Predicting Skin Burns From Convective Air At Elevated Temperatures.

S. Hernandez, P.E.[1]

[1]Meta, Menlo Park, CA

Abstract

Consumer electronic products are often cooled by air-convection to keep them operating at optimum performance. Air at elevated temperature may cause user discomfort and in some cases injury. It is important to understand the levels of air temperatures and velocities that may lead to injury. This study investigates air temperature at 50, 60, 65 and 70 Deg.C and velocities of 1, 5, and 10m/s that may lead to burns. COMSOL's Bioheat Transfer and Heat Transfer in Solids interfaces are used to obtain the transient temperature and exposure profiles in the human skin. A simple 2D model is built to simulate the epidermis, dermis, sub-dermis and inner tissue of the skin. COMSOL's Bioheat interface solves for Pennes Bioheat equation and simulates heat transfer from blood-flow and metabolic heat generation in tissues. To simplify the analysis, heat transfer on a plate is used to calculate the heat transfer from hot air to the skin. Then, to determine the level of injury, two methods are used: (1) The damage function or Arrhenius kinetics, and (2) the cumulative equivalent minutes (CEM43). The analysis shows that elevated air temperatures and velocities result in lower threshold for injury. Lower air temperatures and velocities result in longer exposure time.

Reference

(1) S.C. Jiang, N. Ma, H.J. Li, X.X. Zhang, “Effects of thermal properties and geometrical dimensions on skin burn injuries”, Burns 28 (2002) 713–717.

(2) Francesco Colella, et. al., “Contact Burn Injuries. Part I: The influence of object thermal mass”, IEEE 2020

Figures used in the abstract

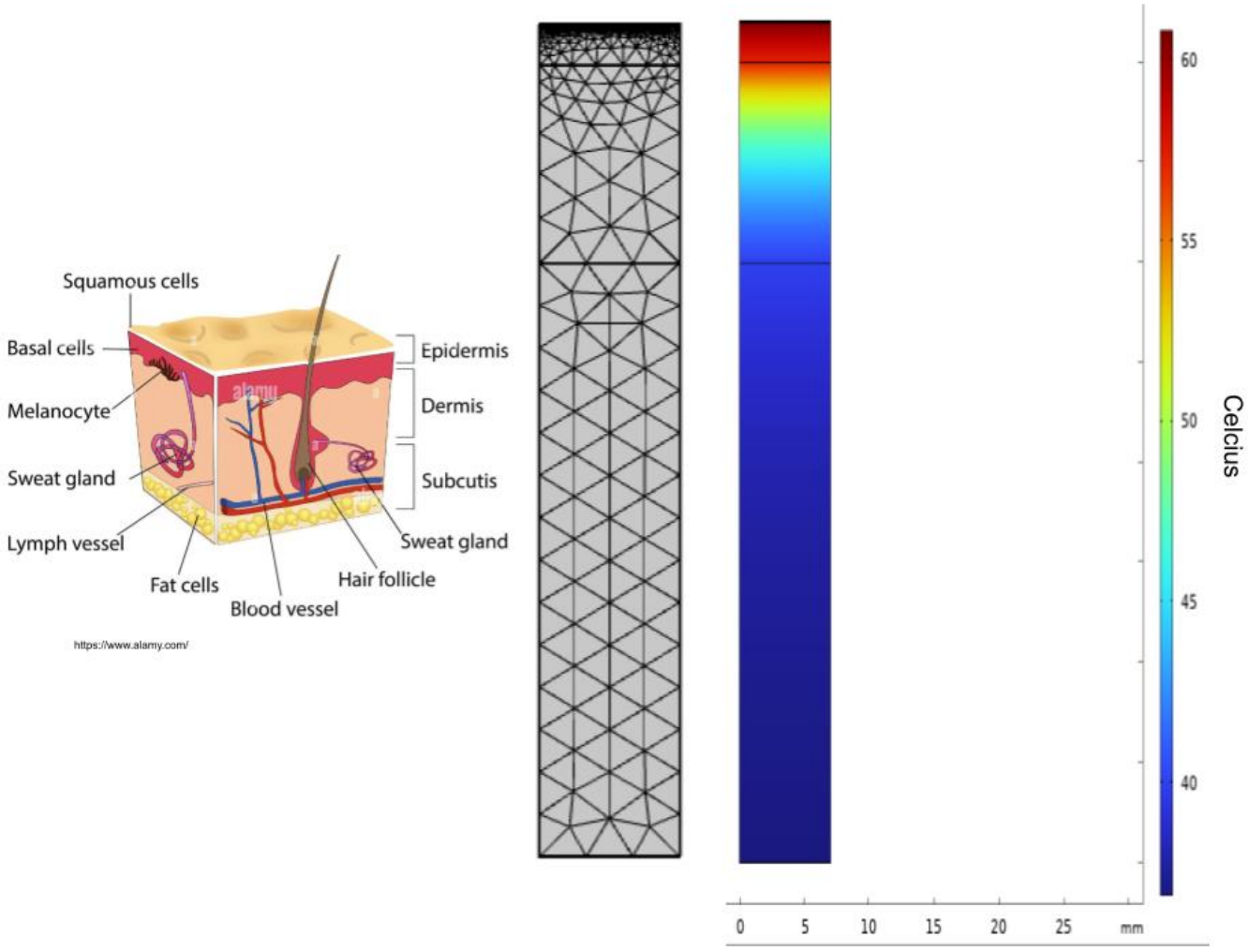
Squamous cells
Basal cells
Melanocyte
Sweat gland
Lymph vessel
Fat cells
Blood vessel
Hair follicle
Sweat gland
Epidermis
Dermis
Subcutis
https://www.alamy.com/
60
55
50
45
40
Celcius
0
5
10
15
20
25
mm

Figure 1