Numerical analysis of heat transfer in human head†

Sarfaraz Kamangar1, Mohammad Anas Khan2, Irfan Anjum Badruddin1,*
T. M. Yunus Khan1 and Nik. Ghazali. N1,3
1Department of Mechanical Engineering, College of Engineering, King Khalid University, PO Box 394, Abha, Kingdom of Saudi Arabia
2Department of Mechanical Engineering, Jamia Millia Islamia, Delhi, India
3Department of Mechanical Engineering, University of Malaya, Kuala Lumpur, Malaysia

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Abstract

An investigation of heat transfer in human head is carried out by using finite element method. The head is modeled with different tissues having varying physical properties. The current work is focused to simulate the effect of various physical and geometrical parameters such as ambient temperature, heat transfer coefficient and variation in the thickness of different tissue layers of human head. The effect of presence of hair on human head is also investigated. It is found that the deep brain temperature remains almost constant whereas a small variation occurs in the other layers with respect to varying environmental and geometrical parameters.

Keywords: Ansys; Hair; Heat transfer; Human head

1. Introduction

The heat transfer in human body is an important and vibrant field, which helps in analyzing the human heat stress in various atmospheric conditions. The two systems namely the active and passive systems constitute the interactive thermoregulatory set up of human body. The former controls the human body temperature at certain level and also predicts regulatory responses such as shivering, vasomotion and sweating. The latter simulates heat transfer with the surroundings. The human body behaves as heat engine and acts as open system thermodynamically. The bio heat is produced by the various chemical reactions taking place in the human body which intern provides energy for the system of the body. In order to maintain healthy bodily function, the human body must maintain a constant internal temperature. Hence the regulation of the internal heat with the surroundings would assist in this process. However, the various metabolic activities (oxidation of food elements) in the human body also assist to maintain the required body temperature. Heat generated in the human body by metabolism is dissipated to the surroundings of the human body by conduction, convection, radiation, evaporation of the moisture from skin and through respiration.

In the year 1934, Burton [1] proposed the first model of human body in which he represented the human body as a single homogeneous cylinder with uniform metabolic heat generation. He demonstrated that the steady state temperature profile which is parabolic is in total agreement with the experimental observations of Bazett and McGlone [2]. Pennes [3] reported the most significant research on the human thermal model in the year 1948 whereby he investigated the effect of blood flow on tissue temperature. Stolwijk [4] presented a mathematical model of physiological regulation of man. The model predicted with reasonable accuracy of thermal responses to loads of ambient temperature and heat generation in human body. The detailed geometry of manikin by surface scan was created by Sorensen and Voigt [5]. They calculated the radiative heat transfer coefficient and natural convection around the manikin by using CFD. They compared the results with the previously published data and found a good agreement. The human thermoregulation model based on stolwijk [4] with the improvements was modeled by Hutzenga [6]. They suggested that the model is capable of predicting human physiological responses in transient and non-uniform environments. A three-dimensional numerical analysis of room heated by two panel radiators with virtual manikin was added to the room was presented by sevigen and kilic [7]. They computed numerically the heat interaction between human body and room, air flow and temperature under various environmental conditions. Miyanaga [8] developed a simplified human body model for evaluating a radiant cooled space by combining cylindrical and rectangular parts. The radiative and convective heat transfer, the effective radiation area and the