



Contribution ID: 976

Type: **Poster Presentation**

## **Mon-Af-Po1.13-06 [26]: A Novel and Fast Method for Inductance and Force Calculation of Multi-Coaxial Coils for NMR Magnet Design**

*Monday 23 September 2019 14:30 (2 hours)*

In the ultra-high field NMR (nuclear magnetic resonance) and MRI (magnetic resonance imaging) application with using high-temperature superconducting (HTS) materials, the elaborate analysis of multiple coaxial solenoid coils is essential for the magnet design. The inductance and force were calculated by some authors using analytical and semi-analytical expressions based on double integrations or elliptical integrals of the first and second kinds, Heuman's Lambda function. In this study, we present new and fast procedures for calculating inductance and force exerted between coaxial coils. The combination of Biot-Savart law and Numerical method are used to calculate magnetic field at the interesting area, the inductance is the flux linkage surface integral over the cross section and the force is the Lorentz force volume integral over the solenoid in the cylindrical coordinate system. The derived inductance and force formula based on double integral can be implemented respectively by MATLAB programming with no concern of singularity. Compared with the traditional method, in the MIT 1-GHz NMR magnet design, the inductance and force calculation results respectively differ by less than 8‰ and 1‰ when the coil distance is 0.26mm. With the increase of the distance, the minimum differences are  $7.0 \times 10^{-3}$ ‰ and  $4.8 \times 10^{-3}$ ‰. The suggested method calculation time is 2 times faster in the meantime. The presented approach is more general for calculating the inductance and force of coaxial coils and more applicable to get highly accurate results caused by a relatively simple procedure and shows low computational time.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2017R1A2B3012208) and Research reported in this publication was supported by the National Institute of General Medical Sciences of the National Institutes of Health under award number R21GM129688.

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**Session Classification:** Mon-Af-Po1.13 - Magnets for NMR