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学位論文題目	Study on Measurement of Water Transport in Fabrics （布の水分移動の測定に関する研究）
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論文内容の要旨

In this study, new measurement methods for water transport were established for fabrics in cases of a limited reservoir and an unlimited reservoir. In the use of these methods, the water transport in fabrics was measured, and the water content was able to predict. Moreover, the relationship of wicking coefficient between fabrics and yarns were discussed.

In Chapter 1, the background and the purpose of this study was described.

In Chapter 2, wicking theory was explained, and measurement used in this study—a thermocouple method was proposed.

In Chapter 3, a multipoint thermocouple-equipped fabric was developed to investigate in detail the conditions that occurred when a droplet of water came into contact with fabrics. T-type thermocouples were inserted into cotton and polyester fabrics, with the measurement points located along the warp yarns to form a pattern consisting two concentric circles with radii of 3 and 6 cm. After verifying the validity of the thermocouples, spot test was carried out to investigate the liquid transmission characteristics of fabrics under 20±1°C and 20±2, 65±2 or 80±2%RH. The results provided useful information regarding temperature changes associated with the wetting and drying process. At the dropped point, the temperature fell down to approximately 12.5, 16.7 and 18.0°C at 20, 65 and 80%RH respectively, after which it showed constant for a relatively long time, finally it returned to ambient temperature. Accompanied with the liquid diffusion from the dropped point, temperature decrease of circumference on the circles was delayed and returned to ambient temperature earlier than the dropped point. The difference of temperature on the circumference showed the properties of two fabrics, as cotton was hydrophilic, it absorbed more liquid water than polyester fabric, and hence its water diffusion area was narrow than polyester and the resulting heat of evaporation was reduced. With the increase of the relative humidity, the recovery time for temperature of dropped point was longer. Based on this investigation, a method was devised to analyze the performance of liquid water transfer on fabrics by measuring the associated temperature changes of fabric in the wetting and drying process. This technique simulated a layered fabric to measure temperature variations as a result of the distribution of these temperature sensors in one of the layers. This method showed the possibility for the prediction of wearer discomfort levels resulting from the temperature decline associated with wetted fabrics.

In Chapter 4, an automatic measurement method was proposed for in-plane capillary water flow within fabrics in case of an unlimited reservoir. Based on the Lucas-Washburn equation, the wicking length had a linear relationship with the square root of time. Therefore, the experiment was carried out to investigate the relationship between wicking length and wicking time, so as to obtain the wicking coefficient of in-plane capillary liquid flow. The measurement device contained an array of nine thermocouple measurement points set 10mm apart and sitting on foam polystyrene for heat insulation. One end of a 20 by 3cm fabric strip clipped to a weight was dipped in water, and the other end was fixed to keep it taut throughout the experimental. This measurement was based on the fabric temperature changes at the flow front during the process of water absorption because of heat transference associated with both wetting and evaporation. As the fabric initially absorbed water, wetting heat is generated and the local temperature temporarily increased, after which it began to fall down. These temperature changes are used for calculating the wicking time to obtain the wicking coefficient. Three kinds of woven fabrics and two kinds of knitted fabrics were pretreated and used in this experiment. Compared the wicking coefficients with the results acquired by the horizontal Byreck method, the thermocouple technique was found to be suitable for the precise and automatic measurement of in-plane capillary water flow through fabrics. Moreover, in order to predict water content of fabric for specified points, the relationship between temperature and water content was investigated by rearranging measurement points to the corresponding locations. The results showed that for cotton fabric, below the critical water content (about 35%), fabric temperature changes were relatively large when the water content fell down. It can be used to predict water content of fabric from temperature changes. This method and the associated apparatus can be applicable to many different areas of fabric analysis, including the assessment of wetting in diapers and the dispersion of sweat in sportswear.

In Chapter 5, the relationship between wicking coefficients of fabrics and yarns were investigated based on the thermocouple array method introduced in Chapter 4. The wicking experiments were conducted for series of woven fabrics, with 100% cotton yarn as the warp yarn, and several kinds of weft yarns (100% cotton yarn, cotton-polyester blended yarns, 100% polyester yarn). Weave density of cotton fabrics was changed from 10 to 90 per inch. Moreover, wicking coefficients of yarn specimens were measured using the same method. The yarn specimens were prepared from the corresponding fabrics. The results showed that the wicking coefficient went down with increasing weft weave density both in the warp and weft directions, because the effective capillary radius was decreased when increasing the weft weave density. The results of yarns showed that the wicking coefficients were almost the same when the densities were below 60 per inch. However, when the density was larger than 80 per inch, the wicking coefficient tended to decrease. To explain this, the yarn crimps for these fabrics were calculated, which presented larger crimps for higher weave densities. The larger crimps at both 80 and 90 per inch caused longer wicking path, and therefore, the wicking coefficients decreased. Moreover, the wicking coefficient increased as the porosity of fabric increased. The results for four kinds of yarns showed that the 100% cotton yarn and cotton fabric had the highest wicking coefficient. Based on scanning electron microscope observation of cross section and longitudinal section of yarns, we discussed the effects of inter-fiber space and yarn twist on the wicking influence factor and found that the wicking rate is higher for larger inter-fiber space and yarns with fewer twists.

In Chapter 6, the conclusion of this study was given.