Contribution ID: **529** Contribution code: **TUE-PO1-402-06** Type: **Poster**

Feasibility Study on a Real-Scale High-Frequency Electromagnets for Magnetic Hyperthermia Base on a Magnetic Scaling Law

Tuesday 16 November 2021 13:15 (20 minutes)

For effective induction heating properties of cancer therapy, the high-frequency electromagnet system's target specifications are 0.06 T of the peak magnetic flux density with 114 kHz of the operating frequency at the center of the used space. Generally, the electromagnet with a narrow air-gap can be designed by the magnetic circuit. However, the electromagnet for magnetic hyperthermia requires a wide air-gap to use the high-frequency spatial magnetic field. In this case, the magnetic flux in the air-gap will spread. Then, it becomes difficult to estimate the self-inductance and magnetic flux density distribution of the electromagnet. Moreover, the electromagnet's power loss becomes difficult to calculate due to the coil windings' current sharing problem and the core loss of the magnetic core. This work aims to carry out a high precision design method for magnetic Hyperthermia high-frequency electromagnet. The high-frequency design method includes the self-inductance calculation model, the center magnetic flux density calculation model, and power loss analysis. In addition to this, the proposed design method was tested compared to the experimental results using a magnet prototype. Basing on the scaling law, the authors summarize the final design of the real-scale high-frequency electromagnet for magnetic hyperthermia. From the results, the electromagnet is designed using 120-A Litz wires coil windings and a magnetic core created with TPW33 core material. The power loss and one-turn voltage of the coil windings are 59.8 kW and 31.9 kV, respectively. It suggests that the coolant of the electromagnet cooling system requires high specific heat and high dielectric strength when the electromagnet is operating.

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Session Classification: TUE-PO1-402 Magnets for Medical App I