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A study on the thermal properties of 100% modal & viscose fabrics

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Abstract
The thermal comfort properties of fabric structures made from Modal yarns. 100% Modal is spun into yarns of identical linear density. Each of the yarns produced was converted to single jersey knitted fabrics, cross tuck fabric, cross miss fabric & twill fabric. The thermal conductivity of the fabrics was generally found to decrease with increase in the proportion of Modal fibre. The water vapour permeability and wicking of the fabrics were observed to increase with increase in Modal fibre content. Statistical analysis also indicates that the results are significant for water vapour permeability of the fabrics. Wicking test was also done which gives fabric absorbency of water that how much it takes.

Keywords: modal fabric, thermal conductivity, air permeability

Introduction

Knitting is a method of forming fabric from a single strand of yarn, using two needles. The resulting fabric has given more than woven fabric. It is a technique to turn thread or yarn into a piece of cloth. Knitted fabric consists of horizontal parallel courses of yarn which is different from woven cloth as said by Prakash. C (2012). The courses of threads or yarn are joined together by interlocking loops in which a short loop of one course of yarn or thread is wrapped over another course. Fabric can be formed by hand or machine knitting, but the basic principle remains exactly the same i.e. pulling a new loop through the old loop. A knitted fabric consist of forming yarns into loops, each of which is typically only released after a succeeding loop has been formed and intermeshed with it so that a secure ground loop structure is achieved by Koushik. C.V.

Modal is a wood pulp based cellulosic fiber, made out of pure wooden chips from the beech tree, technically as the European Schneider Zelkova tree. While viscose rayon can be obtained from the wood pulp from a number of different trees, Modal uses only beech wood thus it is essentially a variety of viscose rayon; a generic name for modified viscose rayon fiber that has high tenacity and high wet modulus.

Modal was first developed by Austria based Lenzing AG Com pany who trademarked the fabrics' name, but now many manu facturers make their own versions. It was initially imported from Czech Republic, Slovakia, Hungary and Germany; but n ow for Indian market, it is catered to by Len zing, Austria, which has tied up with Rajasthan Textile Mills.

Thermal properties: Physical property of a solid body related to application of heat energy is defined as a thermal property. Thermal properties explain the response of a material to the application of heat. Important thermal properties are

- Heat capacity
- Thermal expansion
- Thermal conductivity
- Thermal stresses
- Air Permeability
- Water Vapour Permeability

Heat capacity

External energy required to increase temperature of a solid mass is known as the material's heat capacity, it is defined as its ability to absorb heat energy. Heat capacity is not an intrinsic property i.e. it changes with material volume/mass. Specific heat - For comparison of different materials, heat capacity has been rationalized. Specific heat is heat capacity per unit mass. It has units as J/kg-K or Cal/kg-K. With increase of heat energy, dimensional changes may occur. Hence, two heat capacities are usually defined. Heat capacity at constant pressure, Cp, is always higher than heat capacity at constant volume; Cv. Cp is only marginally higher than Cv. Heat is absorbed through different mechanisms: lattice vibrations and electronic contribution.

Thermal expansion: Increase in temperature may cause dimensional changes. Linear coefficient of thermal expansion (α) defined as the change in the dimensions of the material per unit length.

Thermal conductivity: It is ability of a material to transport heat energy through it from high temperature region to low temperature region. Heat energy transported through a body with thermal conductivity. It is a microstructure sensitive property and has units as W/m.K.

Thermal stresses: Stresses due to change in temperature or due to temperature gradient are termed as thermal stresses. Thermal stresses in a constrained body will be of compressive nature if it is heated, and vice versa. Engineering materials can be tailored using multi-phase constituents so that the overall material can show a zero thermal expansion coefficient. Eg.: Zerodur - a glass-ceramic material that consists of 7080%

crystalline quartz, and the remaining as glassy phase. Sodium-zirconium-phosphate (NZP) have a near-zero thermal expansion coefficient.

Air Permeability: The air permeability is a very important factor in the performance of some textile materials. Especially, it is taken into consideration for clothing, parachutes sails, vacuum cleaners, fabric for air bags and industrial filter fabrics. The air permeability is mainly dependent upon the fabric's weight and construction.

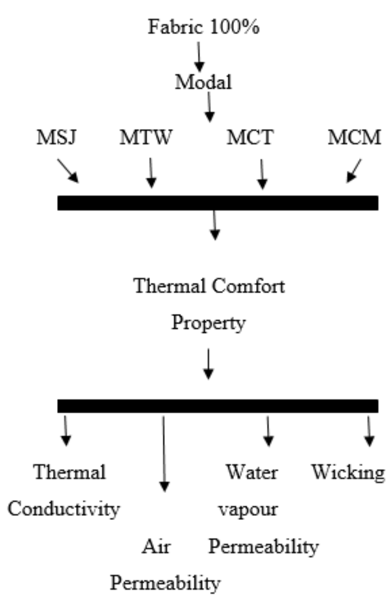
Water vapour permeability: Water vapor permeability is a measure of the passage of water vapor through the material. It is also known as water vapor transmission rate (WVTR) or moisture vapor transmission rate (MVTR). It is the mass of water vapor transmitted through a unit area in a unit time under specified conditions of temperature and humidity. Breathability or also referred to as Water Vapor Permeability can be described as the ability of a fabric to allow moisture vapor to be transmitted through the material.

Wicking

Moisture transfer properties and drying rate of fabrics are two major factors affecting the physiological comfort of garments. Moisture transfer and quick dry behavior of textiles depend mainly on the capillary capability and moisture absorbency of their fibers. These characteristics are especially important in sport garments next to the skin or in hot climates. In these situations, it is critical that textiles are able to absorb large amounts of perspiration, draw moisture to the outer surface and keep the body dry. Therefore, in order to optimize these functionalities in sport clothing, and to support moisture management claims, it is necessary to determine the wicking behavior and quick drying capability of functional fabrics.

Methodology

Flow Chart



MSJ -Modal Single Jersey
MTW - Modal Twill
MCT - Modal Cross Tuck
MCM - Modal Cross Miss

Fabric Production

(Production of Weft Knitted Fabric with 0.30cm Loop Length)
The following stitch combination of fabrics are produced for our study

- Knit Stitch - Single Jersey
- Knit and Tuck - Cross Tuck
- Knit and Miss - Cross Miss
- Knit, Tuck & Miss - Knitted Twill

Single Jersey

Jersey fabric is a type of knit textile made from cotton or a cotton and synthetic blend. Some common uses for jersey fabric include t-shirts and winter bedding. The fabric is warm, flexible, stretchy, and very insulating, making it a popular choice for the layer worn closest to the body. Jersey also tends to be soft, making it very comfortable.

Tuck and miss stitch

Apart from the knitted loop stitch the two most commonly produced stitches are the tuck stitch and the miss stitch (float stitch).

Tuck

A tuck stich is composed of a held loop, one or more tuck loops and knitted loops. It is produced when a needle holding its loop also receives the new loop. The tuck loop assumes an inverted U-shaped configuration.

Miss

A miss stitch or float stich is composed of a held loop, one of more float loops and knitted loops. It is produced when a needle holding its old loop fails to receive the new yarn that passes, as a float loop to the back of the needle, and to the reverse side of the resultant stitch.

Twill

Twill is a type of textile weave with a pattern of diagonal parallel ribs (in contrast with a satin and plain weave). This is done by passing the weftthread over one or more warp threads then under two or more warp threads and so on, with a "step," or offset, between rows to create the characteristic diagonal pattern [1]. Because of this structure, twill generally drapes well.

Thermal comfort characteristics of samples

The air permeability of the knitted fabric structures were measured with the Air Permeability Tester following the ASTM D 737 standard. Thermal conductivity is an intrinsic property of material that indicates its ability to conduct heat. Lee's disk instrument was used to measure the thermal conductivity according to Standard ASTM D1518, GB/T 11048-1989. The evaporative dish method based on BS 7209:1990 was used to determine the water vapour permeability of the fabrics. A strip of 20 cm × 2.5 cm test fabric at 20°C & 65% RH was suspended vertically with its lower edge (0.5 cm) immersed in a reservoir of distilled water. The rate of rise of the leading edge of the water was then monitored for longitudinal wicking. The static immersion method, which follows Standard BS 3449 [26] was used to evaluate the amount of water absorbed by the fabric. (Journal of Engineered Fibers and Fabrics http://www.jeffjournal.org Volume 12, Issue 1 – 2017)

Thermal Conductivity

Before testing the sample must be conditioned. Sample conditioning is done by Humidity Chamber. Specifications of Humidity Chamber are as follows;

- Machine Name – Humidity Cabinet
- Make- MAG Solvics PVT LTD, Coimbatore
- Serial No-7854670016
- Year-2017
- Capasity-20-90% RH
- Product Name-MAG-G0651

The conditioning process is as follows

- Keep the sample inside the cabinet tray.
- The chamber door has to be closed after keeping the sample inside. The sample can be seen from outside through inspection glass of humidity cabinet.
- Conditioning Fabric: 21±2 ˚C or 27 ± 2˚C
- Relative humidity (RH): 65±2% in chamber for 24 hours before testing.
- ASTM-1777 standard for the sample conditioning.

After conditioning the required sample is ready to test for the Thermal Conductivity Tester.

Air Permeability Test

Air permeability was measured in accordance with ASTM D737-04 [22], by the Tex-Test air permeability tester (FX3300, Switzerland). The air permeability is expressed as the quantity of air in cubic centimetres passing through a square centimetre of fabric per second (cm3/sec·cm2). The air permeability tests were done at a test pressure drop of 100 Pa (20 cm² test area). The average of five measurements was used for comparison.

The air permeability is a very important factor in the performance of some textile materials. Especially, it is taken into consideration for clothing, parachutes sails, vacuum cleaners, fabric for air bags and industrial filter fabrics. The air permeability is mainly dependent upon the fabric's weight and construction.

Results and discussion

In this study, the results on the thermal comfort properties of air permeability, & thermal conductivity, has been seen and discussed.

Air Permeability Test

Air permeability test of Modal fabric

The test result of regenerated cellulosic fabric of Modal 100% of different structure is shown in the table & figure.

Table 1: Air permeability of Modal fabric.

Sample Specification	Air permeability (cm3/cm2/sec)
MCT	275.6
MTW	310
MSJ	241.2
MCM	289.8

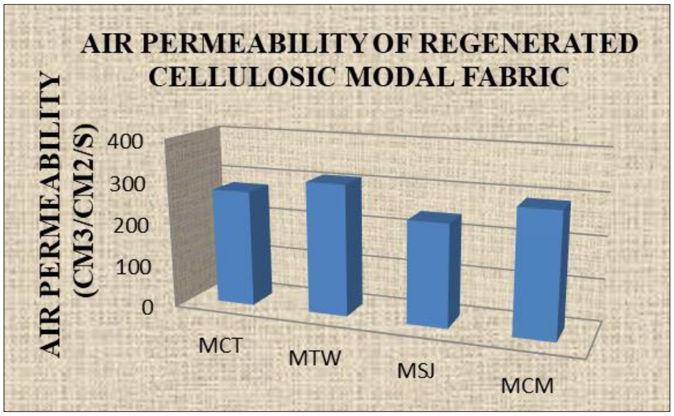


Fig 1: Air permeability of Modal fabric.

From the above result it is clear that the fabric of modal from the four structures in the test of the air permeability of bi-layer knitted fabrics can decrease with increased stitch density and thickness. So it is conclude that Air permeability of Modal Twill gives good result compared to single jersey, cross miss, cross tuck.

Thermal Conductivity of Modal fabric

Table 1: Thermal Conductivity of Modal fabric - Insulation rate

Sample	MCT	MCM	MSJ	MTW
Insulation Rate T.R	14.15%	18.31%	15.07%	11.36%

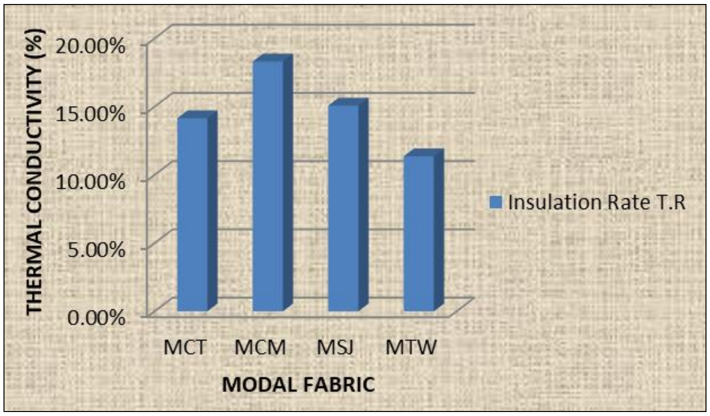


Fig 2: Thermal Conductivity of Modal fabric - Insulation rate

Among the four structural variation of modal cross tuck, modal cross miss, modal twill, modal single jersey. The insulation rate of thermal conductivity of modal cross miss gives good result among the other knit structure.

Table 2: Thermal Conductivity of Modal fabric – Heat Transfer Coefficient HTC

Sample	MCT	MCM	MSJ	MTW
Heat Transfer Coefficient HTC	64.11	46.95	59.23	81.97

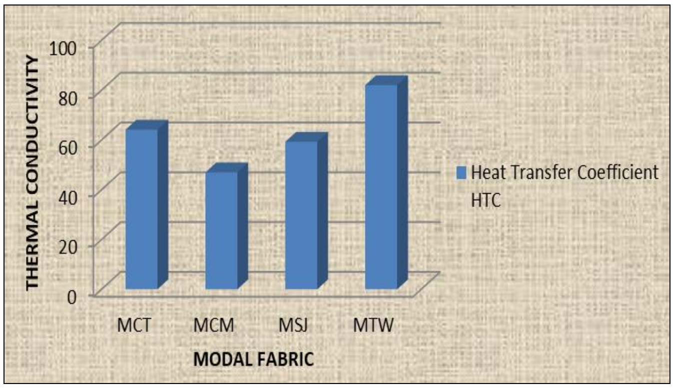


Fig 3: Thermal Conductivity of Modal fabric - Heat Transfer Coefficient HTC

In heat transfer coefficient among the modal single jersey, modal twill, modal cross miss, modal cross tuck it is seen that modal twill gives the good performance then the other one.

Thermal Conductivity of Modal fabric - CLO VALUE

Table 3: Thermal Conductivity of Modal fabric – CLO VALUE

Sample	MCT	MCM	MSJ	MTW
CLO Value	0.1	0.13	0.11	0.07

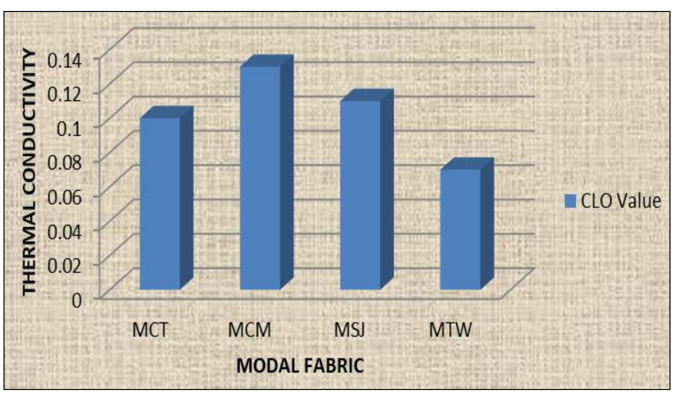


Fig 4: Thermal Conductivity of Modal fabric - CLO VALUE

Thermal conductivity of CLO VALUE among the modal 4 structure of single jersey, twill, cross miss, cross tuck the result is seen that modal cross miss gives the good result.

Summary & Conclusions

A "Warm - cool feeling" is a very important property, as a result of which a human can feel comfort or discomfort in various activities and environmental conditions. This feeling could be achieved by using different types of yarns. It was determined that higher air permeability is characterized for knits manufactured only from pure yarns.

The thermal comfort properties of single jersey fabrics made from yarns of 100% Modal yarns were investigated.

It is observed that the parameters of air permeability, and thermal conductivity are significantly affected by the Moisture Vapour Transport.

However if the wearer performs mild activities, skin wetness is very low and thermal comfort is managed by skin temperature. The fabrics' of air permeability and thermal conductivity are determining properties for thermal comfort, Fabrics must have high air permeability and low thermal resistance. Modal fabrics with single jersey structure fulfill these requirements as well as offering the advantages cited at the outset of this work.

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