	20.36276
10	50	45	18.16626	18.37974	20.32202
10	50	60	18.02954	18.2274	20.12311
10	60	30	18.04567	18.15	20.09368
10	60	45	17.37394	17.82836	20.04616
10	60	60	16.9273	17.29259	19.83704
10	70	30	17.97573	18.1196	19.92246
10	70	45	17.00099	17.42623	19.86759
10	70	60	16.24238	16.50867	19.64981
15	50	30	17.60627	17.9328	20.10398
15	50	45	17.47401	18.09927	20.26336
15	50	60	17.57622	18.06331	20.26491
15	60	30	17.02805	17.60419	19.7857
15	60	45	16.59086	17.39148	19.93939
15	60	60	16.37563	16.96515	19.93352
15	70	30	16.87227	17.43097	19.56959
15	70	45	16.12595	16.8349	19.71358
15	70	60	15.59079	16.01241	19.69837
Untreated sample			23.63	20.29	22.4

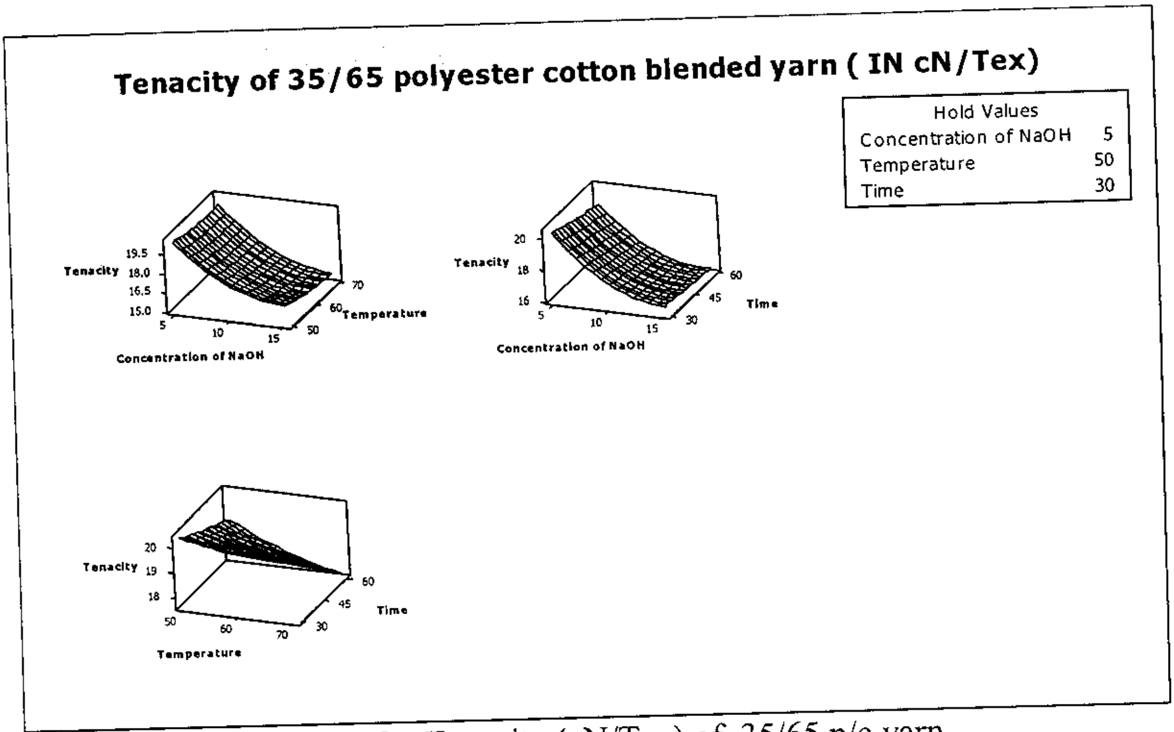


Figure 29 surface plots for Tenacity (cN/Tex) of 35/65 p/c yarn.

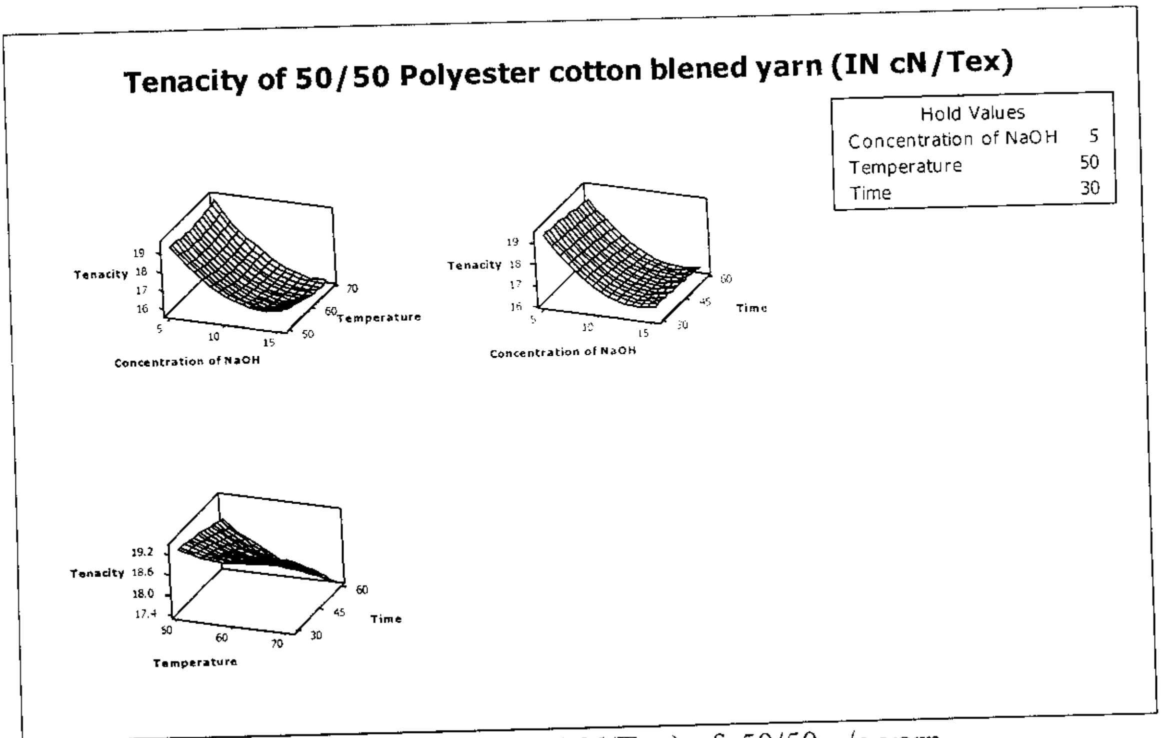


Figure 30 surface plots for Tenacity (cN/Tex) of 50/50 p/c yarn.

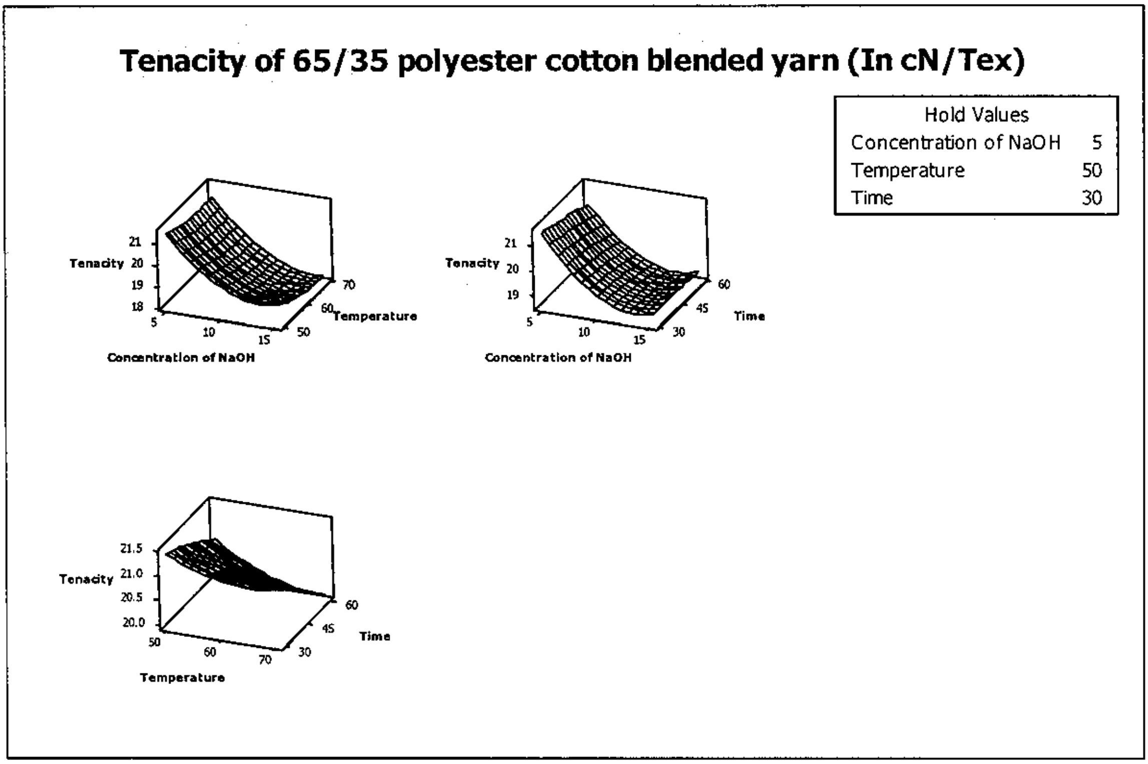


Figure 31 surface plots for Tenacity (cN/Tex) of 65/35 p/c yarn.

The results obtained from the experimental demonstrations shows that the Tenacity value after treatment varies in the range of 20.95 – 15.6 for 35/65, 19.8 – 16.01 in case of 50/50 and in the range of 21.5 – 19.7 in the case of 65/35 as shown in the table 14.

In general the tenacity value decreases with the increase in the severity of the treatment (i.e. with increase in time, temperature and concentration of the alkali) as shown in figure 29, figure 30, figure 31. This shows a direct correlation with weight loss as shown in the figure 32. And a similar trend is being observed for other 2 blends also as shown in the figure 33 and figure 34.

The decrease in tenacity is due to the breakage of bonds in the polyester as well as the mercerization of cotton. Both causes a great impact on yarn tenacity.

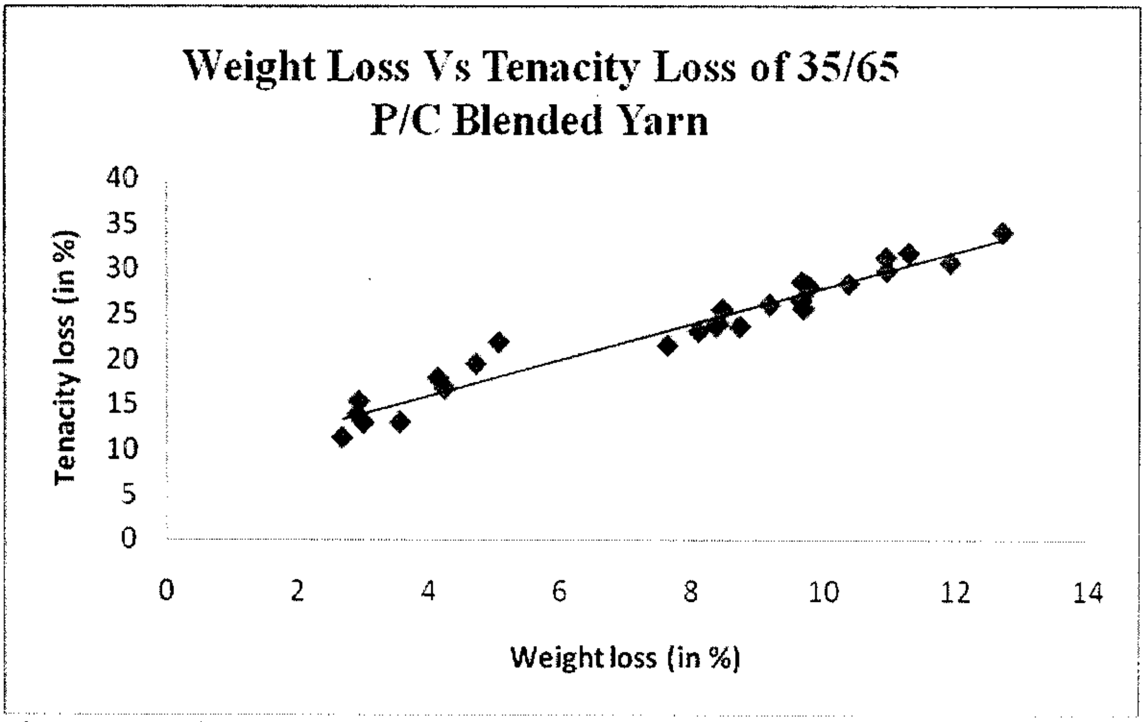


Figure 32 weight loss Vs Tenacity loss of 35/65 P/c yarn.

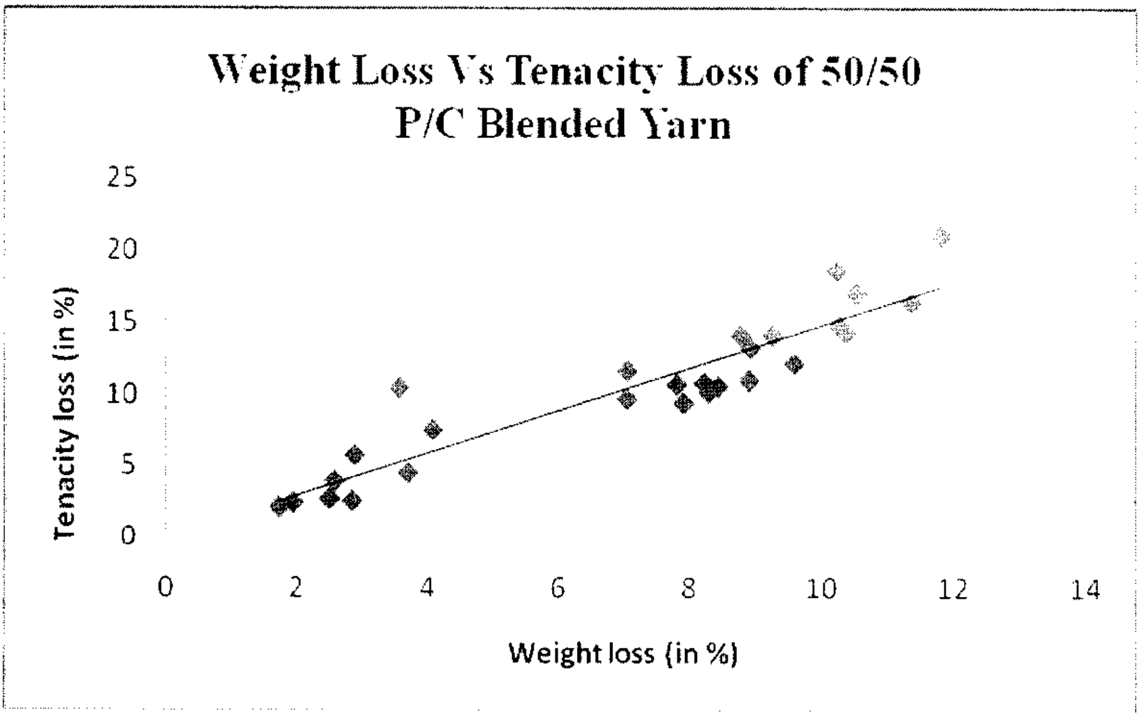


Figure 33 weight loss Vs Tenacity loss of 50/50 P/c yarn.

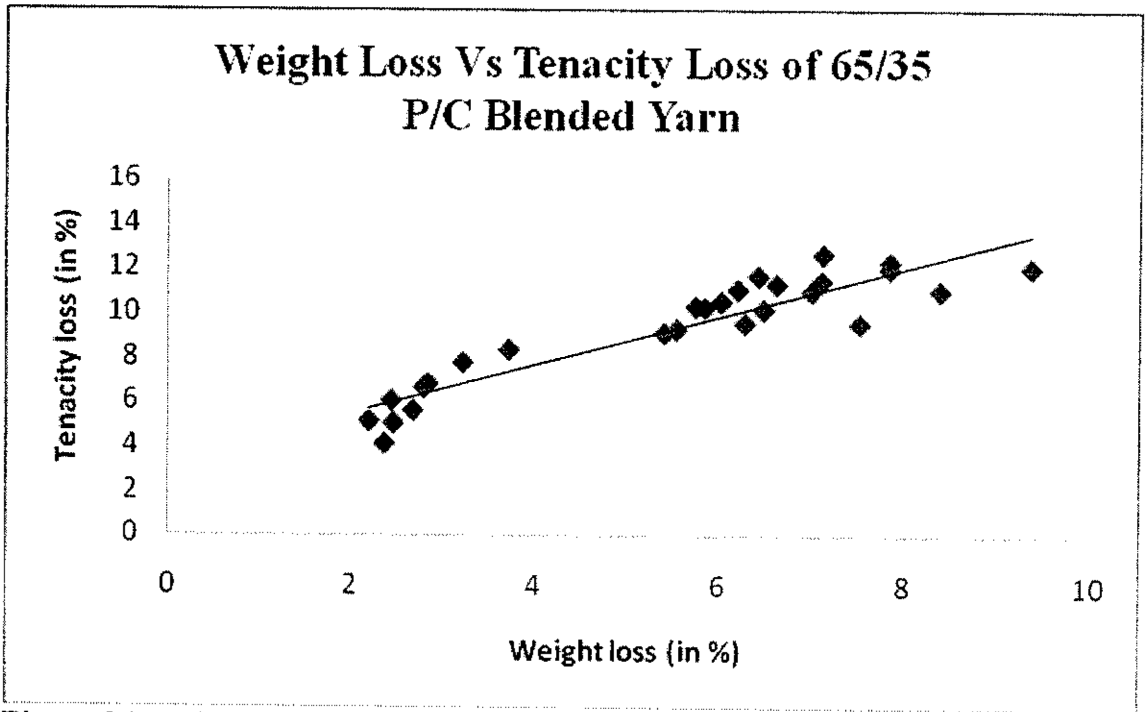


Figure 34 weight loss Vs Tenacity loss of 65/35 P/c Blended yarn.

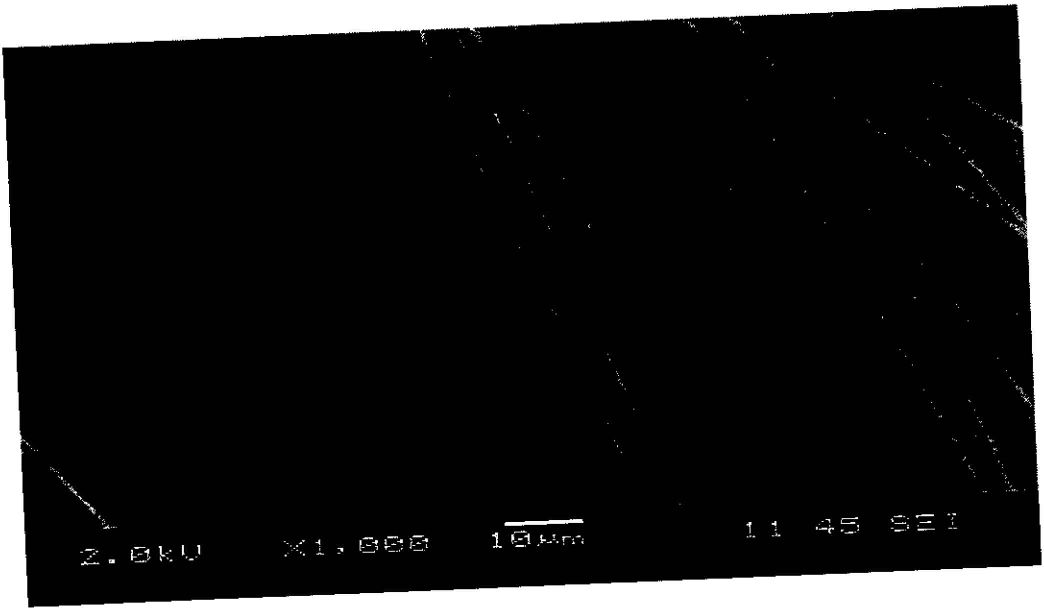


FIGURE 35 SEM image of 35/65 Untreated yarn.

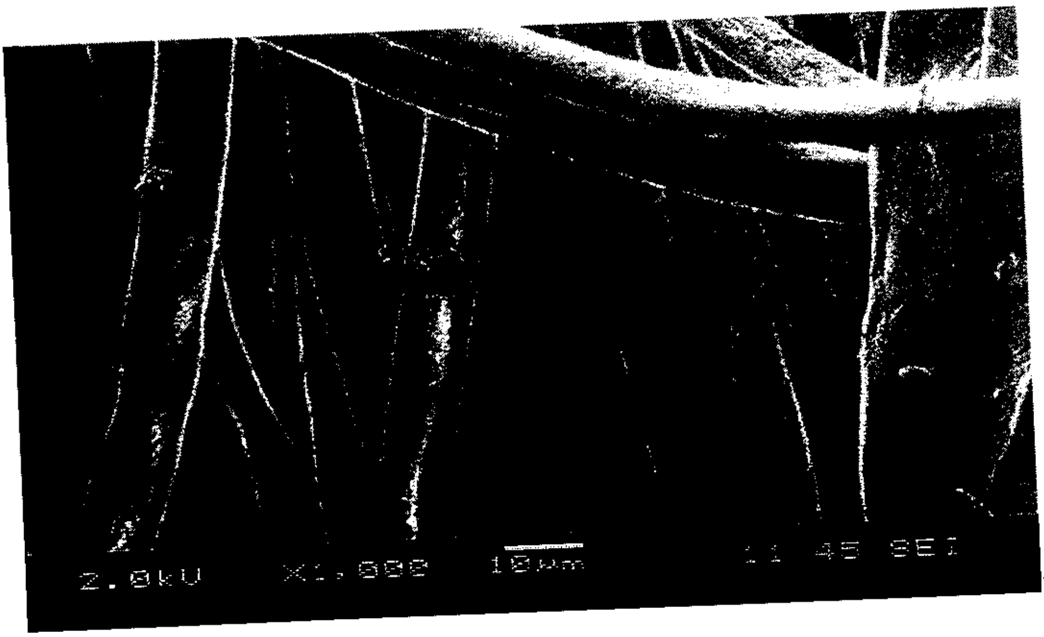


FIGURE 36 SEM image of 35/65 NaOH Treated yarn.

On comparing the figure and figure , we see that a soft silky hand is imparted to the polyester cotton yarn after treating with alkali. And also we can see that the yarn get swelled after NaOH treatment which enhances the wickability and decreases the elongation % of the yarn.

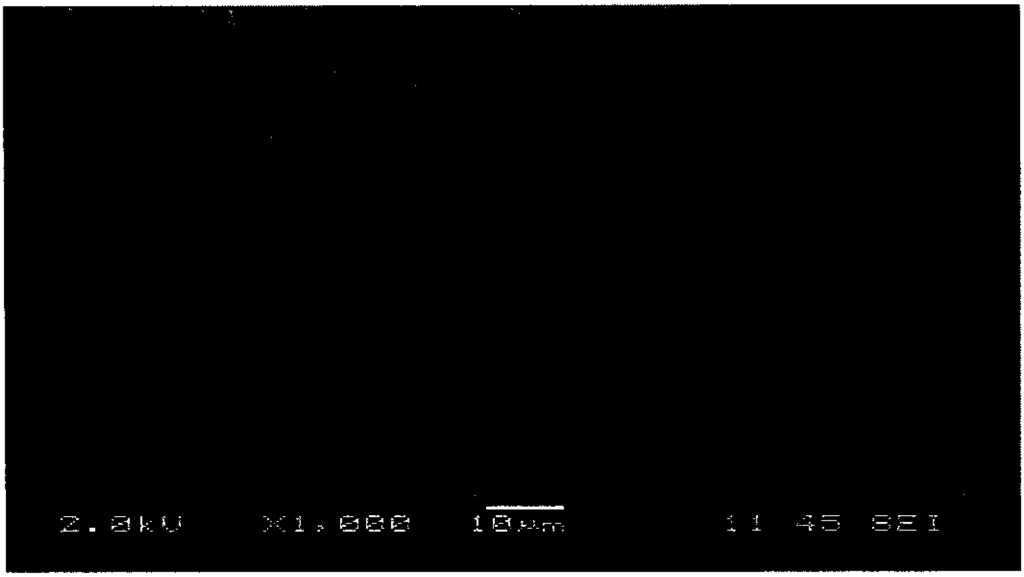


FIGURE 37 SEM image of 50/50 Untreated yarn.

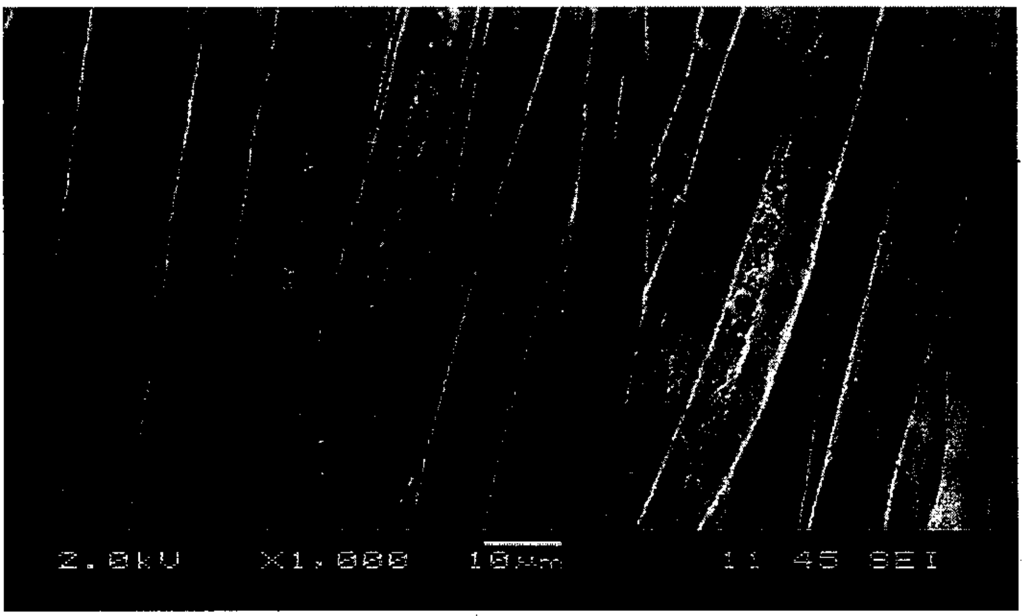


FIGURE 38 SEM image of 50/50 Treated yarn.

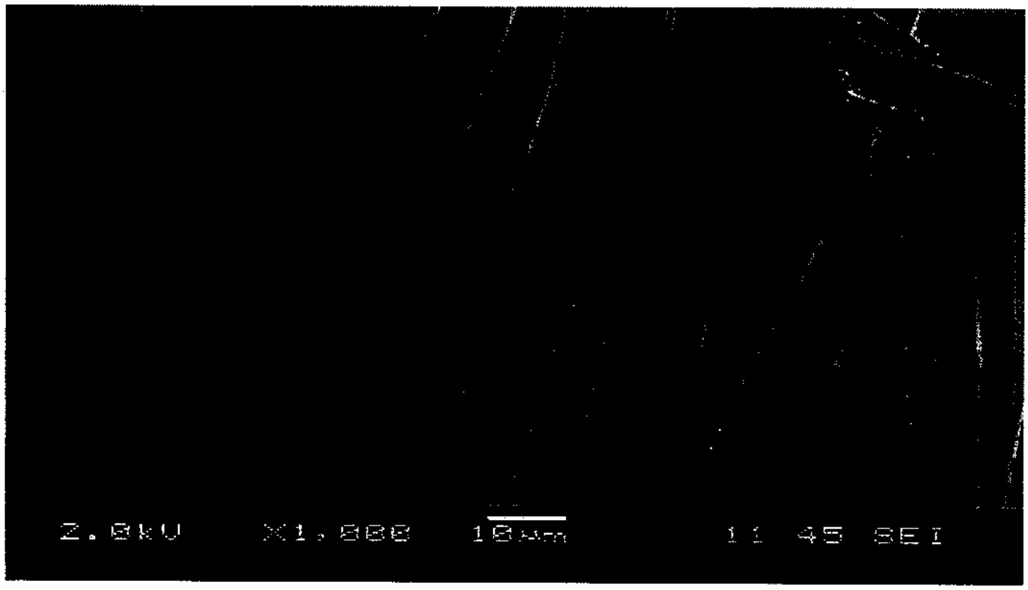


FIGURE 39 SEM image of 65/35 Untreated yarn.

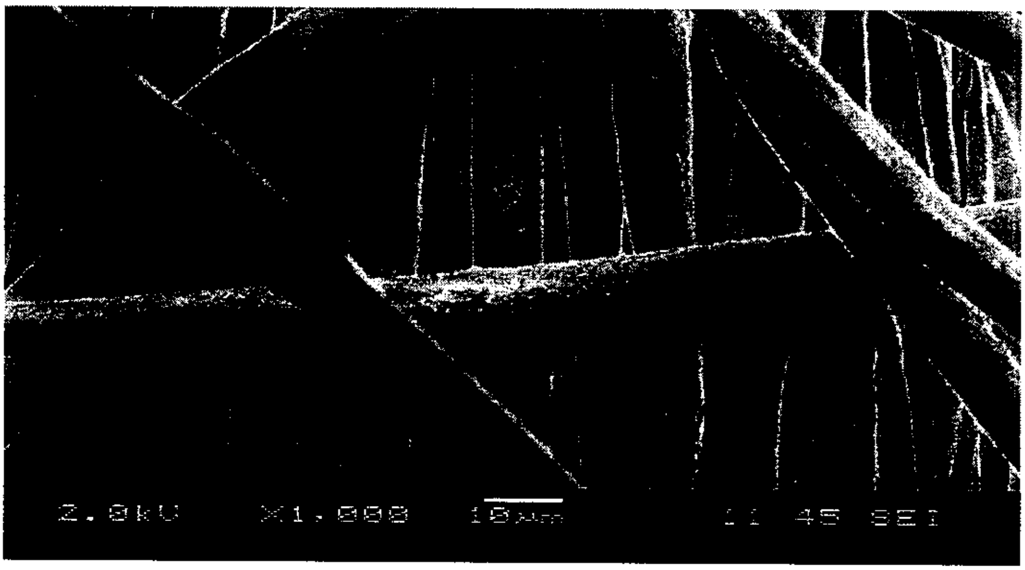


FIGURE 40 SEM image of 65/35 Treated yarn

And a similar trend is seen on other blends on comparing the figures and also figures.

6. CONCLUSION

- Through the process of optimisation it was found that best results on various properties can be obtained for
  - 35/65 polyester cotton yarn with 15% concentration of alkali, at 60°C, for 45 minutes.
  - 50/50 polyester cotton yarn with 15% concentration of alkali, at 60°C, for 30 minutes.
  - 65/35 polyester cotton yarn with 15% concentration of alkali, at 50°C, for 60 minutes.
- weight loss % of the yarn increases with the increase in sevierity of the treatment within the same blend and weight loss% also increases with increase in polyester % between blends.
- wickability of the yarn increases with increase in sevierity of the treatment within the blends and increases with increase in cotton% between the blends.
- CSP of the yarn increases with increase in polyester content between the blends and also CSP decreses with increase in sevierity of the treatment.
- Flexural rigidity of the yarn is not significantly affected neither by the action of alkali nor by the polyester content of the yarn.
- Uneveness of the yarn decreases with increase in polyester content between the blends and decreases with the sevierity of the treatment within the blends.
- S3 value of the yarn shows a drastic reduction with increase in sevierity of the treatment within the blends.
- Elongation % decreases with increase in sevierity of the treatment within the blends.
- The Tenacity value tends to decrease with increase in sevierity of the treatment.

7.REFERENCE

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2. Gorchakov , B.A.L.Zamaitor and V.A.Gartsueva , " Effect of structural modification of Polyester fibres on the strength of non woven materials ", fibre chemistry , vol. 31, No.4 ,1999, pp 315 – 317.
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APPENDIX

Lakshmi Machine Works Ltd.
Textile Laboratory
Coimbatore - 641 020

LMW.

Customer :	**Kumaraguru College of Technology**
Test No. :	205
Letter dated :	25.09.09
Sample Received date :	25.09.09
Material :	40sPC Cones

Samples tested at: RH (65 ± 2) % and Temp (20 ± 2) °C

U % & Imperfections (Uster Tester 4)

Lab Sample Code	205/1	205/2	205/3
Sample No./ details	1 / 50/50 PC blend	2 / 65/35 PC blend	3 / 35/65 PC blend
U %	11.16	11.32	10.77
Thin Places / km	9	5	2
Thick Places / km	58	119	37
Neps / km	78	114	73
Total Imperfections / km	**145**	**238**	**112**
Thin Places -40% / km	190	201	136
Thick Places +35% / km	522	802	355
Neps +140% / km	477	500	319
Total Higher sensitivity / km	**1189**	**1503**	**810**
Hairiness	5.88	5.29	5.49

Single Yarn Tenacity & Elongation (Uster TensoJet 4)

B.Force cN	290.4	279.~~9~~7	361.6
Tenacity cN/tex	20.29	18.75	23.63
Tenacity CV %	9.7	8.9	10.0
Elongation %	6.54	5.76	7.59
Elongation CV %	9.0	7.4	10.9

Yarn Hairiness (Zweigle G566)
As per ASTM D 5647-07 & As per Instruction manual

1mm	17585	12575	13157
2mm	1977	1778	1148
S3	2610	2609	1875

End of Report

Date:26.09.2009

Authorised Signatory

Important:
The results relate only to the sample supplied by the customer.

LMW

Registered Office & Works : Perianaickenpalayam, Coimbatore - 641 020. India.
Phones : 0422 - 2692371 to 379, 2692703 to 2692712. Fax : 0422 - 2692541, 2692702
E-mail : regd.off@lmw.co.in www.lakshmimach.com

USTER® TESTER 4 - S R 2.4.0 Fri 25.09.09 14:04 Operator KS
Lakshmi Machine Works Ltd Textile Laboratory Perianaickenpalayam Coimbatore-641 020 INDIA

Style 205 | Sample ID 02677 | Nom. count Nec 40 | Nom. twist 20.24
Tests 1 / 1 | v= 400 m/min t= 2.5 min | Meas. slot 4 | Short staple

RING FRAME

Article 205/1 | Material class Yarn | Mach. Nr. Millcon
Uster Statistics
Fiber Polyester 0.8den 32mm 50% Cotton 3.8Micr 29mm 50%
205/1,Sample-1,50/50 PC blend,40sPC Cones

Total tests : 1 / 1 Single test(s)

Nr	U% %	CVm %	CVm 1m %	Index	Thin -50% /km	Thick +50% /km	Neps +200% /km	Thin -30% /km	Thin -40% /km	Thick +35% /km	Neps +140% /km	Rel. Cnt ± %	H	sh
1	11.16	14.11	4.97	1.57	9.0	58.0	78.0	1810	190.0	522.0	477.0	0.0	5.88	1.3
Mean	11.16	14.11	4.97	1.57	9.0	58.0	78.0	1810	190.0	522.0	477.0	0.0	5.88	1.3
CV														
Q95														
Max	11.16	14.11	4.97	1.57	9.0	58.0	78.0	1810	190.0	522.0	477.0	0.0	5.88	1.3
Min	11.16	14.11	4.97	1.57	9.0	58.0	78.0	1810	190.0	522.0	477.0	0.0	5.88	1.3

Nr	DR 1.5m 5% %	2DØ mm	CV2D 8mm %	CV FS %	Shape	D (nom) g/cm3	Trash count /km	Trash size um	Dust count /km	Dust size um
1	28.3	0.199	11.15	10.27	0.84	0.47	0.0		32.0	215.0
Mean	28.3	0.199	11.15	10.27	0.84	0.47	0.0		32.0	215.0
CV										
Q95										
Max	28.3	0.199	11.15	10.27	0.84	0.47	0.0		32.0	215.0
Min	28.3	0.199	11.15	10.27	0.84	0.47	0.0		32.0	215.0

USTER® TESTER 4 - S R 2.4.0 Fri 25.09.09 14:07 Operator KS Page

Lakshmi Machine Works Ltd Textile Laboratory Perianaickenpalayam Coimbatore-641 020 INDIA

Style	205	Sample ID	02678	Nom. count	Nec 40	Nom. twist	22.77
Tests	1 / 1	v= 400 m/min	t= 2.5 min	Meas. slot	4	Short staple	

RING FRAME

Article 205/2 Material class Yarn Mach. Nr. Millcon

Uster Statistics

Fiber Polyester 0.8den 32mm 50% Cotton 3.8Micr 29mm 50%

205/2,Sample-2,65/35 PC blend,40sPC Cones

Total tests : 1 / 1 Single test(s)

Nr	U% %	CVm %	CVm 1m %	Index	Thin -50% /km	Thick +50% /km	Neps +200% /km	Thin -30% /km	Thin -40% /km	Thick +35% /km	Neps +140% /km	Rel. Cnt ± %	H	sh
1	11.32	14.35	4.20	1.60	5.0	119.0	114.0	1907	201.0	802.0	500.0	0.0	5.29	1.
Mean	11.32	14.35	4.20	1.60	5.0	119.0	114.0	1907	201.0	802.0	500.0	0.0	5.29	1.
CV														
Q95														
Max	11.32	14.35	4.20	1.60	5.0	119.0	114.0	1907	201.0	802.0	500.0	0.0	5.29	1.
Min	11.32	14.35	4.20	1.60	5.0	119.0	114.0	1907	201.0	802.0	500.0	0.0	5.29	1.

Nr	DR 1.5m 5% %	2DØ mm	CV2D 8mm %	CV FS %	Shape	D (nom) g/cm3	Trash count /km	Trash size um	Dust count /km	Dust size um
1	18.0	0.193	11.66	9.73	0.85	0.50	0.0		57.0	176.0
Mean	18.0	0.193	11.66	9.73	0.85	0.50	0.0		57.0	176.0
CV										
Q95										
Max	18.0	0.193	11.66	9.73	0.85	0.50	0.0		57.0	176.0
Min	18.0	0.193	11.66	9.73	0.85	0.50	0.0		57.0	176.0

LMW
Registered Office & Works : Perianaickenpalayam, Coimbatore - 641 020. India.
Phones : 0422 - 2692371 to 379, 2692703 to 2692712. Fax : 0422 - 2692541, 2692702
E-mail : regd.off@lmw.co.in www.lakshmimach.com

USTER® TESTER 4 - S R 2.4.0 Fri 25.09.09 14:11 Operator KS
Lakshmi Machine Works Ltd Textile Laboratory Perianaickenpalayam Coimbatore-641 020 INDIA

Style 205 Sample ID 02679 Nom. count Nec 40 Nom. twist 20.24 T
Tests 1 / 1 v= 400 m/min t= 2.5 min Meas. slot 4 Short staple

RING FRAME

Article 205/3 Material class Yarn Mach. Nr. Millcon
Uster Statistics
Fiber Polyester 0.8den 32mm 50% Cotton 3.8Micr 29mm 50%
205/3,Sample-3,35/65 PC blend;40sPC Cones

Total tests : 1 / 1 Single test(s)

Nr	U%	CVm	CVm 1m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%	Rel. Cnt ±	H	sh
	%	%	%		/km	/km	/km	/km	/km	/km	/km	%		
1	10.77	13.58	4.97	1.51	2.0	37.0	73.0	1435	136.0	355.0	319.0	0.0	5.49	1.38
Mean	10.77	13.58	4.97	1.51	2.0	37.0	73.0	1435	136.0	355.0	319.0	0.0	5.49	1.38
CV														
Q95														
Max	10.77	13.58	4.97	1.51	2.0	37.0	73.0	1435	136.0	355.0	319.0	0.0	5.49	1.38
Min	10.77	13.58	4.97	1.51	2.0	37.0	73.0	1435	136.0	355.0	319.0	0.0	5.49	1.38

Nr	DR 1.5m 5%	2DØ	CV2D 8mm	CV FS	Shape	D (nom)	Trash count	Trash size	Dust count	Dust size
	%	mm	%	%		g/cm3	/km	um	/km	um
1	27.5	0.192	10.52	9.26	0.85	0.51	0.0		19.0	167.1
Mean	27.5	0.192	10.52	9.26	0.85	0.51	0.0		19.0	167.1
CV										
Q95										
Max	27.5	0.192	10.52	9.26	0.85	0.51	0.0		19.0	167.1
Min	27.5	0.192	10.52	9.26	0.85	0.51	0.0		19.0	167.1

USTER® TENSOJET 4 1.8 Page 1
Lakshmi Machine Works Limited Textile Laboratory Perianaickenpalayam Coimbatore 641 020 INDIA

Style 205 Sample ID CUS 000465 Nom. count Nec 41.27 Nom. twist 20.24 T/
Tests 1 / 1000 v= 400 m/min Fv= 7.2 cN Valve press. Standard

CUSTOMER

Article 205/1 Material class Yarn Mach. Nr. Milleon
Uster Statistics
205/1,50/50 PC blend,Sample-1,40sPC Cones

Total: 1/1000 Single test(s)

Nr	B-Force cN	Elong. %	Tenacity cN/tex	B-Work cN.cm
1/1000	290.4	6.54	20.29	555.9
Mean	290.4	6.54	20.29	555.9
CV	9.7	9.0	9.7	17.0
Q95	1.740	0.04	0.12	5.855
Min	193.9	4.34	13.55	263.0
Max	401.1	8.13	28.03	888.3
P0.1				
P0.5	219.4	5.03	15.34	335.1
P1.0	224.4	5.21	15.68	354.3
P5.0	244.9	5.56	17.11	406.8
USP				
UTRexp*				
Weak places (114.5cN,2%)	F = 0	E = 0	F+E = 0	

* Expected traditional tensile value UTR (Testing speed: 5m/min, Test length: 500mm)

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G 566

DIVIDUAL RESULTS
/2009 PAGE 1 (1)

DESIGN. : 205-1

TE	9/25/2009	MACHINECODE	G566 NR240	205/1,Sample-1,50/50 PC blend
E	3:04:00 PM	MATERIALCODE	TEST	40sPC Cones
TERIAL	Polyester/Cotton	BOBBINS	1	
ENESS	40	TESTS	10	
ETENSION	5 cN	LENGTH	100 m	

BBIN TEST	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1	17024	1792	1449	659	127	23	1	0	0	0	0	0	2259	60
2	16776	1766	1412	768	112	29	4	1	0	0	0	0	2326	75
3	17499	1969	1676	874	150	28	3	0	0	0	0	0	2731	73
4	18180	2137	1665	952	160	26	5	0	0	0	0	0	2808	68
5	17889	2009	1623	868	119	21	5	0	0	0	0	0	2636	57
6	18704	2297	1847	908	132	20	1	0	0	0	0	0	2908	55
7	19416	2256	1944	973	166	29	3	0	0	0	0	0	3115	76
8	18694	2118	1804	1084	159	35	2	0	0	0	0	0	3084	90
9	15041	1586	1178	650	113	30	1	0	0	0	0	0	1972	76
10	16625	1844	1379	733	127	24	2	0	0	0	0	0	2265	63

ERALL

EAN	17584.80	1977.40	1597.70	846.90	136.50	26.50	2.70	0.10	0.00	0.00	0.00	0.00	2610.40	69.30
EAN/100m	17584.80	1977.40	1597.70	846.90	136.50	26.50	2.70	0.10	0.00	0.00	0.00	0.00	2610.40	0.00
	1275.90	230.01	239.56	141.95	20.47	4.60	1.57	0.32	0.00	0.00	0.00	0.00	387.72	10.79
/%	7.26	11.63	14.99	16.76	14.99	17.36	58.04	316.23	0.00	0.00	0.00	0.00	14.85	15.57
AX	19416.00	2297.00	1944.00	1084.00	166.00	35.00	5.00	1.00	0.00	0.00	0.00	0.00	3115.00	90.00
N	15041.00	1586.00	1178.00	650.00	112.00	20.00	1.00	0.00	0.00	0.00	0.00	0.00	1972.00	55.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LAKSHMI MACHINE WORKS LIMITED
Registered Office & Works : Perianaickenpalayam, Coimbatore - 641 020. India.
Phone : 0422 - 26923[illegible] to 2692[illegible] Fax : 0422 - 2692541, 2692[illegible]
E-mail : [illegible]

akshmi Machine Works Limited Textile Laboratory Perianaickenpalayam Coimbatore 641020 INDIA

tyle 205 | Sample ID CUS 000466 | Nom. count Nec 39.58 | Nom. twist ~~20.24~~ 22.77 T/i
ests 1 / 1000 | v= 400 m/min Fv= 7.5 cN | Valve press. Standard

CUSTOMER

rticle 205/2 Material class Yarn Mach. Nr. Millcon
Jster Statistics 65/35, 67/33 PES/CO, combed, ring-spun 2001
05/2,65/35 PC blend,Sample-2,40sPC Cones

Total: 1/1000 Single test(s)

Nr	B-Force cN	Elong. %	Tenacity cN/tex	B-Work cN.cm
1/1000	279.7	5.76	18.75	457.0
Mean	279.7	5.76	18.75	457.0
CV	8.9	7.4	8.9	14.4
Q95	1.537	0.03	0.10	4.089
Min	179.1	4.18	12.00	235.2
Max	372.2	7.07	24.94	689.3
P0.1				
P0.5	213.3	4.66	14.30	301.7
P1.0	218.1	4.74	14.62	313.4
P5.0	236.5	5.04	15.85	347.1
USP01	>95	>95	>95	>95
UTRexp*				
Weak places (119.4cN,2%)	F = 0	E = 0	F+E = 0	

* Expected traditional tensile value UTR (Testing speed: 5m/min, Test length: 500mm)

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Coimbatore 641 020
INDIA

G 566

NDIVIDUAL RESULTS

26/2009 PAGE 1 (1)

DESIGN. : 205-2

ATE	9/25/2009	MACHINECODE	G566 NR240	205/2,Sample-2,65/35 PC blend
ME	3:44:05 PM	MATERIALCODE	TEST	40sPC Cones
ATERIAL	Polyester/Cotton	BOBBINS	1	
NENESS	40	TESTS	10	
RETENSION	5 cN	LENGTH	100 m	

OBBIN	TEST	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
	1	12647	1821	1331	887	213	65	5	0	0	0	0	0	2501	154
	2	12602	1815	1379	874	180	50	5	0	0	0	0	0	2488	124
	3	12780	1750	1460	932	194	41	8	3	0	0	0	0	2638	104
	4	12676	1776	1466	965	184	46	5	0	0	0	0	0	2666	116
	5	12416	1778	1493	946	217	58	7	1	0	0	0	0	2722	141
	6	12572	1736	1406	933	250	56	11	0	0	0	0	0	2656	135
	7	12376	1745	1327	873	160	52	9	1	0	0	0	0	2422	129
	8	12428	1763	1360	941	193	51	3	1	0	0	0	0	2549	126
	9	12283	1758	1409	920	207	66	6	2	0	0	0	0	2610	158
	10	12968	1842	1571	972	211	73	5	1	0	0	0	0	2833	174

VERALL

	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
EAN	12574.80	1778.40	1420.20	924.30	200.90	55.80	6.40	0.90	0.00	0.00	0.00	0.00	2608.50	156.10
EAN/100m	12574.80	1778.40	1420.20	924.30	200.90	55.80	6.40	0.90	0.00	0.00	0.00	0.00	2608.50	0.00
	206.65	35.87	77.47	35.57	24.63	9.86	2.37	0.99	0.00	0.00	0.00	0.00	122.07	21.07
/%	1.64	2.02	5.45	3.85	12.26	17.68	36.98	110.49	0.00	0.00	0.00	0.00	4.68	15.48
AX	12968.00	1842.00	1571.00	972.00	250.00	73.00	11.00	3.00	0.00	0.00	0.00	0.00	2833.00	174.00
N	12283.00	1736.00	1327.00	873.00	160.00	41.00	3.00	0.00	0.00	0.00	0.00	0.00	2422.00	104.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Style 205 Sample ID CUS 000467 Nom. count Nec 38.59 Nom. twist 20.24 T
Tests 1 / 1000 v= 400 m/min Fv= 7.7 cN Valve press. Standard

CUSTOMER

Article 205/3 Material class Yarn Mach. Nr. Millcon
Uster Statistics
205/3,35/65 PC blend,Sample-3,40sPC Cones

Total: 1/1000 Single test(s)

Nr	B-Force cN	Elong. %	Tenacity cN/tex	B-Work cN.cm
1/1000	361.6	7.59	23.63	798.5
Mean	361.6	7.59	23.63	798.5
CV	10.0	10.9	10.0	19.3
Q95	2.242	0.05	0.15	9.587
Min	259.3	4.30	16.94	318.4
Max	496.5	9.62	32.44	1265
P0.1				
P0.5	279.0	5.54	18.23	454.3
P1.0	286.6	5.70	18.73	471.4
P5.0	303.8	6.15	19.85	540.3
USP				
UTRexp*				
Weak places (122.4cN,2%) F = 0 E = 0 F+E = 0				

* Expected traditional tensile value UTR (Testing speed: 5m/min, Test length: 500mm)

AKSHMI MACHINE WORKS LTD.,

& D - Textiles
erianaickenpalayam

Coimbatore 641 020
INDIA

G 566

DIVIDUAL RESULTS
26/2009 PAGE 1 (1)

DESIGN. : 205-3

ATE	9/25/2009	MACHINECODE	G566 NR240	205/3,Sample-3,35/65 PC blend
ME	4:06:37 PM	MATERIALCODE	TEST	40sPC Cones
ATERIAL	Polyester/Cotton	BOBBINS	1	
NENESS	40	TESTS	10	
RETENSION	5 cN	LENGTH	100 m	

OBBIN TEST	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1	13519	1052	1131	743	121	26	3	0	0	0	0	0	2024	66
2	13207	1251	1105	713	105	35	1	0	0	0	0	0	1959	88
3	13329	1090	1061	713	103	24	1	0	0	0	0	0	1902	62
4	13128	1200	994	663	109	29	3	0	0	0	0	0	1798	73
5	12986	1089	1074	638	93	21	1	0	0	0	0	0	1627	55
6	13117	1193	1006	627	97	27	2	0	0	0	0	0	1759	69
7	12862	1172	1055	652	97	32	0	0	0	0	0	0	1836	81
8	13571	1207	1119	753	112	24	2	0	0	0	0	0	2010	62
9	13065	1178	1115	677	105	23	1	0	0	0	0	0	1921	60
10	12786	1045	935	657	100	16	2	0	0	0	0	0	1710	43

OVERALL														
MEAN	13157.00	1147.70	1059.50	683.60	104.20	25.70	1.60	0.00	0.00	0.00	0.00	0.00	1874.60	65.90
MEAN/100m	13157.00	1147.70	1059.50	683.60	104.20	25.70	1.60	0.00	0.00	0.00	0.00	0.00	1874.60	0.00
S	258.06	72.24	63.85	44.13	8.27	5.46	0.97	0.00	0.00	0.00	0.00	0.00	105.81	12.84
CV%	1.96	6.29	6.03	6.46	7.94	21.24	60.38	0.00	0.00	0.00	0.00	0.00	5.64	19.49
MAX	13571.00	1251.00	1131.00	753.00	121.00	35.00	3.00	0.00	0.00	0.00	0.00	0.00	2024.00	88.00
MIN	12786.00	1045.00	935.00	627.00	93.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	1710.00	43.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Lakshmi Machine Works Ltd.
Textile Laboratory
Coimbatore - 641 020

LMW.

Customer : Kumaraguru College of Technology
Test No. : 406
Letter dated : 03.02.10
Sample Received date : 04.02.10
Material : 40s PC Cone

Samples tested at: RH (65 ± 2) % and Temp (20 ± 2) °C

U % & Imperfections (Uster Tester 4)

Lab Sample Code	406/1	406/2	406/3
Sample No./ Blend	1 / 50/50	2 / 65/35	3 / 35/65
U %	11.14	9.72	11.42
Thin Places / km	3	0	4
Thick Places / km	41	6	45
Neps / km	49	13	43
Total Imperfections / km	**93**	**19**	**92**
Thin Places -40% / km	111	17	96
Thick Places +35% / km	406	86	398
Neps +140% / km	234	49	212
Total Higher sensitivity / km	**751**	**152**	**706**
Hairiness	5.59	4.96	5.37

Yarn Hairiness (Zweigle G 566)

1 mm	10200	10153	10184
2 mm	466	291	527
S3	631	514	658

Single Yarn Tenacity & Elongation (Uster TensoJet 4)

B.Force cN	213.3	330.7	212.9
Tenacity cN/tex	14.45	22.40	14.42
Tenacity CV %	11.9	9.5	13.2
Elongation %	9.34	10.00	9.24
Elongation CV %	7.9	6.1	8.2

End of Report

B. R— 24/2/2010.
Authorised Signatory

Date:08.02.2010
Important:
The results relate only to the sample supplied by the customer.

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Style 406 Sample ID 03103 Nom. count Nec 40 Nom. twist 20.2 T/in
Tests 1 / 4 v= 400 m/min t= 1 min Meas. slot 4 Short staple

RING FRAME

Article 406/1 Material class Yarn Mach. Nr. Millcon
Uster Statistics
Fiber Polyester 0.8den 32mm 50% Cotton 3.8Micr 29mm 50%
406/1,Sample-1,40s PC (50/50),Cone

Total tests : 1 / 4 Single test(s)

Nr	U%	CVm	CVm 1m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%	Rel. Cnt ±	H	sh
	%	%	%		/km	/km	/km	/km	/km	/km	/km	%		
1/1	11.02	13.86	6.32	1.54	2.5	50.0	55.0	1205	80.0	430.0	252.5	3.7	5.49	1.22
1/2	11.33	14.24	7.09	1.58	0.0	35.0	50.0	1278	110.0	365.0	240.0	-0.1	5.69	1.33
1/3	11.06	13.94	5.95	1.55	2.5	50.0	45.0	1378	112.5	430.0	227.5	-0.8	5.62	1.33
1/4	11.15	14.05	5.89	1.56	5.0	27.5	47.5	1453	140.0	397.5	217.5	-2.7	5.53	1.32
Mean	11.14	14.02	6.31	1.56	2.5	40.6	49.4	1328	110.6	405.6	234.4	0.0	5.59	1.30
CV														
Q95														
Max	11.33	14.24	7.09	1.58	5.0	50.0	55.0	1453	140.0	430.0	252.5	3.7	5.69	1.33
Min	11.02	13.86	5.89	1.54	0.0	27.5	45.0	1205	80.0	365.0	217.5	-2.7	5.49	1.22

Nr	DR 1.5m 5%	2DØ	CV2D 8mm	CV FS	Shape	D (nom)	Trash count	Trash size	Dust count	Dust size
	%	mm	%	%		g/cm3	/km	um	/km	um
1/1	49.1	0.198	11.26	10.12	0.86	0.48	0.0		0.0	
1/2	42.5	0.196	11.28	9.83	0.86	0.49	0.0		0.0	
1/3	39.5	0.197	11.18	9.65	0.86	0.48	0.0		0.0	
1/4	38.9	0.196	11.11	9.57	0.86	0.49	0.0		10.0	158.0
Mean	42.5	0.197	11.21	9.79	0.86	0.49	0.0		2.5	158.0
CV										
Q95										
Max	49.1	0.198	11.28	10.12	0.86	0.49	0.0		10.0	158.0
Min	38.9	0.196	11.11	9.57	0.86	0.48	0.0		0.0	158.0

Style 406
Tests 1 / 500
Sample ID CUS 000530
v= 400 m/min Fv= 7.4 cN
Nom. count Nec 40
Valve press. Standard
Nom. twist 20.2 T/i

CUSTOMER

Article 406/1 Material class Yarn Mach. Nr. Millcon
Uster Statistics
406/1,Sample-1,40s PC (50/50),Cone

Total: 1/500 Single test(s)

Nr	B-Force cN	Elong. %	Tenacity cN/tex	B-Work cN.cm
1/500	213.3	9.34	14.45	596.9
Mean	213.3	9.34	14.45	596.9
CV	11.9	7.9	11.9	14.7
Q95	2.236	0.06	0.15	7.702
Min	103.8	3.23	7.03	122.3
Max	290.4	11.08	19.67	884.0
P0.1				
P0.5	145.4	7.19	9.85	378.8
P1.0	150.4	7.30	10.18	387.0
P5.0	171.2	8.16	11.59	458.4
USP				
UTRexp*				
Weak places (118.1cN,3%)	F = 1	E = 0	F+E = 0	

* Expected traditional tensile value UTR (Testing speed: 5m/min, Test length: 500mm)

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USTER® TESTER 4 - S R 2.4.1 Sat 06.02.10 14:00 Operator KS
Lakshmi Machine Works Ltd Textile Laboratory Perianaickenpalayam Coimbatore 641 020 INDIA

Style 406 Sample ID 03104 Nom. count Nec 40 Nom. twist 22.8 T/in
Tests 1 / 4 v= 400 m/min t= 1 min Meas. slot 4 Short staple

RING FRAME

Article 406/2 Material class Yarn Mach. Nr. Millcon
Uster Statistics
Fiber Polyester 0.8den 32mm 65% Cotton 3.8Micr 29mm 35%
406/2,Sample-2,40s PC (65/35),Cone

Total tests : 1 / 4 Single test(s)

Nr	U% %	CVm %	CVm 1m %	Index	Thin -50% /km	Thick +50% /km	Neps +200% /km	Thin -30% /km	Thin -40% /km	Thick +35% /km	Neps +140% /km	Rel. Cnt ± %	H	sh
1/1	9.95	12.26	6.82	1.42	0.0	2.5	10.0	325.0	7.5	60.0	45.0	5.4	5.03	1.10
1/2	9.67	12.15	5.17	1.41	0.0	5.0	12.5	637.5	27.5	107.5	40.0	-3.3	4.93	1.09
1/3	9.62	12.09	5.36	1.40	0.0	7.5	7.5	532.5	20.0	100.0	50.0	-1.8	4.92	1.08
1/4	9.65	12.12	5.97	1.40	0.0	7.5	22.5	465.0	12.5	77.5	62.5	-0.2	4.96	1.11
Mean	9.72	12.16	5.83	1.41	0.0	5.6	13.1	490.0	16.9	86.3	49.4	0.0	4.96	1.10
CV														
Q95														
Max	9.95	12.26	6.82	1.42	0.0	7.5	22.5	637.5	27.5	107.5	62.5	5.4	5.03	1.11
Min	9.62	12.09	5.17	1.40	0.0	2.5	7.5	325.0	7.5	60.0	40.0	-3.3	4.92	1.08

Nr	DR 1.5m 5% %	2DØ mm	CV2D 8mm %	CV FS %	Shape	D (nom) g/cm3	Trash count /km	Trash size um	Dust count /km	Dust size um
1/1	40.9	0.191	9.72	8.38	0.86	0.51	0.0		0.0	
1/2	29.7	0.191	9.77	8.34	0.86	0.52	0.0		0.0	
1/3	33.1	0.190	9.65	8.28	0.86	0.52	0.0		0.0	
1/4	38.6	0.190	9.74	8.41	0.86	0.52	0.0		0.0	
Mean	35.6	0.191	9.72	8.35	0.86	0.52	0.0		0.0	
CV										
Q95										
Max	40.9	0.191	9.77	8.41	0.86	0.52	0.0		0.0	
Min	29.7	0.190	9.65	8.28	0.86	0.51	0.0		0.0	

kshmi Machine Works Limited Textile Laboratory Perianaickenpalayam Coimbatore - 641 020 INDIA

yle 406 Sample ID CUS 000531 Nom. count Nec 40 Nom. twist 22.8 T/inc
sts 1 / 500 v= 400 m/min Fv= 7.4 cN Valve press. Standard

USTOMER

ticle 406/2 Material class Yarn Mach. Nr. Millcon
ter Statistics
6/2,Sample-2,40s PC (65/35),Cone

Total: 1/500 Single test(s)

Nr	B-Force cN	Elong. %	Tenacity cN/tex	B-Work cN.cm
1/500	330.7	10.00	22.40	871.8
Mean	330.7	10.00	22.40	871.8
CV	9.5	6.1	9.5	12.8
Q95	2.748	0.05	0.19	9.782
Min	207.6	7.30	14.06	466.6
Max	412.5	11.59	27.94	1159
P0.1				
P0.5	223.7	7.78	15.15	517.3
P1.0	235.3	7.97	15.94	537.0
P5.0	279.7	8.93	18.95	692.1
USP				
UTRexp*				
Weak places (118.1cN,3%)	F = 0	E = 0	F+E = 0	

Expected traditional tensile value UTR (Testing speed: 5m/min, Test length: 500mm)

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LMW

USTER® TESTER 4 - S R 2.4.1 Sat 06.02.10 14:06 Operator KS Page
Lakshmi Machine Works Ltd Textile Laboratory Perianaickenpalayam Coimbatore 641 020 INDIA

Style 406 Sample ID 03105 Nom. count Nec 40 Nom. twist 20.2
Tests 1 / 4 v= 400 m/min t= 1 min Meas. slot 4 Short staple

RING FRAME

Article 406/3 Material class Yarn Mach. Nr. Millcon
Uster Statistics
Fiber Polyester 0.8den 32mm 35% Cotton 3.8Micr 29mm 65%
406/3,Sample-3,40s PC (35/65),Cone

Total tests : 1 / 4 Single test(s)

Nr	U%	CVm	CVm 1m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%	Rel. Cnt ±	H	sh
	%	%	%		/km	/km	/km	/km	/km	/km	/km	%		
1/1	11.14	14.08	7.56	1.51	0.0	37.5	27.5	1238	87.5	345.0	185.0	-2.1	5.48	1.3
1/2	11.21	14.16	6.07	1.52	7.5	45.0	57.5	1438	147.5	490.0	222.5	-5.6	5.42	1.2
1/3	11.39	14.36	7.30	1.54	5.0	57.5	57.5	1178	90.0	430.0	267.5	2.1	5.38	1.2
1/4	11.95	15.02	9.07	1.61	2.5	40.0	27.5	1030	60.0	327.5	172.5	5.7	5.22	1.2
Mean	11.42	14.40	7.50	1.54	3.8	45.0	42.5	1221	96.3	398.1	211.9	0.0	5.37	1.2
CV														
Q95														
Max	11.95	15.02	9.07	1.61	7.5	57.5	57.5	1438	147.5	490.0	267.5	5.7	5.48	1.3
Min	11.14	14.08	6.07	1.51	0.0	37.5	27.5	1030	60.0	327.5	172.5	-5.6	5.22	1.2

Nr	DR. 1.5m 5%	2DØ	CV2D 8mm	CV FS	Shape	D (nom)	Trash count	Trash size	Dust count	Dust size
	%	mm	%	%		g/cm3	/km	um	/km	um
1/1	51.0	0.195	11.60	9.63	0.86	0.49	5.0	746.5	57.5	249.8
1/2	37.9	0.196	11.51	9.85	0.86	0.49	0.0		15.0	260.3
1/3	57.5	0.196	11.55	9.74	0.86	0.49	0.0		90.0	242.8
1/4	67.9	0.197	11.39	9.47	0.86	0.49	10.0	671.1	92.5	232.2
Mean	53.6	0.196	11.51	9.67	0.86	0.49	3.8	708.8	63.8	246.3
CV										
Q95										
Max	67.9	0.197	11.60	9.85	0.86	0.49	10.0	746.5	92.5	260.3
Min	37.9	0.195	11.39	9.47	0.86	0.49	0.0	671.1	15.0	232.2

akshmi Machine Works Limited Textile Laboratory Perianaickenpalayam Coimbatore - 641 020 INDIA

Style 406 Sample ID CUS 000532 Nom. count Nec 40 Nom. twist 20.2 T/in
Tests 1 / 500 v= 400 m/min Fv= 7.4 cN Valve press. Standard

CUSTOMER

Article 406/3 Material class Yarn Mach. Nr. Millcon
Uster Statistics
06/3,Sample-3,40s PC (35/65),Cone

Total: 1/500 Single test(s)

Nr	B-Force cN	Elong. %	Tenacity cN/tex	B-Work cN.cm
1/500	212.9	9.24	14.42	585.9
Mean	212.9	9.24	14.42	585.9
CV	13.2	8.2	13.2	16.1
Q95	2.475	0.07	0.17	8.271
Min	128.1	6.28	8.68	304.5
Max	287.4	10.81	19.47	846.9
P0.1				
P0.5	133.6	6.48	9.05	327.0
P1.0	139.1	6.99	9.42	344.2
P5.0	166.9	7.88	11.30	432.0
USP				
UTRexp*				
Weak places (118.1cN,3%)	F = 0	E = 0	F+E = 0	

Expected traditional tensile value UTR (Testing speed: 5m/min, Test length: 500mm)

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LMW

Textile Laboratory INDIA
Perianaickenpalayam Coimbatore 641 020 G 566

INDIVIDUAL RESULTS
2/8/2010 PAGE 1 (1)

DESIGN. : 406-1

DATE	2/6/2010	MACHINECODE	G566 NR240	406/1,Sample-1,40s PC (50/50),Cone
TIME	3:20:38 PM	MATERIALCODE	TEST	
MATERIAL	Polyester/Cotton	BOBBINS	1	
FINENESS	40	TESTS	4	
PRETENSION	5 cN	LENGTH	100 m	

BOBBIN	TEST	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Inde
1	1	9816	509	336	152	8	2	0	0	0	0	0	0	498	7
1	2	9410	397	350	177	5	0	0	0	0	0	0	0	532	0
1	3	10669	470	512	229	18	0	0	0	0	0	0	0	759	0
1	4	10905	489	466	255	14	0	0	0	0	0	0	0	735	0

OVERALL		1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Inde
MEAN		10200.00	466.25	416.00	203.25	11.25	0.50	0.00	0.00	0.00	0.00	0.00	0.00	631.00	1.75
MEAN/100m		10200.00	466.25	416.00	203.25	11.25	0.50	0.00	0.00	0.00	0.00	0.00	0.00	631.00	0.00
S		704.40	48.84	86.55	47.11	5.85	1.00	0.00	0.00	0.00	0.00	0.00	0.00	135.02	3.50
CV%		6.91	10.47	20.80	23.18	52.02	200.00	0.00	0.00	0.00	0.00	0.00	0.00	21.40	200
MAX		10905.00	509.00	512.00	255.00	18.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	759.00	7.00
MIN		9410.00	397.00	336.00	152.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	498.00	0.00
F		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Textile Laboratory | INDIA
Perianaickenpalayam | Coimbatore 641 020 | G 566

INDIVIDUAL RESULTS

2/8/2010 PAGE 1 (1)

DESIGN. : 406-2

DATE	2/6/2010	MACHINECODE	G566 NR240	406/2,Sample-2,40s PC (65/35),Cone
TIME	3:31:47 PM	MATERIALCODE	TEST	
MATERIAL	Polyester/Cotton	BOBBINS	1	
FINENESS	40	TESTS	4	
PRETENSION	5 cN	LENGTH	100 m	

BOBBIN	TEST	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Ind
1	1	10844	280	399	178	7	0	0	0	0	0	0	0	584	0
1	2	10525	271	369	188	3	0	0	0	0	0	0	0	560	0
1	3	9773	310	290	155	8	0	0	0	0	0	0	0	453	0
1	4	9470	301	300	151	7	0	0	0	0	0	0	0	458	0

OVERALL

	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Ind
MEAN	10153.00	290.50	339.50	168.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	513.75	0.0
MEAN/100m	10153.00	290.50	339.50	168.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	513.75	0.0
S	639.47	18.08	52.98	17.87	2.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.00	0.0
CV%	6.30	6.22	15.61	10.64	35.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.24	0.0
MAX	10844.00	310.00	399.00	188.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	584.00	0.0
MIN	9470.00	271.00	290.00	151.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	453.00	0.0
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

LMW
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INDIVIDUAL RESULTS

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DESIGN. : 406-3

DATE	2/6/2010	MACHINECODE	G566 NR240	406/3,Sample-3,40s PC (35/65),Cone
TIME	3:45:29 PM	MATERIALCODE	TEST	
MATERIAL	Polyester/Cotton	BOBBINS	1	
FINENESS	40	TESTS	4	
PRETENSION	5 cN	LENGTH	100 m	

BOBBIN	TEST	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Inde
1	1	10142	506	420	186	5	0	0	0	0	0	0	0	611	0
1	2	10256	522	459	192	3	0	0	0	0	0	0	0	654	0
1	3	9903	557	455	186	6	0	0	0	0	0	0	0	647	0
1	4	10433	523	469	241	10	0	0	0	0	0	0	0	720	0
OVERALL															
MEAN		10183.50	527.00	450.75	201.25	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	658.00	0.00
MEAN/100m		10183.50	527.00	450.75	201.25	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	658.00	0.00
S		222.04	21.46	21.33	26.65	2.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.42	0.00
CV%		2.18	4.07	4.73	13.24	49.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.90	0.00
MAX		10433.00	557.00	469.00	241.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	720.00	0.00
MIN		9903.00	506.00	420.00	186.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	611.00	0.00
F		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00