Moisture Management Properties of Textiles and Its Evaluation

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Abstract
Moisture management is one of the key performance criteria in today’s apparel industry, which decides the comfort level of any fabric. The consumer’s demand for comfort performance of the garment is on high rise and inevitably apparel manufacturers have been compelled to shift their attention towards the high-performance of moisture management technology and market. This review encompasses the necessity of moisture management in textile apparel, aims of development of moisture management fabrics, technical approach towards moisture management, desired attributes of moisture management fabrics, the route to moisture management, various concepts of moisture managing textiles, developments in moisture management techniques and functional fields of application of moisture management technique.

Keywords: Moisture management; Apparel; Comfort; Development; Application

Abbreviations: MMT: Moisture Management Tester; PCM: Phase Change Materials; MWR: Maximum Wetted Radius; OMMC: Overall Moisture Management Capacity

Introduction
Technical textiles are the textile materials and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics. One of the most important branch of technical textiles is Sportech, used in sports and leisure. The comfort properties of sportswear are largely determined by its moisture management properties. In India, Sportech market is on high growth with increasing popularity [1,2].

There is a rapid change in fashion and apparels worldwide. Whether it is woven or knitted, the demand is for something new and different in the world of high fashion. As the worldwide business gears to tackle the challenges, product diversification has become the key to global opportunities. The main factors affecting consumer’s selection of garments are aesthetic, appearance and fashion. Besides these factors, comfort properties of garments during usage cannot be neglected. Now-a-days, consumers have become much more demanding in terms of properties of clothing, particularly those of leisure and sportswear. One of the textile properties that have steadily gained importance among increasingly well-informed consumers is breathability. To maintain the state of comfortness, clothing must be designed to allow body’s heat balance to be maintained over a wide range of environmental conditions. It should fulfil this function without inhibiting the evaporation of humidity caused by perspiration, and thus not interfering with the temperature regulation of the body [3]. Moisture management can be defined as the controlled movement of water vapor and liquid water (perspiration) from the surface of skin to atmosphere through the textile substrate. This action prevents perspiration remaining next to skin. Wearing garments that transport moisture and evaporate it quickly actually enhance body’s ability to cool itself [4].

The main aim to develop moisture management fabrics is; to transport the humidity to the atmosphere as fast as possible, to evaporate it and making the skin feel dry. Moisture management includes the use of microfiber technology or the application of various softening finishes like silicones at the molecular level to enhance both hydrophobic and hydrophilic properties of a fabric [5]. Water-resistant and moisture-permeable materials may be divided into three main categories: high-density fabrics, resin-coated materials and film-laminated materials.

Some standards and test methods can be employed to evaluate the fabric’s simple absorbency and wicking properties. The liquid strike-through time of non-wovens can be tested according to ISO 9073-8. The Moisture Management Tester (MMT) is an instrument to measure the dynamic liquid transport properties of textiles such as knitted and woven fabrics in three dimensions:
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1. Moisture Management Properties of Textiles and Its Evaluation.

2. Discussion

3. Principle of measurement

4. Requirement for moisture management

5. History of moisture management

6. Approaches for development of Moisture Management

7. Current Trends in Fashion Technology & Textile Engineering

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Wetting is the initial process, involved in fluid spreading; it is controlled by the surface energies of the involved solid and liquid. In case of textile material as soon as water wets the fiber, the water enters the inter fiber capillary channel and is dragged along by the action of capillary pressure. Wetting, wicking and moisture vapor transmission properties are critical aspects for assessing the comfort performance of textile products. Wetting is the initial process involved in fluid spreading. The fiber-air interface is replaced with a fiber-liquid in this process. In the case of clothing with high wicking properties, moisture coming from the skin is spread throughout the fabric offering a dry feeling and spreading of the liquid enables moisture to evaporate easily.

**Developments in moisture management techniques**

The term “moisture management” is often used as an advertising slogan. However, ideas differ among textile manufacturers as to how to achieve an optimized moisture management. In order to bring about the different effects, a suitable fiber material is used or a subsequent finishing is applied. It is also possible to combine specialized fibers and finishings.

**Hydrophobic textiles:** Absorb only a little amount of humidity which can lead to insufficient transmission of humidity away from the skin and to an unpleasant feeling of dampness. Furthermore, the water which is not transported to the outer surface is no longer available for cooling of the body.

**Hydrophilic textiles:** Hydrophilic Textiles are known for their greater capacity to absorb humidity. Emerging liquid is absorbed efficiently and transported to the skin surface for evaporation. However, after exercise, a large amount of liquid has to evaporate to cause stronger cooling and freezing.

**Hydrophobic-Hydrophilic textiles:** Hydrophobic-Hydrophilic Textiles are designed to transport humidity rapidly from the skin and evaporate it outside. The special construction of the material enables transportation of humidity from inside to outside of the substrate. The two-sidedness of the fabric is either attained by processing different materials during manufacturing or by varied coatings of the fabric surfaces.

**Micro fibers:** Micro Fibers by virtue of their extreme fineness, form especially small gaps and have a big surface area. This leads to high capillary effect for the transportation of humidity, and rapid evaporation.

**Special fibers:** Special Fibers are designed to increase the capillary force and the humidity transportation, by means of special profiles. The larger surface area of these fibers also serves to promote evaporation.

**Waterproof-Breathable textiles:** Waterproof-Breathable Textiles provide protection from the environmental factors like wind, rain and loss of body heat. Waterproof fabric completely prevents the penetration and absorption of liquid water. The term breathability implies that the fabric is actively ventilated.

Breathable fabrics passively allow water vapor to diffuse through them yet prevent the penetration of liquid water. High functional fabrics support active sportswear with importance placed on high functions as well as comfort.

**Spacer fabrics:** Spacer Fabrics consists of two separate fabric webs, which are joined together by spacer threads or fibers of varying rigidity. The intermediate zone creates a layer of air, having an insulating and thermoregulatory effect. An important advantage is its low weight in proportion to large volume. The application areas of spacer fabric are unlimited ranging from healthcare, safety, military, automotive, aviation and fashion. Currently it is being largely used for functional clothing comprising sports shoes, bra cups, shoulder pads, knee and elbow protectors etc. [10].

**Phase change materials (PCM):** Phase Change Materials are materials that have the distinctive capacity to soak and emit heat energy without altering the temperature. They possess different freezing and melting points and when mixed in a microcapsule, accumulate and release heat energy and maintaining the temperature range of 30-34 °C, which is very comfortable for the body. PCM microcapsules can create small, transitory heating and cooling effects in garment layers when the temperature of the layers reaches the PCM transition temperature [11].

**Table 1:** Different types of Fabric & its Characteristics.

| Sr. No. | Type of Fabric | Properties |
|---------|----------------|------------|
| 1.      | Water Proof Fabric | Very slow absorption  
No spreading  
No one-way transport, no penetration |
| 2.      | Water Repellent Fabric | No wetting  
No absorption  
No spreading  
Poor one-way transport without external forces |
| 3.      | Slow Absorbing and Slow Drying Fabric | Slow absorption  
Slow spreading  
Poor one-way transport |
| 4.      | Fast Absorbing and Slow Drying Fabric | Medium to fast wetting  
Medium to fast absorption  
Small spreading area  
Slow spreading  
Poor one-way transport |
| 5.      | Fast Absorbing and Quick Drying Fabric | Medium to fast wetting  
Medium to fast absorption  
Large spreading area  
Fast spreading  
Poor one-way transport |
| 6.      | Water Penetration Fabric | Small spreading area  
Excellent one-way transport |
| 7.      | Moisture Management Fabric | Medium to fast wetting  
Medium to fast absorption  
Large spread area at bottom surface  
Fast spreading at bottom surface  
Good to Excellent one-way transport |
Pine cone effect: Pine cones on the trees are seemed to be closed but when they fallout from the tree it gets opened to release the seeds. The scales of the pine cone get opened as they are made up of two layers of stiff fibers running in different directions. As the cone dries out, the scales inside get expanded more than outside, causing the outer scales to bend outwards, releasing the seeds inside. The pine cone effect is a technology designed to offer a solution to the discomfort sensations caused by the moisture which is built up due to the changing temperature in clothing. It is impossible to predict the Indian temperature, humidity and activity level so that to accommodate in a selection of clothing to ensure comfort. There may be the other ways of producing ventilating or insulating fabrics by addition or removal of layers of clothing, addition of garment parts or by introduction of ventilating features to the garments but the limited availability of space and the wearer’s ability makes discomfort sensations (Table 1). To overcome this, the pine cone effect is employed in clothing which is advantageous over others [12].

Measurement and evaluation of moisture management properties of textiles

Below mentioned apparatus and accessories are required to measure moisture management properties of textiles.

- Moisture Management Tester
- Computer with MMT software installed
- Distilled water
- Sodium chloride solution (0.9% NaCl)
- Conductivity meter to check the conductivity of the Sodium chloride solution (conductivity should be 16±0.2 milli Siemens (mS) at 25 °C)
- White textile blotting paper or soft towels (Figure 1 & 2).

Wetting time-WTT (Top) and WTB (Bottom): WTT and WTB are the time period in which the top and bottom surfaces of the fabric just start to get wetted respectively after the test commences, which are defined as the time in second (s) when the slope of total water contents at the top and bottom surfaces (U_{top} and U_{bottom}) become greater than tan (15°) respectively. Wetting time can be compared with the absorbency drop test specified in AATCC 79.

Absorption rate: TAR (Top) and BAR (Bottom): TAR and BAR are the average moisture absorption ability of the fabric top and bottom surfaces in the pump time respectively.

Maximum wetted radius: MWR (Top) and MWR (Bottom): Maximum wetted radii (MWR_{top} and MWR_{bottom}) are defined as maximum wetted ring radius at the top and bottom surfaces respectively, where the slopes of total water content (U_{top} or U_{bottom}) become greater than tan(15°) for the top and bottom surfaces respectively.

Spreading speed: TSS (Top) and BSS (Bottom): Spreading Speed is defined as the accumulative spreading speed from the centre to the maximum wetted radius.

Overall moisture management capacity (OMMC): Overall Moisture Management Capacity (OMMC) is an index to indicate the overall capability of the fabric to manage the transport of liquid moisture. Table 2 & Figure 3 illustrates the grading of liquid moisture management properties of the tested sample.
### Application of moisture management technique

- Inner wears
- Athletic wear (active sportswear)
- Performance wear (climbing, walking, skiing)
- Comfort wear (nightwear)
- Military (multi-climate clothing)
- Health (hospital bed linens, wound dressings)
- Agricultural technology (Geo-textiles, greenhouse screening panels, soil moisture control)
- Technical solutions (Formula 1 protective clothing, firefighting, industrial clothing)
- Industrial (filter & valve technology, building, packaging)
- Upholstery (transport).

### Conclusion

For comfort properties of textiles with varying end use applications, in the normal textile sector, technical textiles and other fields, moisture management plays a key role. Based on moisture management, textiles can be made tailor made for its specific end use. Apparel manufacturers are shifting their attention to the high-performance end use of the moisture management fabrics. As manufacturers of sports and active outdoor wear strive to improve the functionality of their collections, the future will see further developments in the field of moisture management fabrics.

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