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ULTRASONIC HEATING OF THE HUMAN BODY

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Abstract -- This paper deals with the principles of ultrasonic power deposition in fat-muscle-bone systems. A model of parallel plane interfaces and plane wave excitation are used. The effect of the angle of incidence in the distribuition of power deposition is presented. It is also shown how power deposition in bone is distributed between shear and longitudinal waves.

INTRODUCTION

In diagnostic ultrasound, heating is a safety consideration: whereas in ultrasonic therapy, heating is the principal objective. Ultrasonic therapy requires a stringent control of the ultrasonic power than diagnostic ultrasound. This paper deals only with ultrasonic therapy. However, the results and conclusions are applicable to diagnostic ultrasound.

The maximum intensity recommended in ultrasonic diagnostic is presently chosen such that the rise of temperature inside of the body does not exceed $1^{o}C$[1] above physiological levels. The maximum effectiveness of the therapeutic use of heat requires that temperature inside of the body remains in the narrow range from approximately 43^{o} to 45^{o} C. The margin of safety is also very narrow, as the temperature exceeds $45^{o}C$, damage to the tissue may occur[2]. This requires a very stringent control of the ultrasonic power . In the use of heat as therapeutic agent, there is considerable interest in managing the temperature inside of a part of the body. However the measurement of internal temperatures is presently an invasive procedure. Computer simulations could be used to obtain temperatures provided that the geometry of the region in the body, which is being subject to therapy, and the blood circulation were known The geometry of the part can be obtained by x-rays or ultrasound. The circulation however varies with the temperature, position and individuals

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This paper presents a straightforward method for calculating the power deposition. The model used is the simplest possible. It is intended as a help in ellucidating some of the complex phenomena of ultrasonic heating. We express the displacement in terms of a scalar a vector potential These potentials are obtained from the application of boundary conditions which are discussed later in the text.

The calculations to obtain temperature distribution involve the interaction of three phenomena: the generation of heat by the ultrasonic field, the transformation of heat in temperature distribution, and the effects of blood circulation. As we mentioned, we will consider in this paper only the first phenomenum.

REFERENCES

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