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Change of Temperature of Cotton and Polyester Fabrics in Wetting and Drying Process

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Abstract

The purpose of this study was to measure temperatures of cotton and polyester woven fabrics in wetting and drying process by thermocouples placed on them. It also discussed temperature distribution caused by diffusion and evaporation at different relative humidity. The measurement points of thermocouples were located at two concentric circles with radius of 3 cm and 6 cm. The temperatures were measured by covering the same fabric when a droplet of water dropped on the center of circle at 20%RH, 65%RH and 80%RH environmental moistures, respectively. The results showed that because of diffusion determined by distance, it was different of temperature changes of every point. As the center of circle, at different humidity, temperatures when reached dynamic heat balance were different. The drying process of cotton showed consistency with temperature recovery. At 20%RH, it is the shortest for temperature returning to environmental temperature because of diffusion speed caused by steam content of environment. It can be applied to performance assessment for fabrics that liquid water absorbing function is required. It also can be used for evaluation of discomfort of wet fabrics by temperature decline with the wetting.

Keywords: Thermocouples; Temperature; Diffusion; Evaporation; Liquid water; Fabric

1 Introduction

As a basic function of clothing, it is important to restrict heat loss from the body, especially in cold, rainy and some other climates. As the fabrics used in making apparel differ greatly in their moisture sorption and thermal properties, it is important to take these characteristics into account when choosing clothing for particular applications.

In practical terms, heat and moisture transfer properties of fabrics are especially significant, as they play an important role in determining the thermal comfort associated with wearing the materials. The thermal comfort of the wearer is dependent on the clothing relationship with

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the wearer, its activity and the environment, since garment can be an obstacle to the heat and moisture transfers [1].

Research into heat and moisture vapor transfer of textiles focuses on the equilibrium and transient conditions of moist fabrics during skin contact or fabric, and the influencing parameters, such as thickness and porosity of fabric [2-15]. Li et al. investigated on the fiber moisture sorption behavior in the sensory perception of dampness in fabric experimentally and mechanistically [2]. Plante also carried out the dampness perception trials on the influence of fiber type, fabric moisture content, and ambient conditions on the subjective assessment of dampness in fabrics [3]. Alber-Wallerstrom [16] researched on the efficiency of sweat evaporation by a continuous weighing technique. Examining on the relationship between the thickness and thermal resistance of textile fabrics, a significant reduction in sweating evaporation efficiency was found in subjects exercising in moderate, dry and humid heat. Heat transfers of underwear at low activity are mainly governed by conductive, convective and radiative heat transfer mechanisms [17]. At high activity levels or in warm conditions, evaporation becomes predominant [18]. Therefore, at high activity levels, the thermal sensation is mainly influenced by sweating rather than by skin surface temperature, since the evaporative cooling effect by the sweating allows maintaining skin temperature at a favorable level [19]. Moreover, A new test method had been developed based on the contact electrical resistance of fabric [20] [21]. However, because of the diffusion characteristics of liquid water, when rain or sweat impinges on a fabric there will be temperature differences over the surface of the material, and these will have an effect on the wearer's level of comfort. To properly understand the effects of moisture it is therefore necessary to investigate in detail the conditions that occur when a droplet of liquid comes into contact with a particular fabric.

Lyons and Vollers [22] analysed the drying process of textile materials and identified three distinct stages. The first is an initial warm-up period that may or may not be significant in the overall process. The second stage is the constant drying rate period, in which the rate of vaporization balances the rate of heat transfer and the temperature of the saturated surface remains constant. The third stage is the falling rate period, during which moisture flow to the surface is insufficient to maintain saturation and the plane of evaporation moves into the fabric. Fibres in the fabric then begin to desorb moisture until equilibrium is reached between the fabric and the surrounding environment. In order to analyze the temperature of fabric during the drying process, we try to show the relationship between the temperature and water content during the wetting and drying process.

On the basis of Seebeck Effect, Stefan Ziegler and Michal Frydrysiak [23] used conductive textile products to manufacture thermocouples and studied on the relationship between temperature differences and electromotive force differences. This work, however, was limited in its scope because it relied on thermocouples made of metal fibers and fabrics that were not suitable for wearable garments

As noted above, T-type thermocouples have been used on fabrics to allow for temperature measurements based on the theory of the Seebeck Effect. In order to discuss the water diffusion on fabric, and investigate temperature change of wetted fabric, a multipoint-thermocouple fabric had been fabricated. It could be used for on-line multipoint temperature measurement of the fabric on various conditions.

In this study, samples of intact fabric were laid over thermocouple-equipped specimens of the same material, following which the top fabric layer was wetted by the application of a droplet of water. The temperatures during wetting and drying process are measured between two fabrics