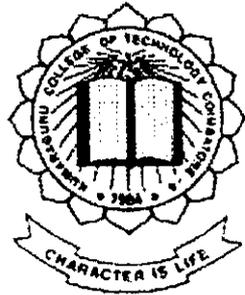


PRODUCTION AND STUDY OF VISCOSE STAPLE MICRO FIBRE KNITTED FABRICS



P-589

PROJECT REPORT

Submitted By

L. GURUMOORTHY

M. PRABHU

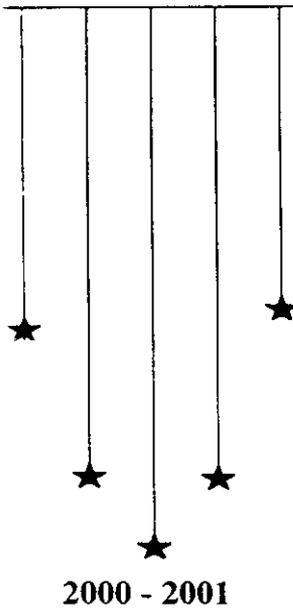
B. KATHIRVEL

Guided By

Mr.G.RAMAKRISHNAN, B.Tech.,

Lecturer,

Department of Textile Technology.



2000 - 2001

In partial fulfillment of the requirements
for the award of the degree of
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Department of Textile Technology

Kumaraguru College of Technology

COIMBATORE- 641 006.

Department of Textile Technology

Kumaraguru College of Technology

COIMBATORE- 641 006.

PROJECT WORK 2000 - 2001

University Register No: _____

Name _____

Roll No. _____

*Certified that this is bonafide record of the
Project Work done by*

Mr. _____

*in the partial fulfilment for the degree of
Bachelor of Technology in
Textile Technology*

Branch of the Bharathiar University, Coimbatore.



Head of the Department

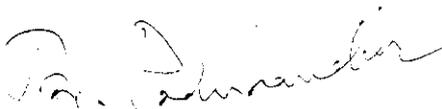


Faculty Guide

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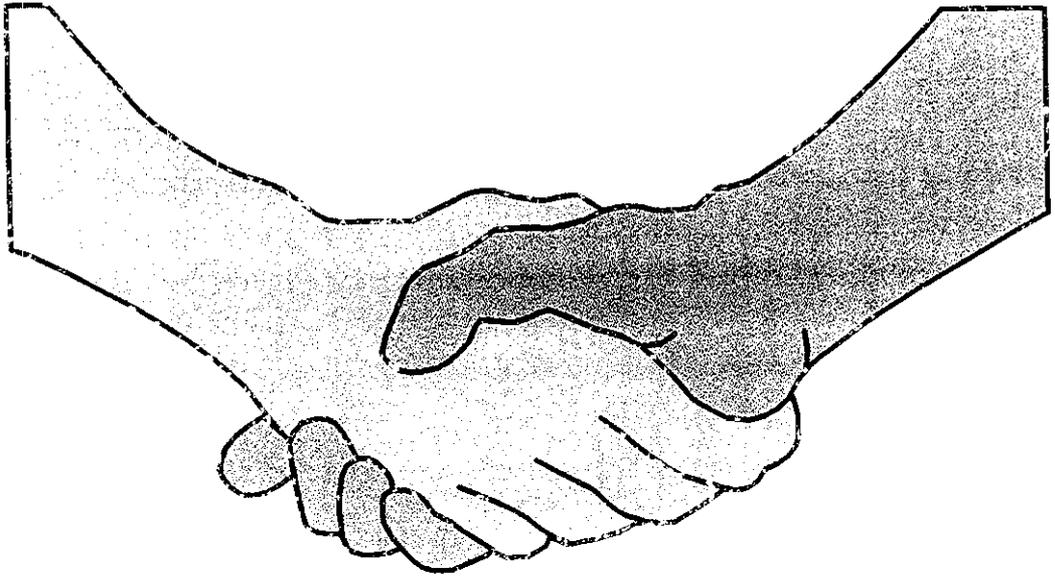


Internal Examiner



External Examiner

P-589



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Abstract

ABSTRACT

The word micros suggest an inherent hi-tech characteristic like Microchips. Micro Fibers would revolutionize the Fibre and the Textile Industry like Microchips did for the Data Processing industry.

In the past it was quite difficult to spin finer counts beyond 100s and the fabrics so prepared from fine counts were lacking strength and other desirable characteristics. Now with the information of micro fibres it is easy to spin finer counts and to prepare fabrics of desirable characteristics economically. Micro fibres and yarns impart special characteristics to the fabric and enhance its utility and applications. Demand for micro textured yarns and fabrics is increasing day by day and it seems that the micro fibre, is the “Fibre of the future”

The advent of very fine man-made fibers (finer than the finest available naturally fibre) known as Micro Fibres has opened up new opportunities for the textile industry. Due to their extra fineness, properties like softness, flexibility, silky appearance, superior handle, improved optical properties, better cover in fabric etc., these fibres are somewhat different. Microfibre show a great prospect for the textile and fashion industry.

The Authors have analyzed and found out the following results from the experimental studies

1. Microfibre fabrics exhibit excellent softness, supple handle and silky appearance due to low denier per filament, which in turn is due to reduction in bending modulus.
2. Microfibre fabrics have excellent drapeability.
3. Spirality of two degrees in the Microfibre knitted fabric is found to be well below tolerance limits.
4. The bursting strength of Micro denier knitted fabric found to be higher than the normal denier knitted fabric.
5. The water absorbency nature of Microfibre fabric is slightly lesser than the normal denier fabric.
6. The Micro denier knitted fabric are dimensionally more stable when compared to that of normal denier and cotton fabrics.
7. The cover of Micro denier knitted fabrics is comparatively better than normal denier knitted fabric.
8. Pilling resistance of the Micro knitted fabric is slightly better than normal denier knitted fabric.
9. Micro denier knitted fabric has poor Abrasion resistance and dyeability.



Contents

CONTENTS

CHAPTER NO

CERTIFICATE

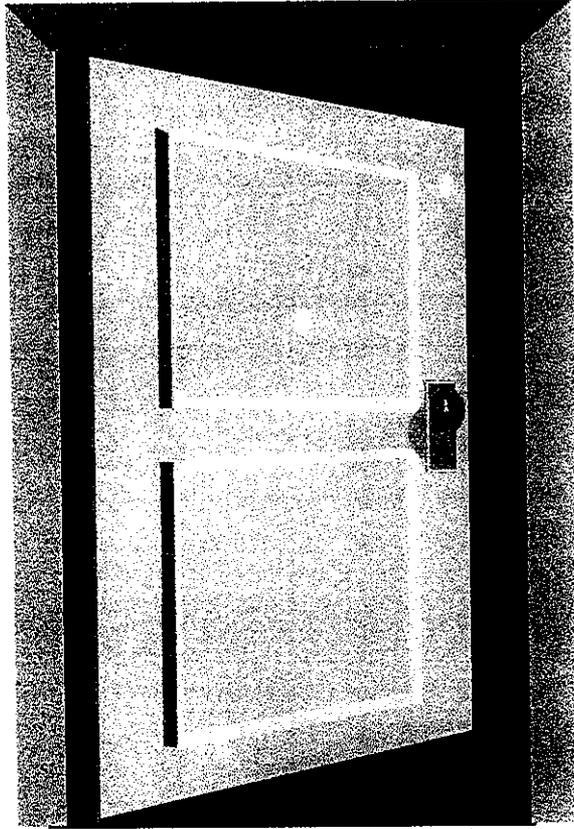
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ABSTRACT

CONTENTS

| | | |
|----------|------------------------------------|----------|
| 1 | INTRODUCTION | 1 |
| 2 | REVIEW OF LITERATURE | |
| 2.1 | INTRODUCTION | 3 |
| 2.2 | ABOUT MICRO FIBRES | 3 |
| 2.3 | DEFINITION | 4 |
| 2.4 | DETERMINATION | 5 |
| 2.5 | COMMERCIALY AVAILABLE MICROFIBRE | 6 |
| 2.6 | ADVANTAGES OF MICROFIBRES | 7 |
| 2.7 | APPLICATION OF MICROFIBRES | 9 |
| 2.8 | PRODUCTION OF VISCOSE STAPLE FIBRE | |
| 2.8.1 | HISTORY OF VISCOSE RAYON | 10 |
| 2.8.2 | CHEMISTRY OF PROCESS | 10 |
| 2.8.3 | MANUFACTURE OF VISCOSE RAYON | 11 |
| 2.8.4 | DEVELOPMENTS IN PROCESS TECHNOLOGY | 22 |

| | | |
|------------|---|-----------|
| 2.8.5 | FIBRE PROPERTIES OF VISCOSE RAYON | 23 |
| 2.8.6 | DEVELOPMENTS IN VISCOSE STAPLE FIBRE | 26 |
| 2.9 | PROCESSING OF MICRO DENIER VISCOSE STAPLE FIBRE | 33 |
| 3.0 | OBJECTIVES | 36 |
| 4.0 | METHODOLOGY | |
| 4.1 | OVERVIEW OF PROJECT | 37 |
| 4.2 | QUALITY REQUIREMENTS OF YARN FOR KNITTING | 37 |
| 4.3 | QUALITY PARAMETERS OF BEST 20s & 30s VISCOSE YARN | 40 |
| 4.4 | MATERIALS USED | 41 |
| 4.5 | PROPERTIES OF SINGLE JERSEY FABRICS | 41 |
| 4.6 | MACHINE DETAILS AND FABRIC PRODUCED | 46 |
| 4.7 | YARN DEFECT AND FABRIC FAULTS | 47 |
| 4.8 | TESTING INSTRUMENTS AND PROCEDURE | 49 |
| 5.0 | RESULTS AND DISCUSSIONS | 58 |
| 6.0 | ECONOMICS OF MICRO FIBRE PROCESSING | 81 |
| | CONCLUSION | 82 |
| | BIBLIOGRAPHY | |
| | ANNEXURE | |



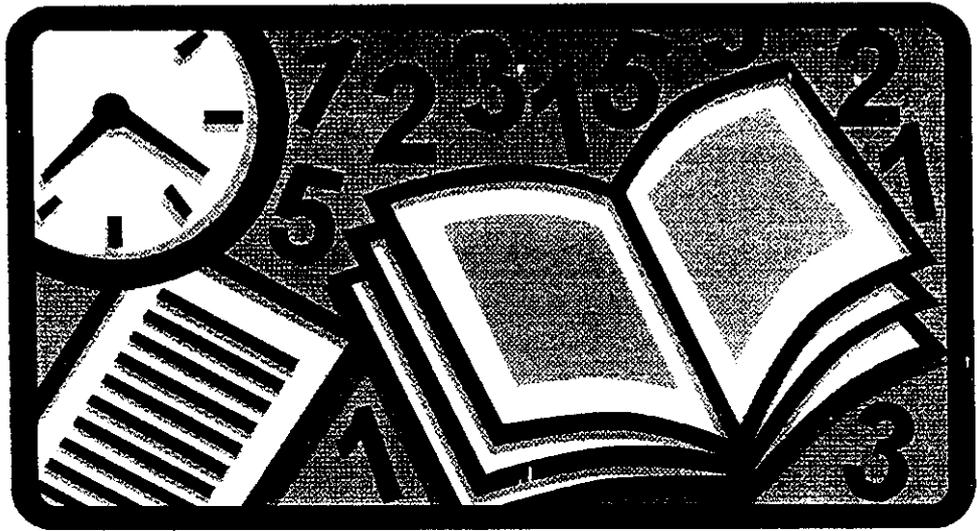
Introduction

INTRODUCTION

The synthetic fiber industry all over the world has seen a tremendous growth and technological development. The development/invention of synthetic fibres is to simulate use of natural fibres like cotton, silk, wool and jute. The development and innovation of various man-made fibres has found an end –use in different applications for textiles, industrial, medical, geotextiles and even contributing to the space technology. Synthetic fibre, especially the micro denier development, has made a big way for sophisticated textiles and apparels, medical and allied applications.

During the last few years, the major concerns for fibre producer have been to go for more value added products with improved properties along with advantage of inherent polyester properties. In recent years there has been a trend towards finer filaments, as fineness of fibre is very important in determining the aesthetic properties of fabric. In this unending race to imitate, perfect and then surpass the nature, in synthetic fibre industry the latest development is microfilament. These filaments are defined as the filaments whose denier is below one. Microfibres were first used mainly used for artificial leather in the 1970s and various sorts of microfibre have since been developed and used for variety of purpose. Microfibres have found their way into almost any area conceivable as their novel properties offer huge potential in terms of both function and aesthetics.

Production of polyester fibre has rapidly increased since its introduction in the world market in the 1950s and presently, polyester accounts for almost 52% of the world synthetic fibre and nearly 25% of the world's all textile fibre production. Continuous research work to improve performance and versatility has led to the development of many new polyester fibres among which microfibre polyester; especially polyethylene terephthate fibre is noteworthy. The advancement in spinning (extrusion) technology has made it possible to reduce the linear density of filament to less than 1.0 to achieve the fineness of natural silk, improve softness of feel and luster. In the field of manufacture of synthetic fibres, one of the developments is the production of microfibres.



Review of Literature

REVIEW OF LITERATURE

2.1 INTRODUCTION:[2,3]

Rayon, which is one of the oldest manufactured fibres, is a regenerated cellulose fibre with a wide spectrum of properties. Historically, rayon faced a strong challenge from synthetic fibres like nylon, polyester and acrylics, which came much later, but in spite of this competition it has retained its place as a major textile fibre. The important considerations in favour of rayon are that the essential raw material for its production, namely cellulose, is abundantly available and a renewable source. Moreover, its hygroscopicity and easy dyeability are additional assets. Furthermore, rayon fibres can be produced with a wide range of properties, particularly mechanical properties, so far unmatched by any other fibre, natural or manufactured.

2.2 ABOUT MICRO FIBRES:[6]

Micro is the term often used to describe many little, small, minute things. A fibre or filament of linear density approximately equal to or less than 1.0 dtex is termed as microfibre. Few years back silk was known to be the finest fibre available, the linear density of the finest silk is about 1.0 dtex per filament. Work to imitate silk and produce a fabric having silk like properties has resulted in development of microfilament polyester yarn. This is an exciting fibre development having excellent market potential. The microfibre used to be a very large extent in filament form is much sought after fibre in the textile world today for creating new dimensions to the fashion as it has the following advantages:

- ❖ Fibres are smooth, soft and having good handle.
- ❖ Drape of the fabric is better than that made with normal filament yarns.
- ❖ Even tightly woven structures made out of microfibres have low weight per unit area and not stiff.

2.3 DEFINITION: [5,6,8]

According to the first introducer of microfibre in Europe, the definition of micro is “finer than what nature permits”. Fibres in the 0.1 to 1.0-dtex ranges are described as microfibres (MF), and below 0.1 dtex as ultramicrofibres (UMF). Generally speaking, all fibres, which are thinner than silk, can be described by the microfibre concept.

Only in finenesses less than 0.5 dtex do their characteristics qualify them as true microfibres of course, and the minimum fineness that can be achieved to date is 0.0001dtex. These fibres are called super-ultra-fine microfibres.

Microdenier yarns contain many more filaments than regular yarns and therefore produce fabrics with improved breathability. Micro denier yarns produce soft, fluid, silky fabrics with excellent drapeability.

The term microfibre yarns indicates filament and staple yarns of acrylic, polyamide, polyester and polyolefin, the individual filaments of which are finer than 1.0 dtex (0.9 denier), but which generally lie between .56 and 0.78 dtex (0.5 and 0.7 denier). Individual filaments finer than 0.3

dtex (0.27 denier) are regarded as supermicrofibres. Efforts are being made with viscose fibres too to produce finer filaments, but in this case individual filaments finer than 2.3 dtex (2.1 denier) come up against manufacturing and processing barriers. The finer filaments fineness also has an adverse effect on certain end-use properties of fabric produced.

2.4 DETERMINATION: [9]

It is easy to determine whether a filament yarn is expressed by two figures, e.g. dtex 156 dtex, the yarn consisting of 256 individual filament (f). If the first figure is now divided by the second, the fineness of the individual filaments is obtained - in this case 0.6dtex.

In the case of man-made fibre yarns, we use the terms coarse, medium, fine and finest fibril yarns, and even microfibres. Yarn fineness is described as count, while the unit of measure is decitex or dtex. The quantity is x grams per 10000 meters. An example of a description of synthetic yarns: 167 f 48. The figure 167 means that 10000m of this yarn weighs 167g.

The letter "f" indicates the number of fibrils, in this case 48. It now becomes especially interesting and important for functioning sportswear fabrics: if the first figure is divided by the second, the result is approximately 3.5 in our case. The smaller this figure, the finer the individual fibrils. Yarns from approx., 1.5 and finer count as fine fibril yarns, and those below 1 as finest fibril yarns.

2.5 COMMERCIALY AVAILABLE MICRO FIBRES: [1]

| COMPANY | PRODUCT | END USES |
|-------------------|-----------------------------------|---|
| Hoechst AG | Trevira Finesse (polyester) | High performance outer wear and active wear Fashion apparel |
| | Trevira Micronesse (polyester) | |
| E.I Dupont | Micromattique (0.7d polyester) | Blend with cotton, silk, wool or rayon to produce fashion fabrics |
| Enichem UK | Myoliss (acrylic) | Knitwear with smooth and fluid appearance, suitable for worsted, woolen and cotton ring and open-end spinning system. |
| Kanebo Gosen Ltd | Belima KX (polyester) | High performance skiwear |
| ICI Fibres | Tactel Micro (nylon 66) | Hosiery goods, lace etc |
| Unitika Ltd | FSY (polyester) | Woven & knitted high grade ladies wear, woven & knitted sports wear such as skiwear, windbreaker, cleaning cloths |
| Reliance Co., | Recron 0.8 d | Woven and knitted fabrics |
| Grasim industries | Grasi Soft 0.8 d | Woven and knitted fabrics with smooth feel |

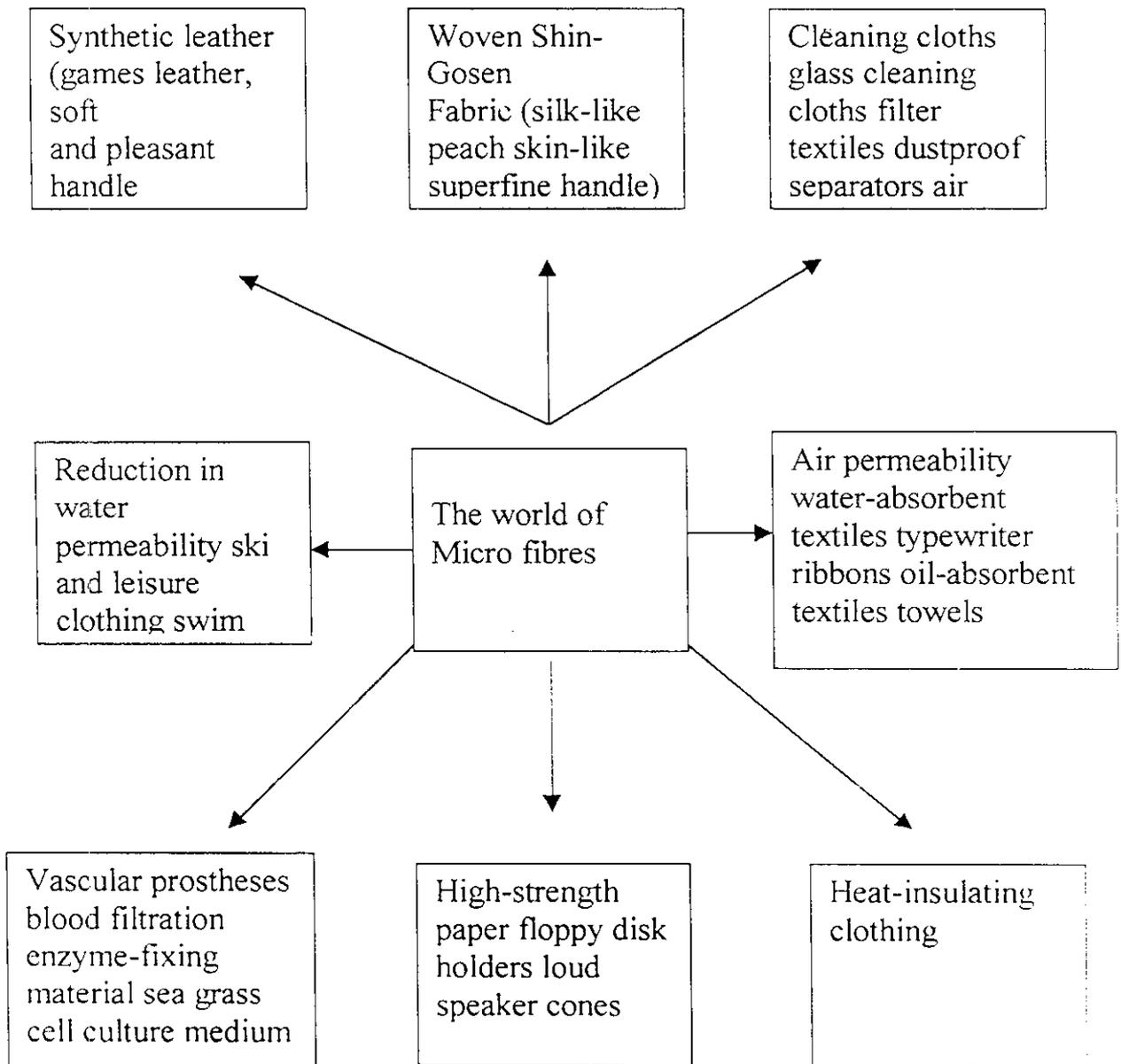
2.6 ADVANTAGES OF MICRODENIER FIBRES:[11]

The micro denier fibre being fine offers various advantages over normal fibres:

1. Owing to lower bending stiffness of the single fibres/filaments, micro fibre yarns impart excellent drapability of the fabrics as well as more or less pronounced softness depending on the fabric construction, blending ratio and blend components selected.
2. The low absolute filament strength makes micro fibre fabrics ideal for emerizing. Yarn strength on the other hand, is on a higher level due to presence of more number of fibres per cross sectional area.
3. As the filament size decreases, the yarn surface (on an equal count basis) increases.
4. Roundness and bulk of the yarns combined with their remarkable regularity ensure the production of the knitwear of smooth and fluid appearance, comfort, light and very soft to guarantee perfect weavability.
5. The yarns made from micro denier fibre contain many more fibres/filaments than regular yarns, producing fabrics with water tightness and wind proof but improved breathability
6. By increasing the fabric density by using micro fibres it is possible to obtain high resistance to slippages. The fabrics produced meet the stringent requirements of 2 non-seam opening at a load of 100 lbs.

7. More filaments/fibres in yarns result in more surface area. This can make printed fabrics more clear and sharp as compared to normal fabrics.
8. Micro denier characteristics lend themselves to the production of new exciting and fashionable fabrics.
9. One of the immediate advantages the spinner can foresee is that improvement in yarn evenness and spinning performance due to presence of more fibres per yarn cross-section.

2.7 APPLICATION OF MICRO FIBRES: [9]





2.8 PRODUCTION OF VISCOSE FILAMENT/ STAPLE FIBRE:

2.8.1 HISTORY OF VISCOSE RAYON: [2]

The viscose resulted from research in the UK by cross, Bevan and Beadle during the 1880s. By 1905 the Samuel Couteau Company (UK) was in serious production of viscose yarn by a process fundamentally similar to that of today. Events in the further development of the viscose process were (1): color pigmentation (1926), production of cut staple fibre (1934), tyre reinforcement yarn (1935), improved tyre yarn (1956), crimped fibre (1957), high wet-modulus fibre (1965) and hollow fibre (1976).

2.8.2 CHEMISTRY OF THE VISCOSE PROCESS: [2]

The chemistry of the viscose process consists of first forcing the cellulose I chains apart in both amorphous and crystalline areas by swelling with hydrates of sodium hydroxide, xanthating some of the hydroxyl groups so that the derivative may be soluble in water or dilute sodium hydroxide, and then reversing the process in spinning by removing the solvent water sodium ions and xanthate groups, so that the cellulose hydroxyl groups may draw the chains together first through van der Waals forces and then through hydrogen bonding to obtain a cellulose II network

1. Coagulation of liquid filament to xanthate gel filament;
2. Neutralization and acidification of the gel filament;
3. Deswelling of the gel filament;
4. Dexanthation of the gel filament.

The speed, interaction, and permitted extent of these mechanisms determine the plasticity, stretchability and orientability of the gel filament. The rates of the above four mechanisms determine the morphological order and the rates can be varied to obtain a wide spectrum of sub microscope order ranging from highly amorphous to highly crystalline. Thus, although the chemistry of the viscose rayon process is basically simple, the succession of chemical reactions is quite complex and the way in which this complicated sequence is carried out determines the fine structural parameters of the rayon fibre and, hence, their physical properties.



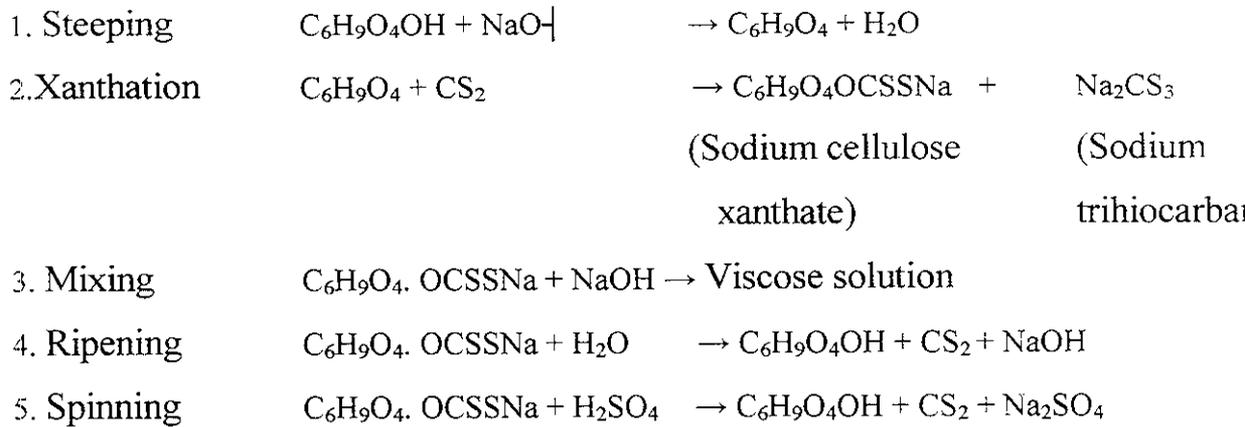
2.8.3 MANUFACTURE OF VISCOSE RAYON: [2]

The basic steps in the manufacture of viscose rayon fibre and filament are presented schematically.

(a) Steeping

Cellulose pulp boards (13x18x30in) containing cellulose between 87 and 98% are stacked vertically 3-6 in a part (separated by perforated spacers) in a steeping tank containing 17.5-18% NaOH. The steeping operation which converts cellulose into alkali and also

Sequence of reactions in the viscose process:



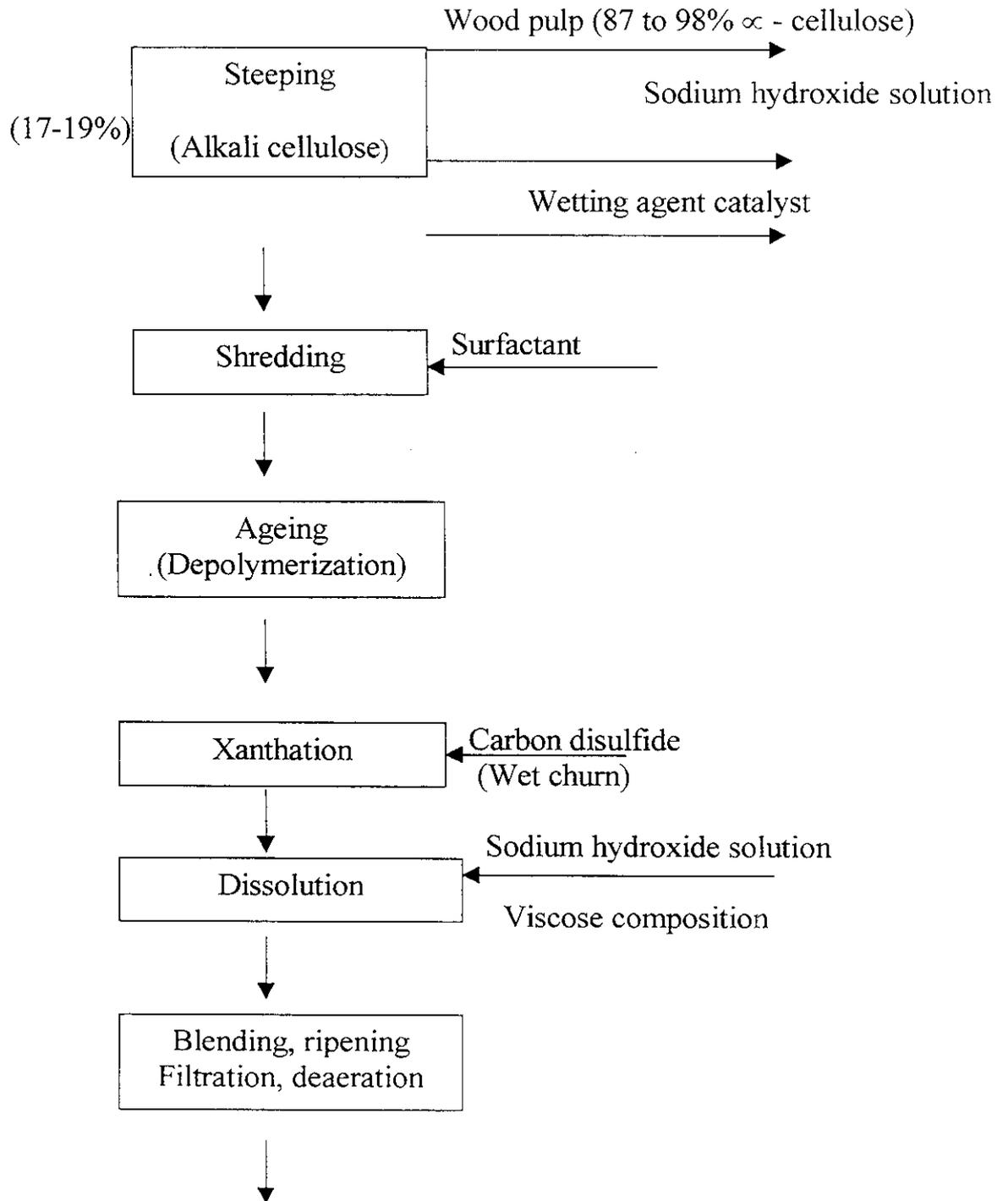
Constitution of alkali cellulose varying press weight ratios

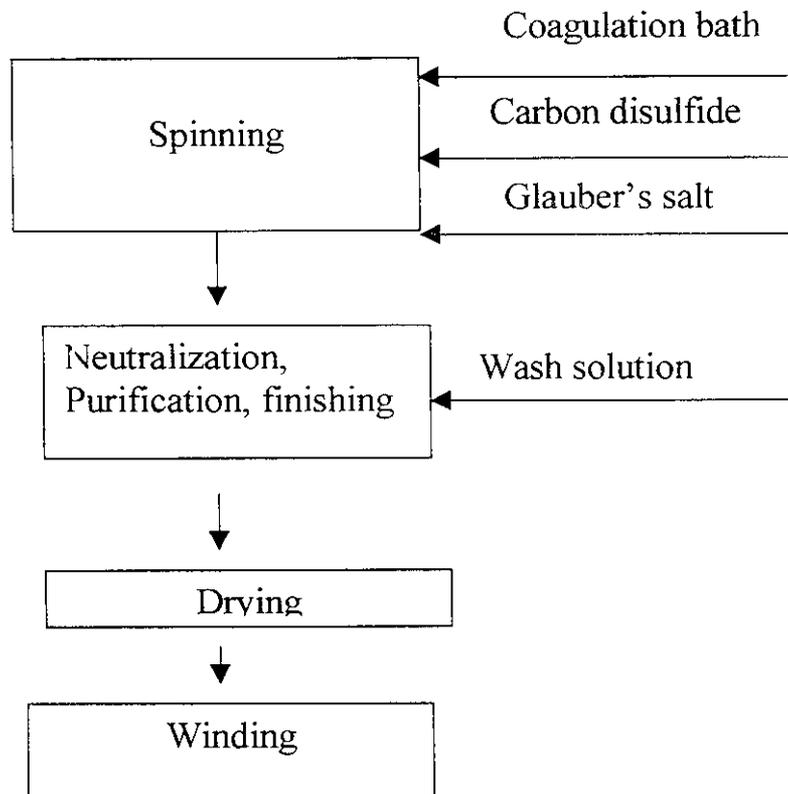
| Press-weight Ratio | Cellulose (%) | NaOH (%) | H ₂ O (%) |
|--------------------|---------------|----------|----------------------|
| 3.0 | 29.8 | 15.2 | 55 |
| 2.5 | 35.0 | 15.0 | 50 |

Removes hemicelluloses and resinous impurities are carried out for 30-60 min, preferably at a temperature of 18°C. Although it has not been firmly established whether a true sodium salt of cellulose is formed in this operation or whether the product is a hydrated adduct between NaOH and cellulose, the alkali cellulose is highly reactive and behaves as a sodium salt of cellulose in many reactions. After the stipulated period of immersion in

NaOH solution, the pulp boards are pressed by a hydraulic ram fitted to the steeping tank to remove the excess alkali. The press-weight

Flow diagram of production of viscose filament





Ratio, which is defined as the ratio between the weight of the pressed alkali cellulose sheet and weight of the air dried pulp, needs to be carefully controlled and is preferably adjusted to 2.7-3.

Although the variation in press-weight ratio does not change the NaOH content in alkali cellulose, both cellulose and water content are changed. Batch-to-batch variation in press-weight ratio could cause serious problems in maintaining the quality of the product as press-weight ratio influences the success of subsequent operations like shredding xanthation and filterability.

(b) Shredding

This is a mechanical operation where the alkali cellulose boards are shredded into fluffy crumbs. Shredding is accomplished through rotating serrated blades and the operation is carried out for 1-3 h at 25-35°C. Occasionally surfactants like polyethylene glycol are added at this stage. Surfactants decrease surface tension; this improves the dispersion of carbon disulphide, resulting in an overall increase in the degree of xanthate substitution.

(C) Ageing

This is an oxidative depolymerization step and needs to be carefully controlled to obtain the desired degree of depolymerization. The shredded crumbs are stored in rectangular galvanized steel containers and covered with lids. The oxygen available from the air within the fluffy crumbs is sufficient and exposure to outside air is avoided as otherwise the crumbs dry out and carbon dioxide from air produces carbonates which affect xanthation and filterability. Ageing is carried out for 1-3 days at a temperature of 25-30°C. The ageing process can be accelerated considerably with the use of higher temperatures and catalysts in the form of heavy metal salts such as manganese or cobalt. The ageing step can be avoided if the degree of polymerization required is high, in the case of polynosics. Occasionally ageing is referred to as a mercerization is distinctly different. During mercerization reactivity increases but there is no loss in the degree of polymerization (DP). During ageing chemical reactivity as measured by rate of hydrolysis or xanthate formation does not increase, but the solution viscosity is greatly affected.

(d) Xanthation

Aged alkali cellulose is transferred into hermetically sealed churns or barrettes where carbon disulphide is introduced in a weight proportion of 32-35% of the weight of cellulose in alkali cellulose. The churns are slowly rotated at 1-4 rev min⁻¹ for a period of 1-3h at a temperature of 20-30°C. Approximately 65% of CS₂ reacts with cellulose while the remainder goes into other reactions, the prominent reaction being formation of Na₂CS₃, which is responsible for the orange coloration of the flake. The xanthation ratio or the degree of substitution (the gamma or γ value) can be increased by increasing the CS₂ content and increasing the xanthation time. Although this does not improve solubility, a higher γ value is required for the manufacture of high performance rayon and polynosics. The ratio of total sulphur to the xanthate sulphur is an important variable during coagulation and regeneration.

(e) Dissolution

Dissolution of cellulose xanthate takes place in cylindrical vessels equipped with agitators. A 4-6% solution of NaOH is used. During dissolution, a considerable amount of air is whipped into solution that is removed by evacuation.

(f) Filtration

Viscose solution is filtered through a filter cloth and other filter aids to remove impurities and undissolved cellulose particles. Filtration is done in several stages, the stage being as close to the spinneret as possible.

(g) Blending

Viscose solutions from several dissolving tanks are blended in a large vessel to homogenize and remove batch-to-batch variations.

(h) Ripening

As initially produced viscose is relatively difficult to coagulate, it is therefore not suitable for industrial use. After blending, the viscose solution is transferred to large tanks in a constant temperature room where it is kept for 1-3 days at a temperature of 15-25°C. Ripening is basically storage at controlled temperature. During the period various changes occur, the most important of which is spontaneous decomposition of xanthate coupled with changes in the distribution of the xanthate groups, both within the cellulose chain as well as among cellulose chains. The viscosity of the xanthate solution initially drops as redistribution of xanthate groups increases the dispersion, and then increases as dexanthation and agglomeration of cellulose molecules gradually reduce solubility. As coagulability is the index of ripeness, determining the readiness to coagulate in standard salt solutions follows the progress of ripeness. The two tests used for measurement of ripeness are Hotternoth number or Hotternoth index and salt index or point index.

- Hotternroth number: this gives the volume in ml of a 10 % ammonium chloride solution which is needed to coagulate 20g of viscose solution diluted with 30ml of water.
- Salt index: this gives the concentration of sodium chloride solution at 15°C needed to coagulate one drop of viscose solution from a glass rod of 3/16 in diameter.

Each type of viscose requires a certain time of ripening to make it spinnable. Amongst the variables for controlling ripening, temperature is the most convenient for obtaining the proper degree of ripening in the desired time. Therefore, precise temperature control is necessary during ripening.

(i) Spinning

The spinning of viscose into a fibre involves the basic reaction of regeneration and is simply the recovery of cellulose from cellulose xanthate by an acid decomposition reaction. Upon entering the bath the viscose filament is coagulated and acid diffuses into the filament, regenerating cellulose. During this time the viscose fibre is also stretched to orient the cellulose molecules in the direction of the fibre axis.

The conventional viscose bath for standard rayon contains the following ingredients:

1. a salting-out agent, Na_2SO_4 ;
2. a regenerating agent, H_2SO_4 ;
3. a compound-forming agent, ZnSO_4

In standard viscose rayon spinning, viscose of 30-50 poise viscosity made with 32% CS_2 (on weight of cellulose) is spun into an aqueous acid salt spin bath of the following type at a temperature of 45-50°C.

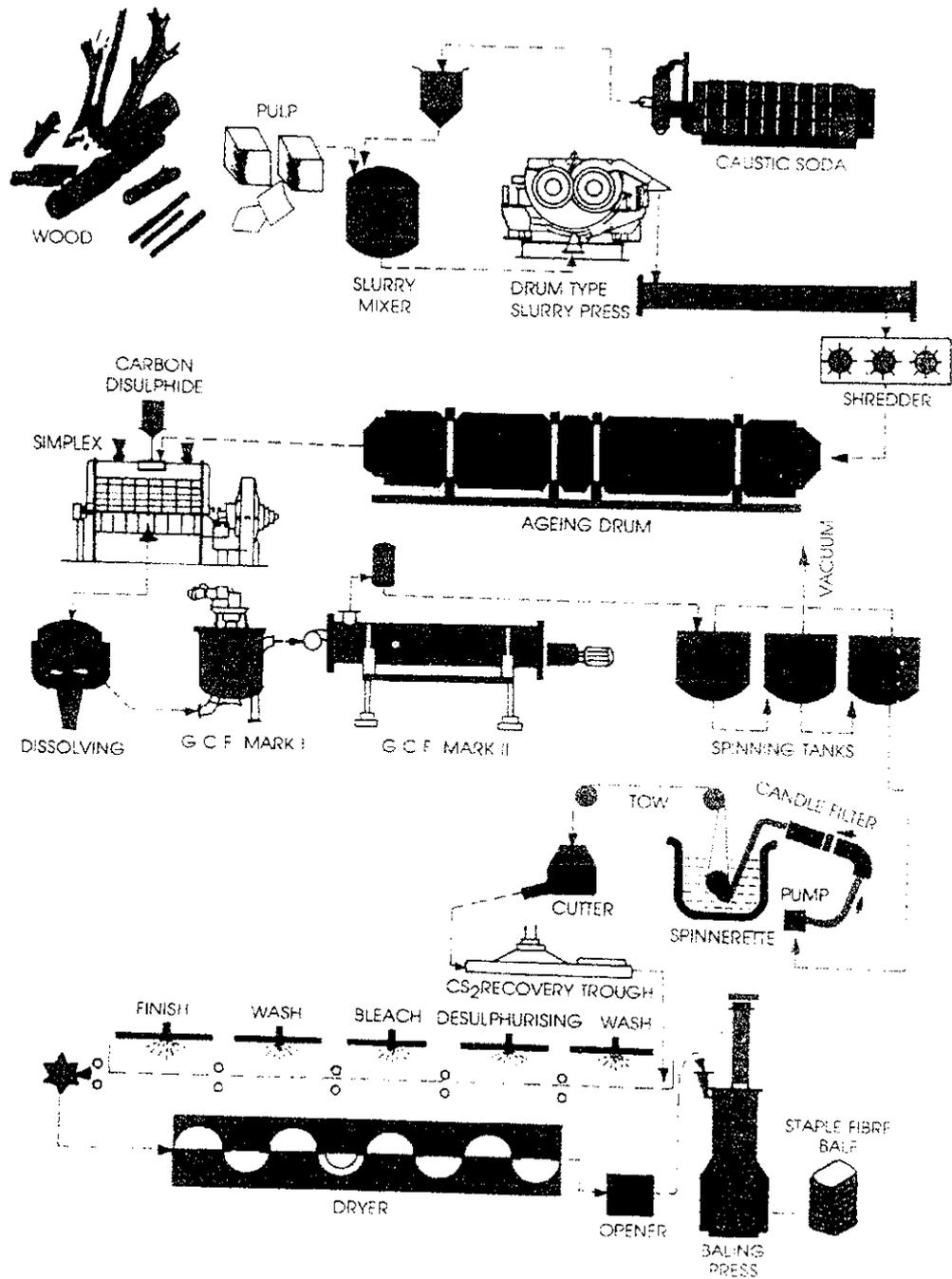
| | |
|--------------------------|--------|
| H_2SO_4 | 8-10% |
| Na_2SO_4 | 16-24% |
| ZnSO_4 | 1-2% |

Spinning speeds may be as high as 120m min^{-1}

When the filaments are being formed in the bath, simultaneous processes take place during which sulphur is evolved and deposited on the surface of the filaments. During subsequent finishing, the filaments are subjected to washing and desulphurization, to a treatment with a solution of sodium sulphide or sulphite for dissolving the sulphur deposited on the filaments. Furthermore, the following operations are carried out: bleaching (with hypo chlorite, hydrogen peroxide or sodium chlorite), soaping or oiling to soften the filaments and final drying.

Modern spinning bath systems may be described as (1) the zinc based spinning bath, and (2) the non-zinc spinning bath. Systems, which use zinc, are employed in the production of regular and crimped rayon, rayon tyre yarn, and modified high wet modulus rayon or high performance rayon. The non-zinc spin bath is used in the spinning of polynosic. Considering that over 95 % of the rayon produced today is spun with zinc in the spin bath, the role of zinc in the structural regulation of viscose fibre is of paramount importance and needs to be clearly understood.

SCHEMATIC FLOW DIAGRAM



Properties of various cellulose fibres [2]

| Property | Standard Rayon | Tyre Yarn | Modified HWM | Polynosic HWM | Ten-x type HWM | Cotton |
|---|----------------|-----------|--------------|---------------|----------------|--------|
| Tenacity (gf den ⁻¹) (Condition) | 2.0-3.0 | 4.5-6.5 | 4.0-6.0 | 4.0-7.5 | 9.0-10.0 | - |
| Tenacity (gf den ⁻¹) (Wet) | 1.3 –2.2 | 3.2-4.8 | 2.7-4.6 | 2.7-6.0 | 7.7-8.0 | - |
| Elongation (%) (Conditioned) | 15-30 | 18-22 | 8-16 | 6-12 | 5-7 | 7-12 |
| Moisture Regain % | 11-13 | 11-13 | 10-12 | 9-11 | 9-11 | 7-7.5 |
| Secondary swelling % | 80-120 | 60-80 | 60-75 | 55-70 | 65 | 40 |
| Crystallinity % | 33-42 | 29-45 | 37-42 | 39-47 | 46-52 | 50-70 |
| Birefringence | 0.027 | 0.037 | - | 0.046 | - | - |

2.8.4 DEVELOPMENTS IN PROCESS TECHNOLOGY: [2]

One of the fundamental changes in the viscose process has been the conversion from the old batch wise process to continuous or semi continuous systems. In the original batch process, the sequence of steeping, pressing and ageing took up to 40h to produce alkali cellulose. More over difficulties in ensuring constant temperature and equal ageing time because of a large number of bins involved frequently resulted in a variable degree of polymerization in the resultant viscose. In modern plants bales of wood pulp are automatically fed into continuous slurry steeping units in which the pulp is simultaneously disintegrated and steeped before passing on to continuous slurry presses where the slurry is first de watered and then pressed. Subsequently ageing is carried out in drums, silos or slow-moving conveyors under controlled temperature and humidity conditions. The use of catalysts and elevated temperatures during ageing has reduced the ageing time to 4-5hours.

The xanthation process has been improved with the use of wet churns in which both xanthation and mixing are carried out. Ripening is now generally carried out. Ripening is now generally carried out continuously in large tanks, which also act as buffers for filtration and spinning.

One thrust area of development has been the improvement in filtration to give a product with a low level of particulate contamination. The purity requirements of viscose are different for each product with the viscose destined for finer denier requiring more stringent filtration. Traditionally a filter press has been used for viscose filtration. Materials used as a filter are

nylon non-woven fabric, cotton flannel or cotton cloth. More recently the introduction of back flush filters with non-woven metal screens has improved the filtration efficiency phenomenally. With the new non-woven metal screen the filtration amount has increased 50-fold². Thus the filter's size could be decreased to one-fiftieth of the former filter press to maintain the same filtration amount. One striking feature in the development of process technology for the manufacture of viscose rayon has been the increase in the level of automation to improve process continuity and fibre quality through improved process control. Automatic analysis and control of spin bath and wash liquors has been introduced and drying is frequently computer controlled using both feed back and feed-forward control loops. Coupled in some with fibre conditioning systems.

2.8.5 FIBER PROPERTIES OF VISCOSE RAYON: [4]

Normally viscose is a white and lustrous with a soft handle. With the use of pigments in the spinning process, dull, matt or spun-dyed staple fibre is made.

Elastic Properties:

Cotton and other natural cellulosic fibres have little inherent elasticity. Viscose staple fibre, however, has a little less elasticity. At 2% extension, normal viscose has an elasticity recovery of about 60%.

Effect of Moisture:

The reduced crystallinity of the cellulose in viscose staple fibre renders the fibre more responsive to water penetration. Viscose staple fibre will absorb twice as much water vapour from air as cotton does. Viscose has a moisture regain of 13% under standard conditions. When soaked in water, viscose staple fibre swells double its original volume.

The increased water penetration is reflected in the change in tensile strength. Viscose staple fibre loses about 45% of its strength when wet and is more easily stretched. The strength returns to original on drying.

Effect of heat:

Viscose staple fibre begins to lose strength at 150 °C after prolonged heating. It gets charred at about 185 °C to 205 °C without melting. This is similar to the cotton.

Effect of age:

This effect is so slight that it is almost negligible.

Effect of sunlight:

Viscose staple fibre withstands exposure to sunlight without discolouration; prolonged exposure may cause gradual loss of tensile strength, as in cotton.

CHEMICAL PROPERTIES:

Viscose staple fibre has a lower degree of polymerization than cotton. The action of chemicals on viscose staple fibre is similar to cotton, but in general, this fibre is more sensitive.

Effects of oxidizing agents:

It withstands normal hypochlorite or peroxide bleaches. High strength hydrogen peroxide weakens this fibre.

Effect of acids:

This is similar to cotton. The fibre is attacked, weakened and disintegrated by the action of hot dilute or cold concentrated mineral acids.

Effect of alkalis:

As in cotton, dilute alkalis have no effect on viscose staple. Strong solutions of alkali cause swelling, with loss of tensile strength.

Effect of organic solvents:

Most of the organic solvents do not have any effect on viscose; it dissolves only in complex solution, such as cupra-ammonium hydroxide. Dry cleaning solvents do not have any delirious effect.

Effects of insects and micro-organisms:

Viscose is resistant to insect attack but with the presence of sizing material, mild dew will discolouration and weaken the fibre, as in the case of cotton.

Electrical properties:

As the moisture absorption is higher, the use of this fibre for insulation purposes under humid conditions is not recommended. The dielectric strength of dry fabrics is fair. Usually, viscose staple fibre does not develop static charges, as it already treated with antistatic agents.

2.8.6 DEVELOPMENTS IN VISCOSE STAPLE FIBRE: [4]

With extensive research work since last so many years, GRASIM have developed following new fibres and these fibres are now commercially available for the use in textile and other industry.

GRASIHIGH:

This fibre is specially developed to meet the demand for superior fibre as compared to the normal fibre. This fibre has following properties:

| | |
|-----------------------|--------------------|
| Denier | : 1.5 |
| Single fibre tenacity | |
| Conditioned | : 2.65 to 2.70 g/d |
| Wet | : 1.35 to 1.40 g/d |
| Elongation % | |
| Conditioned | : 23 |
| Wet | : 25 |

GRASILINE:

This is a high tenacity viscose staple specially developed for blending with polyester and other synthetic fibres which give higher yarn strength and thereby higher yarn production rate in spinning and better weaving efficiency:

| | |
|-------------------------|----------------|
| Denier | : 1.5 |
| Single fibre tenacity : | |
| Conditioned | : 3.0 to 3.1 |
| Wet | : 1.75 to 1.80 |
| Elongation % | |
| Conditioned | :19 |
| Wet: | : 23 |
| No. Of crimps per cm | : 10-12 |

Besides above, recently GRASIM has evolved, after sustained research, four new fibres viz GRASINEP, GRASIRIB, GRASIBOW, and GRASISOFT. These new fibres, based entirely on indigenous know-how, are expected to open new vistas for the development of fashion fabrics. Judicious blends of these fibres with other fibres- both synthetic and natural for manufacture of suiting, shirting & dress materials, can significantly enrich fabric properties in terms of aesthetic appeal, handle and appearance.

Salient features of these newly developed fibres are given below:

GRASINEP:

GRASINEP is ideally suited for producing neps for the manufacture of neppy yarns and fabrics. Its fineness, staple length finish and structure have been so adjusted that good quality neps with higher rate of production can be obtained by the use of this fibre.

GRASIRIB:

GRASIRIB is a ribbon-cut type fibre with flat cross-section. It can be made available in 8,12 and 15 Deniers. Because of its differential light reflection properties and ribbon-like cross section, just by blending 5 to 10% of this fibre, the appearance and handle of this fabric can be improved considerably. It can either be used in grey form or in single colour or in multicolour depending upon end uses and customer's preference.

GRASIBOW:

GRASIBOW is a multi-colour/ multi-denier fibre. The combination of colours and deniers has been so chosen that use of this fibre even in small proportions (say 5 to 10%) provide a wide choice to the textile designer and fashion for production of fabrics in different colour combination and with novel effects to improve aesthetic appeal.

GRASI SOFT: [15]

The Softest and Coolest Fibre

Grasi Soft is the latest innovation from the house of Grasim, world leader in Viscose Staple Fibre. It is the finest cellulose fibre with a denier of 0.8, which gives it a feather like feel.

Grasi Soft has unmatched softness with the most luxurious look and feel. It is even finer than silk which makes the fabric feel so natural with a sparkling brilliance.

Grasi Soft fabrics breathe air and permeate moisture like our skin itself. The flowing drape with an uniformly luxurious sheen in the most vibrant colours make Grasi Soft suitable for the finest knitwear and woven garments

GRASIM VISCOSE FOR ENHANCED COMFORT AND SOFTER:

The world's largest producer of Viscose Staple Fibre, GRASIM of the Aditya Birla Group, has some of the most unique expression in fibre colour, texture and technology. Grasim has helped in path breaking innovations through its customers with an array of delightful choices of the most comfortable fibre, Viscose, in manifold applications.

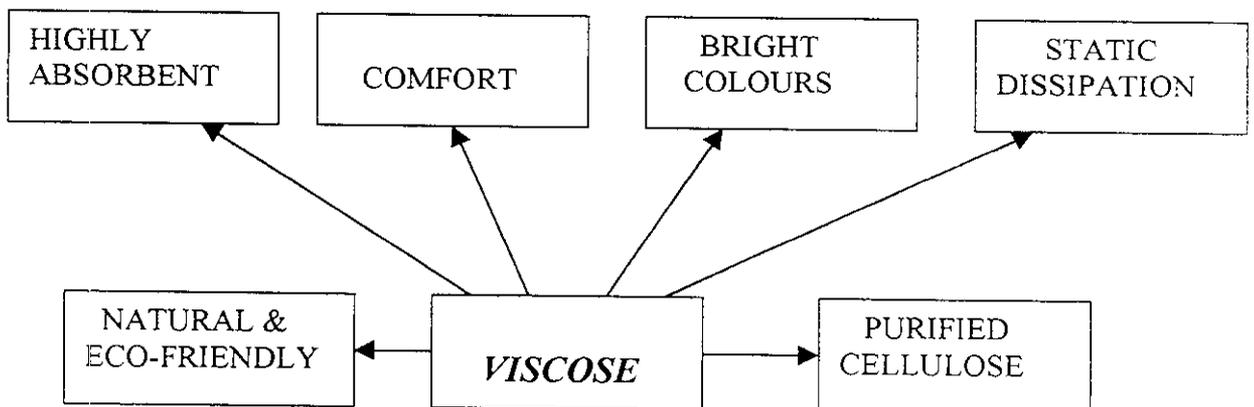
Garments with Viscose have easily the best attributes of softness, absorbency, drape and lusture that merge to form suave and subtle men's wear as well as flamboyant and fashionable women's wear.

Grasim Viscose is a designer's delight as Pure Viscose and in blends with Cotton, Polyester, Acrylic, Lycra and wool. Eco-friendly spun dyed viscose present the most brilliant and fascinating spectrum of colours and tones.

The colours one dreams of are matched in Grasim Viscose, which are splendidly true and uniform at all times with all-round colour fastness beyond comparison.

Cotton Viscose blends offer unmatched uniformity in colour and texture with the highest comfort and therefore are cut out for sensitive premium users.

"Grasi Soft" micro fibre ensures the softest feel, colour brilliancy, with an excellent drape.

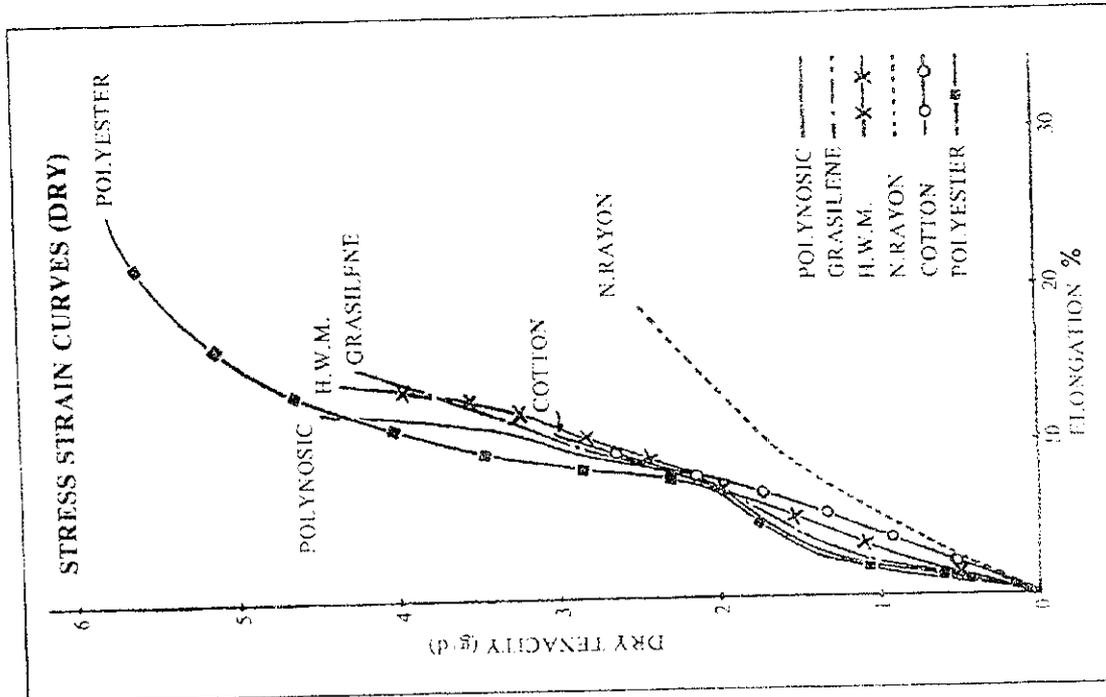
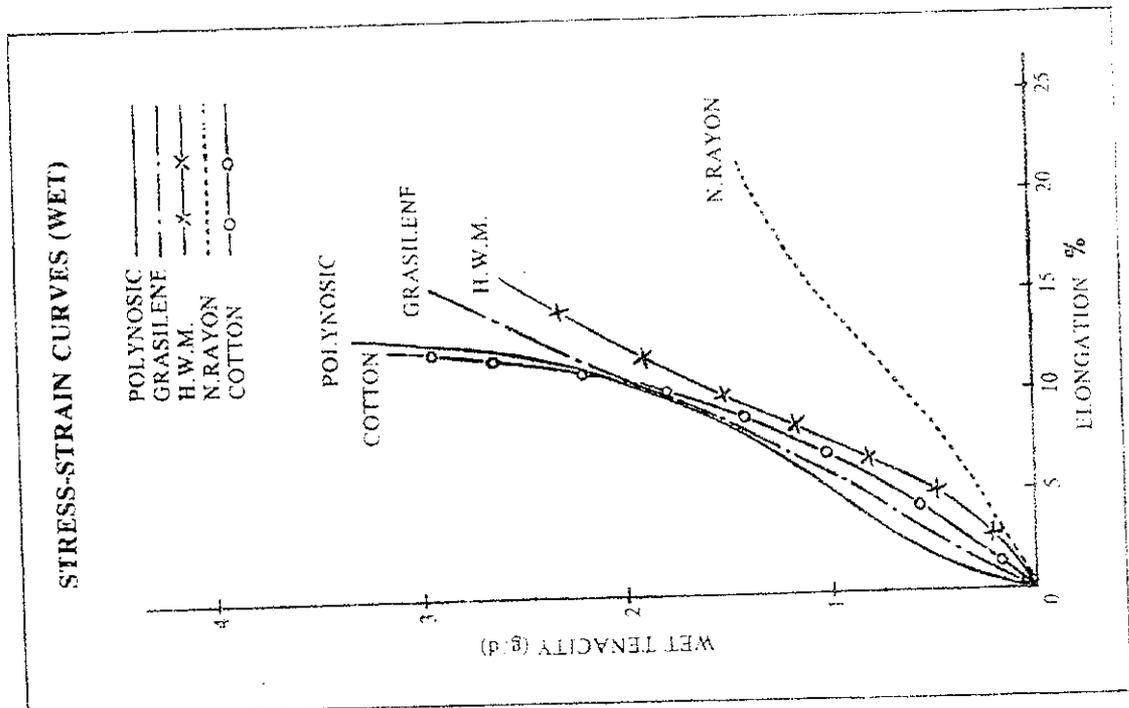


SUPERIOR VISCOSE BASED KNITWEAR

Knitwear has been preferred in garment applications, which are next to the skin. Knitwear should therefore offer the highest degree of comfort to the wearer. Among contemporary fibres, Viscose offers the best comfort due to its higher absorbency and softer feel and therefore is ideally suited for knitwear applications in standalone as well as in blends with Cotton, Acrylic and Polyester. The flow or fall of knitted goods, are unmatched and the share of knitted goods have expanded for these special attributes.

Enhanced features of Viscose Knitwear

- ❖ Softer and cooler on skin leading to comfort
- ❖ Higher absorbency due to nearly twice the moisture regain of Cotton
- ❖ Enhanced lusture leading to brilliant shades
- ❖ More uniform fabrics as the base yarn is highly even
- ❖ Lower wet processing cost
- ❖ Cleaner and hygienic
- ❖ Excellent durability, softer and fuller to feel



2.9 PROCESSING OF MICRO DENIER VISCOSE STAPLE FIBRE:

| Process | Modification |
|--------------------|--|
| Opening & Cleaning | Short machines, short pipelines. Pin type or needle type opener is preferred. |
| Carding | higher number of wire points is required. The card used for fine cotton can be used microfibre. Most modern cards are capable of processing microfibres. |
| Drawing | Reduced delivery speed (around 400 m/min), minimum three passage of drawing. |
| Roving | Less roving twist as compared to conventional fibre. A matt finish flyer and flyer top with more number of ribs are preferred. |
| Ring Spinning | Little lower TM can be used. Higher drafting pressure and more break draft as compared to conventional fibres are required. |
| Sizing | Absorbs 10% -15% more size. Concentration of size bath should be reduced. Cooling must be faster as compared to conventional fibres. |
| Weaving | The surface of harness of drop wires, thread and healds need to have low roughness. Reed wires are cut from flat steel and then edges should be rounded. The temples used for silk or silk like fabrics may be used. The weft accumulation should be equipped with circular leaf and brush tensioners. |

YARN DIAMETER [1]

When fibres are subjected through a series of machines employed in spinning, they experience various types of stresses and strains of different magnitude.

As fineness of fibres reach micro level, the immediate dimensional change that can be foreseen is, a reduction in diameter. But to what extent it gets affected can be realised if the diameter of fibre is plotted as a function of denier covering the denier range from micro to normal level.

$$\text{Diameter } d = \frac{11.8929 * 10^4 * \sqrt{\text{den}}}{\text{Fibre density}}$$

$$\begin{aligned} D (\mu\text{m}) &= 10.0875 \sqrt{\text{den}} && \dots(\text{for polyester}) \\ &= 10.9022 \sqrt{\text{den}} && \dots(\text{for acrylic}) \\ &= 9.6464 \sqrt{\text{den}} && \dots(\text{for viscose}) \end{aligned}$$

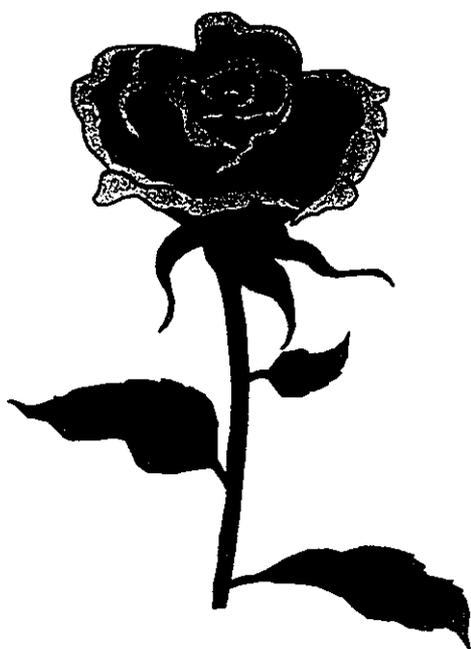
Assuming density of polyester, acrylic and viscose rayon to be 1.39g/cm^2 , 1.19 g/cm^2 and 1.52 g/cm^2 respectively. It can be seen that the diameter changes more rapidly when one goes towards micro level. Due to this reduction in diameter the following properties are being affected significantly.

- flexural rigidity
- tensile strength and
- surface friction

All these properties are extremely important since flexural rigidity relates to easiness with which deformation may lead to nep generation or incidence of lapping. Tensile strength resists damage that may accrue to the fibre during processing and surface friction influences cohesion.

The bending stress is inversely proportional to (diameter)³ and bending deformation is inversely proportional to (diameter)⁴. Hence, a small reduction in diameter through changing denier will cause a fine fibre to get deformed easily, leading to nep formation.

If the tenacity value remains same, the absolute tensile strength will be lower for microdenier fibre. According to some authors the actual tenacities are sometimes lower than normal fibres. This compounds the problem of processing microfibres.



Objectives

3. OBJECTIVES

To study the properties of 100% Viscose Micro denier knitted fabrics and to compare the properties with those knitted fabrics of Viscose Normal denier and Cotton.

To produce

- ❖ 100 % Micro denier viscose fabric
- ❖ 100 % Normal denier viscose fabric
- ❖ 100 % Cotton fabric

To compare the properties of those knitted fabrics.



Methodology

4. METHODOLOGY

4.1 OVERVIEW:

- Procurement of Micro denier, Normal denier and Cotton yarns of same count (25s) in the form of cones.
- Yarn Testing
- Available cones are converted into baby cones in order to suit the number of feeders of the knitting machine.
- Single Jersey fabric is produced in a Circular knitting machine.
- The knitted fabric is processed and dyed.
- Finished fabric is tested.

4.2 Quality Requirements of Knitted Yarn:

(i) Yarn evenness

Better knitting performance and better fabric appearance can be achieved with yarn having better evenness. Yarn containing large knots and slubs will result in excessive needle breakage, causing drop stitches and holes.

(ii) Twist

Soft twisted yarn give soft handle and bulkiness to the fabric. High twisted yarn makes fabric rough and these yarns get snarled during knitting causing needle damage and fabric faults. Generally, the twist factor in Hosiery yarn ranges from 3.0 to 3.4. Luster and hand of fabric are affected by amount of twist.

(iii) Count variation

Higher count variation in yarn show thick and thin places in knitted fabric.

(iv) Neps and foreign matters

Selection of fibres and processing in blowroom, carding and combing departments should be given careful consideration for the better appearance of the fabric. The foreign matters present in the yarn such as Jute, hair, colored yarn, rubber, plastic pieces, cloth pieces, Polypropylene, etc. should be removed in blow room and winding processes.

(v) Thick and Thin Places

Higher number of thick and thin places and the undrafted places affect the knitted fabric appearance. Thick places due to poor opening and carding and undrafted places may damage the needles and thus result in fabric defects as well as increase in stores expenditure.

(vi) Elasticity and elongation

Higher tenacity of yarn does not always give good knitting quality. A good hosiery yarn should possess enough elongation to withstand tension during knitting and knitting action by the needles. The elasticity of yarn varies with humidity and temperature, spinning technique, single or double yarn with high (or) low twist.

(vii) Resistance to friction

During knitting the yarn passes through several paths, and this will increase the friction unless the yarn and the paths are polished (or) smooth. Therefore the yarn to metal friction should be reduced to a considerable extent, otherwise yarn breakage, will occur and hence fabric damage.

The low coefficient friction value of less than 0.2 can be achieved by waxing the yarn either by passing through wax in winding or by wax emulsion method.

(viii) Moisture content in yarn

A very dry yarn impairs extension characteristics and also leads to fluff build up. On the other hand the coefficient of friction of the yarn increase with increasing moisture content. Moisture content in the yarn should be 10 to 14 %

(xi) Winding package buildup

Knit yarn package are generally offered with a conicity of $5^{\circ} 57'$ instead of $9^{\circ} 15'$. A high friction yarn produces a harder package due to higher winding tension and this will knit a tighter structure. The package

hardness can be assumed at around 0.4kg/dm^2 for the practical purpose. The winding faults such as tight cones, soft cones, uneven winding, loose ends, double ends, thick places, thick knots, should be avoided.

x) Knots and splices

Generally the knots size will be about 4 to 5 times the yarn diameter, but in the spliced yarn, the diameter at the spliced point will not exceed more than 1.5 to 2 times the yarn diameter. Generally, combed yarns offer a clean appearance, better lusture than carded yarns. Combed yarns are used in quality knit wear while carded are used for cheep varieties. Some knitter's even use mercerized (or) gassed and mercerized yarn to make superior quality outerwear fabrics for exports markets.

4.3. QUALITY REQUIREMENTS OF BEST 20s AND 30s YARN

| PARAMETER | Ne 30/1 | Ne 20/1 |
|------------|----------|----------|
| Fiber | 1.2 * 38 | 1.2 * 38 |
| U % | 9.8 | 8.9 |
| Thin | 0 | 0 |
| Thick | 3 | 0 |
| Neps | 8 | 4 |
| Total | 11 | 4 |
| Csp | 2650 | 2820 |
| Parameter | Ne 30/1 | Ne 20/1 |
| Elongation | 11.2 | 11.4 |
| Hairiness | 4.8 | 4.7 |

| | | |
|-------------|-------|-------|
| Total fault | 140 | 74 |
| Obj.fault | 5.5 | 5.2 |
| Spl.speed | 16000 | 14000 |
| TM | 3.35 | 3.38 |

4.4 MATERIAL USED:

| PARTICULARS | COUNT | FIBRE DENIER | STAPLE LENGTH | TM |
|---------------------------------|-------|--------------|---------------|-------|
| 100% Spun Viscose Micro denier | 25s | 0.8d | 38 mm | 3.184 |
| 100% Spun Viscose Normal denier | 25s | 1.2d | 38 mm | 3.076 |
| 100% Cotton | 25s | 1.5d | 28 mm | 3.918 |

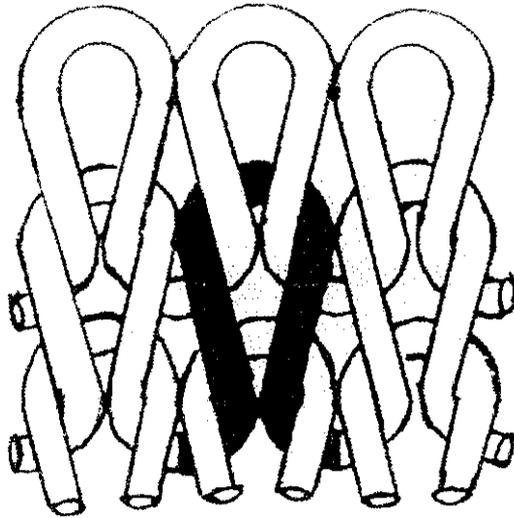
4.5 PROPERTIES OF SINGLE JERSEY FABRICS:

The simplest and the most widely used weft-knit fabric is 'jersey' or 'Plain' knit fabric. It consists of face loop stitches only. The technical 'face' and 'back' sides of a jersey or a plain knit fabric can be easily identified. The main characteristic features and properties of this fabric are :

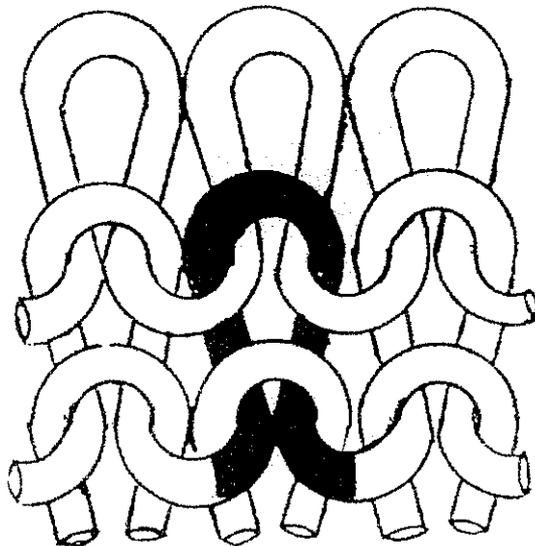
- ❖ The loops have a V-shaped loop appearance on technical face side and show semi-circular loops on the technical backside.

- ❖ Because of the side limbs of the loop on the face side, it feels smoother on face side than on the backside. It is thus not reversible, from the feel and appearance point of view.
- ❖ The interlocking semi-circles at the technical back can be used to produce interesting effects if alternate courses are knitted in different coloured yarns.
- ❖ Knitted loops in plain-knit fabrics tend to distort easily under tension, which help to give a 'form fitting' and 'comfort' due to property of elastic recovery.
- ❖ It has potential recovery of about 40 percent in width after stretching. Its width shortens if the length is extended by tensions while the length shortens if width is stretched. Normally width way extensibility is approximately twice the length-way extensibility.
- ❖ The structures can be unraveled from the course knitted last by pulling the 'needle loops' through from technical back or from the course knitted first by pulling the 'sinker loops' through from the technical face side.
- ❖ As explained earlier, if the unrelaxed plain knit fabric is kept flat on the surface, it curls upwards at the top and bottom and backwards at the sides.
- ❖ Its production rate is very high because of stitch simplicity and its cost is low because of machine simplicity (capital cost also low) and rate of production is high.

- ❖ The stitch length can be varied with cam setting giving more courses per unit length with short stitch length and vice-versa. The properties such as rigidity, air permeability, width per unit area, bursting strength changes with the stitch length. The fabric may appear thick or flimsy if the stitch length is reduced or increased.
- ❖ It is knitted on a single cylinder machine with a single set of latch needles



(a) Technical Face Side



(b) Technical Reverse Side

Technical Face & Reverse side of
a single Jersey Weft-knit Structure.

DYE RECIPE

| | |
|----------------------|---|
| Colour | : Stone colour (Natural) |
| Dye type | : Azo dye |
| Shade: Light | |
| Dye concentration | : Blue MR: 0.013% Yellow MR: 0.018% Red M5B: 0.004% |
| Salt concentration | : 40% |
| Alkali concentration | : 0.5% |
| M: L ratio | : 1:15 |
| Time: | |
| Bleaching | : 6 hrs |
| Dyeing | : 6 hrs |
| Temperature | : Room temperature |

**4.6 MACHINE DETAILS AND FABRIC PRODUCED:
KNITTING MACHINE DETAILS:**

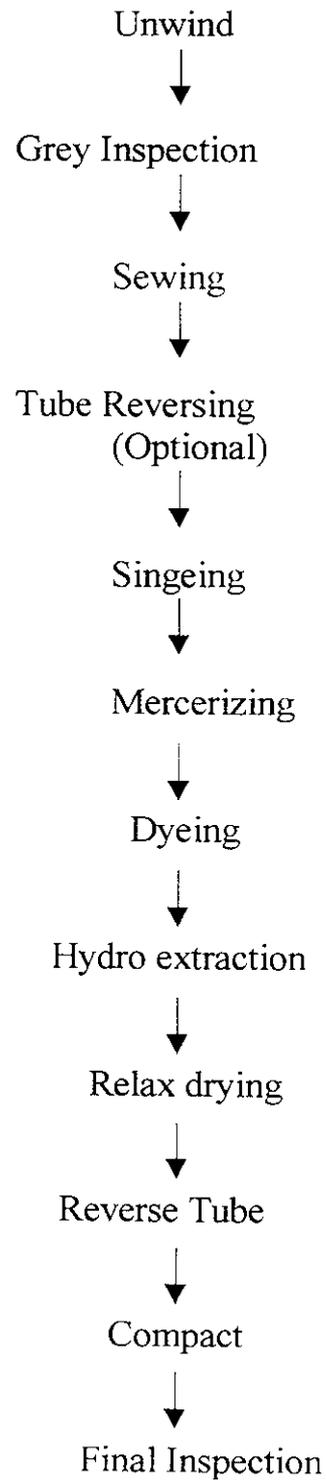
| | |
|----------------------|----------------------------------|
| Machine type | : Circular Weft Knitting machine |
| Type of fabric | : Single Jersey |
| Machine Name | : BMW |
| Model & Year | : 1990 |
| Machine speed | : 28 rpm |
| Gauge | : 24 |
| Cylinder diameter | : 14 inches |
| No. Of feeders | : 18 |
| Total no. Of needles | : 1080 |
| Needle type | : Groz-Beckert |
| Texture | : 20 |

4.7 YARN DEFECTS AND FABRIC FAULTS:

The following table shows the relationship between knitted fabric faults and their causes (Yarn defects):

| Causes | Effect |
|---|--|
| 1. Very uneven yarn | Cloudy fabric |
| 2. Yarn with very low strength and too many thin places | Holes (or) cracks |
| 3. Yarn with long period unevenness | Fabric with stripes |
| 4. Bad dyeing (or) blending | Horizontal Stripes |
| 5. Insufficiently paraffinated yarn | Drop stitches, holes (or) cloth fall out |
| 6. Too large (or) Weak Knots (or) bad splicing | Yarn end separation (or) break during knitting |
| 7. Uncleared thick places | Irreparable faults in the fabric |
| 8. Too much yarn Hairiness | Diffused stitch appearance and fluff build up |

Processing sequence:[2]



4.8 TESTING INSTRUMENTS AND PROCEDURE:

STITCH DENSITY:

Stitch density or loop density is calculated by multiplying the number of courses per inch and wales per inch.

$$\text{Stitch density} = \text{CPI} * \text{WPI}$$

DIMENSIONAL & GEOMETRICAL PARAMETERS OF FABRIC:

Munden and Postle calculated these from the following equations as proposed:

$$K_c = \text{CPC} * l$$

$$K_w = \text{WPC} * l$$

$$K_s = K_c * K_w$$

$$\text{Loop shape factor}(R) = K_c / K_w$$

Where K_c , K_w and K_s are the dimensional parameters

CPC – Courses per cm

WPC- Wales per cm

l- stitch length.

TIGHTNESS FACTOR:

Tightness factor of the knitted fabric is determined by the following formula:

$$\text{Tightness factor} = \sqrt{(\text{tex}) / l}$$

MEASUREMENT OF DRAPE:

Drapeability of a fabric can be determined using the instrument DRAPEMETER and is expressed in terms of Drape Co-efficient.

PROCEDURE:

A circular specimen of diameter 10 inches is supported on a circular disc of diameter 5 inches. When doing so, the unsupported area of the fabric drapes over the edges of the supporting disc. When the fabric is supported, it will assume the folded configuration due to gravity and the shape of the projected area will not be circular.

Measuring the following areas, the drape co-efficient, F, can be calculated

- a. The area of the specimen, A_D
- b. The area of the supporting disc, A_d
- c. The actual projected area of the specimen, A_s

The drape co-efficient, F is the ratio between the projected area of the draped specimen and its undraped area, after the deduction of the area of the supporting disc.

$$\text{Thus, } F = \frac{A_s - A_d}{A_D - A_d}$$

Instead of the areas of the draped and undraped specimen, their corresponding weights of the paper projection can also be taken to calculate the drape co-efficient.

$$F = \frac{W_s - W_d}{W_D - W_d}$$

where,

W_D - Weight of the paper whose area is equal to the area of the specimen.

W_d - Weight of the paper whose area is equal to the area of the supporting disc

W_s - Weight of the paper whose area is equal to the area of the projected area of the specimen

The thickness of the paper used to trace the outline must be uniform. The small value of F indicates the better drapability of the fabric and the large value indicates the bad drapability.

I.C.I PILL BOX TESTER:

A piece of fabric measuring 5inch*5inch is stitched so as to be a firm fit when placed round a rubber tube 6inch long, 1.25inch outside dia and 1/8 inch thick. The cut ends of the fabric are placed in a box (9in*9in*9in) lined with cork 1.8 inch thick. The box is then rotated at 60 rpm for 5 hours.

For garments, which are normally subjected to repeated washing as well as to wear, washing may be done prior to sample preparation. After the test is over, the extent of pilling is assessed visually by comparison with the arbitrary standards 1,2 and 3. Under test conditions, fabrics of standard 1

become hairy but donot pill, fabrics of standard 2 become hairy and pills lightly, while fabrics of standard 3 become hairy and pill severely.

FABRIC THICKNESS TESTER:

01. Size and shape of the presser foot: Normally a circular foot of diameter $\frac{3}{8}$ inches is used. The ratio between the foot diameter to the cloth thickness should not be less than 5:1.
02. Shape and size of the anvil: If the anvil is of circular type its diameter should be at least 2inch greater than the presser foot. When the sample is larger than the anvil, a smooth plane board may be conveniently surround the anvil for suitable support of the cloth.
03. Applied pressure: Suitable weights may be added to the presser foot and preferred pressure may be applied.
04. Velocity of Presser foot: The presser foot should be lowered on to the sample very slowly and carefully.
05. Time: The thickness is read from the dial of the instrument only when the pointer ceased vibrations and not earlier.
06. Indication of thickness: Usually a clock-type dial guage is built into the thickness tester. It should be rigidly mounted in a suitable frame. After setting the dial to zero, the instrument must be capable of measuring to an accuracy of 1% for fabrics over 0.1 mm thickness and to 0.001 mm for fabrics, which are not exceeding 0.1mm in thickness.

METHOD OF MEASURING:

01. The presser foot and the anvil are cleaned by a clean paper.
02. If required, the weights are added to the presser foot and the gauge is set to zero.
03. No specimen preparation is required.
04. At least, thickness is measured at 5 places and the mean value is reported.
05. In test report the details of the pressure, size of presser foot and the time should be given.

ABRASION RESISTANCE:

1. Five-cloth specimens are cut into 1 1/2" diameter. The specimen remains exactly circular since the template circular in shape.
2. These specimens are fastened to the mushroom shaped folders. 400 gms/weight are put on to the top of the holders.
3. The top plate with the specimen are lowered on to its working position such a way that,
 - a. The ball steel caster supports the plate.
 - b. The pegs of the discs enter into the holes of the plate.
 - c. The cloth touches the energy sheet.
 - d. Counter reads zero

The motor is started and starting time is noted. The specimen is rubbed. The end point of the test is reached after rubbing for 150 cycles and the percentage loss in weight is found from the formula,

$$\text{Percentage weight loss} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}}$$

BURSTING STRENGTH TESTER:

The specimen for this test should be cut so that the sample is 0.5 inch greater in diameter than the outside diameter of the clamp ring.

The instrument used for bursting strength should have a constant rate of speed and must be capable of giving a uniform displacement of 6 cubic inches per minute. The clamp ring should have an internal diameter of 1.20 inches. For proper operation, the machine must be stopped at the instant of rupture in order to avoid additional application of pressure and load on the specimen.

PROCEDURE:

The specimen is clamped by a ring over thin flexible rubber diaphragm which itself is clamped over a circular hole in the upper face of a reservoir. The liquid used may be water or glycerin. The pressure in the liquid is increased, by valves or screw-driven piston. Due to increase in pressure, the diaphragm bulges, taking with it the specimen. At some point the fabric bursts, and the pressure at that point is indicated by the pressure gauge.

SPIRALITY

Spirality or skewness of single jersey fabric is a distortion of plain knitted fabric where by the wales and courses align at an angle other than 90°. Spirality is measured when fabric is in tubular form according to the procedure laid down in ASTM standards (1997f).

Fabric spirality is a distortion of a circular-knitted fabric in which the wales follow a spiral path around the axis of the knitted fabric tube. This distortion affects both aesthetics and functional performance of the knitted material and the garments produced thereoff.

At present, several treatments can be adopted to eliminate or alleviate the problems associated with spirality in fabrics knitted using twisted single yarns. These treatments can be divided into two categories: (a) setting of single yarn to reduce its residual torque and (b) balancing the yarn torque by various means.

Tightness factor, number of feeder and yarn density depicted highly significant effects upon the spirality value of single jersey knit fabrics.

Spirality value of knit fabrics is inversely related to tightness factor, no of feeders and yarn density. Where as state of relaxation positively effect the spirality of single Jersey fabric

PROCEDURE:

The knitted fabric sample is cut into 6 inch * 6 inch for measurement of Spirality. The sample is unravelled course-wise to obtain a distinct inclination to that of the vertical. A perpendicular to the inclination is drawn and the angle between the perpendicular and the vertical is measured using a protractor. This angle is identified as the Spirality angle and the tolerance lies between 4° and 5°.



Results & Discussions

Yarn Test Results

HAIRINESS:

| STATISTICS | 1mm | 2mm | 3mm | 4mm | 6mm | 8mm | 10mm | 12mm |
|------------------|----------|------------|---------|---------|---------|---------|---------|--------|
| MICRO DENIER | | | | | | | | |
| mean value | 15188 | 2768 | 1101 | 712 | 73 | 2 | | |
| Std value | 2379,62 | 638, 61 | 249, 66 | 156, 60 | 25,09 | 2,46 | | |
| CV value | 15,69 | 24,70 | 22,68 | 22,00 | 34,47 | 100, 44 | | |
| NORMAL DENIER | | | | | | | | |
| Mean value | 12423 | 2776 | 1032 | 693 | 133 | 13 | 1 | 0 |
| Std value | 1051,05 | 185, 05 | 76,71 | 45,12 | 15,20 | 3,54 | 1,48 | 0,32 |
| CV value | 8,46 | 6,67 | 7,42 | 6,51 | 11,47 | 27, 04 | 1 | 316,23 |
| COTTON | | | | | | | | |
| Mean value | 23398 | 6467 | 3009 | 2442 | 610 | 201 | 30 | 6 |
| Std value | 2741, 61 | 1019, 76 | 474, 75 | 386, 43 | 111, 83 | 39, 14 | 147, 23 | 3,71 |
| CV value | 11, 60 | 15, 75 | 15, 78 | 15, 82 | 18, 33 | 19, 43 | 23,71 | 61,86 |

Fabric Test Results

5. RESULTS & DISCUSSIONS

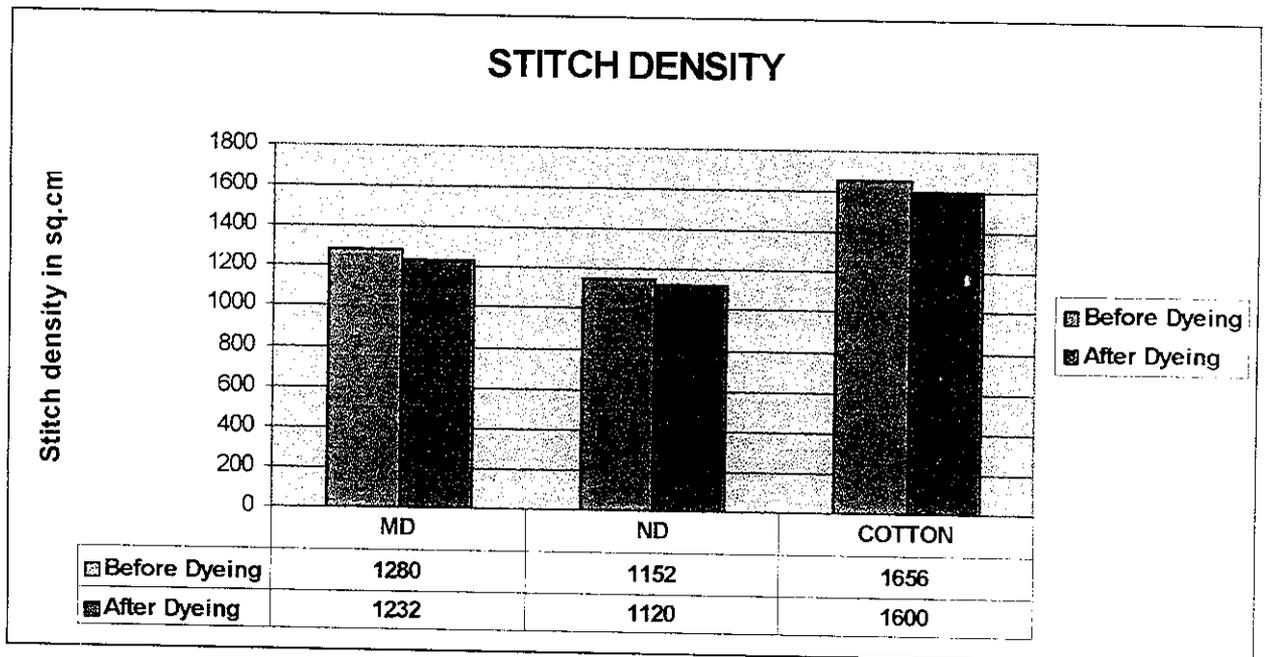
CPI, WPI, STITCH DENSITY:

The table no. 1 indicates the values of Course Per Inch (CPI), Wales Per Inch (WPI) and Stitch density for both types of Before Washing and After Washing treatments. From the table we could find out that there is a uniform increase of 10% in the value of CPI and uniform decrease of 12.5% in the value of WPI because of the course-wise shrinkage and wale-wise elongation.

CPI, WPI AND STITCH DENSITY: [TABLE NO: 1]

| | Before Dyeing | | | After Dyeing | | |
|---------------|---------------|-----|----------------|--------------|-----|----------------|
| | CPI | WPI | Stitch density | CPI | WPI | Stitch density |
| Micro Denier | 40 | 32 | 1280 | 44 | 28 | 1232 |
| Normal Denier | 38 | 32 | 1152 | 42 | 28 | 1120 |
| Cotton | 46 | 34 | 1656 | 46 | 30 | 1600 |

TABLE NO 1:



Dimensional and Geometrical Parameters of Knitted fabric: [TABLE NO: 1]

Change in loop length:

The table no.2 shows the value of change in loop length before and after relaxing treatments for all the three samples from which Cotton has maximum change in loop length percentage whereas Viscose Micro denier and Normal denier shows little change in loop length. Hence, the Viscose Micro denier and Normal denier knitted fabrics have better Dimensional stability. Excess change in loop length is due to the fact that the twist in Cotton is more. Twist Multiplier (TM) value is much more higher in case of cotton which can be inferred from the yarn test results. The Dimensional changes is more pronounced in case of Cotton than in the Viscose Micro denier and Normal denier fabrics which may be attributed to the TM value which inturn can be referred from the yarn test results.

Tightness Factor:

$\sqrt{(\text{Tex})/l}$ is nothing but the ratio of l/d (slenderness ratio) which indicates the tightness factor. From the table no.2 we could find TF values for both before dyeing and after dyeing relaxing treatments. The above table gives lesser values for both Viscose Micro denier and normal denier knitted fabrics compared to that of the Cotton knitted fabric.

Loop shape factor which is equivalent to the cover factor of woven fabrics is shown in table no.1. We can infer that the loop shape factor R is higher for Micro denier fabrics which in turn gives better closeness in fabrics because of the fineness factor percentage increase in stitch density compared to Normal denier and Cotton knitted fabrics.

Stitch Density:

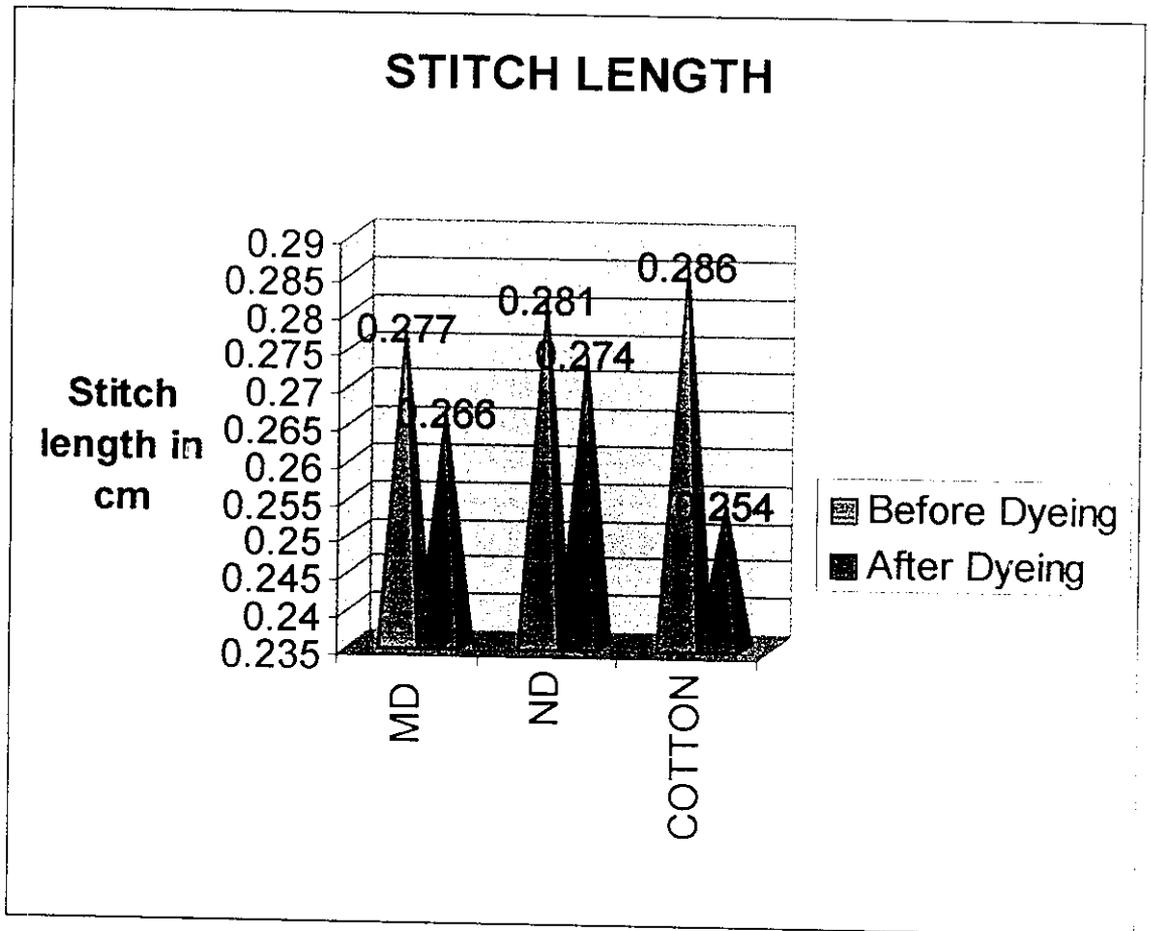
From the table no.2 we find the stitch density per centimeter square values for before and after washing treatments. With the values obtained we could find out that the Viscose Micro denier knitted fabrics has the highest values. These values may be attributed due to high shrinkage of Micro denier fibres.

DIMENSIONAL STABILITY:

TABLE NO: 2

| FABRIC | COUNT | CP/CM | W/CM | SD/CM ² | SL | Kc | Kw | Ks=Kc*Kw | Tf | R |
|------------------|-------|-------|-------|--------------------|-------|------|------|----------|-------|------|
| Micro denier | | | | | | | | | | |
| Before wash | 23.62 | 15.74 | 12.59 | 198.17 | 0.277 | 4.36 | 3.49 | 15.22 | 17.55 | 1.24 |
| After wash | 23.62 | 17.32 | 11.02 | 190.86 | 0.266 | 4.62 | 2.93 | 13.54 | 18.27 | 1.58 |
| Normal denier | | | | | | | | | | |
| Before wash | 23.62 | 14.17 | 12.59 | 178.4 | 0.281 | 3.98 | 3.54 | 14.08 | 17.29 | 1.12 |
| After wash | 24.6 | 15.75 | 11.02 | 173.5 | 0.274 | 4.32 | 3.02 | 13.05 | 17.75 | 1.43 |
| Cotton | | | | | | | | | | |
| Bcfore wash | 23.62 | 18.11 | 14.17 | 256.6 | 0.286 | 5.18 | 4.05 | 20.98 | 16.9 | 1.28 |
| After wash | 23.62 | 19.68 | 12.59 | 247.8 | 0.254 | 4.99 | 3.18 | 15.87 | 19.13 | 1.57 |

CHANGE IN LOOP LENGTH: [TABLE NO: 2]



GSM OR AREAL DENSITY (g/sq.cm): [TABLE NO: 3]

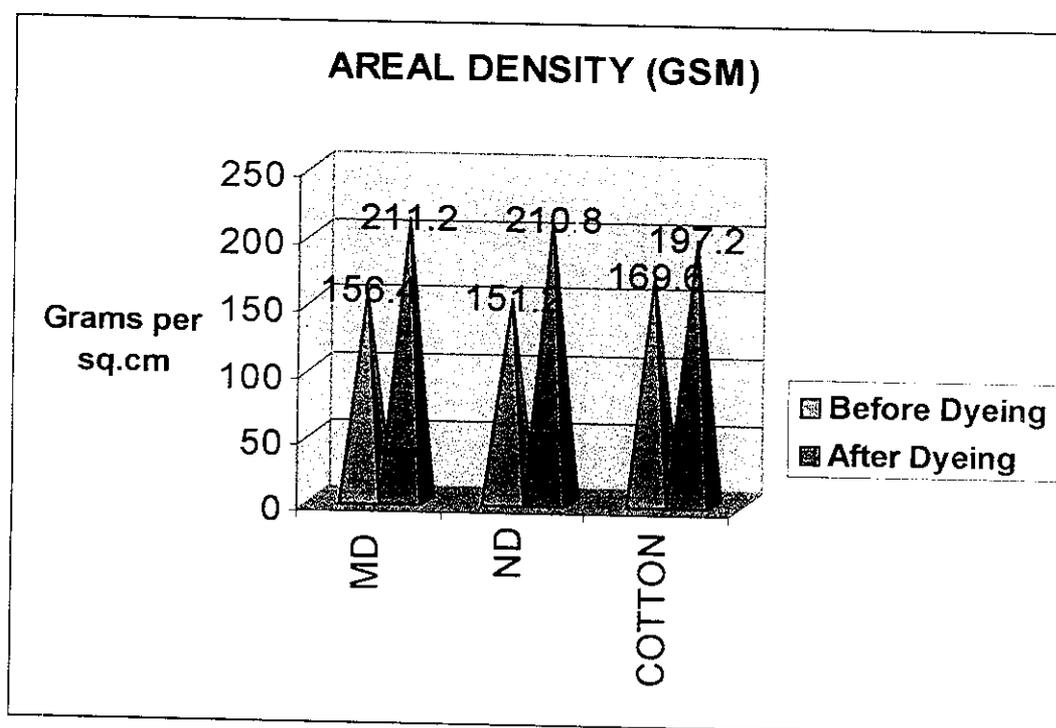
From the table no.3, we find that the percentage increase is very high in case of normal denier, which is followed by Micro denier knitted fabrics. Cotton knitted fabric is found to have the lowest GSM value among the three types.

The higher increase in percentage for Viscose knitted fabrics is due to higher shrinkage, which in turn is because of excessive stretch applied during their fibre manufacture

AREAL DENSITY (GSM): [TABLE NO: 3]

| TYPE | BEFORE DYEING (gm) | AFTER DYEING (gm) |
|---------------|-------------------------------|------------------------------|
| Micro denier | 156.4 | 211.2 |
| Normal denier | 151.2 | 210.8 |
| Cotton | 169.6 | 197.2 |

AREAL DENSITY: [TABLE NO: 3]



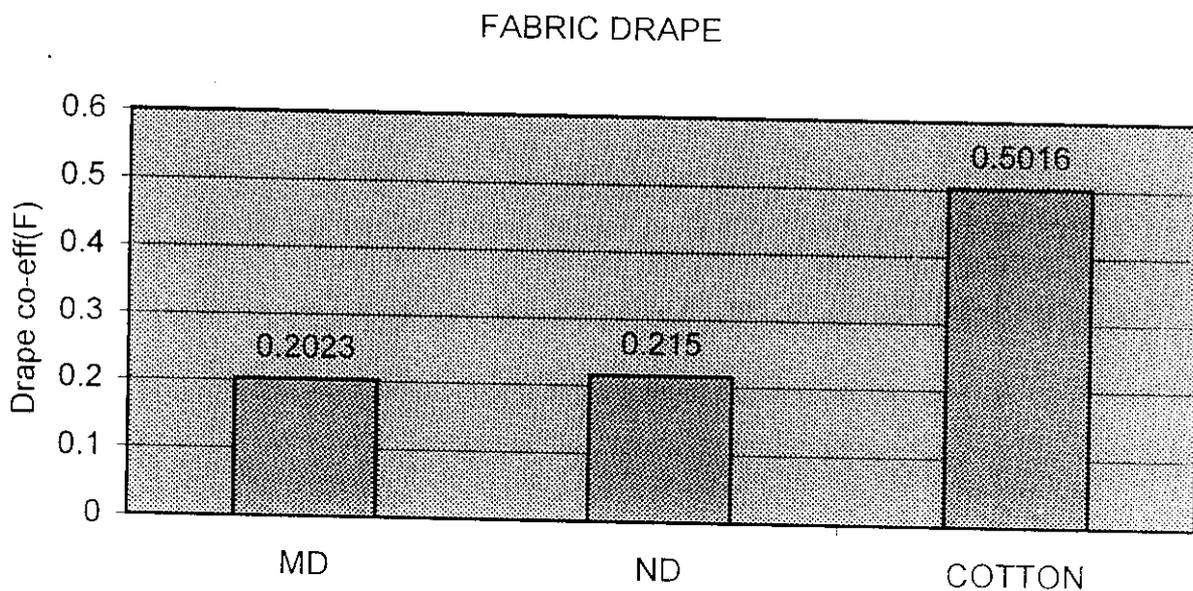
DRAPE:[TABLE NO:4]

The table no.4 indicates the values of Drapes for all three samples. From the given table, we could find out that Viscose Micro denier knitted fabrics has better Drapes-coefficient than normal denier Viscose and Cotton knitted fabrics, which is due to basic fibre fineness. Micro denier has 0.8d value whereas Cotton and normal denier have 1.5d and 1.2d respectively. This better Drapes found in Micro denier can also be correlated with tightness factor compared to that of Cotton.

TABLE NO: 4**FABRIC DRAPE:**

| FABRIC TYPE | W _D gm | W _S gm | W _d gm | DRAPE COEFFICIENT |
|---------------|----------------------|----------------------|----------------------|-------------------|
| Micro denier | 4.218 | 1.974 | 1.405 | 0.2023 |
| Normal denier | 4.219 | 2.010 | 1.405 | 0.2150 |
| Cotton | 4.218 | 2.816 | 1.405 | 0.5016 |

DRAPE TEST: [TABLE NO: 4]



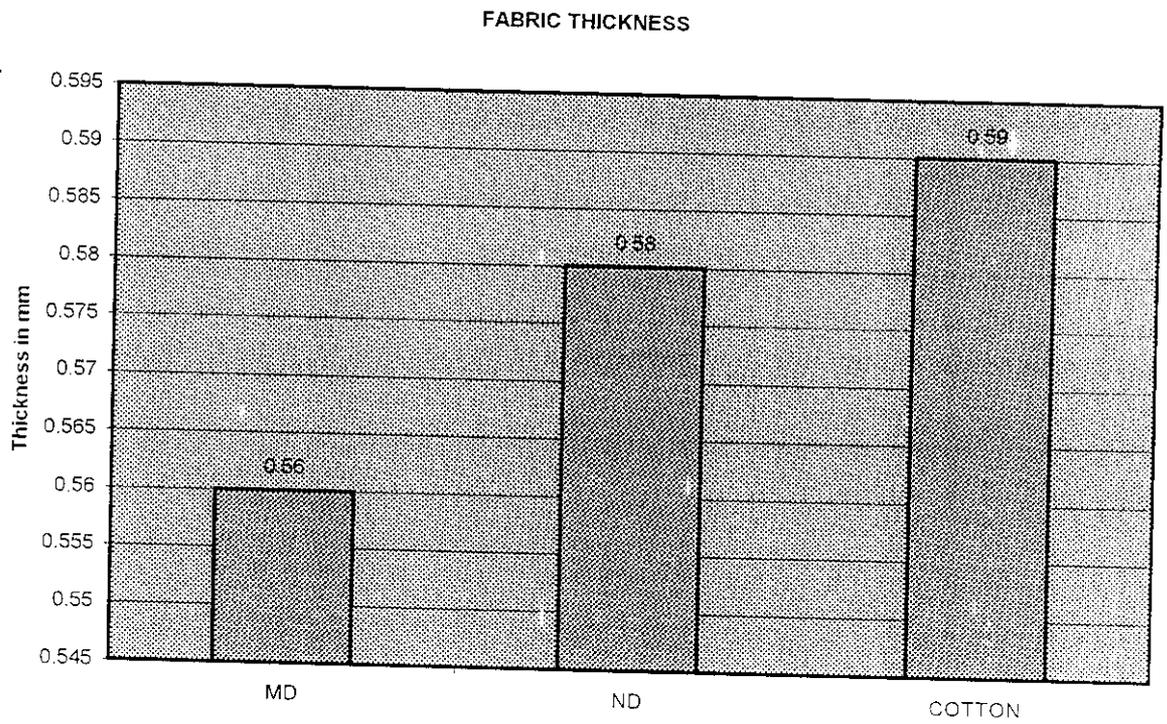
THICKNESS:[TABLE NO: 5]

The table no.5 shows thickness values for Viscose Micro denier and normal denier and Cotton knitted fabrics. Micro denier has lowest thickness because of its basic fineness in fibre denier. This lowest thickness value in Micro denier fabrics contributes towards better feel that is a prime property of Micro denier knitted fabric.

FABRIC THICKNESS:[TABLE NO: 5]

| MICRO DENIER (mm) | NORMAL DENIER (mm) | COTTON (mm) |
|-------------------|--------------------|-------------|
| 0.56 | 0.59 | 0.58 |
| 0.56 | 0.61 | 0.59 |
| 0.56 | 0.59 | 0.59 |
| 0.54 | 0.59 | 0.59 |
| 0.56 | 0.59 | 0.60 |
| 0.56 | 0.60 | 0.58 |
| 0.55 | 0.58 | 0.58 |
| 0.56 | 0.59 | 0.58 |
| 0.55 | 0.61 | 0.59 |
| 0.56 | 0.59 | 0.58 |

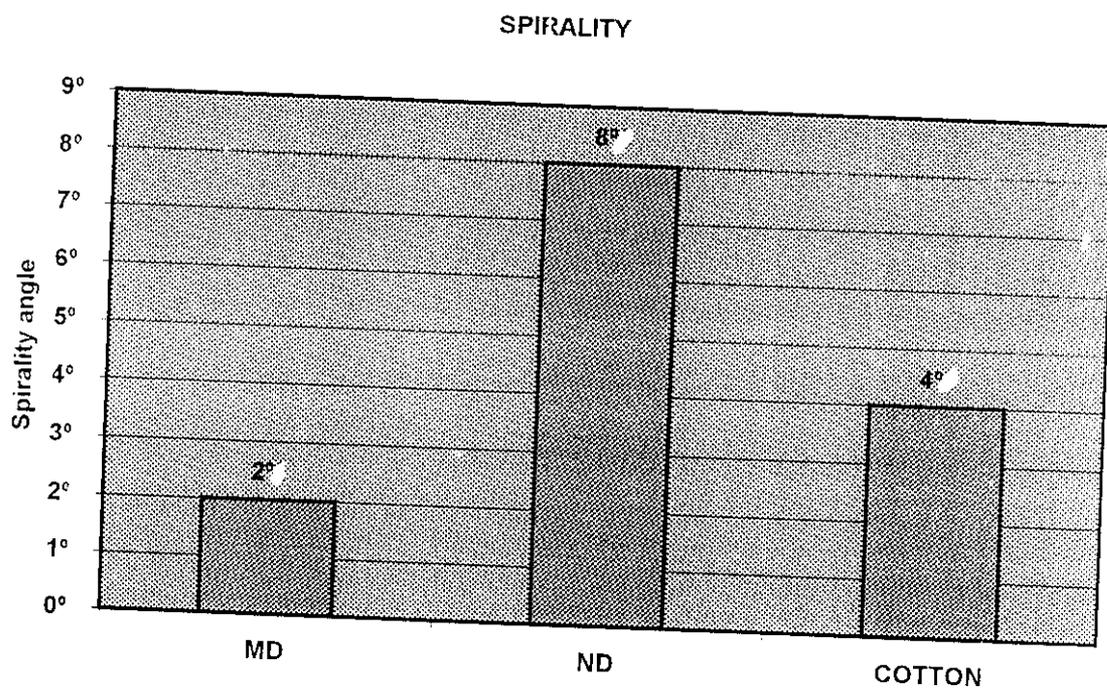
FABRIC THICKNESS: [TABLE NO: 5]



SPIRALITY: [TABLE NO: 6]

| FABRIC | SPIRALITY ANGLE (Degrees) |
|---------------|-----------------------------|
| Micro denier | 2° |
| Normal denier | 8° |
| Cotton | 4° |

SPIRALLITY: [TABLE NO: 6]



BURSTING STRENGTH: [TABLE NO: 7]

The table no.7 clearly gives values of bursting strength for Viscose Normal denier and Micro denier and Cotton knitted fabrics. The table shows that Micro denier has comparatively higher bursting strength than normal denier since more number of fibres can be accommodated in the yarn cross section for the same yarn diameter.

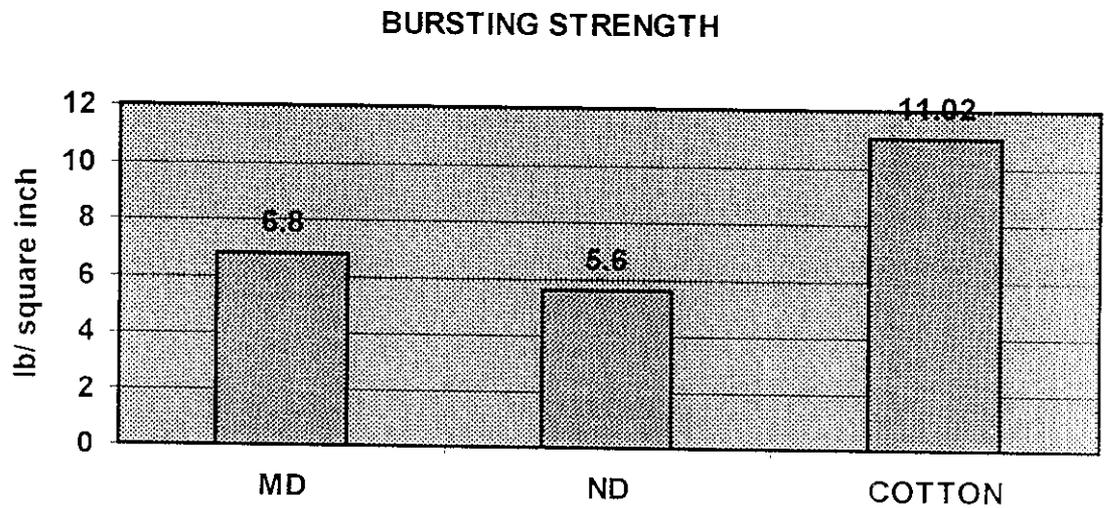
Higher bursting strength of Micro denier knitted fabrics can also be attributed to the high tenacity (GF/tex) of the Micro denier yarn, which can be inferred from the yarn test result.

Cotton has highest bursting strength value inspite of its lower yarn tenacity compared to Micro denier yarn due to higher yarn diameter maintained in basic fabrics.

BURSTING STRENGTH: [TABLE NO: 7]

| S.No | MICRO DENIER lb/sq. in | NORMAL DENIER lb/sq. in | COTTON lb/sq. in |
|------|---------------------------|----------------------------|---------------------|
| 1 | 6.8 | 5.6 | 11.2 |
| 2 | 6.8 | 5.8 | 11.0 |
| 3 | 6.8 | 5.6 | 10.5 |
| 4 | 6.8 | 5.6 | 11.2 |
| 5 | 6.8 | 5.4 | 11.2 |

BURSTING STRENGTH: [TABLE NO: 7]



WICK TEST:[TABLE NO: 8]

From the table no.8 both course-wise and wale-wise test values can be known. The Viscose normal denier knitted fabric has higher absorbency compared to both Viscose Micro denier and cotton knitted fabrics.

The low water absorbency found in Micro denier knitted fabric is due to higher crystallinity which inturn is due to excessive orientation.

WICK TEST: [TABLE NO: 8]

Wale-wise

Time In Seconds

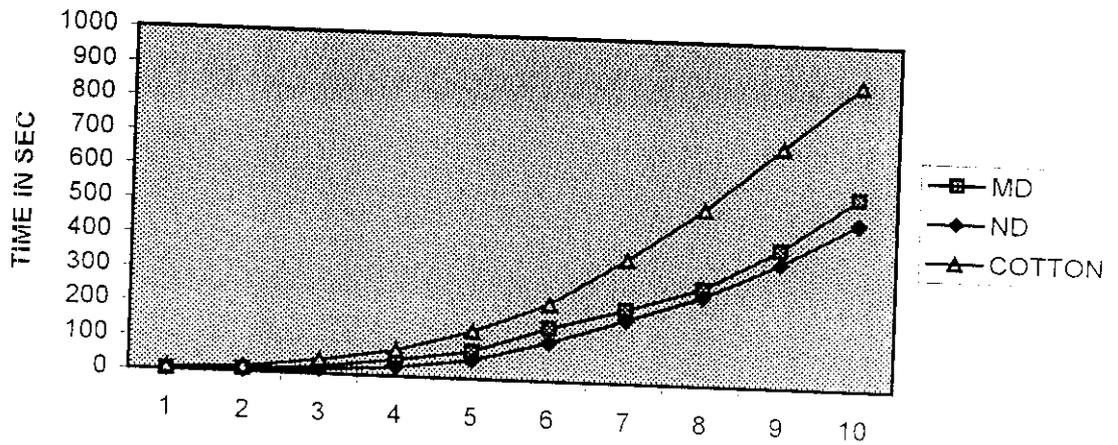
| HEIGHT IN CM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------------------|---|----|----|----|-----|-----|-----|-----|-----|-----|
| MICRO DENIER | 2 | 6 | 11 | 22 | 54 | 107 | 155 | 252 | 384 | 590 |
| NORMAL DENIER | 1 | 4 | 9 | 20 | 35 | 62 | 105 | 185 | 273 | 391 |
| COTTON | 8 | 21 | 45 | 84 | 166 | 248 | 351 | 475 | 598 | 752 |

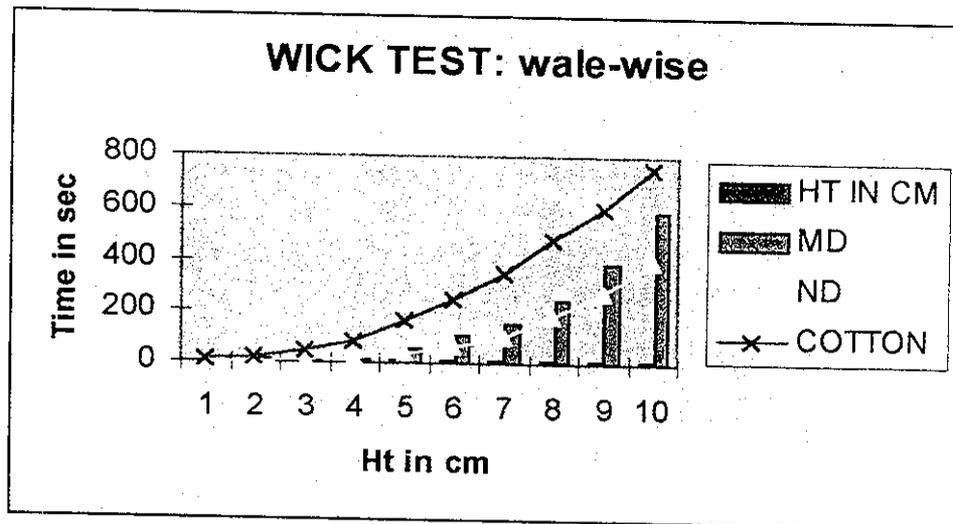
COURSE WISE

| | | | | | | | | | | |
|---------------|---|----|----|----|-----|-----|-----|-----|-----|-----|
| MICRO DENIER | 2 | 8 | 20 | 48 | 78 | 155 | 213 | 282 | 401 | 556 |
| NORMAL DENIER | 1 | 4 | 12 | 25 | 53 | 112 | 184 | 257 | 360 | 481 |
| COTTON | 7 | 15 | 41 | 75 | 138 | 222 | 360 | 512 | 697 | 885 |

WICK TEST: [TABLE NO: 8]

COURSE WISE



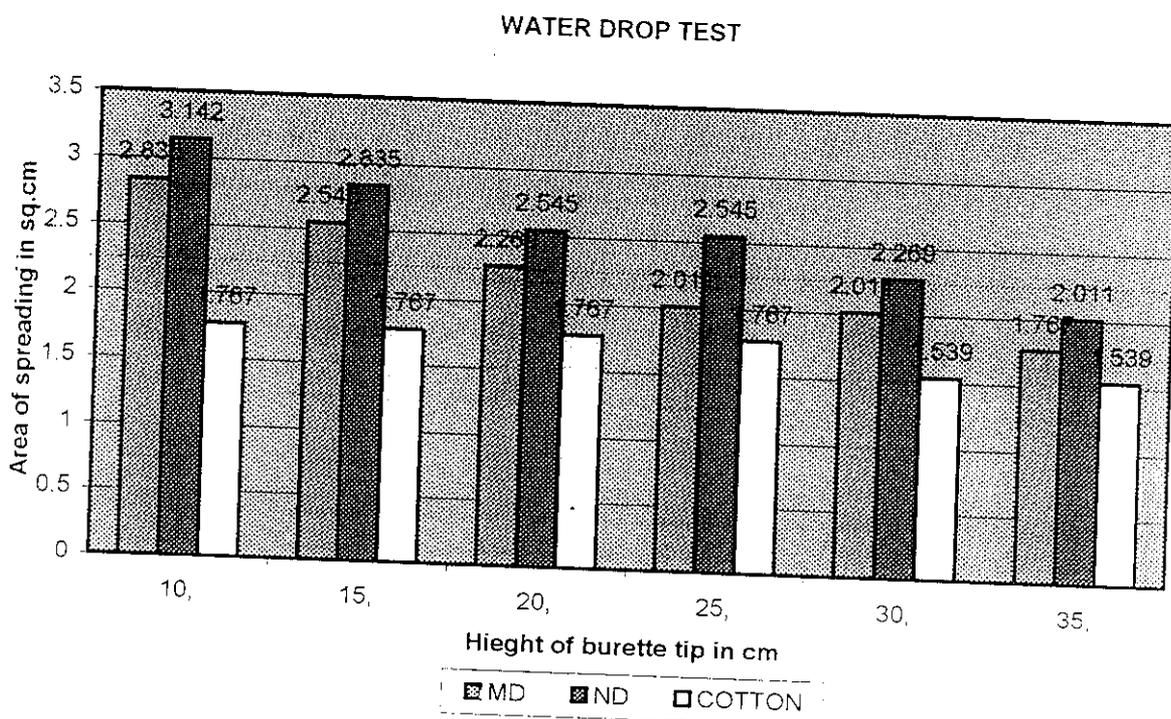


WATER DROP TEST: [TABLE NO: 9]

The table no.9 indicates the values for Water drop test for the previously mentioned three types of knitted fabrics. It is very clear from the table that after dyeing and relaxing Water drop from different heights spreads or absorbs more quickly in Viscose normal denier knitted fabrics which inturn is due to higher moisture regain for Viscose fabrics. Poor absorbency experienced in Cotton fabrics is due to low moisture regain value of Cotton (7-8%) instead of a 12-14% regain value in case of Viscose.

WATER DROP TEST: [TABLE NO: 9]

| HEIGHT OF BURETTE TIP | MICRODENIER | | NORMALDENIER | | COTTON | |
|--------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
| | Water spread dia (cm) | Spreading area (sq.cm) | Water Spread dia (cm) | Spreading area (sq.cm) | Water Spread dia (cm) | Spreading area (sq.cm) |
| 10 | 1.9 | 2.835 | 2.0 | 3.142 | 1.5 | 1.767 |
| 15 | 1.8 | 2.545 | 1.9 | 2.835 | 1.5 | 1.767 |
| 20 | 1.7 | 2.269 | 1.8 | 2.545 | 1.5 | 1.767 |
| 25 | 1.6 | 2.011 | 1.8 | 2.545 | 1.5 | 1.767 |
| 30 | 1.6 | 2.011 | 1.7 | 2.269 | 1.4 | 1.539 |
| 35 | 1.5 | 1.767 | 1.6 | 2.011 | 1.4 | 1.539 |



DIMENSIONAL CHANGES: [TABLE NO: 10]

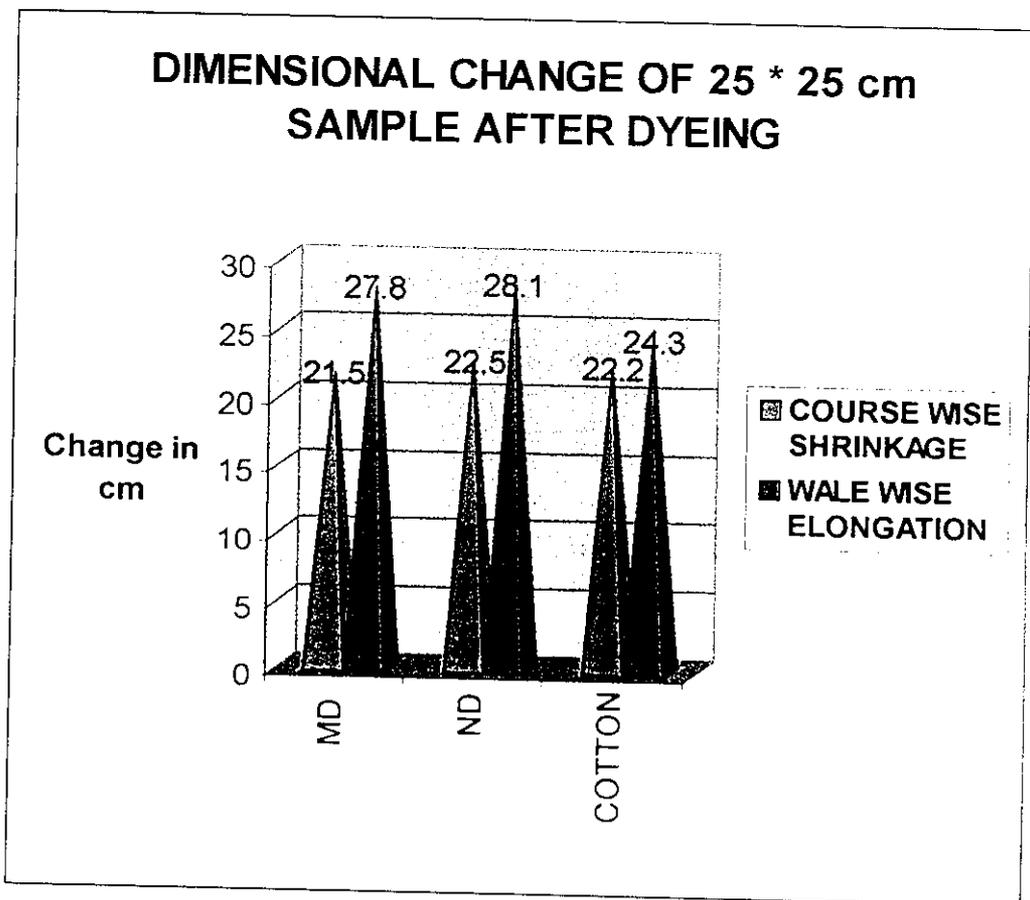
The table no.10 indicates the values for shrinkage for Micro denier and normal denier Viscose knitted fabrics and even Cotton knitted fabrics. Excess shrinkage in Micro denier fibre is due to excessive stretch given during spinning. This excessive stretch puts more strain on the fibre and the fibre tends to relax after spinning which inturn causes more shrinkage.

Sample Fabric Size – 25cm *25cm

TABLE NO: 10

| TYPE | SHRINKAGE COURSEWISE | ELONGATION WALEWISE |
|---------------|---------------------------------|--------------------------------|
| Micro denier | 21.5 cm | 27.8 cm |
| Normal denier | 22.5 cm | 28.1 cm |
| Cotton | 22.2 cm | 24.3 cm |

DIMENSIONAL CHANGES: [TABLE NO: 10]



ABRASION RESISTANCE: [TABLE NO: 11]

From the table no.11, we infer that Viscose Micro denier has very poor resistance compared to normal denier and Cotton knitted fabrics. This result is obtained due to very low individual fibre diameter which inturn attributes to poor Abrasion Resistance of the fabrics.

ABRASION RESISTANCE: [TABLE NO: 11]

NO OF CYCLES: 150

ABRADANT: 1/0

COTTON:

| S.No | Initial weight | Final weight | Loss in weight | % Loss in weight |
|------|----------------|--------------|----------------|------------------|
| 1 | 0.241 | 0.232 | 0.009 | 3.73 |
| 2 | 0.228 | 0.217 | 0.011 | 4.82 |
| 3 | 0.229 | 0.216 | 0.013 | 5.68 |
| 4 | 0.2239 | 0.227 | 0.012 | 5.02 |
| 5 | 0.2335 | 0.225 | 0.010 | 4.25 |

Avg. % weight loss = 4.7%

NORMAL DENIER:

| S.N O | INITIAL WEIGHT (gm) | FINAL WEIGHT (gm) | LOSS IN WEIGHT | % LOSS IN WEIGHT |
|----------|---------------------------|----------------------|-------------------|---------------------|
| 1 | 0.310 | 0.286 | 0.024 | 7.74 |
| 2 | 0.301 | 0.282 | 0.019 | 6.3 |
| 3 | 0.313 | 0.285 | 0.028 | 8.94 |
| 4 | 0.308 | 0.283 | 0.025 | 8.9 |
| 5 | 0.299 | 0.281 | 0.018 | 6.1 |

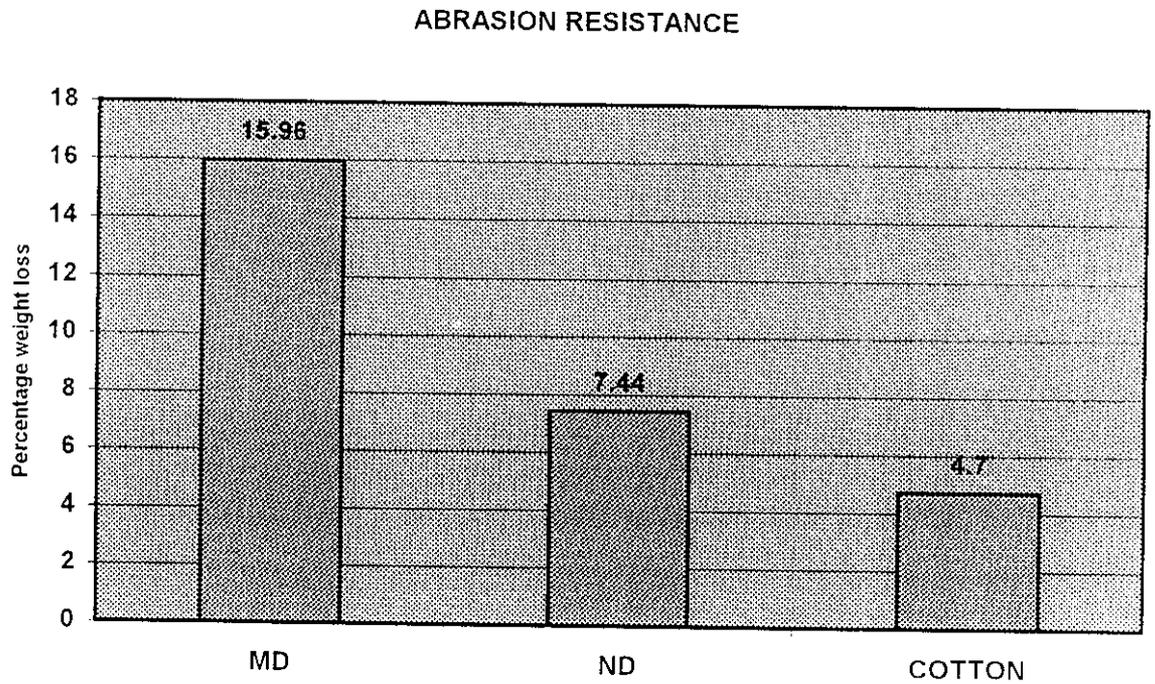
Average % loss in weight = 7.44%

MICRO DENIER:

| S.N O | INITIAL WEIGHT (gm) | FINAL WEIGHT (gm) | LOSS IN WEIGHT | % LOSS IN WEIGHT |
|----------|---------------------------|----------------------|-------------------|---------------------|
| 1 | 0.0284 | 0.242 | 0.042 | 14.79 |
| 2 | 0.286 | 0.236 | 0.050 | 17.58 |
| 3 | 0.283 | 0.236 | 0.047 | 16.06 |
| 4 | 0.289 | 0.256 | 0.043 | 14.8 |
| 5 | 0.280 | 0.235 | 0.055 | 16.07 |

Average % loss in weight = 4.7%

ABRASION RESISTANCE [TABLE NO: 11]



PILLING: [TABLE NO: 12]

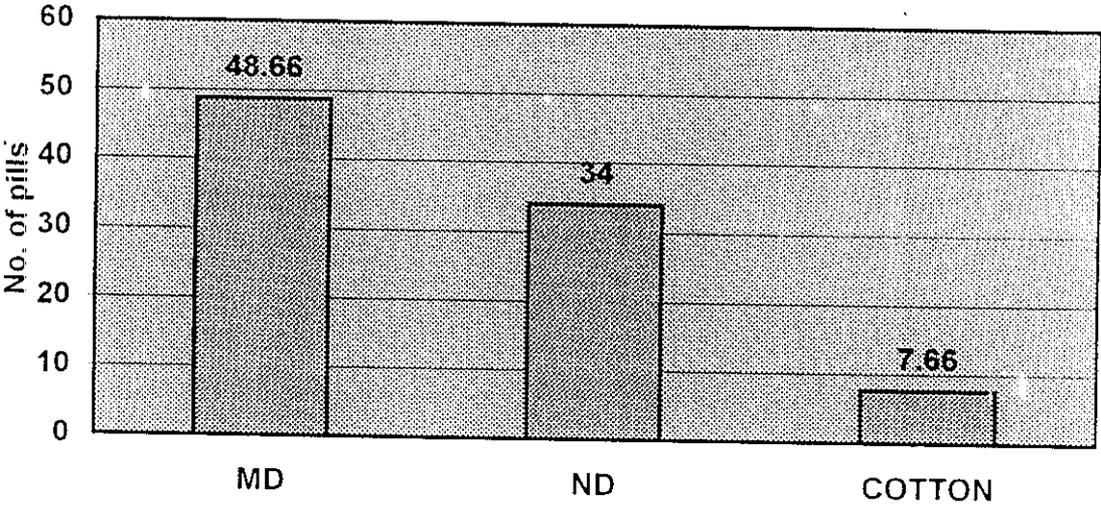
Table no.12 indicates the pilling values of the sample fabrics. We can infer from the table that micro denier forms less pills than normal denier fibre which can be attributed to the fibre fineness. Due to fibre fineness during pill formation they fall off the fabric surface.

| NO. OF PILLS | STANDARD |
|--------------|----------|
| 0 - 4 | 5 |
| 5 - 10 | 4 |
| 11 - 20 | 3 |
| 21 - 40 | 2 |
| 41 - 60 | 1 |
| > 60 | 0 |

| FABRIC | NO. OF PILLS | AVERAGE | STANDARD |
|--------|--------------|---------|----------|
| ND | 48 | | |
| | 52 | 46 | 1 |
| | 46 | | |
| MD | 34 | | |
| | 36 | 34 | 2 |
| | 32 | | |
| COTTON | 8 | | |
| | 9 | 7 | 4 |
| | 6 | | |

PILLING: [TABLE NO: 12]

FABRIC PILLING

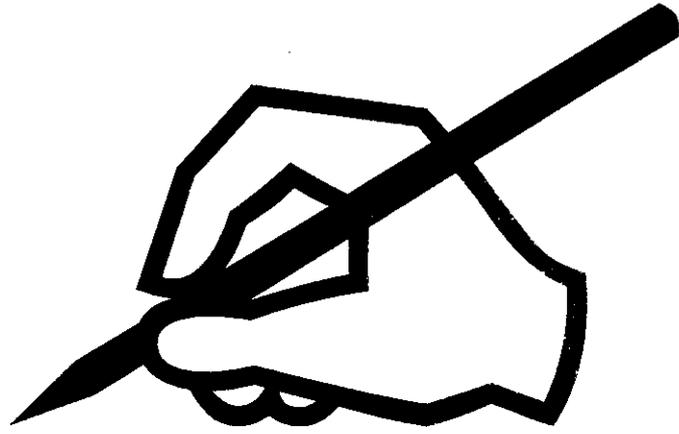


6.0 ECONOMICS OF MICROFIBRE PROCESSING^[1]

The price of microfibre is generally 5-10% higher than the conventional fibre (e.g. 0.8 denier is 8% costlier than 1.0 denier) that will push up the yarn price by 4%. However, the conversion cost of fibre to yarn will come down due to increased production per spindle at ring frame and flyer frame owing to reduction in twist by 5-10%. Also due to the better working of ring frame, the work assignment of ring frame tenters can be increased to some extent. Consequently, the net increase in yarn cost may become 2%.

As against the 2% increase in yarn cost there are many advantages. The products made out of microfibre yarns are more attractive due to their softer feel, greater absorbency etc. The fabrics fetch more prices due to their specialized nature. Besides, it is possible to produce value added products using these fibres. Hence, the benefits outweigh the marginal increase in yarn cost.

The above figures are based on the experience of mills that used 0.8 denier fibres. Also the products made out of these yarns are more attractive due to their softer feel, greater absorbency and other benefits described earlier. The fabrics fetch more prices due to their specialized nature. In conclusion, it can be said that use of micro fibres is economically attractive if the products are marketed properly.



Conclusion

CONCLUSION

As rightly said in the introduction, Micro fibres are one of the epochal achievements of the man-made fibres industry, which has introduced a new era in textile products, in that they have outdone the natural fibres.

The Micro fibres had become a fascinating a high quality product of the man-made fibres industry on today's textile market.

From the experimental studies, Micro denier fibres exhibit better properties in the following aspects,

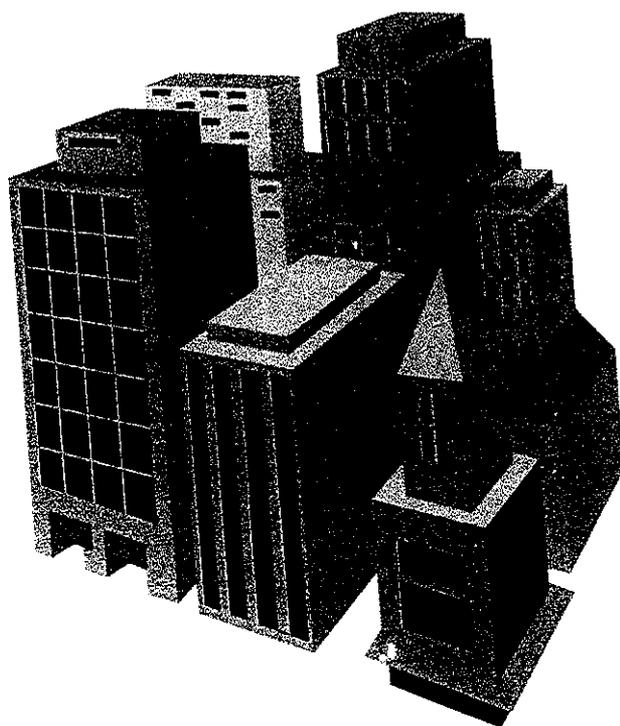
1. Microfibre fabrics exhibit excellent softness, supple handle and silky appearance due to low denier per filament, which in turn is due to reduction in bending modulus.
2. Microfibre fabrics have excellent drapeability because of low bending modulus, which is due to less area of yarn cross-section.
3. Spirality of two degrees in the Microfibre knitted fabric is found to be well below tolerance limits due to low twist given to the yarn.
4. The bursting strength of Micro denier knitted fabric found to be higher than the normal denier knitted fabric as the micro denier yarn has more number of fibres in its cross-section.
5. The water absorbency nature of Microfibre fabric is slightly lesser than the normal denier fabric since the Micro denier fibres are highly oriented.

6. The Micro denier knitted fabric is dimensionally more stable when compared to that of normal denier and cotton fabrics because loop shape deformation is minimum.
7. The cover of Micro denier knitted fabrics is comparatively better than normal denier knitted fabric due to the fact that micro fibre fabrics have better tightness factor.
8. Pilling resistance of the Micro knitted fabric is slightly better than normal denier knitted fabric because of soft nature of the micro fibres.
9. Micro denier knitted fabric has poor Abrasion resistance and dyeability due to fineness of micro fibres.

Major portion of single jersey knitted fabrics is rejected due to spirality problem. From these studies, we found that using the micro fibre yarns for production of single jersey knitted fabrics considerably reduces the spirality and makes it to lie well below the tolerable limits. This inturn will enhance the fabric realization and reduce the fabric rejection.

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15. Web-sites such as www.adityabirla.com, www.grasim.com



Annexure

ANNEXURES

CONSUMPTION OF MAJOR FIBRES / YARNS

| Year | Cotton | Man-Made Fibre | | Man-Made Filament Yarn | | Total (Including Other Fibres) |
|---------|--------|----------------|-----------|------------------------|-----------|--------------------------------------|
| | | Cellulose | Synthetic | Cellulose | Synthetic | |
| 1980-81 | 1313 | 145 | 39 | 47 | 44 | 1588 |
| 1981-82 | 1229 | 175 | 48 | 45 | 62 | 1559 |
| 1982-83 | 1195 | 121 | 56 | 40 | 70 | 1482 |
| 1983-84 | 1418 | 111 | 62 | 43 | 93 | 1727 |
| 1984-85 | 1475 | 119 | 73 | 35 | 98 | 1808 |
| 1985-86 | 1559 | 105 | 85 | 40 | 111 | 1911 |
| 1986-87 | 1624 | 97 | 110 | 45 | 11 | 2013 |
| 1987-88 | 1649 | 119 | 108 | 43 | 125 | 2142 |
| 1988-89 | 1622 | 129 | 123 | 43 | 189 | 2186 |
| 1989-90 | 1689 | 148 | 133 | 46 | 204 | 2307 |
| 1990-91 | 1822 | 154 | 169 | 48 | 244 | 2522 |
| 1991-92 | 1766 | 163 | 191 | 52 | 247 | 2502 |
| 1992-93 | 1895 | 161 | 206 | 46 | 276 | 2680 |
| 1993-94 | 2051 | 181 | 291 | 51 | 340 | 3037 |
| 1994-95 | 2065 | 195 | 348 | 56 | 382 | 3151 |
| 1995-96 | 2295 | 207 | 350 | 55 | 433 | 3446 |
| 1996-97 | 2566 | 186 | 460 | 53 | 528 | 3913 |
| 1997-98 | 2719 | 196 | 563 | 54 | 673 | 4385 |
| 1998-99 | 2485 | 183 | 598 | 52 | 768 | 4218 |

**GROWTH OF THE MAN-MADE FIBRE INDUSTRY
(INSTALLED CAPACITY)**

| AS ON | MAN-MADE FIBRES | | | | | |
|-----------|-----------------|---------|-----------|---------|---------------|-----------|
| | Viscose | Acetate | Polyester | Acrylic | Polypropylene | Total |
| 31-3-1981 | 97,400 | 800 | 33,575 | 16,000 | - | 147,775 |
| 31-3-1982 | 97,670 | 800 | 35,825 | 16,000 | - | 150,295 |
| 31-3-1983 | 97,670 | 800 | 36,925 | 16,000 | - | 151,395 |
| 31-3-1984 | 97,670 | 800 | 44,368 | 16,000 | - | 158,838 |
| 31-3-1985 | 107,670 | 800 | 44,994 | 20,000 | - | 173,464 |
| 31-3-1986 | 107,670 | 800 | 43,272 | 22,500 | - | 174,242 |
| 31-3-1987 | 112,700 | 800 | 128,506 | 22,500 | - | 264,506 |
| 31-3-1988 | 112,700 | 800 | 146,218 | 22,500 | - | 282,506 |
| 31-3-1989 | 116,700 | 800 | 204,062 | 36,000 | - | 357,562 |
| 31-3-1990 | 157,850 | 800 | 230,062 | 48,000 | - | 436,712 |
| 31-3-1991 | 176,050 | 800 | 230,062 | 63,000 | 4,300 | 474,212 |
| 31-3-1992 | 186,575 | 800 | 230,062 | 63,000 | 4,300 | 484,737 |
| 31-3-1993 | 186,575 | 800 | 230,062 | 87,000 | 5,300 | 509,737 |
| 31-3-1994 | 222,950 | 800 | 230,062 | 87,000 | 5,800 | 546,612 |
| 31-3-1995 | 206,000 | 800 | 271,713 | 98,000 | 5,800 | 582,313 |
| 31-3-1996 | 220,650 | 800 | 277,113 | 98,000 | 5,800 | 602,363 |
| 31-3-1997 | 220,650 | 800 | 461,113 | 98,000 | 5,800 | 792,363 |
| 31-3-1998 | 287,975 | 800 | 613,798 | 98,000 | 7,800 | 1008,373 |
| 31-3-1999 | 306,225 | 800 | 631,568 | 118,500 | 7,300 | 1,064,383 |

FIBRE WISE CAPACITY / PRODUCTION & CAPACITY UTILISATION

| Product | 1994-95 | 1995-96 | 1996-97 | 1997-98 | 1998-99 |
|---|---------|---------|---------|---------|---------|
| 1. <u>Viscose Staple Fibre</u> | | | | | |
| (a) Capacity | 206,000 | 220,650 | 220,650 | 287,975 | 306,225 |
| (b) Production | 173,113 | 194,340 | 178,783 | 188,399 | 178,180 |
| (c) Capacity Utilization | 84.04 | 88.08 | 81.03 | 65.42 | 58.19 |
| 2. <u>Polyester Staple Fibre</u> | | | | | |
| (a) Capacity | 271,713 | 277,113 | 467,113 | 613,798 | 631,568 |
| (b) Production | 221,074 | 228,096 | 324,729 | 438,616 | 522,670 |
| (c) Capacity Utilization | 81.36 | 82.31 | 69.52 | 71.46 | 82.76 |
| 3. <u>Arcylic Staple Fibre</u> | | | | | |
| (a) Capacity | 98,000 | 98,000 | 98,000 | 98,000 | 118,500 |
| (b) Production | 82,734 | 74,082 | 82,818 | 79,430 | 78,917 |
| (c) Capacity Utilization | 84.42 | 75.59 | 84.51 | 81.05 | 66.60 |
| 4. <u>Polypropylene Stable Fibre</u> | | | | | |
| (a) Capacity | 5,800 | 5,800 | 5,800 | 7,800 | 7,300 |
| (b) Production | 1,703 | 1,863 | 1,892 | 1,971 | 1,880 |
| (c) Capacity Utilization | 29.36 | 32.12 | 32.62 | 25.27 | 25.75 |

PRODUCTION AND DELIVERY OF MAN-MADE FIBRES

| Year | Viscose | Acrylic | Polyester | Poly – propylene | Viscose | Polyester | Acrylic | Poly – propylene |
|---------|---------|---------|-----------|---------------------|---------|-----------|---------|---------------------|
| 1980-81 | 82,668 | 10,063 | 22,434 | - | 85,027 | - | 24,874 | - |
| 1981-82 | 84,199 | 13,606 | 29,709 | - | 79,997 | - | 28,073 | - |
| 1982-83 | 49,288 | 16,155 | 25,773 | - | 50,300 | - | 24,130 | - |
| 1983-94 | 82,784 | 16,589 | 26,872 | - | 82,221 | 15,203 | 27,572 | - |
| 1984-85 | 102,018 | 20,883 | 38,976 | - | 99,579 | 22,172 | 42,008 | - |
| 1985-86 | 89,981 | 21,819 | 42,828 | - | 92,589 | 21,020 | 42,931 | - |
| 1986-87 | 96,301 | 23,062 | 65,627 | - | 94,516 | 23,407 | 56,319 | - |
| 1987-88 | 119,451 | 22,092 | 79,434 | - | 117,773 | 22,075 | 76,687 | - |
| 1988-89 | 125,702 | 26,344 | 111,579 | - | 124,064 | 32,262 | 103,245 | - |
| 1989-90 | 147,646 | 30,480 | 127,120 | - | 148,132 | 24,717 | 124,333 | - |
| 1990-91 | 160,173 | 42,483 | 134,207 | 993 | 154,027 | 40,817 | 131,610 | 956 |
| 1991-92 | 158,075 | 46,994 | 135,944 | 1,501 | 164,646 | 48,098 | 142,954 | 902 |
| 1992-93 | 162,453 | 55,027 | 161,820 | 1,066 | 162,211 | 50,631 | 158,274 | 1,048 |
| 1993-94 | 183,335 | 68,352 | 200,090 | 1,558 | 179,930 | 63,818 | 205,203 | 1,450 |
| 1994-95 | 173,113 | 82,734 | 221,074 | 1,703 | 177,794 | 82,896 | 213,157 | 1,748 |
| 1995-96 | 194,340 | 74,082 | 228,096 | 1,863 | 192,674 | 75,901 | 225,352 | 1,817 |
| 1996-97 | 178,783 | 82,818 | 324,729 | 1,892 | 174,338 | 81,624 | 317,805 | 1,842 |
| 1997-98 | 188,399 | 79,430 | 438,616 | 1,971 | 183,975 | 77,532 | 442,638 | 1,989 |
| 1998-99 | 178,180 | 78,917 | 522,670 | 1,880 | 177,009 | 73,823 | 488,818 | 1,928 |

IMPORT AND EXPORT OF MAN-MADE FIBRES

| Year | Viscose | Polyester | Acrylic | Acetate | Viscose | Polyester | Acrylic |
|---------|---------|-----------|---------|---------|---------|-----------|---------|
| 1980-81 | 59,686 | 4,285 | 2,090 | 50 | - | - | - |
| 1981-82 | 94,416 | 3,199 | 1,869 | 26 | - | - | - |
| 1982-83 | 70,604 | 10,588 | 3,914 | - | - | - | - |
| 1983-84 | 26,626 | 16,893 | 3,884 | 239 | - | - | - |
| 1984-85 | 18,561 | 5,645 | 3,412 | 10 | - | - | - |
| 1985-86 | 12,152 | 16,087 | 5,907 | 49 | - | - | - |
| 1986-87 | 1,986 | 26,928 | 3,315 | 157 | - | - | - |
| 1987-88 | 1,369 | 8,202 | 4,563 | 202 | - | 5,595 | - |
| 1988-89 | 262 | 5,545 | 6,242 | 63 | 52 | 17,072 | 114 |
| 1989-90 | 307 | 9,455 | 11,246 | 290 | 560 | 35,945 | 191 |
| 1990-91 | 343 | 10,476 | 8,327 | 258 | 356 | 23,871 | 180 |
| 1991-92 | 27 | 8,369 | 3,136 | 376 | 1,552 | 13,185 | 396 |
| 1992-93 | 885 | 9,106 | 3,967 | 67 | 1,742 | 17,313 | 350 |
| 1993-94 | 1,559 | 19,137 | 6,370 | 307 | 630 | 7,105 | 469 |
| 1994-95 | 18,573 | 44,306 | 14,322 | 640 | 725 | 11,002 | 1,069 |
| 1995-96 | 14,577 | 40,433 | 13,894 | 521 | 326 | 8,889 | 217 |
| 1996-97 | 12,667 | 38,564 | 27,847 | 532 | 568 | 8,229 | 379 |
| 1997-98 | 13,833 | 29,766 | 34,087 | 440 | - | 10338* | - |
| 1998-99 | 2,570 | 17,285 | 33,193 | 804 | - | 2291* | - |

Table I : World production of fibre materials in 1000 tones and % proportion

| Year | Cotton | % | Wool | % | Filament | % | Staple Fibre | % | Cellulose | % | Total |
|------|--------|----|------|---|----------|----|--------------|----|-----------|----|-------|
| 1970 | 11784 | 54 | 1659 | 8 | 2399 | 11 | 2419 | 11 | 3579 | 16 | 21840 |
| 1975 | 11723 | 49 | 1578 | 7 | 3679 | 16 | 3670 | 15 | 3201 | 13 | 23941 |
| 1980 | 13844 | 47 | 1599 | 5 | 4743 | 16 | 5882 | 20 | 3557 | 12 | 29625 |
| 1985 | 17383 | 49 | 1744 | 5 | 5811 | 16 | 7307 | 21 | 3218 | 9 | 35463 |
| 1990 | 18997 | 48 | 1927 | 5 | 7173 | 18 | 8201 | 21 | 3145 | 8 | 39443 |
| 1995 | 19962 | 46 | 1486 | 3 | 10169 | 23 | 9021 | 21 | 3014 | 7 | 43652 |
| 1996 | 18960 | 41 | 1476 | 3 | 12180 | 27 | 10285 | 23 | 2859 | 6 | 45761 |
| 1997 | 19849 | 41 | 1441 | 3 | 13419 | 27 | 11207 | 23 | 2899 | 6 | 48815 |

USER TESTER 3 V2.42 TU 20-20-01 16:06
STATEX MILLS, PALLADAM ROAD, COIMBATORE. 641 032

SINGLE - / OVERALL RESULTS

Art.no. COPS Test.no. 00011 Fiber assembly: 25 %

Imperfections: short staple

100 % VISCOSE MICRODENIER

V:100 m /min t: 1.0 min Test : 1/1 Slot: 3/yarns Yarn tenstion: 25 %

Imperfection: short staple

| Test no. | Um (%) | CVm (%) | CV(im) (%) | Index (-) | Thin places (-50%) | Thick Pl. (+50 %) | Neps (+200%) | Rel. count (%) |
|------------|--------|---------|------------|-----------|--------------------|-------------------|--------------|----------------|
| 1 | 7.85 | 9.95 | 3.74 | 1.30 | 0 | 2 | 2 | 100.0 |
| Mean value | 7.85 | 9.95 | 3.74 | 1.30 | 0 | 2 | 2 | 100.0 |

STATEX MICROPROCESSOR TWIST TESTER

| | | | | |
|----------------------|---|------------------|-----------------|------------|
| YARN | : | MICRO DENIER VSF | | |
| PROGRAMMED TIME | : | 0600 | DATE | : 20-02-01 |
| SPINDLE NO | : | 2 | MACHINE NO | : 2196 |
| COUNT | : | 25 | YARN TENSION | : 7.9 |
| NO. OF TEST/PACKAGE | : | 10 | No.OF PACKAGE | : 10 |
| SAMPLE LENGTH (Inch) | : | 20.0 | STANDARD T.P.I: | 20 |

RESULT : SINGLE YARN – ‘Z’ OPERATOR CODE NO:

| | | |
|----------|----|-------|
| Test No. | 01 | 16.57 |
| Test No. | 02 | 15.67 |
| Test No. | 03 | 15.92 |
| Test No. | 04 | 16.34 |
| Test No. | 05 | 16.72 |
| Test No. | 06 | 15.37 |
| Test No. | 07 | 16.54 |
| Test No. | 08 | 15.19 |
| Test No. | 09 | 15.37 |
| Test No. | 10 | 15.54 |

| | |
|---------------------|-------|
| Average T.P.I. | 15.92 |
| T. P.M | 627.0 |
| Standard Deviation | .5739 |
| Coeff. Of Variation | 3.603 |

Statex Tensostate
 Statex Mills,
 Coimbatore

Date : 20/02/2001
 Count : 25 NeC Micro Denier VSF
 Speed : 5000 mm/min
 Load Lts : 100-1000
 Operator : S. GANESH
 Article : 1
 Shade : 1

Time : 5:11:27 PM
 Pretension : 12.30 GF
 Length : 500 mm
 Elongation Lts: 3-30 %
 Report Type : Statistical
 Ticket No : 1
 Requisition : 1

| Sample | Test No | Load (GF) | Elongation (%) | Time To Break | Tenacity (GF/Tex) |
|--------------|---------|-----------|----------------|---------------|-------------------|
| Sample No:-1 | | | | | |
| | | 439.01 | 12.60 | 0.91 | 18.59 |
| Average | | | | 5.77 | 6.04 |
| C. V. | | 6.04 | 6.56 | | |
| Sample No:-2 | | | | | |
| | | 458.32 | 12.01 | 0.87 | 19.40 |
| Average | | | | 5.48 | 6.37 |
| C. V. | | 6.37 | 6.56 | | |

Sample No:-3

| | | | | |
|---------------|--------|-------|------|-------|
| Average | 466.87 | 13.16 | 0.97 | 19.77 |
| C. V. | 5.26 | 6.06 | 5.39 | 5.26 |
| Overall Avg | 454.73 | 12.59 | 0.92 | 19.25 |
| Overall C.V. | 6.26 | 7.24 | 6.88 | 6.26 |
| Overall Min | 402.23 | 10.73 | 0.78 | 17.03 |
| Overall Max | 501.09 | 14.53 | 1.05 | 21.21 |
| Overall Range | 98.86 | 3.80 | 0.27 | 4.18 |
| Overall S. D. | 28.47 | 0.91 | 0.06 | 1.21 |

Statex Tensostate
Statex Mills,
Coimbatore

Date : 20/02/2001
Count : 25 NeC Micro Denier VSF
Speed : 5000 mm/min
Load Lts : 100-1000
Operator : S. GANESH
Article : 1
Shade : 1

Time : 4:24:54 PM
Pretension : 11.81 GF
Length : 500 mm
Elongation Lts: 3-30 %
Report Type : Statistical
Ticket No : 1
Requisition : 1

| Sample | Test No | Load (GF) | Elangation (%) | Time To Break | Tenacity (GF/Tex) |
|--------|---------|-----------|----------------|---------------|-------------------|
|--------|---------|-----------|----------------|---------------|-------------------|

Sample No:-1

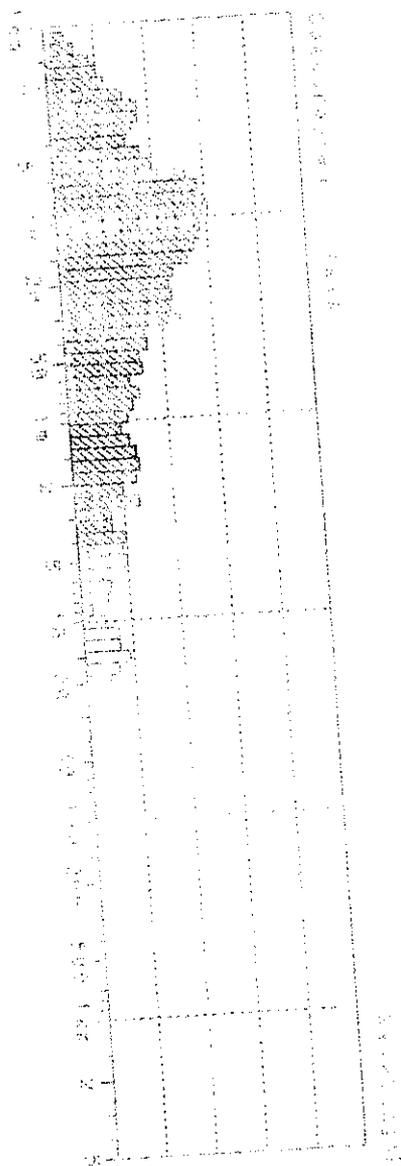
| | | | | | |
|---------|--|--------|-------|------|-------|
| Average | | 445.97 | 13.41 | 0.96 | 18.88 |
| C. V. | | 4.30 | 5.08 | 6.40 | 4.30 |

Sample No:-2

| | | | | | |
|---------|--|--------|-------|------|-------|
| Average | | 443.92 | 13.54 | 0.96 | 18.79 |
| C. V. | | 7.27 | 6.48 | 4.50 | 7.27 |

| | | | | | |
|---------------|--|--------|-------|------|-------|
| Overall Avg | | 444.92 | 13.47 | 0.96 | 18.84 |
| Overall C.V. | | 5.81 | 5.69 | 5.38 | 5.81 |
| Overall Min | | 383.79 | 11.95 | 0.89 | 16.25 |
| Overall Max | | 495.97 | 14.54 | 1.04 | 21.00 |
| Overall Range | | 112.18 | 2.59 | 0.15 | 4.75 |
| Overall S. D. | | 25.85 | 0.77 | 0.05 | 1.09 |

MICRO DENIER



STATEX MILLS, PALLADAM ROAD, COIMBATORE. 641 032

SINGLE - / OVERALL RESULTS

Art.no. COPS Test.no. 00012 Fiber assembly: 25 %
Fiber : 3.5 % ug/i

100 % NORMALDENIER

V:400 m/min t: 1.0 min Test : 1/1 Slot: 3/yarns Yarn tenstion: 25 %

| Test no. | Um (%) | CVm (%) | CV(im) (%) | Index (-) | Thin places (-50%) | Thick Pl. (+50 %) | Neps (+200%) | Rel. count (%) |
|------------|--------|---------|------------|-----------|--------------------|-------------------|--------------|----------------|
| 1 | 13.11 | 16.88 | 8.64 | 2.21 | 6 | 101 | 209 | 100 |
| Mean value | 13.11 | 16.88 | 8.64 | 2.21 | 15/ km | 252/km | 522/km | 100 |

STATEX MICROPROCESSOR TWIST TESTER

YARN : NORMAL DENIER VSF
PROGRAMMED TIME : 0640 DATE : 20-02-01
SPINDLE NO : 2 MACHINE NO : 2196
COUNT : 25 YARN TENSION : 6.9
NO. OF TEST/PACKAGE : 10 No.OF PACKAGE: 10
SAMPLE LENGTH (INCHE): 20.0 STANDARD T.P.I: 20

RESULT : SINGLE YARN – ‘Z’ OPERATOR CODE NO:

| | | |
|----------|----|-------|
| Test No. | 01 | 15.59 |
| Test No. | 02 | 14.82 |
| Test No. | 03 | 14.42 |
| Test No. | 04 | 16.87 |
| Test No. | 05 | 15.97 |
| Test No. | 06 | 15.94 |
| Test No. | 07 | 16.84 |
| Test No. | 08 | 14.14 |
| Test No. | 09 | 14.04 |
| Test No. | 10 | 15.17 |

| | |
|---------------------|-------|
| Average T.P.I. | 15.38 |
| T.P.M | 605.6 |
| Standard Deviation | 1.036 |
| Coeff. Of Variation | 6.734 |

Statex Tensostate
Statex Mills,
Coimbatore

| | | | |
|-------------|----------------------------|-----------------|--------------|
| Date | : 20/02/2001 | Time | : 5:11:27 PM |
| Count | : 25 NeC Normal Denier VSF | Pretension | : 12.30 GF |
| Speed | : 5000 mm/min | Length | : 500 mm |
| Load Lts | : 100-1000 | Elongation Lts: | 3-30 % |
| Report Type | : Statistical | Article | : 1 |
| Ticket No | : 1 | Shade | : 1 |
| Requisition | : 1 | | |

| Sample | Test No | Load (GF) | Elangation (%) | Time To Break | Tenacity (GF/Tex) |
|--------|---------|-----------|----------------|---------------|-------------------|
|--------|---------|-----------|----------------|---------------|-------------------|

Sample No:-1

| | | | | | |
|---------|--|--------|-------|-------|-------|
| Average | | 355.67 | 12.36 | 0.89 | 14.46 |
| C. V. | | 12.86 | 10.97 | 10.40 | 12.86 |

Sample No:-2

| | | | | | |
|---------|--|--------|-------|------|-------|
| Average | | 390.60 | 12.70 | 0.91 | 15.88 |
| C. V. | | 10.22 | 6.67 | 6.95 | 10.22 |

Sample No:-3

| | | | | | |
|---------|--|--------|-------|-------|-------|
| Average | | 291.18 | 11.72 | 0.85 | 11.83 |
| C. V. | | 14.08 | 14.71 | 13.25 | 14.09 |

Sample No:-4

| | | | | | |
|---------|--|--------|-------|------|-------|
| Average | | 324.22 | 12.04 | 0.88 | 13.18 |
| C. V. | | 13.68 | 8.57 | 7.05 | 13.68 |

Sample No:-5

| | | | | |
|---------------|--------|-------|------|-------|
| Average | 374.1 | 12.61 | 0.92 | 15.20 |
| C.V. | 6.94 | 8.02 | 6.43 | 6.95 |
| Overall Avg. | 347.13 | 12.29 | 0.89 | 14.11 |
| Overall C.V. | 15.15 | 10.08 | 9.10 | 15.15 |
| Overall Min | 209.63 | 7.58 | 0.59 | 8.52 |
| Overall Max | 439.11 | 14.80 | 1.01 | 17.85 |
| Overall Range | 229.48 | 7.22 | 0.42 | 9.33 |
| Overall S. D. | 52.58 | 1.24 | 0.08 | 2.14 |

NORMAL DENIER



USER TESTER 3 V2.42 TU 20-20-01 16:06
STATEX MILLS, PALLADAM ROAD, COIMBATORE. 641 032

SINGLE - / OVERALL RESULTS

Art.no. COPS Test.no. 00013 Fiber assembly: 25Nec

Fiber : 3.5 % ug/inch

100 % COTTON

V:400 m/min t: 1.0 min Test : 1/1 Slot: 3/yarns Yarn tenstion: 25 %

| Test no. | Um (%) | CVm (%) | CV(im) (%) | Index (-) | Thin places (-50%) | Thick Pl. (+50 %) | Neps (+200%) | Rel. count (%) |
|------------|--------|---------|------------|-----------|--------------------|-------------------|--------------|----------------|
| 1 | 9.52 | 12.00 | 4.21 | 1.57 | 0 | 8 | 12 | 100.0 |
| Mean value | 9.52 | 12.00 | 4.21 | 1.57 | 0 /km | 20/km | 32/km | 100.0 |

STATEX MICROPROCESSOR TWIST TESTER

| | | | |
|----------------------|---|--------|-----------------|
| YARN | : | COTTON | |
| PROGRAMMED TIME | : | 0620 | DATE |
| | | | : |
| SPINDLE NO | : | 2 | MACHINE NO |
| | | | : |
| COUNT | : | 25 | YARN TENSION |
| | | | : |
| No. OF TEST/PACKAGE | : | 10 | No.OF PACKAGE |
| | | | : |
| SAMPLE LENGTH (Inch) | : | 20.0 | STANDARD T.P.I. |
| | | | : |
| | | | 20 |

RESULT : SINGLE YARN – ‘Z’ OPERATOR CODE NO:

| | | | |
|----------|----|--|-------|
| | | | 19.74 |
| Test No. | 01 | | |
| Test No. | 02 | | 19.37 |
| Test No. | 03 | | 20.32 |
| Test No. | 04 | | 19.94 |
| Test No. | 05 | | 19.54 |
| Test No. | 06 | | 18.75 |
| Test No. | 07 | | 20.19 |
| Test No. | 08 | | 19.42 |
| Test No. | 09 | | 19.77 |
| Test No. | 10 | | 18.89 |

| | |
|---------------------|-------|
| Average T.P.I. | 19.59 |
| T. P. M | 771.4 |
| Standard Deviation | .5115 |
| Coeff. Of Variation | 2.610 |

Statex Tensostate
Statex Mills,
Coimbatore

Date : 20/02/2001
Count : 25 NeC COTTON
Speed : 5000 mm/min
Load Lts : 100-1000
Report Type : Statistical
Ticket No : 1
Requisition : 1

Time : 5:11:27 PM
Pretension : 12.30 GF
Length : 500 mm
Elongation Lts: 3-30 %
Article : 1
Shade : 1

| Sample | Test No | Load (GF) | Elongation (%) | Time To Break | Tenacity (GF/Tex) |
|--------------|---------|-----------|----------------|---------------|-------------------|
| Sample No:-1 | | | | | |
| Average | | 321.20 | 4.33 | 0.44 | 13.05 |
| C. V. | | 4.10 | 4.14 | 7.32 | 4.09 |
| Sample No:-2 | | | | | |
| Average | | 320.89 | 4.34 | 0.45 | 13.04 |
| C. V. | | 6.17 | 6.49 | 6.20 | 6.18 |

Sample No:-3

| | | | | |
|---------|--------|------|------|-------|
| Average | 327.75 | 4.56 | 0.47 | 13.32 |
| C. V. | 7.90 | 4.62 | 6.41 | 7.90 |

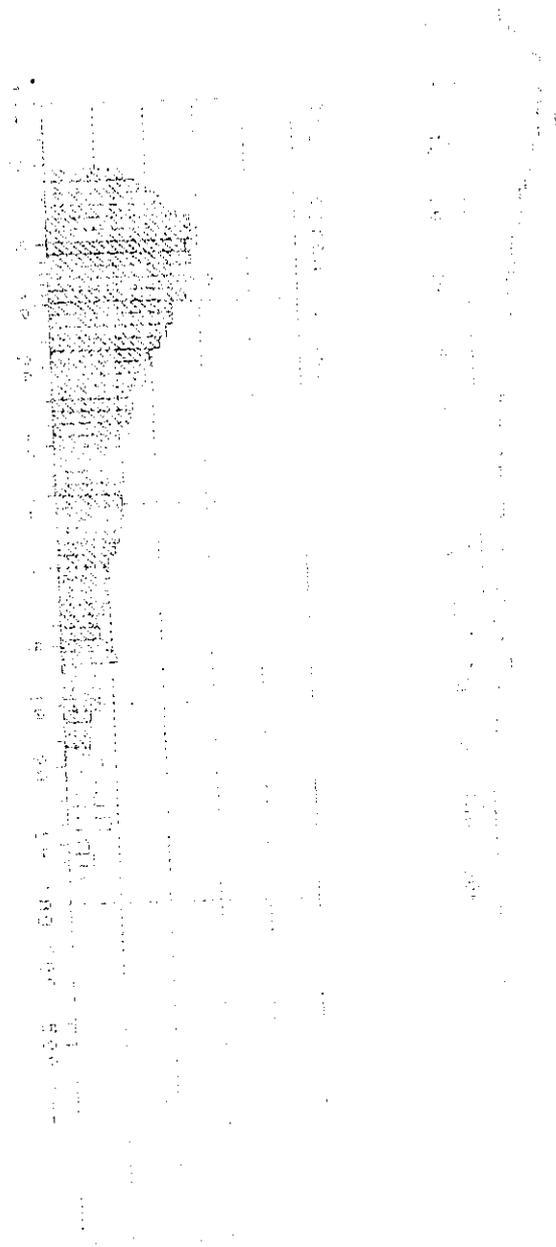
Sample No:-4

| | | | | |
|---------|--------|------|------|-------|
| Average | 324.27 | 4.41 | 0.43 | 13.18 |
| C. V. | 4.84 | 4.62 | 6.26 | 4.85 |

Sample No:-5

| | | | | |
|---------------|--------|------|------|-------|
| Average | 295.53 | 4.14 | 0.43 | 12.01 |
| C.V. | 7.39 | 4.81 | 6.05 | 7.40 |
| Overall Avg | 317.93 | 4.35 | 0.44 | 12.92 |
| Overall C.V. | 6.99 | 5.71 | 6.93 | 6.99 |
| Overall Min | 259.83 | 3.79 | 0.38 | 10.56 |
| Overall Max | 373.54 | 4.95 | 0.50 | 15.18 |
| Overall Range | 113.71 | 1.16 | 0.12 | 4.62 |
| Overall S. D. | 22.23 | 0.25 | 0.03 | 0.90 |

COTTON



HAIRINESS TESTER G 565

Test length (m) : 100 Twist (S/Z) : Z
 Pretension : 5 cN
 Remarks : 25s Micro denier Viscose Spun

| Statistics | 1 mm | 2 mm | 3 mm | 4 mm | 6 mm | 8 mm |
|------------|---------|--------|--------|--------|-------|--------|
| Mean value | 15188 | 2768 | 1101 | 712 | 73 | 2 |
| S. D | 2379.62 | 638.61 | 249.66 | 156.60 | 25.09 | 2.46 |
| C.V | 15.67 | 24.70 | 22.68 | 22.00 | 34.47 | 100.44 |
| 95 % \pm | 12.05 | 18.99 | 17.45 | 16.92 | 26.51 | 77.24 |
| Min. value | 12871 | 2169 | 865 | 497 | 36 | 0 |
| Max. value | 19343 | 4194 | 1636 | 939 | 101 | 7 |
| F value | 1.28 | 1.12 | 2.52 | 34.60 | 64.24 | 2.17 |

*100% Viscose Micro Denier
Knitted Fabric*
