EFFECT OF BLEND RATIOS ON MODAL / COTTON INNER WEARS

A PROJECT REPORT

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ABSTRACT

In the prevailing Textile world, where high production with good quality is the only criteria taken in to account, producing the garment with new fibers is a needed one to meet the requirements. At this juncture fibers which have properties equivalent to cotton can be suited as an ideal option to adopt.

Modal is such an option which is a regenerated cellulose fiber of high wet modulus type. This fiber is manufactured according to the viscose spinning technology using high quality wood pulp like beach wood and special machines and processing parameters. Modal fiber is like a bridge between the properties of manmade and natural fibers. Like an alloy it can be blended with several natural and synthetic fibers.

Due to novel manufacturing process, the cost of modal fiber is at higher side and in order to overcome this disadvantage, blending with cotton is a good practice. The modal/cotton blends have occupied a prominent position because of its exceptional versatility and has gained a significant place in textile industry.

This project is the outcome of a study aimed at investigating the effects of two different Modal/cotton blend ratio on a number of mechanical

properties of the fabric, which are important for the serviceability, comfort and aesthetics value of inner wears.

Two different types of blends of Modal/cotton yarns and 100% Modal were chosen and fabrics were prepared by circular Knitting machine with same loop length. The properties like Air permeability, Moisture Regain, Pilling, Drapability, Dimensional Stability, Rate of Evaporation and color fastness properties are studied for these fabrics and compared for the comfort properties for inner wear.

சாரம்சம்

இன்றைய நாகரீக உலகில் வியாப்பித்து விளங்கும் துகிலியல் உலகில் முக்கிய குறிக்கோள், மிகத்தரமான பொருளை அதிக அளவில் உற்பத்தி செய்து ஏற்றுமதி செய்வது ஒன்றே ஆகும். தற்போது வளர்ந்து வரும் ஆயத்த ஆடை தொழிலில் முக்கிய அம்சம் அனைவரின் எதிர்ப்பார்புக்கு ஏற்ப ஆடைகளை உற்பத்தி செய்வது ஆகும். இதற்கு புதிய குணாதிசயங்கள் நிறைந்த புதிய பஞ்சை தேர்ந்தெடுத்து ஆடையை வடிவமைக்க வேண்டும். இத்தகைய சந்தர்பத்தில் புதிய ஆடைகளை உருவாக்க தேர்ந்தெடுக்கப்படும் புதிய பஞ்சானது, பருத்திப் பஞ்சின் குணாதிசயங்களை ஒத்துக் காணப்படவேண்டும்.

இத்தகைய சூழ்நிலையில் மொடால் எனப்படும் சீர்திருத்தப்பட்ட செல்லுலோசிக் பஞ்சானது தேர்ந்தெடுக்கப்பட்டது. இந்த மொடால் பஞ்சானது அதிகமான ஈரத்தை உறிஞ்சும் தன்மை கொண்டது. . இந்த மொடால் பஞ்சானது விஸ்கோஸ் எனப்படும் நூல் நூற்பு தொழில் நுட்பத்தைப் பயன்படுத்தி உருவாக்கப்ப்டுகிறது. இதற்காக "பிரீச்" எனப்படும் மிகத்தரம் வாய்ந்த மரத்தின் கட்டை மற்றும் சிற்ப்பு இயந்திரங்களும் பயன் படுத்தப்படுகிறது. இந்த மொடால் பஞ்சானது இயற்க்கையான மற்றும் செயற்கையான முறையில் உருவாக்கப்படும் பஞ்சின் குணாதிசயங்களின் கலவையாக உள்ளது.

புதுமையான முறையைக் கொண்டு உருவாக்கப்படும் மொடால் பஞ்சின் விலையானது சற்றே அதிகம். இது பருத்தி பஞ்சுடன் கலவை செய்யும்போது நல்ல விளைவைத் தருகிறது. இந்த மொடால்/பருத்தி பஞ்சின் கலவையானது துகிலியலில்

முக்கிய இடத்தை ஆக்கிரமித்துள்ளது. ஏனெனில் இந்த கலவையானது அசாதாரணமான வல்லமையுள்ள குணாதிசயம் கொண்டது.

இந்த திட்டத்தின் நோக்கம் யாதெனில் இரண்டு வெவ்வேறு சதவிகிதம் கலவையுள்ள மொடால்/ பருத்தி ஆடை மற்றும் 100 சதவிகிதம் மொடால் பஞ்சின் மூலம் உருவாக்கப்பட்ட ஆடையின் குணாதிசயங்களை ஆராய்வதேயாகும். இதன் மூலம் தயாரிக்கப்படும் உள்ளாடைகளின் பயனளிப்பு, உடலுக்கு ஆறுதலான பண்பு, அழகுணர்ச்சியூட்டக்கூடிய பண்பு ஆகியவைகளை ஆராயமுடியும்.

இரண்டு வெவ்வேறு விதமான கலவையுடைய மொடால்/பருத்தி நூலும், 100 சதவிகிதம் மொடால் நூலும் தேர்வு செய்யப்பட்டது. பின்பு ஆடையானது வட்ட வடிவ ஆயத்த ஆடை இயந்திரத்தில் ஒரே மாதிரியான சுருள் நீளம் வைத்து தனித்தனியே உருவாக்கப்பட்டது. இவ்வாறு தனித்தனியே உருவாக்கப்பட்ட ஆடைகளில், காற்று பரவும் திறன், ஈர்த்தை உறுஞ்சும் திறன், பில்லிங், ட்ரேப், பரிமாண சமநிலை, நீர் ஆவியாகும் மதிப்பு, நிற மாற்றம் ஆகிய பண்புகள் ஆராயப்பட்டு பின்பு ஒப்பீடு செய்யபட்டது.

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LIST OF SYMBOLS

S.NO	NOMENCLATURE	SYMBOL
1	Cotton	C
2	Modal	M
3	Percentage	%
4	Cutting and Making	C&M

CHAPTER 1

INTRODUCTION

Cotton, with its unlimited versatility has been servicing mankind for a long period. Although, a perfect alternative to cotton is yet to be discovered, some manmade fibers with properties closer to it have been developing in the recent years.

One such innovative technological development is the introduction of high wet modulus rayon, which is termed as 'MODAL' by Lenzing Ltd., Austria. Modal which is a cellulose fiber as cotton, have less percentage of cellulose content than in cotton.

1.1 Modal – Definition

As per the ISO definition Modal is a regenerated fibre obtained by the processes giving a high tenacity and a high wet modulus. In other words "Modal" is a regnerated cellulose fiber which when wet remains stronger and distorts less than viscose. The word "Modal" is derived from modulus and this was introduced all regenerated viscose fibers having tenacities in the conditioned state and wet module at 5% extension above certain values.

1.2 Important properties of Modal

Modal encapsulates all the properties that are required for a garment. Some of the properties highlight as,

- Modal fiber has higher strength and greater dimensional stability.
- It is 65% amorphous and 35% crystalline there by making the wearers to feel the comfort.
- Brilliant softness
- Ideal blends
- It is commercially available in the fineness of 1.0 d tex and staple length of between 32mm and 40mm

- ❖ High average degree of polymerization.
- ❖ High resistance to alkali therefore its surface remains is not affected very much after repeated washing.
- ❖ Easy to wash
- ❖ Very high water retention capacity.

1.2.1 Friendly to the skin and comfortable

- ❖ Modal consists of 100% pure cellulose, which is a building block for all plants and therefore identical in its composition to cotton, the primary material.
- ❖ Modal satisfies all human- ecological requirements according to is produced exclusively of chlorine-free unbleached pulp.
- ❖ Modal does not contain any toxic substances and is free from any pesticides
- ❖ It does not cause any skin irritation.
- ❖ This advantage is particularly important in textiles that are in direct contact with skin

1.3 Areas of applications

- ❖ Fabric for shirts, blouses and dresses.
- ❖ For ladies, men's and children clothing
- ❖ Sportswear and leisure-wear.
- ❖ For T-shirts, polo shirts sweat shirts.
- ❖ Soft denim fabrics.
- ❖ For towels and bathrobes.
- ❖ Also for technical applications such as tyre cords, abrasive ground fabrics, rubber cloths and other coating supports
- ❖ For socks and stockings.

CHAPTER 2

LITERATURE REVIEW

2.1 Modal fiber manufacture

The Modal fiber is manufactured by the viscose spinning technology with some modification. In the manufacture of viscose rayon, the breakdown of molecules takes place during the ripening of sodium cellulose xanthate solution. If these steps (ageing & ripening) are avoided then viscose solution can be made in which the sodium cellulose xanthate molecules are longer than those in the normal viscose process. This principle is used in Tachikawa process of manufacturing Modal fibers in addition, slowing down of the regeneration and coagulation of the filament is also resorted to permit stretching to be carried out gently and in many stages.

Tachikawa process:-

1. Preparation of soda cellulose –
   - Steeping of wood pulp in 17.5% NaOH.
   - Followed by pressing and shredding as viscose (shredding is done within 2 hours whereas in viscose it takes 3 hours).
   - Temperature is maintained 20^0C throughout.
   - Ageing is omitted.

2. Xanthation –
   - The obtained soda cellulose is treated with Carbon disulphide for $2^1/_2$ hours at 15 to 20^0 C then raised to 25^0C for 1 hour. (In viscose 70% of this is used)

3. Mixing –

- To the soda cellulose xanthate obtained from the above process is then added with water to obtain a solution of 6% cellulose xanthate and 2.8% NaOH.(whereas in viscose production it will be 7.5% cellulose xanthate and 3% NaOH).
- The Ripening process is omitted.

3. Spinning –

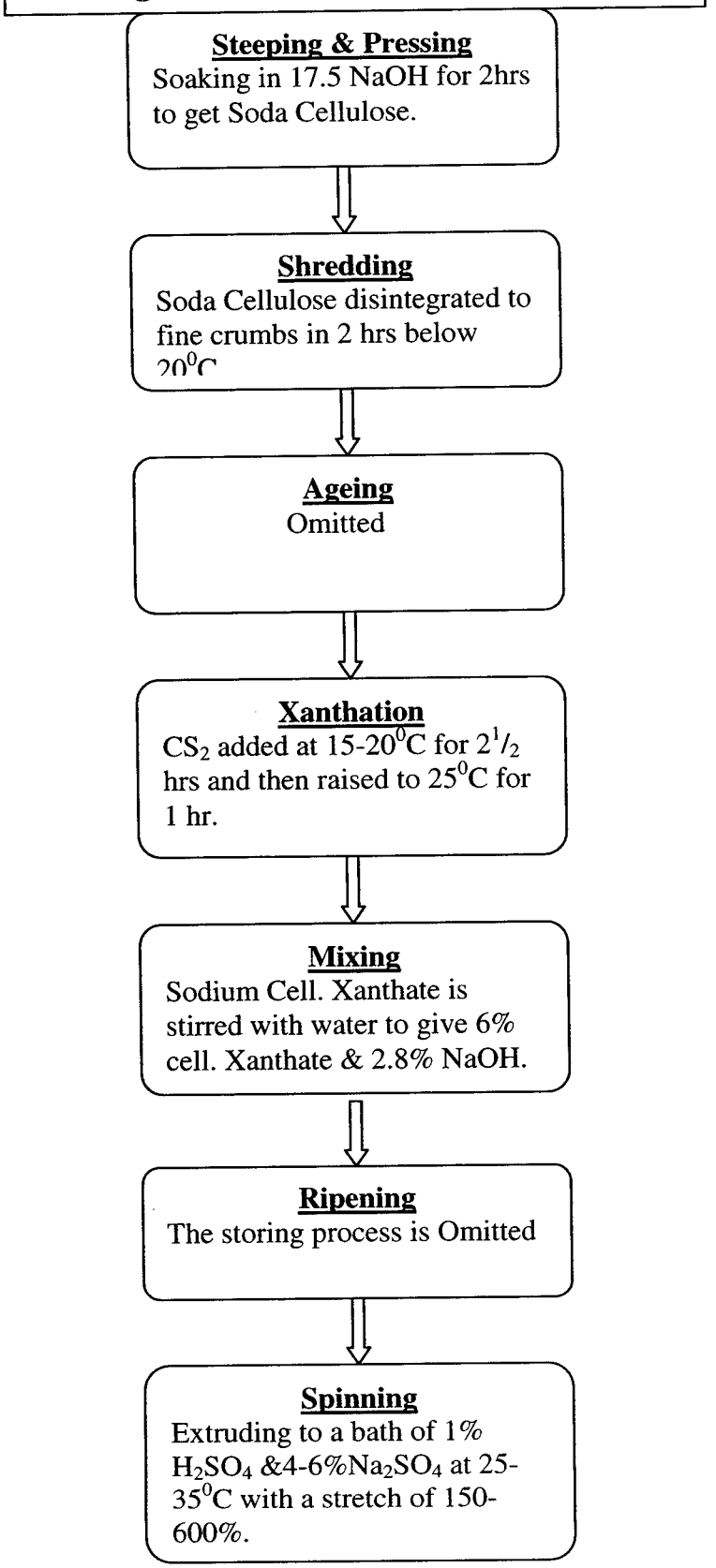
- The above solution is then extruded in a bath containing 1% H_2SO_4, 4-6% Na_2SO_4 at a speed of 20-30 m/min. The temperature is maintained at 25-35^{0}C and the stretch is given 150-300%. The filaments are stretched three times original length. In viscose 10% H_2SO_4 and 18% glaubers salt is used.
- The spinning bath of low concentration favors slow regeneration of rayon high crystallinity.
- Spinning speed is lower than viscose (20-30m/min).
- Glass spinnerette with more holes are used.

Under these conditions, the degradation of cellulose is held to a minimum by the omission of ageing and ripening stages, and by the milder conditions used in preparing the viscose solution. The regeneration and coagulation of the cellulose take place slowly and gently in the dilute acid of the spinning bath, which contains little or no salt. This permits stretching to be carried gradually, allowing the molecules to assume a high degree of orientation and crystallization. The filaments produced are of more uniform composition; the cross-section is round. A flowchart of the Tachikawa process is shown in figure 2.1.

The conditions described above are typical of those used in high wet modulus Modal fiber production, but they may be varied in number of ways to provide fibers of

the desired characteristics within the modal range. The coagulation bath, for example may contain sulphuric acids and sodium sulphate in various proportions. Zinc salts may be used to slow the regeneration of cellulose by forming zinc cellulose xanthate. Formaldehyde may be added to viscose solution or to the spinning bath, forming an ester between xanthate and formaldehyde, which also serves to slow the regeneration process.

Figure 2.1-Flowchart of Modal fiber



2.2 Fiber Structure

2.2.1 Physical Structure

Blending is the process of combining two types of textile fibers in a single yarn. Blending can be done in any stage of spinning process. Draw frame blending is considered as best of all others. Before studying the effect of different blend ratios of Modal/cotton blends, the structure of the fibers have to be studied.

Both cotton and modal are cellulosic fibers. Both have same chemical structure, but the physical characteristics differ in nature. Generally fibers are made up of fibrillar filaments and their molecules are grouped to form linear polymers. An X-ray examination of Modal fibers shows that their molecules are grouped in a regularly shaped crystalline structure (i.e.) crystalline element immersed in a substance of amorphous structure.

Optical micrographs study of Modal fibers shown in figure 2.2 indicates that they are highly oriented all-skin filaments with a near-circular cross-section.

2.2.2 Chemical Structure

The basic of the chemical composition of all vegetable fibers is cellulose, which is present to a greater extent modified from cotton to viscose and Modal. They all have the basic repeating unit's i.e.:

COTTON, VISCOSE, MODAL = $C_6H_{10}O_5$.

All the cellulosic nature fibers consist of the number of cellobiose units as shown in figure 2.3.

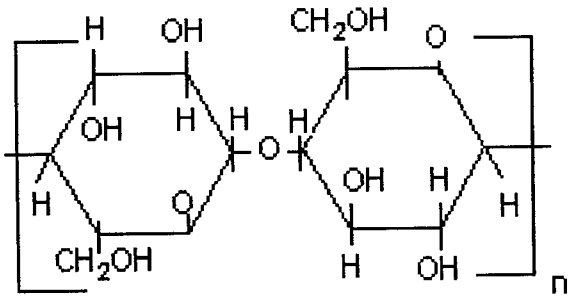


Figure 2.3 Cellobiose unit

The repeating unit $(C_6H_{10}O_5)_n$ differs from cotton to Modal. The repeating unit of cotton is 10,000 whereas for Modal is 450-750. The main difference in the chemical structure of Modal and cotton is that the chain length of Modal is shorter.

The percentage of crystallinity is greater than the viscose, which comes around 55% and for cotton it is 70%. In table 2.1 the polymer system of cotton, Modal and viscose are given. From these parameters we can differentiate the chemical structures of those fibers.

Table 2.1 Polymer system of different fibers

Polymer	Approx. no. of cellobiose units.	Approx. polymer length	Approx. polymer thickness	Approx. D.P	Degree of Crystallinity (%)
Cotton	5000	5000	0.8	5000	70-80
Viscose	175	180	0.8	175	40-45
Modal	500	510	0.8	500	55

2.3 Fiber Properties.

Modal fibers have several properties similar or closer to the cotton fibers. When compare to the viscose fibers these fibers have superior properties. Comparison of different properties of Modal with cotton and viscose is given in the table 2.2.

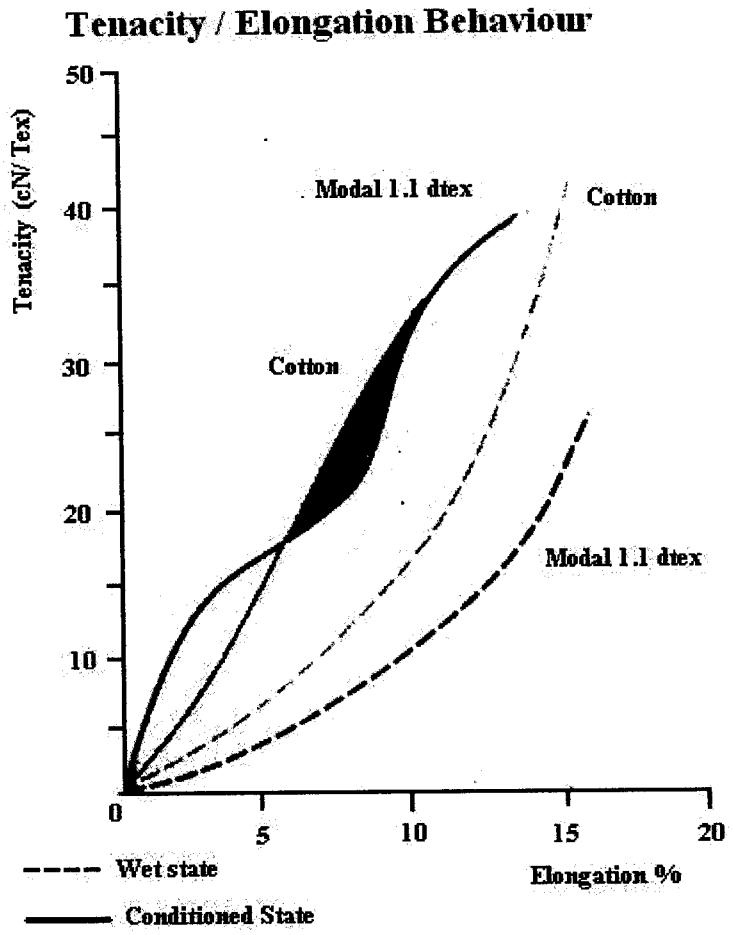
Table 2.2 Comparison of modal fiber properties with other fibers.

	Cotton	Viscose	Modal
Tenacity Cond(cN/teX)	24 - 28	24 - 26	34 -36
Tenacity Wet(cN/teX)	25 - 30	12 -13	20 -22
Elongation Cond (%)	7 - 9	18 - 20	12 -14
Rel.Wet strength (%)	105	50	60
Hygroscopic property (%)	50	90	60
Elongation Wet (%)	12 - 14	21 - 23	13 -15
Natural moisture content (%) (65% rel F.)	8	13	12,5
Recovery from stretch	Good	Poor	Good
Cross-section	Bean shaped	Serrated	Round

Tenacity of Modal at dry stage is greater than cotton but at the wet stage it is observed as it is slightly less. Similarly other properties of Modal are similar to cotton and are higher than viscose.

The tenacity / Elongation behavior of Modal and cotton are compared in the graph shown below.

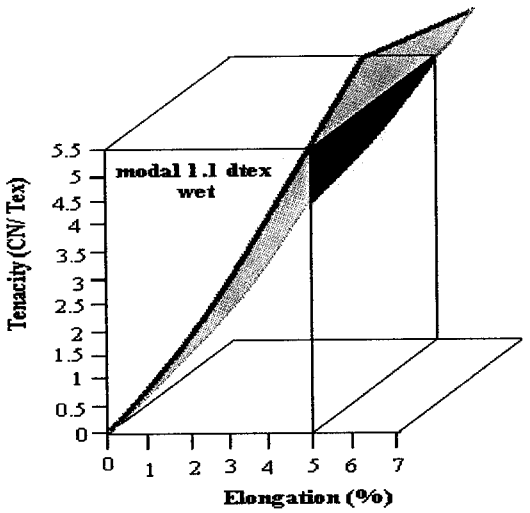
Figure 2.3 – Tenacity/ Elongation behavior of Modal and cotton



The above graph shows that the strength of Modal is slightly less than cotton in wet state but its dry strength is more than cotton.

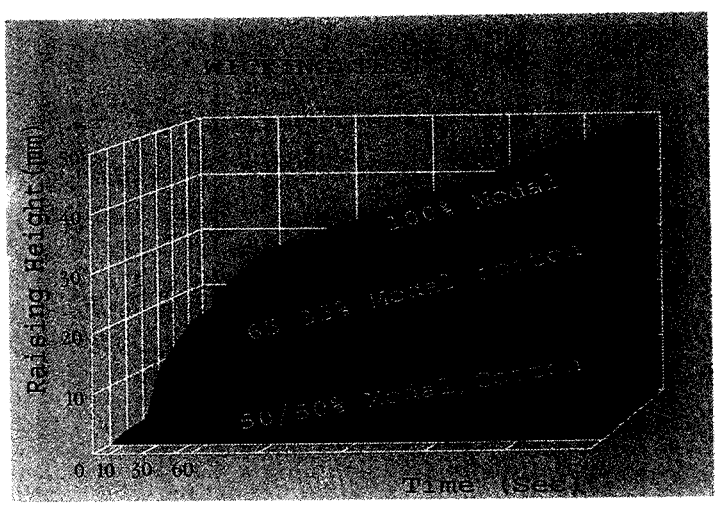
The tenacity and elongation behavior of 1.1 d tex Modal in wet state is shown in the figure 2.4 below:

Figure 2.4 – Tenacity/ Elongation behavior of Modal in wet state



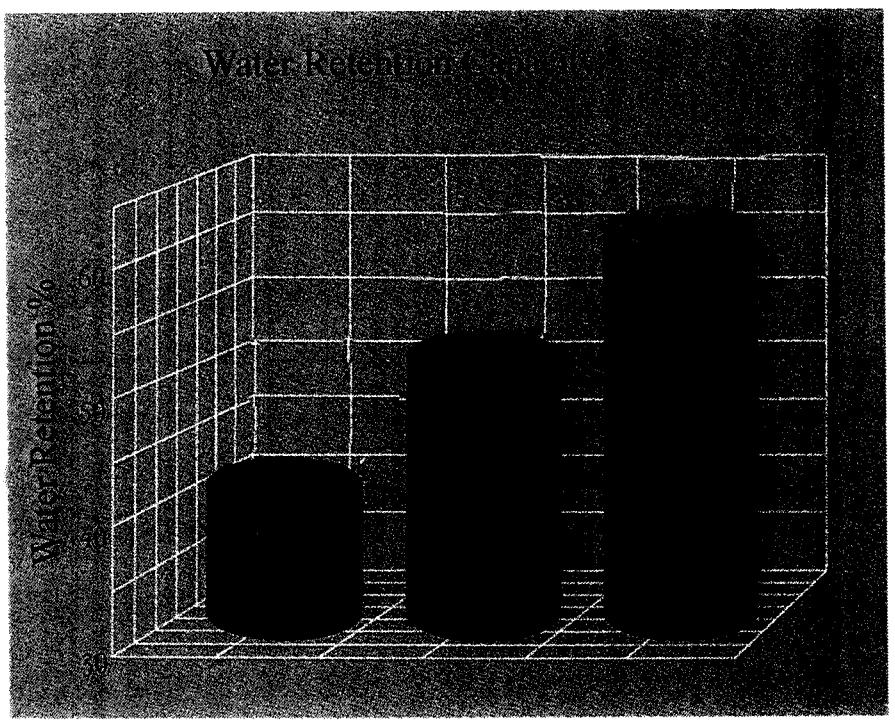
The wicking test 100 % Modal and its blends with cotton are shown in the figure2.5. The raising height for a time of 0 to 300 seconds has been shown. It is clear that raising height increases proportionately with increase in Modal proportion. The raising height is more for the initial 100% Modal.

Figure 2.5-Wicking test graph



The Water Retention Capacity for 100 % Modal and its blends with cotton are shown in the figure 2.6. The Water Retention Capacity increases proportionately with increase in Modal proportion. And 100 % Modal has more Water Retention Capacity compared to other blend ratios.

Figure 2.6 – Water Retention Capacity 100% Modal and its blends



CHAPTER 3

METHODOLOGY

Project sequence

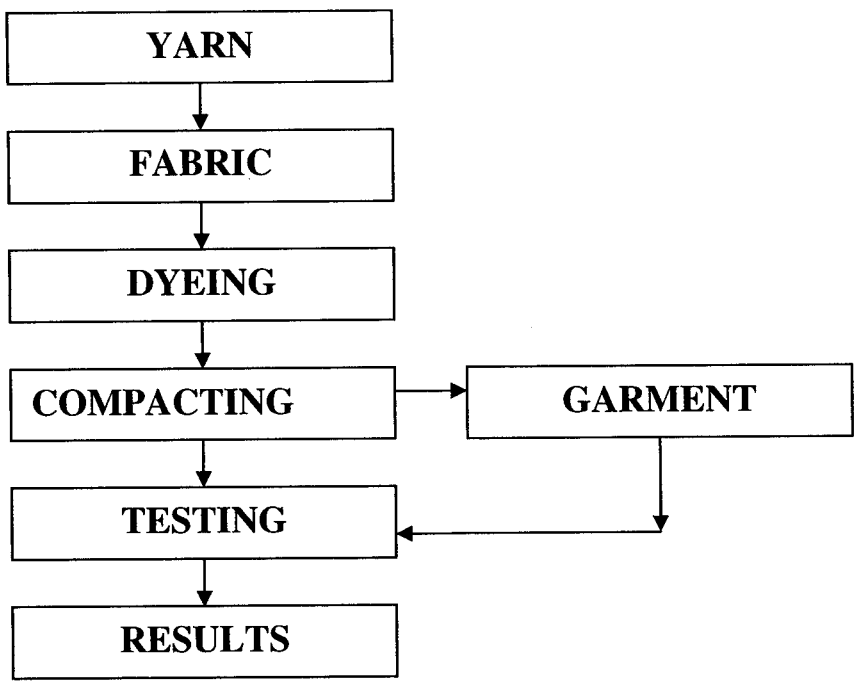


Figure 3.1 – Project Sequence

3.1 YARN

- In order to study the effect of blend ratio of Modal and Modal /cotton blends, three types of yarns of same count with different blend Proportions are used.

Yarn parameters

Count **30^s**

Blend 100% Modal.

35/65% Cotton / Modal.

50/50% Cotton / Modal.

Table3.1 - Yarn parameters tested.

Parameters	100% M	35/65 C/M	50/50 C/M
Elongation%	**9.23**	**4.8**	**5.73**
Tenacity(g/tex)	**24.19**	**14.76**	**13.94**

(M-Modal; C-cotton)

3.2FABRIC

- Knitted samples have been used for testing purpose. Modal and its blends are knitted using high speed circular knitting machines. The machine parameters and the fabrics specifications are given in table 3.2 and table 3.3.

Table3.2 – Knitting machine specification

MACHNIES USED	**CIRCULAR KNITTING MACHINE**
MODEL	**PL-XS-3B/A/C**
MAKE	**PAILUNG MACINERY,TAIWAN**
CYLINDER DIA	**17"**
MACHINE GAUGE	**24GG**
NEEDLES	**1284**
FEEDER	**50**
RPM	**40**

- All the three types of yarns are knitted using the same machine with same loop length in order to compare their properties.

Table3.3 – Fabric specifications

Parameters	**100% M**	**35/65 C/M**	**50/50 C/M**
Fabric dia	**21"**	**21"**	**21"**
Loop length(mm)	**2.8**	**2.8**	**2.8**
GSM	**105**	**111**	**117**

(M-Modal; C-cotton)

- Since the fabric is knitted in the machine under tension its diameter tends to extend.
- Since Modal being a micro denier fiber (1 dtex) its GSM decreases as its percentage increases.

3.3 DYEING

1. Since the fabric is to be used for garment purpose it is dyed in order to check certain color fastness properties. All the three fabrics where dyed to the same color. Since they where of different blends the concentration of the dye liquor changes in order to give the same color.
2. The samples where first bleached in order to improve the absorbency, to remove impurities and improve the dye uptake percentage.
3. All the three blends were dyed using ordinary winch dyeing machine with 5kgs capacity.

Table 3.4 -Bleaching liquor concentration

CHEMICALS	100% M	35/65 C/M	50/50 C/M
Wetting agent	0.4%	0.4%	0.4%
Caustic	3.0%	3.0%	3.0%
Stabilizer	0.75%	0.75%	0.75%
Peroxide	3.0%	3.0%	3.0%
Peroxide killer	0.5%	0.5%	0.5%

(Bleaching Time 60 min. Temperature 80°C) (M-Modal; C-cotton)

Table 3.5 - Dyeing liquor concentration

Chemicals	100% M	35/65 C/M	50/50 C/M
Blue CA	0.17%	0.19%	0.20%
Salt	40%	40%	40%
Soda	4%	4%	4%
Acetic	2%	2%	2%

(Dyeing Time 480 minutes; Temperature 60°C)

(M-Modal; C-cotton)

From the above table we can say that the dye percentage requirement for Modal is slightly less than cotton and its blends.

1.4 COMPACTING

1. It is a very important finishing process with regarding to knitted fabrics.
2. It helps us to maintain the dimensional stability of knitted fabrics.
3. It also improves the handle of the fabric to a small extent.

3.4.1 IMPORTANCE OF COMPACTING

1. Knitted fabrics after dyeing usually tend to extend in widthwise and shrink in lengthwise. If a knitted fabric is made into a garment without this compacting

means the garments shrinkage percentage will be more than 15% which is very high than the allowable 5% .

2. During compacting the fabrics width and length are setted, by passing the fabric between two high temperature rubber surfaces.

3. The length is usually compressed in order to prevent further extension during daily uses and the width is maintained to the fabrics machine dia. (that is the width is kept as 17" dia. if the fabric has been knitted using 17" dia. machine).

4. The fabric length is compressed so that its GSM will tend to increase after compacting.

Table 3.6 - Compacting machine specification

Machine type	Tubular compacting
Make	FERRARO
Model	FE-4S-IT

Table 3.7 - Fabric settings

Parameter	100%	35/65%	50/50%
Inlet speed	9.8mpm	9.8mpm	9.8mpm
Temperature	145°C	140°C	135°C

Table 3.8 - Parameters before compacting and Parameters after compacting

Parameters before compacting

Parameter	100 %	35/65 %	50/50 %
Width	15"	15.2"	15.5"
GSM	128	134	141

Parameters after compacting

Parameter	100 %	35/65 %	50/50 %
Width	17"	17"	17"
GSM	135	142	147

1.5 GARMENTS

- Since the main aim of this project is to compare the comfort properties for inner garments using 100% modal and its cotton blends, we had made three types of inner garment samples and the shrinkage properties for this garments has studied.
- In order to predict the commercial usability of this garment we had also made cost analysis for the three garments that we have designed.

MENS BRIEF

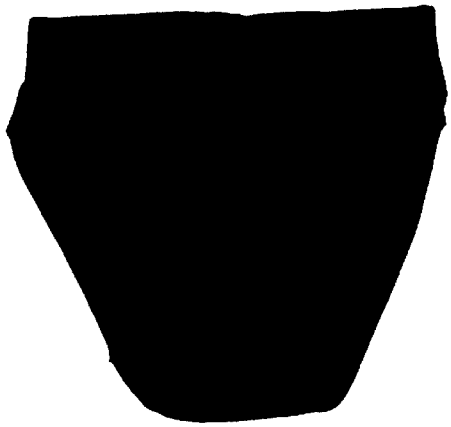


Figure 3.2

Table 3.9 SIZE SPECIFICATIONS

SPECIFICATIONS	IN CM
Waist Relaxed	31
Waist Stretched	52
Front Length Relaxed	27
Front Length Folded	31
Side Seam Incl.Elastic	7
Front Gusset Width Incl.Elastic	10
Leg Hole Opening	21
Leg Hole Opening Stretched	36
Seat (Bottom folded at waist)	33

BOXER SHORTS

Figure 3.3

Table 3.10 SIZE SPECIFICATIONS

SPECIFICATIONS	IN CMS
Waist unstretched	34
Total length front	36
Total length back	38
Leg opening	30
Leg inside	7
Front length	33
Waist band	3
Half seat hip	56

MENS SINGLET

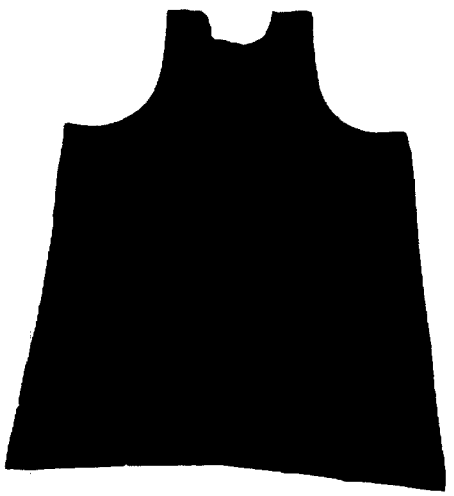


Figure 3.4

Table 3.11 SIZE SPECIFICATIONS

SPECIFICATIONS	IN CMS
Front length	45
Chest width	43
Neck opening	10
Neck drop	10
Arm hole opening	21
Shoulder	5.5

3.6 - TESTING

A total of nine tests were conducted for the study. More importance are given to the testing of fabric comfort properties. The tests are broadly classified as primary tests and secondary tests. The primary tests are done to study the important properties that an inner wear should posses. The secondary tests are the one which have not that much significance, like good color fastness properties to ordinary washing, perspiration and rubbing.

3.6.1 - PRIMARY TESTS:

- Air Permeability
- Rate of Evaporation
- Moisture Regain
- Drape
- Dimensional Stability

  a) fabric Stage b) Garment Stage
- Pilling Test

3.6.2 - SECONDARY TESTS:

- Color Fastness to washing
- Color Fastness Rubbing Fastness
- Color Fastness Perspiration Fastness

3.7 AIR PERMEABILITY:

Standard: ASTM D 737 – 96

3.7.1 DEFINITION:

Air permeability is defined as the rate of air flow passing perpendicularly through a known area under a prescribed air pressure between the surfaces of the two materials.

3.7.2 TESTING:

Air permeability of a material is tested by passing the air through the fabric specimen. The rate of air flow passing perpendicularly through a known area of the fabric is adjusted to obtain a prescribed air pressure differential between the two fabric surfaces. From this rate of air flow, the air permeability of the fabric is determined.

3.7.3 APPARATUS REQUIRED:

Air permeability apparatus consists of the following:

1. Test head that provides circular test area.
2. Clamping system to secure test specimens.
3. Means of drawing a steady flow of air perpendicularly through the test area and for adjusting the airflow rate.
4. Pressure gage or manometer to measure the pressure drop across the test specimen.
5. Flow meters, volumetric counter to measure air velocity.
6. Calibration plate.
7. Cutting dies or Templates, to cut specimen.

3.7.4 PROCEDURE:

1. Test the conditioned specimens in the standard atmosphere for testing textiles, which $27^0C \pm 2^0C$ and 65%±2% R.H.
2. Handle the test specimen carefully to avoid the altering the natural state.
3. Place each specimen onto the test head.
4. Make tests at water pressure differential specification in a material specification.
5. Read and record the individual test results in SI units as ml/sec/cm.sq
6. Remove the tested specimen and continue as directed in early steps.

3.8 TEST FOR MOISTURE REGAIN:

3.8.1 MOISTURE REGAIN:

It is defined as the ratio of mass of absorbed water in specimen to the mass of dry specimen.

$$\text{Regain \%} = \frac{\text{mass of absorbed water in specimen}}{\text{Mass of dry specimen}} * 100$$

3.8.2 APPARATUS REQUIRED:

Conditioning oven.

1. **Balance**, having a sensitivity of one part in 1000 of the mass of the specimen.

3.8.3 PROCEDURE:

1. The specimen (2 grams) that has to be tested for moisture regain is placed in conditioned atmosphere of 65%±2% and temp.27 °C±2 °C for 24 hours.
2. The specimen that has been fully conditioned is placed in a conditioning oven at 110°C.
3. Since the temperature inside the oven is greater than the outside temperature the specimen tends to give off its water content.
4. The specimen is tested for weight loss for every half-an-hour.

5. This is done until two consecutive readings get the same value.
6. Care should be taken in properly handling the specimen that is while weighing the specimen the outside air may change the regain percentage.

The regain is calculated as

Mass of undried specimen = W+D = m_1;

Mass of dried specimen = D = m_2;

Where,

W=mass of water absorbed

D=dry mass of the specimen

$$\mathbf{R\% = m_1 . m_2 / m_2 * 100}$$

3.9 RATE OF EVAPORATION

3.9.1 SAMPLE PREPARATION:

This method is used to find the amount of water that evaporates in a particular span of time. The sample required for testing is 2 grams.

3.9.2 LABORATORY CONDITION:

Temperature: 21±1°C

Relative Humidity: 65 ± 2 %

3.9.3 APPARATUS REQUIRED:

1. Weighing balance of accuracy ± 0.0001g
2. Scissors

3.9.4 TEST PROCEDURE:

About 2 grams of specimen is taken using a weighing balance and it's been allowed for 100% moisture pickup using distilled water.

The wetted specimen has been hanging dried at conditioned environment. The conditioned environment refers to 65%±2% and temp.27 °C±2 °C. Since the specimen is fully wet it tends to give off its excess moisture to the atmosphere, due to which it losses its weight. For this loss of weight the rate of evaporation is calculated.

The rate of evaporation E can be calculated as follows:

$$E = (M_W - M_D) / M_D * 100$$

Where,

M_W = mass of the specimen in 100% moisture pick up state.

M_D = mass of the specimen after drying a few minutes.

Rate of evaporation is expressed in percentage.

3.10 DRAPE MEASUREMENT

Standard: BS 5058-1973

3.10.1 SAMPLE PREPARATION:

A circular template of 10 inch diameter is provided with the drape meter. The template is placed on the specimen and the outline is marked with pen. There will be two slots with the template it is also marked. Now the specimen is cut exactly on the line and the slots marked. A white paper is also cut with similar dimension.

3.10.2 APPARATUS REQUIRED:

1. Drape meter
2. Test sample, cut in 10 inch dia circle
3. Scissors
4. Weighing balance
5. Paper of uniform thickness

3.10.3 THE DRAPE COEFFICIENT:

The drape coefficient F, is the ratio of projected area of the draped specimen to its undraped area, after deduction of the area of the supporting disk. Thus,

$$F = \frac{A_s - A_d}{A_D - A_d}$$

where,

A_s = **the area of the specimen**
A_d = **the area of the supporting disc**
A_D = **the actual projected area of the specimen**

3.10.4 TEST PROCEDURE:

- The smaller disc (5 inch dia) is mounted on the drape meter. The fabric is mounted on the disc with the slots in the fabric exactly suiting at the right place.
- Now the drape meter lid is closed and switched on. The fabric will drape on the sides and the draped area will be visible on the top of the drape meter.
- A paper is placed on the drape meter and the outline is marked.
- The paper is cut along the outline and then weighed. It is noted as A_S. Paper is cut with its size corresponding to, smaller dics and larger disc.
- Their weights are noted down as A_d and A_D respectively. The weights of the paper are substituted in the formula for calculating the drape coefficient and the drape coefficient is found out.

3.11 DIMENSIONAL STABILITY

Standard: ISO 5077

3.11.1 FABRIC STAGE

3.11.1.1 PRINCIPLE

The dimensional change of knitted fabric specimens are subjected to washing, drying, and restoration procedures typical of commercial laundering are determined by measuring changes in bench mark distances applied to the fabric before laundering.

3.11.1.2 APPARATUS REQUIRED:

1. Wash wheel
2. Dryer of rotary tumble type
3. Conditioning / Drying rack
4. Indelible ink marking pen
5. Tape or rule with divisions in millimeters
6. Detergents

3.11.1.3 TEST SPECIMEN:

- The sample is cut in 60 * 60 cm squares.
- Three specimens are taken for the test. Mark each specimen with 50 cm pair of bench marks parallel to the length of the fabric, and three 50 cm pairs of bench marks parallel to the width of the fabric.
- Each bench mark should be at least 8 cm from all edges of the specimen. Pairs of bench marks in same direction must be 15 cm apart.

3.11.1.4 TEST PROCEDURE:

- Place the specimen in the wash wheel with other fabrics similar to test specimen to make 1.8 kg load.
- Add 66 ± 1 g of standard detergent (1993 AATCC Standard) in soft water start wash wheel and note the time.
- Immediately add water at 40 ± 3 ° C to the wash wheel to a level of 18 ± 1 cm. Stop the wash wheel after 15 min.
- Now refill the wash wheel to a level of 22 ± 1 cm with water at a temperature of 41 ± 3 ° C and start the machine to rinse the specimen for first time. Stop the machine after 5 minutes.
- Rinse the specimen for the second time at same temperature for 10 minutes. Now stop the machine and the specimen is dried using tumble dryer at 60 ± 11 ° C for 30 minutes until dry.
- After drying, the specimen is conditioned for at least 4 hours by laying separately in the conditioning rack in an atmosphere for 21 ± 1 ° C and 65 ± 2 % RH.

3.11.1.5 MEASUREMENT AND EVALUATION:

Lay each specimen without tension on a smooth surface and measure the distance between each pair of bench marks to the nearest millimeter. Record the readings.

3.11.1.6 CALCULATION:

The dimensional change of the fabric in length wise or width wise can be calculated by using the below formula,

% Dimensional Change = (B-A) / A*100

Where,

A = the original measurement of bench mark in the specimen

B = the measurement of bench mark in the specimen after washing and drying.

The average of three readings gives the dimensional change of the fabric.

3.11.2 GARMENT STAGE

STANDARD: ISO 3759

3.11.2.1 PRINCIPLE

The dimensional change of garment specimen subjected to home laundering care procedures are measured using bench marks applied to the garments before laundering.

3.11.1.2 APPARATUS REQUIRED:

1. Automatic washing machine.
2. Automatic tumble dryer.
3. Conditioning / Drying rack.
4. Facilities for drip drying and line drying.
5. Indelible ink marking pen.
6. Tape or rule with divisions in millimeters
7. Detergent

3.11.1.3 TEST SPECIMEN:

Each garment used will be considered as a specimen. Garment used as specimen should be representative of the whole lot. The following are the areas that are to be bench marked to find the dimensional changes.

SINGLET

1. Body length
2. Chest width

BRIEF

1. Waist
2. Front length

BOXER SHORTS

1. Waist
2. Overall length

- ❖ Benchmarks are made in the garment in their respective areas using indelible ink.
- ❖ Usually bench marking are made for at least 250mm, and hence it should be at a distance of 25mm from the edges or seams in order to have correct results.

3.11.1.4 TEST PROCEDURE:

- ❖ Place the specimen in the automatic washing machine with other garments to make a 1.8 kg load.
- ❖ Select the specified water level, the desired water temperature for the washing cycle and a rinse temperature of 29 ° C.
- ❖ Fill the washing machine to 18±0.5 gal water level. Now add 66 ± 1 g of standard detergent (1993 AATCC Standard) in the detergent chamber.
- ❖ Agitate water briefly to dissolve detergent. The machine is now switched on for a washing time of 30 minutes at a temperature of 40 ± 3 ° C.
- ❖ During this time hydro extraction of water present in the specimen also occurs. After washing the specimen is taken off from the machine and it is subjected to dry in a flat surface in order to dry.

3.11.1.5 MEASUREMENT AND EVALUATION:

Lay each specimen without tension on a smooth surface and measure the distance between each pair of bench marks to the nearest millimeter. Record the readings.

3.11.1.6 CALCULATION:

The dimensional change of the fabric in length wise or width wise can be calculated by using the below formula,

% Dimensional Change = (B-A) / A*100

Where,

A = the original measurement of bench mark in the specimen

B = the measurement of bench mark in the specimen after washing and drying.

The average of three readings gives the dimensional change of the fabric.

3.12 FABRIC PILLING TEST

3.12.1 SAMPLE PREPARATION:

The template provided is of 5 * 5 inch in size along with four grooves. The template is placed on the fabric and its outline is marked with reference to the grooves. The fabric is cut and stitching is done corresponding to the groove markings. The sewn sample is firm fit in a round rubber tube 6 inches long. Cut ends of the fabric are covered by cellophane tape.

3.12.2 APPARATUS REQUIRED:

1. Pilling Tester
2. Test Specimen, Cut in 5 * 5 inch
3. Rubber tube 6 inch long, 1.25 inch outer dia, 0.125 inch thick
4. Needle for Stitching
5. Scissors
6. Grey scale

3.12.3 SPECIFICATION:

Rotating Speed : 60 RPM

Time : 5 Hours

No. of tubes/box : 4

3.12.4 TEST PROCEDURE:

Sample is taken and subjected to a hand wash in ½ % soap at 45°C for 15 minutes before preparing tubes. Four tubes are placed in one box. And the door is closed. The machine is started and run at 60 RPM for 5 hours. After the test is over, the machine is stopped and samples are taken out and compared grey scale and extent of pilling is noted down.

3.12.5 EVALUATION:

The extent of pilling is assessed visually by comparing with the arbitrary standards.

3.12.6 PILLING STANDARD RATINGS:

1 - Extremely high pilling

2 - Unacceptable pilling

3 - Moderate pilling

4 - Slight pilling

5 - No pilling

3.13 COLOR FASTNESS TO WASHING

Standard: IS765:1979

3.13.1 SAMPLE PREPARATION:

The sample size for the test is 5 * 8 inch. The sample is placed between two pieces of white cloth on either sides of same size. The white cloth should be desized and free from starch. Then the specimen is stitched on three sides and top side is left free. The sewing thread used must have excellent fastness so that its color may not stick to the fabric. Steel balls (around 20 Nos) should be put into the slot in the specimen.

3.13.2 APPARATUS REQUIRED:

1. Washing fastness tester
2. Test cloth, Cut in 5 * 8 inch
3. Grey scale for staining
4. Desized white cloth
5. Needle for stitching
6. Weighing balance with accuracy ± 0.0001 g
7. Steel balls

3.13.3 RECIPIE:

1. Neutral soap: 5 g/l soap,
2. 2g/l sodium carbonate
3. Material: Liquor Ratio is 1:50

3.13.4 TEST PROCEDURE:

The sample is weighed in the balance and its weight is noted down. Distilled water measuring 50 times the weight of the sample is taken in vessel of washing fastness tester. Neutral soap solution (5g/l) of weight equal to weight of the

specimen is added to vessel. Sodium Carbonate (2 g/l) of weight equal to the weight of the specimen is added to the vessel. Now the sample is put into the vessel and the vessel is closed with its lid along with gas kit. The vessel is mounted in the washing fastness tester. The time (45 min) and temperature (90° C) is set in the digital panel in the front of the machine and the machine is started. After the test is completed, the machine stops automatically and the vessel is taken out. The sample is washed with cold water. The sample is dried in the oven. Then the sample is separated from the white cloths on either sides. The degree of staining on the white cloth is noted. The specimen is compared with the grey scale and the degree of fastness is evaluated.

3.14 COLOUR FASTNESS TO RUBBING

Standard: IS3426:1982

3.14.1 PRINCIPLE:

1. A colored test specimen is rubbed with white crock test cloth under controlled conditions.
2. Color transferred to the white test cloth is assessed by a comparison with the grey scale for staining or the chromatic transference scale and a grade is assigned.

3.14.2 TERMINOLOGY:

1. Color Fastness

The resistance of a material to change in any of its color characteristics, to transfer of colorant(s) to adjacent materials, or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage or use of the material.

2. **Crocking**

A transfer of colorant from the surface of the coloured yarn or fabric to another surface or to on adjacent area of the Same fabric principally by rubbing.

3.14.3 APPARATUS AND MATERIAL:

1. AATCC Crock Meter
2. Test cloth, Cut in 50mm Squares
3. AATCC Chromatic transference scale
4. Grey scale for staining
5. White AATCC textile blotting paper
6. Specimen holder for crock meter

3.14.4 TEST SPECIMEN:

1. Two specimens are used, one each for the dry and the wet tests.

    1.1 Additional specimens may be used to increase the precision of the average.

2. Cut specimen at least 50 * 130 mm and position for testing preferably with the long dimension oblique to warp and filling or wales and courses.

    2.1 Larger or full width lab samples may be used with out cutting individual specimens, when multiple tests are needed and when using for production testing.

3. Yarns knit a piece of fabric at least 50 * 130 mm or wind yarn tightly on a suitable form at least 50 * 130 mm with the yarn running in the long direction or otherwise stretched.

3.14.5 CONDITIONING:

Prior to testing, pre condition and condition the test samples and the crock squares for dry crock testing as directed in ASTM D 1776, conditioning textiles for testing. Condition each specimen for at least 4 hours in an atmosphere of 21 ± 1 ^{o} C and 65 ± 2 % RH by laying each test specimen or crock square separately on a screen or perforated shelf of conditioning rack.

3.14.6 PROCEDURE:

1. **Dry Crocking test**

1.1 Place a test specimen on the base of the crock meter resting flat on the abrasive cloth with its long dimension in the direction of rubbing

1.2 Place the specimen holder over specimen as an added means to prevent slippage

1.3 Mount a white test cloth square, the weave parallel with the direction of rubbing, over the end of the finger which projects downward from the weighted sliding arm. Use the special spiral wire click to hold the test square in place. Position the clip with loops upward. If the loops point downward they can drag against the test specimen

1.4 Lower the covered finger on to the test specimen. Beginning with the finger positioned at the front end, crank the meter handle 10 complete turns at the rate of 1 turn per second to slide the covered finger back and forth 20 times. Set and run the motorized tester for ten complete turns. Refer to individual specimens for any other required number of turns.

1.5 Remove the white test cloth square, condition and evaluate as per the standards. In the case of napped, brushed or sanded material when loose fiber might interfere with the rating, remove the extraneous fibrous material by pressing lightly on the crock circle with the sticky side of cellophane tape before evaluating

2. **Wet Crocking Test:**

2.1 Prepare the wet crock cloth square by weighing a conditioned square, then thoroughly wet out white testing square in distilled water. Prepare only one square at a time

2.2 Bring the wet pick-up to 65 ± 5 % by squeezing wet testing squares between blotting paper through a hand wringer or similar convenient means.

2.3 Avoid evaporative reduction of the moisture content below the specified level before the actual crock test is run.

2.4 Repeat Dry crocking test

2.5 Air dries the white test square, then condition before evaluating. In the case of napped, brushed or standard material then loose fiber might interfere with the rating, remove the extraneous fibrous material by pressing lightly on the crock circle with the sticky side of cellophane tape before evaluating

3.15 COLOUR FASTNESS TO PRESPIRATION

ISO 105 E 04

3.15.1 PRINCIPLE

A specimen of colored textile in contact with other fibre material is wet out in simulated acid perspiration solution, subjected to a fixed mechanical pressure and allowed to dry slowly at a slightly elevated temperature. After conditioning, the specimen is evaluated for color change and the other fiber material is evaluated for color transfer.

3.15.2 APPARATUS, MATERIAL AND REAGENTS

1. AATCC Perspiration tester, Plastic plate
2. Drying oven
3. Balance with weight accuracy of ± 0.001g
4. Multi fiber test fabric
5. pH meter accurate to ±0.01
6. 9-Step AATCC Chromatic Transference Scale for staining
7. Grey scale for Color change

8. Wringer
9. White AATCC Blotting Paper
10. Acid Perspiration Solution

3.15.3 PREPARATION OF REAGENT

1. Prepare the acid perspiration solution by filling a 1 L volumetric flask half full of distilled water. Add the following chemicals and mix to be sure that all chemicals are thoroughly dissolved:
    1. 10± 0.01g sodium chloride
    2. 1±0.01g lactic acid USP 85%
    3. 1±0.01g Sodium Phosphate, dibasic, anhydrous
    4. 0.25 ± 0.001g l-histidine monohydro-chloride

   Fill the volumetric flask with distilled water to the 1 L mark
2. Test the pH of the solution with a pH meter. If it is not 4.3 ± 0.2 discard it and prepare a new one, making sure all ingredients are weighed accurately.
3. Do not use perspiration solution that is more than three days old.

3.15.4 TEST SPECIMEN

1. Cut one 6* 6 ± 2 cm specimen from each sample and an unequal size piece of multi fiber test fabric. Do not use multifiber test fabric that has fused edges because it might have thickness variations at the edges which would cause uneven compression during testing. If the fiber or fibers in the dyed fabric are not present in the multifiber test fabric, also include a piece of undyed original material in the test.
2. Sew or lay the multifiber test fabric to test specimen and if used, the undyed original fabric, with the specimen between to make a sandwich assembly.

3.15.5 PROCEDURE

1. Place the test specimen in a 9 cm diameter, 2 cm deep Petri dish. Add freshly prepared perspiration solution to a depth of 1.5 cm in the Petri dish. Soak this test specimen in the solution for 30± 2 min with occasional agitations and squeezing to ensure complete wetting. For fabrics hard to wet out, alternately wet the solution and pass it through the wringer until it is completely penetrated by the solution.
2. After 30 ± 2 min pass each test samples assembly through the wringer with the multifiber stripes perpendicular to the length of the wringer rolls. Weigh each test specimen to the sure its weights 2.25 ± 0.05 times its original weight. Because certain fabrics may not be able to retain this amount of solution when passing through the wringer, such fabrics may be tested after blotting to the required wet pickup with white AATCC blotting paper. To obtain consistent results all specimens of a given constructions in a test series should have identical pickup, as the degree of staining increases with the amount of retain solution.
3. Place each test specimen assembly on a marked plexiglass or glass plate with the multifiber stripes running perpendicular to the long dimension of the plate.
4. Depending upon equipment available, use the following alternates:

    1. **AATCC Perspiration tester:** Place the plates in the perspiration tester with the specimen assemblies evenly distributed between the 21 plates. Place all 21 plates into the unit regardless of the on of specimens. After placing final plate in position (on top) set the dual plates with compensating springs in position, place the 3.63 kg weight on top making 4.54 kg under the pressure plate and lock the pressure plate in position by turning the thumbs screw. Remove the weight and place the unit lying on its side in the oven.

    2. **Perspirometer:** Assemble the plates in the perspiration tester with the specimens evenly distributed between the 21 plates. Place all 21 plates into the unit regardless of the number of specimen. The plates are held in a

vertical position between an indicating scale with a fixed metal plate at one end and an adjustable metal plate at the other end. Use the adjusting screw to excert a 4.54 kg force against the plates. Lock the specimen unit containing the test specimen with a set screw. Remove the pressure gauge unit from the specimen and place the specimen unit in the oven. Another specimen unit maybe added to the pressure gauge unit and the loading procedure repeated.

5. Heat the loaded specimen in an oven at 38 ± 1 °C (100 ± 2 ° F) for six hours ± 5 min. Check the oven temperature periodically to be sure it remains at the specified temperature through out the test.
6. Remove the tester from the oven and for each test specimen assembly, separate the multifiber fabric and, if used, the adjacent fabric from the test fabric. Place the multifiber fabric and test fabric specimens separately on a wire screen in a conditioned atmosphere (21± 1 °C, 65± 5%RH) over night.

3.15.6 EVALUATION:

General – unsatisfactory perspiration fastness may be due to bleeding or migration of color or it may due to change in color of the dyed material. It should be noted that objectionable change in color may be encountered with no apparent bleeding.

CHAPTER-4

RESULTS AND DISUSSIONS

4.1AIR PERMEABILITY

Air Permeability is an important parameter with respect to comfort properties of inner garments. Higher the air Permeability means high amount of air penetrates through the garment. Comparing the results obtained from the table4.1, the air permeability of 100% modal is better than other blend ratios.

Standard: ASTM D 737 – 96

Table4.1 – Air Permeability

PROPERTY	100% Modal	65/35% Modal/Cotton	50/50% Modal/Cotton
Air Permeability (ml/sec/cm.sq)	9.158*	5.158*	4.289*

* - Forty fold samples are subjected to test

4.2 MOISTURE REGAIN

The moisture regain is important in case of garment worn immediately next to the skin. The fabric which has more regain % absorbs more moisture from skin and keeps it relatively dry hence giving high degree of comfort. The moisture regain of cotton is 8.5% where as in case of 100% modal is nearly 1.5 times that of cotton. Higher the blending with modal higher the moisture regain. The results are tabulated table 4.2.

Table4.2 – Moisture Regain

PROPERTY	100% Modal	65/35% Modal/Cotton	50/50% Modal/Cotton
Moisture regain	12.5%	10.3%	9.7%

4.3 RATE OF EVAPORATION:

Rate of evaporation is the amount of moisture evaporating from the fabric at room temperature. The sweat absorbed must be evaporated from the garment as quick as possible to keep the skin dry, which increases the breath ability of the skin. By the results obtained from the table 4.3, 100% modal have a high rate of evaporation. And 65/35 modal/cotton blend have rate of evaporation comparatively lower than 100% modal but higher than 50/50 modal/Cotton blend.

The rate of evaporation is calculated at two stages one after 5 minutes and another after 30 minutes. The values are shown in the table below.

The rate of evaporation E % can be calculated as follows:

$$E\% = (M_W - M_D) / M_D * 100$$

Where,

M_W = Mass of the material in full wet state.

M_D = Mass of the material after drying a few minutes.

Table4.3 – Rate of evaporation

PROPERTY		100% Modal	65/35% Modal/Cotton	50/50% Modal/Cotton
Rate of evaporation	after 5 Min	9.2%	6.8%	5.6%
	after 30 Min	39.2%	23.2%	20%

4.4 DRAPE COEFFICIENT

The drape is the amount of sliding of the fabric on the body. More the fabric drapes, the fabric becomes more flexible and increases comfort. Fabric materials used as trousers must have more drape coefficient i.e., the fabric should be rigid to have elegant appearance. But fabrics used as inner garments should process more comfort. Inner wears are knitted garments and process much less drape coefficient than wovens.

Here the results obtained from the table 4.4 shows that 100% Modal process much higher drape than its blends with cotton. The drape of 65/35 and 50/50 Modal / Cotton blends is slightly less than that of 100% Modal.

Table4.4 – Drape Coefficient%

	100% MODAL	35/65% Cotton/Modal	50/50% Cotton/Modal
Mean Drape Coefficient %	47.06	51.40	51.02

4.5 DIMENSIONAL STABILITY:

4.5.1 FABRIC STAGE:

For any fabric to be used as a garment dimensional stability is an important parameter to be considered. The dimensional stability has been in two stages for fabric and in one stage for garment.

It has been founded that the dimensional changes are within the allowable limit of 5% only.

Formula used:

Dimensional change%= (B-A) / A*100

Where,

A = the original measurement of bench mark in the specimen

B = the measurement of bench mark in the specimen after washing and drying.

Table-4.5.1.1 Dimensional change in the fabric before compacting

TYPE	DIMENSIONAL CHANGES IN WIDTH	DIMENSIONAL CHANGES IN LENGTH
100%	+3.5%	-5%
35/65%	+6.2%	-9%
50/50	+8.5%	-12%

("+" indicates extension and "–" indicates shrinkage)

Since the dimensional change in the fabric are more than the allowable limit of 5% the fabric is compacted to maintain its dimensional stability.

Table-4.5.1.2 Dimensional change in the fabric after compacting

TYPE	DIMENSIONAL CHANGES IN WIDTH	DIMENSIONAL CHANGES IN LENGTH
100%	-1.2%	-1.8%
35/65%	-1.3%	-1.3%
50/50	-1.3%	-1%

("+" indicates extension and "–" indicates shrinkage)

4.5.2 GARMENT STAGE:

Table 4.4.2.1 Dimensional changes for Brief

TYPE	DIMENSIONAL CHANGE AT WAIST	DIMENSIONAL CHANGE AT FRONT LENGTH
100%	-3%	-2.8%
35/65%	-3%	-2.8%
50/50	-3.1%	-2.9%

("+" indicates extension and "–"indicates shrinkage)

Table 4.5.2.2 Dimensional changes for Singlet

TYPE	DIMENSIONAL CHANGE AT CHEST WIDTH	DIMENSIONAL CHANGE AT BODY LENGTH
100%	-3.1%	-3%
35/65%	-3%	-2.8%
50/50	-3%	-3%

("+" indicates extension and "–" indicates shrinkage)

Table 4.5.2.3 Dimensional changes for Boxer shorts

TYPE	DIMENSIONAL CHANGE AT WAIST	DIMENSIONAL CHANGE IN OVER ALL LENGTH
100%	-2.9%	-3%
35/65%	-3%	-3.1%
50/50	-3%	-3%

("+" indicates extension and "–" indicates shrinkage)

Thus both at the fabric and at the garment stage the dimensional changes are within in the allowable limits of 5%.So that there won't be any problem regarding shrinkage with the usage of Modal as garments.

4.6 FABRIC PILLING

It is considered that any fabric which pills under the conditions of test is not completely satisfactory. Fabric which is used next to the skin and subjected to frequent washing pills more. The garment used as inner wear will pill more severe than other garments such as shirts, trousers, blouses, etc,.

The results obtained from the table shows that 100% modal have moderate pilling and other blends have slight pilling which is comparatively less than that of 100% modal fabric. The pilling rating is shown in the table 4.6.1 below.

Table4.6.1 – Pilling Rating

Parameter	100% MODAL	35/65% Cotton/Modal	50/50% Cotton/Modal
Pilling Rating	3	4	4

4.6.1 PILLING STANDARD RATINGS:

1 - Extremely high pilling

2 - Unacceptable pilling

3 - Moderate pilling

4 - Slight pilling

5 - No pilling

The Yarn twist is an important parameter that affects pilling. Normally yarns with low twist pills more severe than yarn with higher twist. Thus the twist of the yarn is taken into account.

Here 100% modal have less TPI compared to 35/65 and 50/50 Modal / Cotton blends. Hence this may account for much higher pilling than other blend of Modal / Cotton blends. The TPI values are shown in the table4.6.2 below.

Table4.6.2 -Yarn twist per inch

Particulars	100% MODAL	35/65% Cotton/Modal	50/50% Cotton/Modal
Mean TPI	14.6	17.2	18.3

4.7 COLOUR FASTNESS TO WASHING

The test is important in case of garments subjected to repeated washing. The fabric we use must not stain other fabrics during washing. The inner garments are normally washed repeatedly. From the results obtained from the table4.7, 100% Modal and its other blends have excellent wash fastness. Fastness property also depends on type of dyes used. Here the sample is dyed with hot brand reactive dyes which influence fastness.

Table4.7 – Fastness to Washing

Particulars	100% MODAL	35/65% Cotton/Modal	50/50% Cotton/Modal
Fastness Rating	4-5	4-5	4-5

4.7.1 Rating:

4-5 – *Excellent Fastness*

4.8 COLOUR FASTNESS TO RUBBING

The rubbing fastness shows amount of color transferred from the surface of coloured textile materials to other surfaces by rubbing. The test is important for all garments especially inner wears which touches the skin and subjected to strain

continuously. The rubbing fastness is checked out in two stages, i.e., one at dry state and other is at wet state. From the results obtained from the table 4.8, all the three specimens have excellent fastness both in dry and wet state. This property also depend upon the dye used since we have used hot brand reactive dyes, the rubbing properties are excellent.

Table4.8 – Rubbing Fastness

STATE	100% MODAL	35/65% Cotton/Modal	50/50% Cotton/Modal
WET	4-5	4-5	4-5
DRY	4-5	4-5	4-5

4.8.1 Grading:

4-5 – *Negligible / No colour transfer*

4.9 COLOUR FASTNESS TO PERSPIRATION

Human body sweats all through the day in the present climatic conditions and the fabric worn should absorb sweat. The test confirms the colour fastness to the sweat absorbed, and so called Colour fastness to perspiration. The inner garments should have excellent colour fastness to perspiration. The test is carried on acids and alkalis. The results obtained from the table 4.9 shows that there is poor shade change of material for 100% Modal and its blends either on acids and alkalis. And there is no staining on cotton, acrylic, acetate, nylon and polyester for 100% Modal and its blends either on acids and alkalis.

Table4.9 - Colour Fastness to Perspiration

Factors considered	100% Modal		35/65 % Cotton/Modal		50/50% Cotton/Modal	
	Acid	Alk.	Acid	Alk.	Acid	Alk.
Shade change	4	4	4	4	4	4
Staining on cotton	4-5	4-5	4-5	4-5	4-5	4-5
Acrylic	4-5	4-5	4-5	4-5	4-5	4-5
Acetate	4-5	4-5	4-5	4-5	4-5	4-5
Nylon	4-5	4-5	4-5	4-5	4-5	4-5
Polyester	4-5	4-5	4-5	4-5	4-5	4-5

4.9.1 Grading:

4-5 – *Negligible / No colour transfer*

4.10 COST CALCULATIONS

4.10.1 FABRIC:

The cost of the fabric should also be considered in the economic point of view and for the purpose of commercialization. The fabric cost includes yarn cost, knitting cost, dyeing cost, compacting cost and fabric loss. The fabric's cost is calculated and shown in the table 4.10.1.

Table4.10.1 – Fabric Cost

Type of cost	100% Modal	35/65	50/50
Yarn	Rs.230/kg	Rs.215/kg	Rs.200/kg
Knitting	Rs.10/kg	Rs.10/kg	Rs.10/kg
Dyeing	Rs.40/kg	Rs.40/kg	Rs.40/kg
Compacting	Rs.9/kg	Rs.9/kg	Rs.9/kg
Fabric loss	5%	5%	5%
Total	**Rs.304/kg**	**Rs.289/kg**	**Rs.274/kg**

4.10.2 GARMENTS

Three types of garments are taken into account. They are Singlet, Brief, and Boxer Shorts. The garment charges include waste cost, Cloth cost, Labeling cost, stitching cost, Elastic cost etc. The Garment costs are calculated and shown in individual tables.

4.10.2.1 SINGLET:

From the result obtained from the table 4.10.2.1, we can see that the garment cost of 100% modal singlet is slightly higher than 65/35 Modal/Cotton blend which in turn slightly higher than 50/50 Modal / Cotton blend. The cost does not vary much between 100% Modal and its blends.

Table4.10.2.1 – Cost Calculation of Singlet

Particulars	100% Modal	65/35% Modal/Cotton	50/50% Modal/Cotton
Piece Wt. (grams)	95	95	95
Cloth	Rs.28.88	Rs.27.45	Rs.26
C&M	Rs.3.50	Rs.3.50	Rs.3.50
Label	Rs.0.30	Rs.0.30	Rs.0.30
Packing	Rs.1.50	Rs.1.50	Rs.1.50
Master box	Rs.0.50	Rs.0.50	Rs.0.50
Garment waste	4%	4%	4%
TOTAL	**Rs.37***	**Rs.35.50***	**Rs.33.75***

*(*cost calculation by M/S.SANGU KNIT LANDS, TIRUPUR)*

4.10.2.2 BRIEF

From the result obtained from the table 4.10.2.2, garment cost of 100% modal brief is slightly higher than 65/35 Modal/Cotton blend which in turn slightly higher than 50/50 Modal / Cotton blend. The cost does not vary much between 100% Modal and its blends.

Table4.10.2.2 – Cost Calculation of Brief

Particulars	100% Modal	65/35% Modal/Cotton	50/50% Modal/Cotton
Piece Wt. (grams)	45	45	45
Cloth	Rs.13.68	Rs.13	Rs.12
C&M	Rs.3.50	Rs.3.50	Rs.3.50
Elastic For waist For leg opening	 Rs.1.50 Rs.0.7	 Rs.1.50 Rs.0.7	 Rs.1.50 Rs.0.7
Label	Rs.0.30	Rs.0.30	Rs.0.30
Packing	Rs.1.50	Rs.1.50	Rs.1.50
Master box	Rs.0.50	Rs.0.50	Rs.0.50
Garment waste	4%	4%	4%
TOTAL	**Rs.23***	**Rs.22***	**Rs.21.50***

*(*cost calculation by M/S.SANGU KNIT LANDS, TIRUPUR)*

4.10.2.3 BOXER SHORTS

From the result obtained from the table 4.10.2.3, the garment cost of 100% modal boxer shorts is slightly higher than 65/35 Modal/Cotton blend which in turn slightly higher than 50/50 Modal / Cotton blend. The cost does not vary much between 100% Modal and its blends.

Table4.10.2.3 – Cost Calculation of boxer shorts

Particulars	100% Modal	65/35% Modal/Cotton	50/50% Modal/Cotton
Piece Wt. (grams)	90	90	90
Cloth	Rs.26.55	Rs.26	Rs.24.50
C&M	Rs.4	Rs.4	Rs.4
Elastic For waist	Rs.1.50	Rs.1.50	Rs.1.50
Label	Rs.0.30	Rs.0.30	Rs.0.30
Packing	Rs.2	Rs.2	Rs.2
Master box	Rs.0.50	Rs.0.50	Rs.0.50
Garment waste	4%	4%	4%
TOTAL	**RS.37***	**Rs.36***	**RS.35***

*(*cost calculation by M/S.SANGU KNIT LANDS, TIRUPUR)*

CHAPETR-5

CONCLUSION

From the study we conclude that

1. 100% Modal gives good dye ability, excellent feel and brightness.
2. Pilling is high in 100% Modal when compared to 65:35 and 50:50 blend ratios. It is due to the low twist in 100% Modal.
3. Air permeability is good in 100% Modal when compared with its blends.
4. Drapability is also good when compared with other blends.
5. Rate of evaporation and the moisture regain properties of 100% Modal is good
6. Although there is no major difference with the colour fastness properties of the three samples as it mainly depends on the type of dye (Hot brand Reactive) used.
7. Cost of 100% Modal is only Rs.1.50/unit higher than blends which is not much significant.
8. 100% Modal is not only good with the comfort properties but economically also most suitable when compared with other blends of 50/50% Modal/cotton and 65/35%modal/cotton.

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