World Academy of Science, Engineering and Technology
International Journal of Biotechnology and Bioengineering
Vol:8, No:09, 2014

Bio-Heat Transfer in Various Transcutaneous Stimulation Models

Authors : Trevor E. Davis, Isaac Cassar, Yi-Kai Lo, Wentai Liu

Abstract : This study models the use of transcutaneous electrical nerve stimulation on skin with a disk electrode in order to simulate tissue damage. The current density distribution above a disk electrode is known to be a dynamic and non-uniform quantity that is intensified at the edges of the disk. The non-uniformity is subject to change through using various electrode geometries or stimulation methods. One of these methods known as edge-retarded stimulation has shown to reduce this edge enhancement. Though progress has been made in modeling the behavior of a disk electrode, little has been done to test the validity of these models in simulating the actual heat transfer from the electrode. This simulation uses finite element software to couple the injection of current from a disk electrode to heat transfer described by the Pennesbioheat transfer equation. An example application of this model is studying an experimental form of stimulation, known as edge-retarded stimulation. The edge-retarded stimulation method will reduce the current density at the edges of the electrode. It is hypothesized that reducing the current density edge enhancement effect will, in turn, reduce temperature change and tissue damage at the edges of these electrodes. This study tests this hypothesis as a demonstration of the capabilities of this model. The edge-retarded stimulation proved to be safer after this simulation. It is shown that temperature change and the fraction of tissue necrosis is much greater in the square wave stimulation. These results bring implications for changes of procedures in transcutaneous electrical nerve stimulation and transcutaneous spinal cord stimulation as well.

Keywords : bioheat transfer, electrode, neuroprosthetics, TENS, transcutaneous stimulation
Conference Title : ICBBBE 2014 : International Conference on Biotechnology, Bioengineering and Bioprocess Engineering
Conference Location : Los Angeles, United States
Conference Dates : September 29-30, 2014