Eddy Current Signal Response Model using COMSOL Multiphysics

Team Members: S. Cloutier, R. Garcia, R. Grilo, T. Singh
Supervisor: Professor Anthony Sinclair
Industrial Supervisor: Ranald Mckay, Ramy Ghattas

The Big Picture
- Ontario Power Generation (OPG) uses the Channel Inspection and Gauging Apparatus for Reactors (CIGAR) tool to perform non-destructive testing on the fuel channels of nuclear reactors.
- Changes to the tool can be expensive, therefore an electromagnetic simulation is needed to:
  - accurately simulate current CIGAR tool operations and the effects of any proposed changes;
  - be used to provide recommendations to optimize the eddy current response.

What was our contribution?
- Created a simplified simulation model that consisted of the:
  - Transmitter
  - High frequency receive coil
  - Low frequency receive coil
  - Obtained the Open Circuit Voltage (OCV) generated in the receive coils accurately simulate current CIGAR tool operations and the effects of any proposed changes; be used to provide recommendations to optimize the eddy current response.

How did we do it?
- Neglected the displacement currents since the frequency is so low, 2-16 kHz (electro-technical hypothesis)²
- Modelled the transmitter coil as a hollow cylinder due to a uniform vector current density, and a high number of turns
- Utilized COMSOL Multiphysics simulation software to model the geometry and electromagnetic fields to obtain tabular results
- Calculated the OCV in the receive coils using Faraday's Law³ by multiplying the electromagnetic field by the surface area of the receive coil

How do we know we are on the right track?
- Validated the output from the simulated model with experimental results obtained during a visit to the client site
- Comparison showed similar trend overall

What's next in the future?
- Increase accuracy of the simulation by modeling the three components as their physical representation (Coil with N number of turns)
- Divide the near and far receiver into concentric cylinders with constant volume
- Incorporate the increased accurate model into the full assembly of the CIGAR tool

References:
⁴ R.Grilo, T. S.Singh
⁵ R.Garcia, Mckay, S.Cloutier, R. Garcia, R. Grilo, T. Singh
⁶ Nelligan, M. & Comsol, R.Grilo, T. S.Singh