Magnetically-Induced Displacement Force on Medical Devices in the Magnetic Resonance Environment

A. Ferreira[1], J. Ochoa[2], R. Siskey[2]

[1]Drexel University, Philadelphia, PA
[2]Exponent Failure Analysis Associates, Philadelphia, PA, USA

Abstract

Introduction: Medical devices undergo a series of evaluations in order to determine their performance and level of safety in a magnetic resonance (MR) environment. The standard of focus for this work is ASTM F2052-15 which measures the induced displacement of a device due to the spatial gradient fields present in the MRI scanner bore [1]. This test entails suspending the device from a string near the entrance of the MRI bore and measuring the angle of deflection. Evaluation the performance of medical devices in the MR environment is a costly endeavor, both in time and resources. This work aims to develop a predictive model to help eliminate some of the burden associated with this testing.

Use of the COMSOL Multiphysics® software: For this simulation a stationary study is done in the COMSOL® software using the "Magnetic Fields, No Currents" interface within the AC/DC Module. The spatial gradient field is read in as point cloud data. The field data was experimentally obtained by physically mapping the field values using a custom-designed fixture and an AlphaLab gaussmeter sensor. Figure 1 demonstrates the map of the experimental data already gathered. Measurements were taken in multiple slices along the z-axis of the scanner bore. A cylindrical sample representing the physical sample used for experimental validation was modeled and placed within this spatial gradient field. This sample is constrained along a specified path in order to simulate the sample being hung from a fixed string, and placed in the surrounding space with constraints representative of those used on physical bodies within a magnetic field during testing. Following the completion of this model, an application will be constructed allowing individual medical devices to be imported into and evaluated within this same magnetic field. The application would allow the user to change materials, geometries, and orientation to analyze the performance of the device. Using the COMSOL Server™, this application can be shared with either clients or employees in order to evaluate their devices in an efficient and cost-effective manner.

Results: The current method of testing magnetically induced displacement force is by measuring the deflection angle between the device and the test fixture. The displacement force is then computed using this deflection angle. It is expected that this deflection angle can be recreated within the simulation and the forces acting on the device be accurately displayed, and the associated displacement force estimated numerically.

Conclusion: This model provides the freedom of manipulating a device and evaluating its performance almost instantaneously. Extensions of this model have the potential to further the detailed numerical evaluation of medical devices in the MR environment. The next step entails modeling devices implanted in tissue in order to evaluate tissue damage due to magnetically induced torque and displacement. This information could lead to reevaluation of the current ASTM standards surrounding medical devices in the MR environment.

Reference

ASTM F2052-15, Standard Test Method for Measurement of Magnetically Induced Displacement Force on Medical Devices in the Magnetic Resonance Environment, ASTM International, West Conshohocken, PA, 2015.

Figures used in the abstract

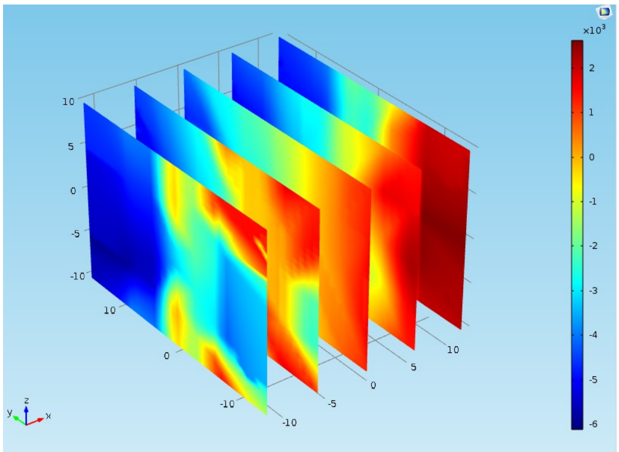

Figure 1: Spatial Gradient Field