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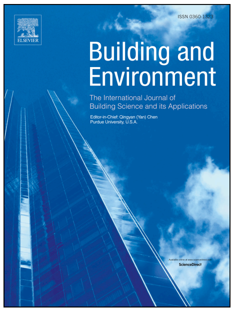

Numerical Modeling of Heat and Moisture Transfer in a Wearable Convective Cooling System for Human Comfort

Yu Sun, Warren J. Jasper

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Numerical Modeling of Heat and Moisture Transfer in a Wearable Convective Cooling System for Human Comfort

Yu Sun and Warren J. Jasper*
Department of Textile Engineering, Chemistry and Science
North Carolina State University
Campus Box 8301, NCSU Campus, Raleigh, NC 27695

Abstract

The design and analysis of a lightweight wearable convective cooling system was proposed for human thermal comfort in minimally air-conditioned work environments. The aim of this system was to reduce the overall energy consumption and realize energy savings by minimizing air-conditioning during the summer months without compromising human comfort. The proposed system consists of a series of microfans, placed in a ribbon and attached to a garment to provide cooling through convective and evaporative heat transfer. Three different configurations were analyzed: one had four 1 cm microfans; the second one had four 2 cm fans and the third had eight 1 cm fans. With these configurations, a series of 2-dimensional models of the convective and evaporative heat transfer at the skin surface were numerically simulated using COMSOL Multiphysics at 0.25m/s, 0.5m/s, 0.75 m/s and 1 m/s inlet airflow velocities. The convective and evaporative heat transfer coefficients at the skin surface were calculated which indicated peaks at the skin surface facing the inlet airflows from the fans. The combination of two opposing sub-flows produced small eddies and increased the coefficient of convective and evaporative heat transfer at high inlet airflow velocities and thicker air gaps. Our convective cooling system significantly improved the convective and evaporative heat transfer coefficients when the inlet airflows were at 0.75 m/s and 1 m/s. This modeling method provides an analytical approach to study the design of a microfan system to optimize heat exchange and minimize energy usage.

Keywords: wearable cooling system, human thermal comfort, convective heat transfer, evaporative heat transfer, electrical energy saving;

Highlights:

1. Design of a light-weight wearable convective/evaporative cooling system.
2. Numerical simulation of the convective and evaporative heat loss.
3. Eddy currents enhance the convective/evaporative heat loss at higher fan speeds.

* Corresponding Author: wjasper@ncsu.edu