STUDIES ON MOISTURE TRANSMISSION THROUGH FABRICS

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My work is devoted to my parents

Sh. Nrishingha Charan Das

&

Smt. Kalpana Das

Who have given me the Dream of Sky

And the Wings to Fly

CERTIFICATE

This is to certify that the thesis titled **"Studies on moisture transmission through fabrics"**, being submitted by **Ms. Brojeswari Das** to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by her. Ms. Brojeswari Das has worked under our guidance and supervision and fulfilled the requirements for the submission of the thesis. The results contained in this thesis have not been submitted, in part or in full, to any other university or institute for the award of any degree or diploma.

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ABSTRACT

Moisture transmission behaviour of clothing plays an important role in determining thermophysiological clothing comfort. In order to maintain the wearer's body comfort, the clothing should allow the generated vapour and liquid perspiration to transmit through it, both in hot and in cold weather conditions and during normal and high activity levels. Determination of the factors involved in moisture transmission and prediction of moisture transmission behaviour of the clothing has become a main issue of concern for years to the researchers. Prediction of moisture transmission properties of textile materials is useful to characterize the clothing comfort as well as it helps to design the fabric as per the specific requirement. The effects of different environmental factors, human factors and material factors on water vapour as well as liquid moisture transmission properties of the fabric have been studied by many researchers. Effect of different textile parameters, i.e. fibre and fabric finish, fibre type, surface modification, thickness and porosity of the material on moisture transmission characteristic of textile materials have been reported. Many methods of measurement have been devised by the scientists to measure the water vapour permeability and liquid moisture transmission properties of textile materials in different conditions. The problem associated with the prediction of moisture transmission behaviour of textile material is its complex structure which involves interactive effects of different fibre, yarn and fabric parameters. Adequate number of theoretical work has been reported on the prediction of water vapour transmission through textile material. Regarding liquid moisture transfer through textile material most of the works found to be concentrated in in-plane wicking and transverse wicking area. No theoretical work has been reported to predict the vertical wicking through fabric.

In the present thesis, theoretical and experimental works have been carried out to establish the relationship between different fibre and yarn parameters with vapour and liquid moisture transmission characteristics of woven fabrics. Work has been carried out to understand the effect of different fibre and yarn parameters and their interactive effects on vapour as well as liquid moisture transmission properties of fabric and to develop a model to predict the vertical wicking behaviour of yarn and fabric. Based on the understanding from the experimental findings the influencing parameters have been included in the development of the theoretical models.

The effect of fibre type (proportion of hygroscopic fibre in a blended fabric), yarn linear density, twist per unit length in the yarn, fibre diameter and fibre cross-sectional shape on liquid moisture as well as water vapour transmission behaviour of the fabrics have been studied in detail. Water vapour transmission of the fabrics has been measured using the PERMETEST and liquid water transmission property of the fabrics has been measured using the gravimetric in-plane wicking tester and the vertical wicking tester. From the experimental results it has been observed that water vapour permeability and absorbency of the material increases with the increase in proportion of hygroscopic fibres in the blend, but it has an adverse effect on the liquid moisture transmission behavior. The vertical as well as in-plane wicking of the material decreases with the increase in viscose proportion in the polyester/viscose blended fabrics.

In order to determine the interactive effect of fibre type and yarn structure on moisture transmission properties of fabrics, fibre blend proportion, yarn twist and yarn linear density have been taken as varying parameters. Samples have been developed using 3 levels and 3 factors Box Behnken design for the experiments and the analysis of the experimental results have been done using MINITAB software. From the analysis it has been observed that water vapour permeability of polyester viscose blended fabrics (having similar area density) increases with the increase in yarn linear density and twist per unit length. With the increase in polyester proportion in the fabrics, both the wicking height and in-plane wicking of the fabric, increases initially upto a point and then reduces. The wicking height and in-plane wicking of the fabrics increase with the increase in yarn linear density and reduce with the increase in yarn twist. Using optimization tool in MINITAB software the suitable combinations of fibre blend proportion, yarn linear density and yarn twist have been found in order to obtain required transmission properties.

Three different types of polyester multifilament with different cross-sectional shapes and circular microdenier multifilament yarns with similar linear density have been used for the fabric preparation in order to study the effect of fiber cross sectional shape and fibre denier on moisture transmission through fabric. The result shows that the fibre diameter and fibre shape factor play an important role on liquid moisture transmission through fabric.

The fibre and yarn factors which have been considered during the development of the mathematical model to predict the vertical wicking through yarn are fibre-water contact angle, number of filaments in a yarn, fibre denier, fibre shape factor, yarn radius and twist level in yarn. The model has been developed based on Laplace equation and the Hagen-Poiseuille's equation. Model to predict the vertical wicking through plain woven fabric has been developed based on the yarn model. The structural parameters of the capillary channel in the fabrics have been calculated considering the path of thread as per inclined tube geometry and later on as per Peirce clothing geometry. Apart from the parameters taken into account during yarn modelling, the parameters have been included in fabric model are warp and weft linear density, fabric sett, warp and weft crimps. Experimental verification of the models has been done using polyester and polypropylene yarns and fabrics. It has been observed that the initial wicking rate in yarn was higher than that of the fabric, made out of that yarn. Based on the mathematical model a software program has been developed to obtain the vertical wicking profile (wicking height at any given time as well the equilibrium height) of yarn and fabric, just by entering the before mentioned constructional parameters. The theoretical and experimental curves (wicking height vs time) of the yarns and fabrics have been compared and it has been seen that the model can predict the wicking behaviour of yarns and fabrics reasonably.

CONTENTS