International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Wicking Behaviour of Woven Cotton Fabrics by Horizontal Method

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Abstract: ***This research seeks to investigate the horizontal wicking behavior of woven cotton fabrics. Cotton yarns of count 60^s/9.84 (Ne/tex) for both warp and weft directions were chosen and the reed and pick densities were kept constant while weaving into different weave structures i.e. plain, twill and satin. The woven cotton fabrics were subjected to laboratory tests like fabric weight, fabric thickness and porosity. A new horizontal wicking tester has been developed to examine the wicking behaviour. The woven samples were mercerized and then examined for horizontal wicking behaviour. Satin weave fabric showed maximum wicking behaviour compared to twill and plain structures.***

Keywords: cotton fabric, weave structures, porosity, fabric wicking, horizontal wicking.

1. Introduction

The comfort characteristics of garments for industrial, sports, and military end-uses have been extensively investigated over many years. Attempts have been made to relate a number of fabric properties to the physiological, as well as to the psychological, well-being of the wearer involved in various activities, generally those producing higher levels of metabolic-heat output (Silva, Greenwood, Anand, Holmes, and Whatmough, 2000; Slater, 1977). The absorption of metabolic sweat and its dispersion across the fabric surface are therefore of topical interest and have been claimed by many researchers working in the area of thermo physiological aspects of comfort as important contributors for aiding comfort of next-to-skin garments. Considerable effort has been channeled into the development of meaningful test methods to determine the absorptive properties of the fabrics. The methods developed generally fall into two broad categories, i.e. absorption and wicking (Silva et al., 2000). The previous measurements of wicking were mostly based on the visual observations of dye-water penetration (Hollies, Martha, Kaessinger, Watson, & Bogaty, 1957), the mass of liquid retained in the sample (Hsieh, 1995; Hsieh and Yu, 1992), electrical resistance technique (Ansari & Kish, 2000; Ansari, Nosraty, and Rahmani, 2007; Hollies et al., 1957; Kamath, Hornby, Weigmann, & Wilde, 1994). Wicking of liquid into fabrics is a very complicated problem with big significance and is much dependent on the fabric porosity (Weiner, Binedova, & Sikang, 2003). Kissa (1996) explained wicking as a spontaneous flow of a liquid into porous substrate, driven by capillary forces. Consequently, the fiber wettability is a prerequisite for the occurance of wicking ans a liquid that does not wet the fibers cannot wick into the fabric (Kissa, 1996). Kissa also stated that the wicking rate is affected by the morphology and shape of the fiber in the yarn or fabric structure and may be affected by the size and geometry of the capillary spaces between fibers as well. Yoo and Barker (2005) indicated that the liquid absorption capacity of fabrics is determined primarily by fabric structure. They showed that twill weaves have a higher capacity due to higher porosity in comparison with plain weaves. Cotton fabrics also have the greatest liquid retention after evaporation (Yoo & Barker, 2005). Hsieh et al., (1996) demonstrated that the water retention capacity in satin weave designs is greater than plain fabrics at the same condition which mainly refers to the higher porosity of the satin weaves. Thus a numbers of researchers have carried out studies on the wicking behaviour of fabrics. The present study is therefore planned to compare the horizontal wicking behaviour of plain, twill and satin structures.

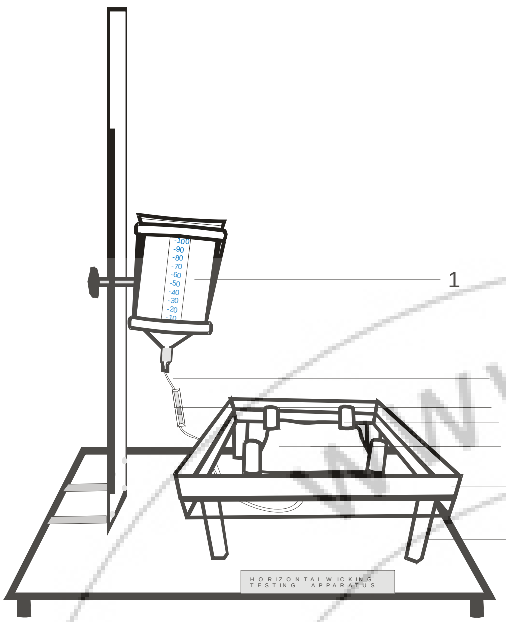
Objectives

- To construct plain, twill, satin weave with 60^s/9.84 (Ne/tex) count.
- To determine the geometrical properties like fabric weight, thickness and porosity.
- To scour, bleach and mercerize the grey fabrics.
- To examine the wicking behaviour after finishing treatments.
- To analyze the wickability of plain, twill and satin weave structures by various methods.

2. Horizontal Wicking

Horizontal wicking is the transmission of water through the thickness of a fabric, i.e. perpendicular to the plane of the fabric (Kissa, 1996 and Saville, 1999). It is also termed 'demand wetting' (Lichstein, 1974) or spontaneous transplanar liquid uptake' (Miller and Tyomkin, 1984). It is perhaps of more importance than longitudinal wicking because the mechanism of removal of liquid perspiration from the skin involves its movement through the fabric thickness.

2.1Development of Horizontal Wicking Tester



1. Water reservoir
2. Tube
3. Adjustable knob
4. Magnetic holder
5. Fabric
6. Glass plate
7. Stand

Plate 1: Horizontal Wicking Apparatus

2.2 Wicking Procedure

The developed instrument (Plate-1) is made up of a wooden stand in which a water reservoir is fixed on the left side of the apparatus to record the height of water absorbed by the fabric. The fabric is placed on the top of the glass plate with the help of magnetic holder and draws water from it at a rate which depends on its wicking power. It is important that the water level is adjusted to touch the underside of the fabric but not to flood it. The rate of uptake of water is measured by timing the movement of the meniscus along the measuring water reservoir for every 1min, 2min ………10min respectively.

H = IWL – RWL

where,

H= Water absorbed by the fabric in ml

IWL=Initial water level in the reservoir

RWL=Recorded water level in the reservoir.

3. Experimental Procedure

Cotton yarns of count 60^s/9.84 (Ne/tex) for both warp and weft directions were chosen and woven into different weave structure i.e. plain, twill and satin the reed and pick densities were chosen for the study was 90 x 82.The woven cotton fabrics were subjected to laboratory tests like fabric weight, fabric thickness and porosity. Then the samples were finished by scouring, bleaching and followed by mercerization and then examined for the horizontal wicking behaviour.

4. Results and Discussion

4.1 Fabric Weight

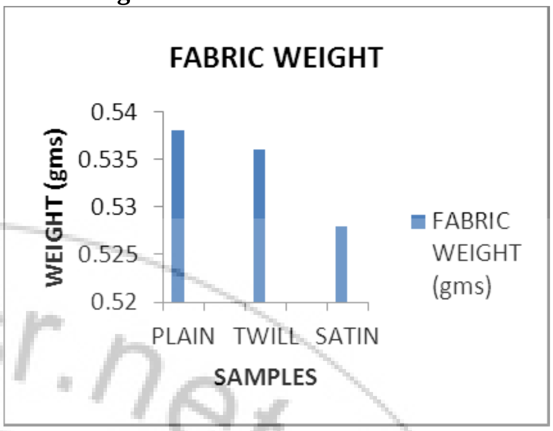


Figure 1: Fabric Weight

The above figure shows that the plain sample has more weight than the twill and satin samples due the interlacement of yarns (1/1) resulting in firm structure.

4.2 Fabric Thickness

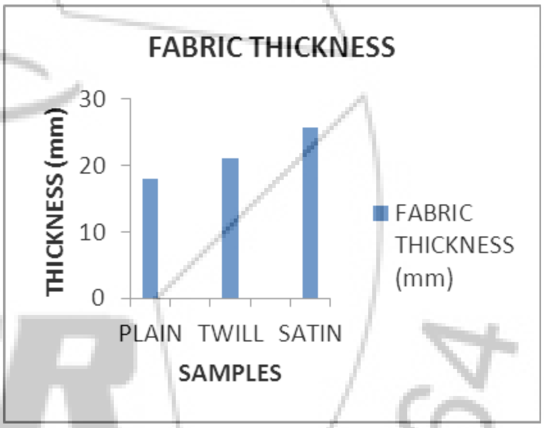


Figure 2: Fabric Thickness

The above figure shows more thickness for satin sample than the twill and plain samples due to the more number of floats.

4.3 Porosity

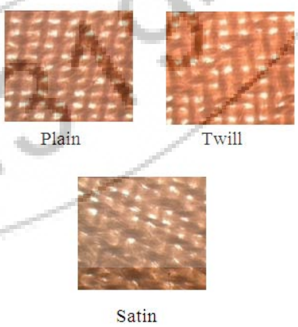


Plate 2: Images Showing the Porosity of Plain, Twill and Satin weaves

The above images were captured by Motic Microscope under 40 x magnifications. The width of the interstices has become tight in plain weave construction and this change in the pore size will affect wickability.

4.4 Wicking Behaviour of Woven Cotton Fabric by Horizontal Method (Water Adsorption and Time)

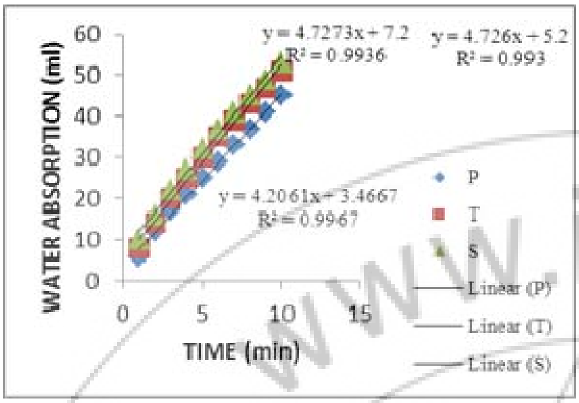


Figure 3: Water Absorption and Time

In this method of analyzing wicking, the wicking time was plotted against the water absorption and the correlation coefficient and regression equation were computed. The satin sample showed higher value of slope and intercept compared to the other samples. The plain sample showed reduction in wickability due to the interlacement of yarns. Higher the slope and intercept better the wickability and vice versa. The correlation between water absorption and time was found to be good.

Table 1: Regression Values and Correlation Coefficient of Woven Cotton Fabrics (Water Absorption and Time)

SAMPLES	SLOPE (cm/min)	INTERCEPT (cm)	CORRELATION COEFFICIENT (R^2)
SATIN	4.727	7.200	0.993
TWILL	4.726	4.726	0.993
PLAIN	4.206	4.206	0.996

The slopes obtained were plotted to illustrate the trend as shown below.

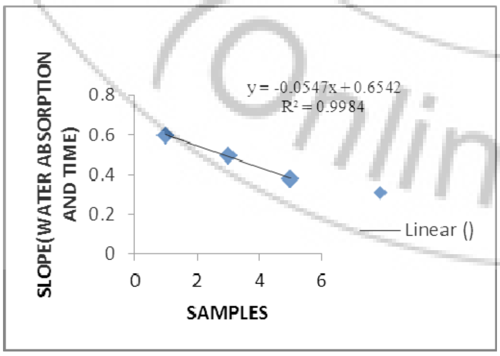


Figure 4: Slope (Water Absorption and Time)

4.5 Wicking Behaviour of Woven Cotton Fabric by Horizontal Method (Water Adsorption and Square Root of Time)

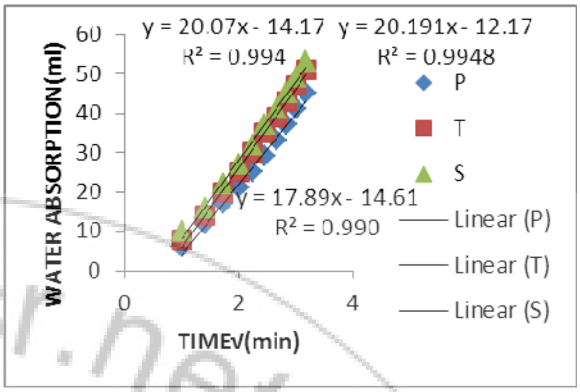


Figure 5: Water Absorption and Square Root of Time

In this method, the wicking water absorption was plotted against the square root of time and the correlation coefficient and regression equation were computed. Higher the slope and intercept better the wickability and vice versa. The correlation between water absorption and square root of time was found to be good.

Table 2: Regression Values and Correlation Coefficient of Woven Fabric (Water Absorption and Square Root of Time)

SAMPLES	SLOPE cm/ $(min)^{1/2}$	INTERCEPT (cm)	CORRELATION COEFFICIENT (R^2)
SATIN	20.19	-12.17	0.994
TWILL	20.17	-14.17	0.994
PLAIN	17.89	-14.61	0.990

The slopes obtained were plotted to illustrate the trend as shown below.

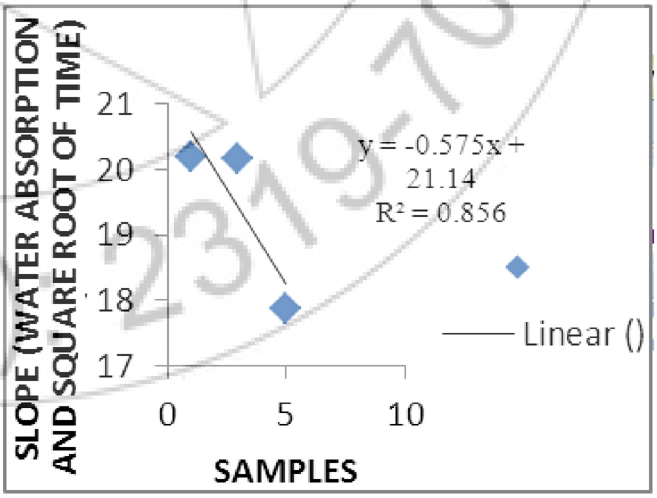


Figure 6: Slope (Water Absorption and Square Root of Time)

4.6 Wicking Behaviour of Woven Cotton Fabric by Horizontal Method (Log Water Absorption and Log Time)

In the third method of analyzing wicking, the logarithm of wicking time was plotted against the logarithm of wicking height. Value of the time exponent (k) and intercept values were computed. Higher values of 'c' and lower values of 'k' indicate good wickability and vice versa. Slopes and intercepts obtained from log h- log t values were plotted to illustrate the trend. There was a negative correlation between slope k and intercept c as suggested by Laughlin and Davies (1961) which has to be considered for interpreting wickability. It is clear that there is an independency between k and c.

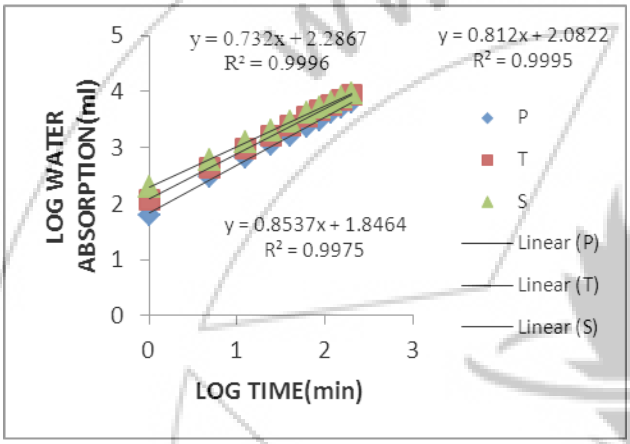


Figure7: Log of Water Absorption and Log of Time

5. Conclusion

From the analysis of the results, it may be concluded that satin weave fabrics showed maximum wickability due to more number of floats in construction. This may be also due to their high thickness value, which provides more space to accommodate water, which leads to more water transferred depending on the capillary space available. This statement agrees with the findings of Cimilli et al., (2010).

6. Future Scope

This study will enable the manufacturers to adopt better weave structures for personnel who do hard work and perspire easily.

7. Acknowledgement

The authors are grateful to Mr.Dinesh, Dinu Technology, Coimbatore and the Management of Kongu Arts and Science College, Erode for their encouragement and support.

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