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PREDICTION HUMAN SKIN TEMPERATURE IN COMFORT LEVEL

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Author's Biography

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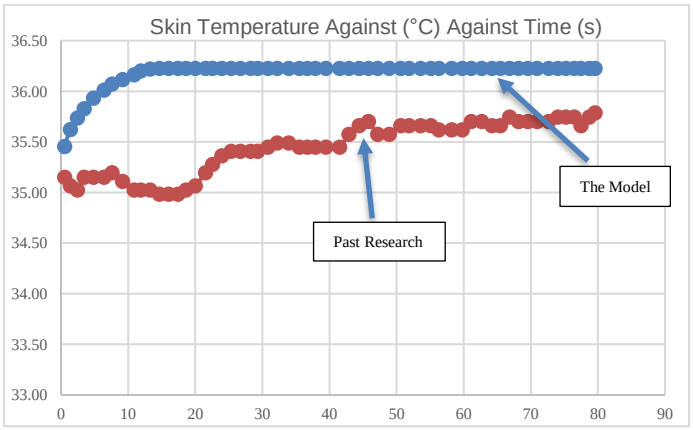
RESEARCH HIGHLIGHTS

Thermal comfort is the human subject perceive satisfaction to the work environment. The thermal comfort need to be achieve towards productive working environment. The comfort level of the subject is affected by the human skin temperature. To assess the skin temperature with the sorrounding by conducting human experiment in the climatic chamber. It is rigorous and complex experiment.This study was developed to predict human skin temperature in comfort level with the finite element method and the bioheat equation. The bioheat equation is a consideration of metabolic heat generation and the blood perfusion to solve heat transfer of the living tissue. It is to determine the skin temperature focussing at the human arm. From the study, it is found that the predicted skin temperature value were in well agreement with the experimental results. The percentage error insignificant with acceptable error of 1.05%.



RESEARCH OBJECTIVES

There are other studies developed a thermal comfort assessment using Fanger (1) thermal comfort Predicted Mean Vote (PMV), Stolwijk (2)standard effective temperature (SET) and Höppe (3) physiological equivalent temperature (PET). These models were index value based on the human subject perception without consideration of the matebolic heat generation and blood perfusion that significantly affects human thermal comfort level (4). Blood perfusion is important as it is affected by physical activities and the surrounding environment (4). The blood perfusion of the human body is influenced by the human body thermoregulation (5). The overall thermal sensation and skin temperature show a linear relation, which means the overall human thermal sensation can be reflected by skin temperature (6). Therefore, these factors must be considered to determine the accuracy of skin temperature prediction under comfort level. In this study, a new practical approach that focused on the human arm was developed to predict the human skin temperature under comfort level using the finite element method and bioheat equation. The study aimed at identifying the interaction of the surrounding condition with the human physiology without conducting experiment on human subjects.

MATERIALS AND METHODS

The study begins with solving the bioheat equation to determine the initial value of skin temperatue with consideration of the metabolic heat generation and blood perfusion (7). The Ansys version 14 software is used to design the one dimensional quarter cylinderical geometry representative of the human arm. The material properties of the clothing is specified as cotton spendex. The meshing of the model is in quardrilateral uniform. The boundary condition is

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specified similar to the environment sorrounding. The simulation was performed under transient condition for a duration of 80 second. The initial ambient temperature was specified at 31.5°C similar as prescribed by (4). The GIT was conducted to determine the suitable number of elements to be used. The skin temperature was chosen as the reference parameter when performing the GIT. The number of elements used was increased until the skin temperature became stable and unchanged. Therefore, a total of 620 elements were used in the preceding finite element analysis.

RESULTS

The outer clothing layer experienced the lowest temperature, i.e. 31.76°C. It was found that the temperature changed gradually with the variation of layers from the skin surface to the outer layer of the clothing. The single-layered structure consisted of cotton spandex and air gap layers, causing the thermal resistance to grow, which led to a small increment of the skin temperature to around 37°C as compared to the outer layer temperature. Clothing plays an important role in thermal comfort. It regulates the skin temperature and exchanges the heat between the skin surface and the environment. The clothing is the causative factor in achieving thermal comfort (8, 9).

FINDINGS

The time of the experiment was obtained from the model by Huizenga, Zhang (4) and the research model. The temperature started at an initial condition of 35.5°C and it gradually rose with time. The research model result showed the temperature remained constant at t=13 s until the simulation ended. However, in the experiment, the result showed that the skin temperature fluctuated and was unstable. Huizenga, Zhang (4) stated that the human skin temperature will fluctuate and remain unstable depending on physical activities and blood perfusion rate. Furthermore, in this model, the inner layer of the skin temperature and other variables remained constant throughout the simulation. This clearly explains why the skin temperature in the research model remained constant and unchanged starting from t=13 s. The difference between the experiment and the research model was significantly small, i.e. approximately 1.05%. According to (10), this error value is acceptable, as long as it is less than 20%. Thus, the research model is reliable to predict human skin temperature.

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