Interaction of High Intensity Focused Ultrasound with Biological Structures

Ajit Mal, Feng Feng
Mechanical and Aerospace Engineering Department

Michael Kabo, Jeffrey Wang
Department of Orthopaedic Surgery
University of California, Los Angeles, CA

Yoseph Bar-Cohen
Jet Propulsion laboratory
Pasadena, CA

Abstract

This work is motivated by possible medical applications of focused ultrasound in minimally invasive treatment of a variety of disorders. The mechanical and thermal effects caused by focused high-frequency ultrasound in different material systems are calculated. The temperature distribution in the focal zone is also calculated. The results indicate that the heating efficiency of the ultrasound energy in the focal region depends on the exciting frequency and the geometry of the focal zone depends on the material being tested. The thermal effects in both linear and nonlinear models are calculated and compared in a two-layered structure consisting of water and bone. In order to apply this numerical analysis technique to future clinical applications, a realistic problem consisting of a series of 2-D models of the human torso at the level of the second and third lumbar vertebrae (L2-L3) is considered. The model is subjected to simulated focused ultrasound with changing positions and angles of incidence. The purpose of this exercise is to determine the operating parameters that minimize damage to the surrounding tissue and nerve while focused ultrasound generates thermal energy within the intervertebral disk. The geometry of the model was generated by digitizing the relevant structural elements from a transverse CT image containing an intervertebral disk at L2-L3. Elements important to the model included the internal and external bone contours, spinal cord, soft tissue boundaries, and skin envelope.

Keywords

Focused ultrasound, Finite Element Method (FEM), Therml Field.