A review on wicking of yarns and fabrics

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Abstract

This paper reviews methods of measuring wicking of yarns and fabrics and further research work which is required on it is also outlined. Wicking is an important property which gives an idea of the absorbency, dye uptake and comfort of fabrics. This subject has attracted the attention of physicists, physical chemists, civil engineers, textile technologists and chemical engineers for several years. It was Washburn and Lucas who laid the foundation of wicking studies. Numerous papers have been published on the measurement of wicking and the results emanated out of them.

I. Introduction

Monitoring of wicking height was made by CCD camera (Perwuelz et al. 2000) Wihelmy balance (Hsieh et al. 1992) for recording the weight variation of the impregnating liquid on the fabric. Anne's et al (2000) work on capillary rise in yarns by a new technique merits consideration. The other most important contribution comes from Kamath et al. (1994), who have suggested a measure to represent wickability, namely, wicking coefficient. This coefficient A is related to the interfibre pore structure, the chemical composition of the fibre surface, and to the surface properties of the liquid by the equation

$$A = R\left[\frac{\gamma \cos\theta}{2\eta}\right]$$

Where R is an equivalent radius of the capillary γ is the surface energy, η the viscosity of the liquid and θ the contact angle between liquid and fibres. This has been employed by Sharabaty et al. (2008) in their studies.

Studies carried out on yarn wicking include the effect of twist, packing factor crimp, type of finish and yarn structure. Liu et al. (2008) have conducted some theoretical studies and found that their model was found to be satisfactory. They used a macroscopic force balance method and obtained wicking time as a function of capillary rise. They also investigated the effect of twist on wickability of yarns. Ansari et al. (2000) also conducted studies on wicking of yarn and studied the effect of yarn twist. Thus these two workers Liu et al (2008) and Ansari et al. (2000) contributed significantly to the studies on yarn wicking.

Hamdaoui et al (2007) have used a charge couple device camera to take images during the capillary flow a device for suspending the yarn and a lighting system. They have determined two constants R and cos θ by suitably modifying Washburn's equation where R represents capillary radius cos θ contact angle. Cotton and viscose yarns were tested for wickability and it was found that the latter showed higher wickability than that of the former. Also, the effects of alkali concentration on liquid height and diffusion coefficient have been studied in depth. The research work of Hamdaoui et al (2007) on dynamics of capillary rise in yarns merits consideration from the theoretical point of view. That acrylic yarn has higher wickability than that of cotton yarns has been pointed out (Das et al. 2007) Bulking process has provided better wickability of acrylic yarns. Rajagopalan et al (2001) have found that wicking velocity increases with the increase in cross sectional area of yarn and decrease in liquid viscosity. This has been supported by the work of Wang and Zha (2008). Wicking heights of bulked yarns, in particular, cotton-acrylic blends were found to be higher than those of cotton yarns.

A method of studying wicking behaviour by magnetic induction technique has been suggested (Mazloumpour et al. 2011). In a classic work on wicking of spin finishes and related liquids into continuous filament yarns (Kamath et al. 1994), the measurement by a simple electronic method is described. That horizontal wicking follows Lucas-Washburn equation and that viscosity surface tension and contact angle affect wicking have been pointed out. An interesting fact that cos θ values of ~ 0.7 or higher are needed for wicking to take place has been mentioned (Kamath et al. 1994). It is also pointed out that certain kinds of fluorosurfactants seem to have a considerable effect on the wicking of model finishes in yarns and on the distribution of these finishes on the surfaces of constituent fibres. In their paper on wickability, the authors (Zhu et al. 2015) have introduced some novelty in the method of measurement of wicking of cotton fabrics. The liquid is drained off after it has attained 0.5, 1, 2 and 3 cm respectively during the wicking test and the durative wicking height was measured.

It was found that that mass of the absorbed water in the fabrics did not have a significant difference in the weft and warp directions. That square of the wicking height was well correlated with time in both warp and weft directions and that weft was wickability was higher than that of warp way was demonstrated. Also, the increment in mass absorbed per centimeter time of the fabric was found to be inversely proportional to wicking height (Saricum and Kalaoglu 2014) have recently carried out an interesting study on the wicking and drying behaviour of polyester woven fabrics. The effects of yarn type, weft density, weave structure, thickness and air permeability on vertical transfer wicking and drying tests were studied. The drying behaviour has been found to be influenced by the thickness, air permeability and yarn type used. An interesting finding that following texturing the wickability of fabrics shows an increase has been pointed out. For a good account of the various methods of determining wicking, the monograph by Patnaik et al. (2006) may be consulted.

Recently, a thesis by Chunhong Zhu (2014) has dealt with a study on measurement of water transport in fabrics. In this work, an automatic measurement method for in plane capillary water flow within fabrics has been proposed. The measurement device contained an array of nine thermo couple measurement points set 10mm apart and sitting on foam polystyrene for heat insulation. Results of wicking of yarns and fabrics are reported by him. Kumar and Das (2014) have described the design and development of a computerized wicking tester for studying longitudinal wicking in fibrous assemblies.

Owens et al. (2013) have described an integrated upward horizontal downward wicking test for wickability. The measures they found were permeability and effective capillary radius R as functions of saturation (S). They used different liquid and found simulate effects as far as K vs S and K vs R. They then used K - S – R properties to successfully predict the inplane horizontal and downward wicking rates of two different fluids, octanol and water. In another paper, Simile and Beckam (2012) have reported that in the new UHD tester upward governs saturation, the horizontal section gives capillary pressure and the downward test on analysis gives permeability. The results are provided as K-S-Pc relations for water. Das et al. (2009) have found that wickability of polyester viscose blends are affected by count and twist.

Wong et al (2001) have looked at the wicking properties of linen treated with low temperature plasma treatment. Laughlin and Davies (1961) discuss some aspects of capillary absorption in fibrous textile wicking. Sharabaty et al. (2008) have investigated the moisture treatment through polyester cotton fabrics. A paper by Kissa (1996) discussed wetting and wicking. Morent et al (2006) have described a method of measuring the wicking behavior of textiles by the combination of a horizontal wicking experiment and image processing. Wicking behavior of single knit structures has been discussed by Patil et al (2009), DeBoer (1980) has discussed the wettability of scoured and dried cotton fabrics. He has established a relation between ‘a’ and ‘c’ in the following equation.

$H = CT^a$

Nyoni (2011) has reported wicking studies on nylon fabrics and points out the divergence from Washburn’s equation. His work in vertical and horizontal wicking is noteworthy for his painstaking experiments.

II. Conclusion

Ghali, Jones and Tracy (1994) have described experimental techniques that allow capillary pressure and permeability to be measured over a vide range of saturation. Many of their ideas have been used by many research workers. Brojeswari Das (2009) has carried out vertical and horizontal wicking studies in respect of polyester viscose blended fabrics. The effect of fibre blends composition, yarn count and yarns twist on the vertical and in-plane wicking have been studied. The most interesting part is the study of wickability on yarns varying in diameter and cross section of fibres. Mathematical model to predict the vertical wicking through yarns and fabrics has been carried out. There are Ph.D., Theses which are exclusively devoted to wickability. Nyoni (1998), Zhuang (2001), Brojeswari Das (2009) Law (1988), Maroufi (1997), Sungnoo (1997), Mao (2000), Mhetre (2011) and Shu (2014). Research should be carried out on yarns and fabrics under different temperatures of water and environment conditions of predict wickability. Also, wicking under rapid heating and cooling should be conducted.

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