Numerical Simulation of Human Skin Burns Using Finite Element Method

Abul Mukid Mohammad Mukaddes[1], Ryuji Shioya[2], Md. Rezwan Jaher[1] and Dipon Roy[1]

1. Department of Industrial and Production Engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh

2. Faculty of Information Sciences and Arts, Toyo University, Japan

mukaddes1975@gmail.com

Bio-heat transfer deals with the heat transfer in the biological bodies. Bio-heat transfer has become an interesting topic recently because of its increased application in estimating and treating burn injury, cancer therapy and cryosurgery. Human skin burn also known as thermal burn can result from direct contact with heated object such as a hot disk, hot fluid or being exposed to radiation or electricity. The purpose of this study is to examine the effects of different cases of heat transfer in biological tissue and perform the burn intensity analysis. This study also aims to compare different methods of initial treatment of burn injury in the human skin. In this study, a 3D model of human skin is developed. Three different modes have been considered for human skin burn namely conduction, convection and radiation heat transfer. Human skin burn is mostly analyzed by using the Pennes bio-heat equation, which has been adopted in many commercial finite element software. COMSOL Multiphysics® is such a software based on the finite element method. The temperature in the biological tissue is computed using COMSOL Multiphysics® because of its wide use by other researchers for similar application. Then the burn intensity analysis is completed using Henriques burn integral equation. The temperature profile obtained from the study is also used to evaluate and compare various methods of initial burn treatment such as air cooling, 15°C tap water, 15°C steady water, 15°C conduction and ice.

From this study, it is found that conduction heat transfer causes more damage to the biological tissue than convection and radiation heat transfer. It is also found that the time required for 3rd degree burn to occur decreases exponentially for each degree increase in temperature of the hot object. From treatment analysis it is found that the fastest way to decrease the elevated temperature in the human skin is by using ice and the slowest method is by air-cooling. It is expected that the results obtained from this analysis will help to understand human skin burn under different burning conditions and treatment of different burn injuries and designing safer working environment in different industries where higher temperature is involved. This research work can be further improved by using a more detailed human skin model with artery and vein and also comparing solar and surface radiation.