Analyses of thermal properties using heterogeneous fabric model

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Abstract

Fabric is not homogeneous because the constituent yarns are interlaced at a certain weave angle. This structure must be considered to investigate the heat transfer behavior in a fabric. The heat transfer in the cross section and on the surface of a fabric was simulated by a two-dimensional (2D) heterogeneous model and a three-dimensional (3D) heterogeneous model, respectively. In the 2D heterogeneous model, the thermal anisotropy of the yarn was taken into account and heat transfer along the longitudinal and transverse directions of the yarn was treated independently. The temperature distribution in the cross section of fabric indicated that when the anisotropy of the fiber thermal conductivity was high, heat transferred significantly faster along the longitudinal direction than along the transverse direction of the yarn, and the equilibrium temperature distribution was strongly influenced by heat transfer in the longitudinal direction. In the 3D heterogeneous model, heat can transmit along the warp and weft yarns of mixed fabric independently. The temperature distribution on the surface of fabric suggested that longitudinal thermal conductivity of yarn had a substantial effect on the heat transfer for mixed yarn fabric. For the thermal insulation of multilayer fabrics, the fabric resistance and air layer resistances between fabrics cannot be ignored. The estimation equation to predict the fabric and air layer resistance was constructed. By using this equation, the surface roughness of fabrics showed the strong effect on the air layer resistance. The heat transfer in the furs and fabrics was also studied using the finger sensor method. The temperature change ($UT_{\max}$) inside

the furs and on the surface of fabrics under different compression pressure was determined to simulate a finger pressing a fabric. The change inside the furs showed that UT_{max} was affected by the pile length and air volume ratio. When the pile length was long, UT_{max} was almost constant and independent of pile length. A linear relationship between the volume ratio of air and UT_{max} was observed when the pile length was long.