CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter is concerned with the general introduction, importance of transverse wicking and need for research on it. The objectives of the study and organization of the thesis are discussed.

1.2 GENERAL

The physics of liquids in porous media namely, spreading or imbibitions gives rise to many interesting phenomena. It is easy to do qualitative observations on the physics of fluid penetration in inhomogeneous media; a drop of coffee on a napkin or a sugar cube held partly in the same coffee cup are adequate to demonstrate two fundamental facts. A moving interface is formed between the wet and non-wet regions of the medium. The dynamics of the phenomenon slows down with time, meaning that the wetted area of the napkin or volume of coffee absorbed by the cube increases more and more slowly. In fact, the average position of the interface $H$ of the wet front usually increases with time as $H(t) \sim t^{\frac{1}{2}}$. The coffee drop shows an example of spontaneous imbibition, and it obeys, what is known as Washburn’s law. The force driving the liquid from the liquid reservoir to the front between the wet region and the air in the medium has a weaker and weaker effect on the total flow as the distance between these two becomes larger.
Wetting is due to absorbing of the liquid and spreading is of importance for technological applications, they range from oil recovery (using water to displace it out of rock) to biology (water in living organism) and manufacturing processes. The flow of liquids through porous media thus forms a very vast field which combines the porous structure of the medium with the surface chemistry and physics of the liquids and/or gases involved and is characterized by several parameters such as the viscosity contrast of the fluid, their wettability and surface tension as well as the displacement rate. The areas in which imbibitions or spreading plays a role are given in Table 1.1.

Table 1.1 Some practical situations where imbibition is important

<table>
<thead>
<tr>
<th>Application</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil recovery</td>
<td>Displacement of oil by another immiscible liquid</td>
</tr>
<tr>
<td>Polymer composites</td>
<td>Invasion of voids in the perform by a resin</td>
</tr>
<tr>
<td>Textile</td>
<td>Interaction of liquids and garments</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Moving ground water from wet to dry areas of the soil</td>
</tr>
<tr>
<td>Absorption</td>
<td>Removing liquids from a surface</td>
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<tr>
<td>Printing Process</td>
<td>Ink penetration into paper or coating of paper</td>
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<tr>
<td>Food</td>
<td>Wine filtering</td>
</tr>
<tr>
<td>Plants</td>
<td>Transport of water and minerals in plants</td>
</tr>
<tr>
<td>Air fresheners</td>
<td>Dispensing air fresheners into the air</td>
</tr>
<tr>
<td>Insect repellents</td>
<td>Dispensing insect repellents into the air</td>
</tr>
<tr>
<td>Surface chemistry</td>
<td>Contact angle measurement</td>
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</tbody>
</table>

In textiles, clothing comfort plays an important role for any garment used for sportswear and leisurewear. Every human being sweats during different kinds of activities. Therefore, an important feature of any fabric is how it transports this sweat (perspiration) out of the body surface and
makes the wearer feel comfortable. The basic requirement of fabric worn next to skin should assist for the moisture release to the atmosphere.

Clothing made of performance fabrics is said to be designed not only for fashion or just a passive cover for the skin, but to critically influence the comfort and performance of the wearer. Mills and manufacturers have engineered these fabrics to manage moisture, regulate temperature, and provide protection from the surrounding environment. They are designed to interact with and modify the heat-regulating function of the skin as the surrounding environment interacts with them.

Mainly, performance fabrics are engineered to keep the body dry during vigorous athletic activities. Keeping the body dry, especially during cold weather sports, ensures that the wearer does not lose heat unnecessarily by having wet skin. Interaction of a fabric with moisture affects the two main categories of body comfort: sensorial and thermophysiological (thermal).

Sensorial comfort pertains to the satisfaction of the wearer as the fabric or garment is perceived by the basic senses of the body. This type of comfort may be affected by how a fabric feels against the skin, how it appears to the eye, how it smells, or even how it sounds. In the case of performance fabrics worn in hot climates, how a fabric feels to the wearer is one of the most important attributes. Performance fabrics help to ensure that the athlete does not start to feel clammy because, in general, “dry feels better.”

Thermophysiological comfort describes how the fabric controls the microclimate, which is the air encompassing the body. This type of comfort is crucial during activities performed in colder climates.

Therefore wetting, wicking and moisture vapour transmission properties are critical aspects for the performance of clothes. Also transverse
wicking behaviour of the fabric or garment is more responsible for sweat evaporation during active sports events (Supuren et al 2011).

1.3 TRANSVERSE WICKING

Transverse wicking is the transmission of water through the thickness of the fabric i.e. perpendicular to the plane of the fabric (horizontally aligned fabric specimens). As per AATCC 198 (2011), horizontal or transverse wicking is the ability of horizontally aligned fabric specimens to transport liquid along and/or through them by capillary action.

Figure 1.1 Illustration of transverse wicking in a fabric

Analysis of transverse wicking characteristics of the fabric is also important as longitudinal wicking because the perspiration (sweat) transfer from skin involves its movement through the lateral direction of the fabric i.e., through the thickness of the fabric (Sampath et al 2011).

Figure 1.1 shows the movement of liquid perspiration into a fabric from the body skin. The wicked moisture spreads throughout the fabric allowing the moisture to easily evaporate.
When the area spread is high, the evaporation of the fabric is also high. The influence of longitudinal gravity is not considered in horizontal wicking but being multi-directional, it eliminates the directional effect and the results will be most effective for developing fabrics for sportswear.

Transverse wicking is more difficult to measure than longitudinal wicking as the distances involved are very small and hence the time taken to traverse the thickness of the fabric is short.

1.4 IMPORTANCE OF TRANSVERSE WICKING

It is well known that the heat and moisture transfer properties of clothing materials are critical to thermal comfort of garments as they affect the direct and latent heat loss from the human body. The objective measurement of the moisture transfer properties of clothing is therefore important to apparel product development.

Recently, the use of sportswear has been quite widespread due to the fact that many people are involved in sports. The heat generated in the body while doing sports leads to considerable sweating. The sweat rate is likely to vary with the many sports activities and individuals.

In the sportswear design, among the most influencing parameters of the fabric used, the rates of the liquid spreading on the surfaces are of great importance. Liquid spreading and quick dry behaviour 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. Also their experimental measurement and theoretical prediction are therefore challenging in view of the varying conditions.
Wicking simply means the capillary movement of moisture within fabric structure. Capillary action is determined by two fundamental properties of the capillary – its diameter and surface energy of its inside face. The smaller the diameter or the greater the surface energy, the greater the tendency of a liquid to move up the capillary. Wicking will not begin when the moisture content of the wet fabric is less than that of 30% moisture regain. The fibre surface properties, pore structure, structure of component yarn and the fabric are the main determinants of wicking properties.

Transverse wicking behaviour of the fabric or garment is more responsible for sweat evaporation during active sports events. Recent studies are focused on analysis of transverse wicking behaviour of fabric for active sportswear.

A very important feature of transverse wicking is that it is close to actual transportation of liquid perspiration in the fabric during different sports activities of individual. Transverse wicking increases the spreading of the liquid or vapor throughout the fabric by increasing the evaporation of the moisture (Supuren et al 2011) leaving a drying feeling in the end.

Therefore transverse wicking is independent of moisture management properties of the fabric. So, an analysis of transverse wicking behaviour of the fabric is important as it provides additional information to re-engineer the active sportswear for specific sports activity since, one type of garment does not suit for all type of sports activity.

1.5 NEED FOR NEW TEST METHODS

An average consumer may not understand what is wicking, transverse wicking or the characteristics of a good transverse wicking fabric.
That is because a quantitative definition of wicking is lacking and claims are easily made for fabrics that are said to be the best.

Moisture transfer and quick dry behaviour 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. Therefore, in order to optimize these functionalities in sport clothing, and to support moisture management claims, it is necessary to determine the transverse wicking behaviour and quick drying capability of functional fabrics. And it is well known that the heat and moisture transfer properties of clothing materials are critical to thermal comfort of garments as they affect the direct and latent heat loss from the human body. The objective measurement of the moisture transfer properties of clothing is therefore important to apparel product development. There are two parameters most commonly used to characterize the properties of liquid moisture management performance of fabrics, namely the rate of absorbency and the total absorbent capacity.

Transverse wicking measurement is also important as well as vertical wicking measurement for engineering and designing sportswear. Transverse wicking behaviour of the fabric or garment is more responsible for sweat evaporation during active sports events. Recent studies are focused on analysis of transverse wicking behaviour of fabric for active sportswear. In order to analyze transverse wicking behaviour of textiles quantitatively in the model, there is a need for more work in this area.

Some standards and test methods can be employed to evaluate a fabric’s simple absorbency and wicking properties. However, the existing standards are unable to measure the behaviour of dynamic liquid transfer in clothing materials. Because, the static test results would not serve the purpose of sportswear re-engineering, dynamic liquid transfer analysis will help to
reengineer the active sportswear products. In this research work, dynamic transverse wicking test methods have been developed using different techniques. Applying these new methods can be helpful for measuring the transverse wicking in textiles more accurately and cost effectively. Also comparison of the performance of the different test methods helps to understand the test results and the reliability of the test results and devices.

In image analysis method, different software techniques are there to find exact colour of pixels (wet area pixels) from the image. Still there is further scope in terms of speed (using embedded image processing system using digital signal processor) and accuracy improvement in the image analysis method.

The existing transverse wicking test has the following drawbacks

- It is manual method which consumes more time
- It lacks in accuracy
- It is a static measurement
- It has less scope for data recovery and speed of measurement

Also transverse wicking evaluation method is of utmost importance in determining the material properties accurately. The experimental apparatus and the testing methods used must be appropriate and should simulate the wear conditions very closely.

1.6 OBJECTIVES OF THE RESEARCH WORK

The objectives of the study were:

(i) Design and development of transverse wicking measurement device using embedded image analysis system (EIAS).
(ii) Design and development of transverse wicking measurement device using image analysis method

(iii) Design and development of cyclic stress instrument to study the effect of cyclic stress on the transverse wicking behaviour of cotton/lycra knitted fabrics.

(iv) Design and development of dynamic sweat transfer tester and analysing the sweat transfer behaviour of multi design fabrics in transverse direction

The advantage of the proposed instrument is the accuracy and ease of data recovery. Further, the proposed computer-aided transverse wicking tester represents a unique system, which will be a very simple, economical and novel device that produces quick and accurate results, very much useful for determining the moisture comfort of textile fabric.

Using developed instrument, the influence of fabric parameters such as count, type of yarn, type of doubled yarn combinations, weave structure, fabric cyclic stress on transverse wicking has been examined.

1.7 ORGANIZATION OF THESIS

The aim of this research work is to develop different dynamic test methods and instruments to measure the transverse wicking behaviour of woven and knitted fabrics. The thesis is divided into nine chapters.

Chapter 1: This chapter contains general introduction, need for new test methods, instrument, objectives of the research work and organization of thesis.

Chapter 2: This chapter includes a literature review consisting of research work already done in the areas of transverse wicking. It first
introduces fundamentals of wicking, types of wicking and theoretical background related to transverse wicking measurement.

Chapter 3: This chapter describes the materials and methods used for preparing woven and knitted fabrics that have been used for measuring transverse wicking behaviour through new developed techniques.

Chapter 4: This chapter contains design and development of transverse wicking measurement device using embedded image analysis method.

Chapter 5: This chapter discusses design and development of transverse wicking measurement device using image analysis method.

Chapter 6: This chapter discusses the effect of cyclic stress on the transverse wicking behaviour of cotton/lycra knitted fabrics. It includes design and fabrication of cyclic stress instrument for applying repeated extension and recovery action on cotton/lycra knitted fabrics for the purpose of studying dynamic liquid spreading behaviour.

Chapter 7: This chapter contains design and development of dynamic sweat transfer tester and analysis of the sweat transfer behaviour of multi design fabrics in transverse directions.

Finally, summary of the entire study and the various conclusions drawn from the research work are presented in Chapter 8. It also includes recommendations for future work.