Proceedings of the 10th World Congress on Electrical Engineering and Computer Systems and Sciences (EECSS'24)
Barcelona, Spain – August 1 - 21, 2024
Paper No. ICBES 154
DOI: 10.11159/icbes24.154

Design of A Novel Liquid Cooling System In Simulation Environment For Radio Frequency Coils Used In Magnetic Hyperthermia Systems

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Extended Abstract

Magnetic hyperthermia is a technique used for focal treatment of cancer [1], based on adherence of magnetic nanoparticles [2] to the tumor site, subsequently increasing the temperature up to 44° C by applying an alternating magnetic field [3]. Radio frequency coils operating between 0.1–3 MHz are used for inducing the alternating magnetic fields for magnetic hyperthermia [4]. This study aims to the optimization of magnetic hyperthermia radio frequency coils for reducing energy loss through the wires, thereby improving focal treatment by preventing unnecessary heating of healthy tissues far from tumor sites. The performance of three different coil cooling designs; a coil with no cooling system that transfers heat with stagnant air through natural convection, a conventional liquid cooling system that runs axially to coil axis and makes contact with the outer surface of wires and a novel liquid cooling system that runs inside of the wires and makes contact with the inner surface of wires, were evaluated using FEM simulations via COMSOL Multiphysics 5.5 software. Both liquid cooling systems used water flowing at a rate of 0.1 m/s. All coils were fed with 25 A peak sine waves. Simulations were realized for frequencies between 0.1–2.9 MHz with 0.2 MHz steps with a duration of 60 minutes in a 20° C ambient temperature. The new design demonstrated the best performance over the frequency range; after 60 minutes, the coil wires for the conventional design reached 22.9 and 38.5° C for 0.1 and 2.9 MHz frequencies, respectively, while the new design's reached 21 and 26.6° C respectively, which is cooler than the conventional design by 1.9 and 11.9° C. Simulation results indicate the novel design performs better than the conventional design. The performance gap increased in favor of the novel design at higher frequencies. showing its potential for overcoming heating pattern from skin effects.

Acknowledgement: This project is funded by Bogazici University Research Fund Grant Number 19661.

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