

A MATHEMATICAL MODEL OF THE DYNAMIC THERMAL INTERACTIONS BETWEEN CLOTHING AND HUMAN THERMOREGULATORY SYSTEM

Z. Wang, Y. Li and Z.X. Luo, Institute of Textile and Clothing, The Hong Kong Polytechnic University, Hong Kong.

This paper presents a mathematical model that simulates the dynamic thermal interactions between clothing materials and the human thermoregulatory system, which is solved by finite difference method. The model consists of two parts: a clothing heat and moisture transfer model and a thermoregulatory model of the human body. The clothing heat and moisture transfer model is a mathematical model that describes the heat transfer processes by conduction and radiation and the moisture transfer processes by diffusion, fiber moisture sorption. Condensation/evaporation, and capillary actions, as well as the coupling effects among them are considered. With specification of boundary conditions of the temperature and humidity at the clothing-skin and clothing-environment interfaces, the dynamic changes of the distribution of the temperature, moisture contents and the volumetric fraction of the liquid water throughout the fabric are calculated. For describing the thermoregulatory responses of the human body, Gagge's two-node thermoregulatory model is used, which takes into account of the passive heat balance and transfer processes and the moisture transfer processes in the body, and the thermoregulatory controlling mechanisms of heat production, sweating and blood flow. By interfacing these two models, we developed a mathematical model that is able to simulate the dynamic thermal interactions between clothing and the body thermoregulatory system, particularly in the transient conditions. Using this model, we are able to illustrate mathematically how the clothing materials influence the thermoregulatory responses of the body such as sweating rate, blood flow, heat production by shivering, body core temperature and skin temperature profiles, as well temperature and moisture profiles in the clothing during the transient changes of environment and/or physical activities. By changing the various combination of thermal status of human body, clothing material and environmental conditions, the model can be used to study the physiological thermal responses and comfort status of the human body such as heat stresses and cold stresses under various transient conditions.

tcrsch5@inet.polyu.edu.hk