

# Modeling Magnetic Configurations for Improved Separations of Magnetic and Non-Magnetic Materials

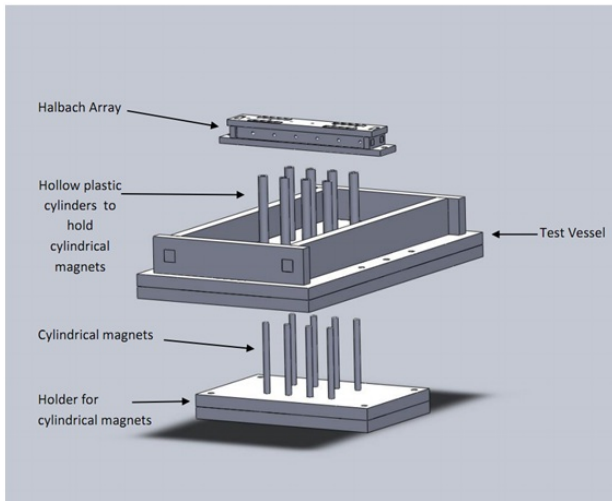
Shahriar Khushrushahi<sup>1</sup>, T.A. Hatton<sup>1</sup>, Markus Zahn<sup>1</sup>

<sup>1</sup>Massachusetts Institute of Technology, Cambridge, MA, USA

## Abstract

Magnetic separation of magnetic liquid phases/particles from non-magnetic liquid phases/particles are needed for applications such as cleaning up oil spills by separating oil and water liquid phases or separating magnetic materials from non-magnetic materials in biomedical and microfluidic applications. This work describes how COMSOL Multiphysics was used to verify magnetic configurations (Figure 1.) by comparing the volume of recovered magnetic phase from non-magnetic phase with experimental results. Designs of magnetic separators (such as Figure 1.) were made in SolidWorks® and were imported into COMSOL Multiphysics 4.2. The magnetic fields from the permanent magnet edges and Halbach array (a Halbach array is a special arrangement of permanent magnets that create a one-sided magnetic flux) were modeled using magnetic fields. The magnetic and non-magnetic liquid phases were modeled using laminar two-phase flow. The amount of magnetic phase collected on top of the Halbach array or on the magnet edges was calculated using COMSOL Multiphysics and the results compared to recovered magnetic phase from built designs. The experimentally recovered volume of magnetic phase was in good agreement with the results obtained using COMSOL Multiphysics 4.2 for the different magnetic separators and configurations tested. This work describes how COMSOL Multiphysics 4.2 was used to test and verify novel magnetic separation techniques, using various configurations of permanent magnet edges and Halbach arrays, to separate a variable volume fraction of a mixture of non-magnetic and magnetic liquid phases. The SolidWorks designs were imported into COMSOL and the calculated recovered magnetic phase was in good agreement with the amount recovered from test units built. COMSOL Multiphysics helped to rapidly and accurately test and optimize different magnetic configurations saving time and energy in building test units.

## Figures used in the abstract



**Figure 1:** Separator with Halbach array and cylindrical edges (exploded view) for improved separation of a mixture of magnetic and non-magnetic liquids. The vessel can be seen in the center with hollow plastic tubes coming from the base of the test vessel. The tubes prevent magnetic fluid from contacting the cylindrical magnets that fit inside the inner diameter of the hollow tubes in the test vessel. The Halbach array is shown on top.