Human Torso Model for Heat Transfer Analysis

Xiaojiang Xu[1], T. Patel[1], Reed W. Hoyt[1]

[1]U.S. Army Institute of Environmental Medicine, Natick, MA, USA

Abstract

This paper describes an approach to creating a human torso model for heat transfer analysis in COMSOL. The torso was derived from the 'Virtual Family' whole-body voxel labelmaps from the ITIS Foundation (Zurich, Switzerland) [1] and built in Solidworks. ITIS data is 1 millimeter voxel data segmented into 77 tissue types. Since the major tissue types that affect metabolic heat transfer are skin, fat, muscle, bone, and core, all tissues were binned into these categories. First, measurements were taken from the ITIS male along the axial plane at key anatomical landmarks. The geometry was then developed in Solidworks using the measurements taken. Individual components were created to represent the skin, fat, muscle, and bone regions of the torso anatomy. The tissue volumes of the Solidworks model were closely matched to that of the ITIS model. ITIS volumes: Whole Torso - 2183.3 in3, Fat - 454.2 in3, Muscle - 861.1 in3, Skin - 102.0 in3, Core - 765.5 in3. Solidworks volumes: Whole Torso - 2187.9 in3, Fat - 422.5 in3, Muscle - 875.7 in3, Skin - 127.7 in3¬, Core - 761.9 in3. The Solidworks model was inputted into COMSOL via Livelink™ and steady state heat transfer analysis was conducted with the heat transfer module. As an example, the torso surface was divided into four regions: front and back, top and bottom. Each region can have its own boundary conditions, representing different clothing properties as seen in Figures 1-2. The results show that boundary conditions in each region have impact on the temperature distribution of the skin resulting from metabolic heat production in the muscle (Figures 3-4). This shows that this FEA heat transfer model has the capabilities or flexibilities to simulate inhomogeneity of a clothing ensemble.

Reference

1. Foundation for Research on Information Technologies in Society (IT'IS): Human & Animal Models, http://www.itis.ethz.ch/services/human-and-animal-models/human-models

Figures used in the abstract

Figure 1: Torso front view with distinct clothing boundary condition.

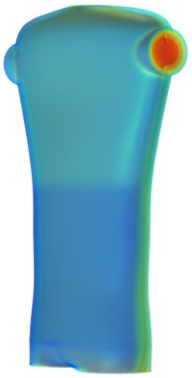

Figure 2: Torso rear view with distinct clothing boundary condition.

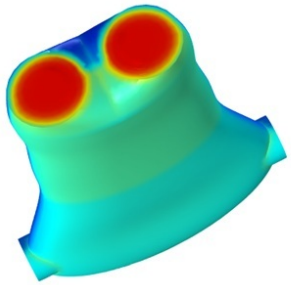

Figure 3: Torso bottom view showing metabolic heat production in muscle.

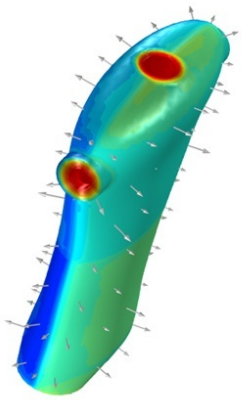

Figure 4: Flow of metabolic heat from muscle through fat and skin layers into environment.