



Contribution ID: 118 Contribution code: WED-PO2-723-01

Type: Poster

## A Simple Calculation Method for Center Magnetic Flux Density of a Magnetic Core Electromagnet with a Wide Air-Gap

*Wednesday, 17 November 2021 10:30 (20 minutes)*

Generally, electromagnet equipment such as an electric transformer is designed with the air-gap as narrow as possible for assuming that the magnetic flux in the air-gap does not spread. Therefore, it is possible to design the electromagnet equipment using the magnetic circuit theorem. However, the other electromagnet, such as a high-frequency electromagnet for magnetic hyperthermia, some equipment requires a wide air-gap to use the spatial magnetic field. In this case, the electromagnet cannot be designed by the magnetic circuit theorem because of the spread of magnetic flux in the air-gap. Then, it becomes difficult to estimate the magnetic reluctance of the wide air-gap. Therefore, it is difficult to formulate the center magnetic flux density in the wide air-gap. This work aims to discuss a simple calculation method for the center magnetic flux density of the electromagnet with the wide air-gap using the principle of superposition concerning simple solenoids. In this work, the authors assume that the wide air-gap of the electromagnet can be assembled by an infinite length solenoid with the opposite magnetomotive force finite length solenoid. In this model, the center magnetic flux density in the wide air-gap can be formulated using the magnetic circuit and the Biot-Savart law. The proposed model was tested in comparison with the experimental results of test electromagnets. The result shows that the proposed model can be used in the engineering design of the electromagnets with the wide air-gap.

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**Session Classification:** WED-PO2-723 Moel Coil II & Test Facilities