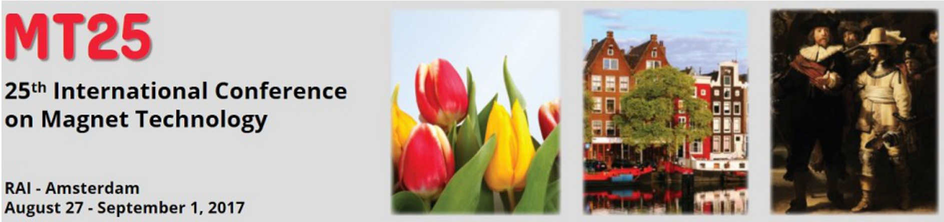

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Coupling of Mechanical and Magneto-Thermal Models of Superconducting Magnet by Means of Mesh Based Interpolation

Thursday 31 August 2017 11:30 (15 minutes)

The Finite Element Method (FEM) is used to perform accurate modelling of superconducting magnets for magnetic field design, mechanical design, and calculations of the peak temperature and voltages to ground in the magnet during a quench.
Each design step solves a set of partial differential equations with appropriate boundary conditions, nonlinear material properties, and problem-adapted meshes. For as long as possible, physical problems are dealt with independently and solved with appropriate FEM programs. The study of multiphysics phenomena, however, requires to solve coupled systems of equations, and a monolithic solution using a single tool might not always be desirable. Another approach treats the coupled models independently by means of input and output relations. In this setting, the interpolation of the results obtained with two different mesh definitions has to be carefully addressed. As a result, each model is treated with an optimal tool. Models created for independent studies can be reused for multiphysics analyses, and the overall development time is reduced.
We study the mechanical impact of temperature gradients and Lorentz-force evolution during a quench and subsequent current discharge in a superconducting magnet. The magneto-thermal study is performed with COMSOL Multiphysics and the mechanical analysis is carried out with an ANSYS APDL. Both models are created through the STEAM (Simulation of Transient Effects in Accelerator Magnets) coupling environment developed at CERN. We use the MpCCI (Multi-physics Code Coupling Interface), which allows for a generic mesh-based interpolation of results obtained with a variety of FEM tools. Integrating MpCCI in STEAM workflows increases in important way the flexibility and reliability of STEAM coupling workflows. The coupling method is illustrated with a simulation of an 11-T dipole magnet for the High-Luminosity upgrade of the LHC. In the study the magnet is protected on a test bench with the CLIQ (Coupling-Loss Induced Quench) technology.

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