UNIVERSITY of HOUSTON

FEA Mechanical Modeling of Torque Transfer Components for Fully Superconducting Rotating Machines

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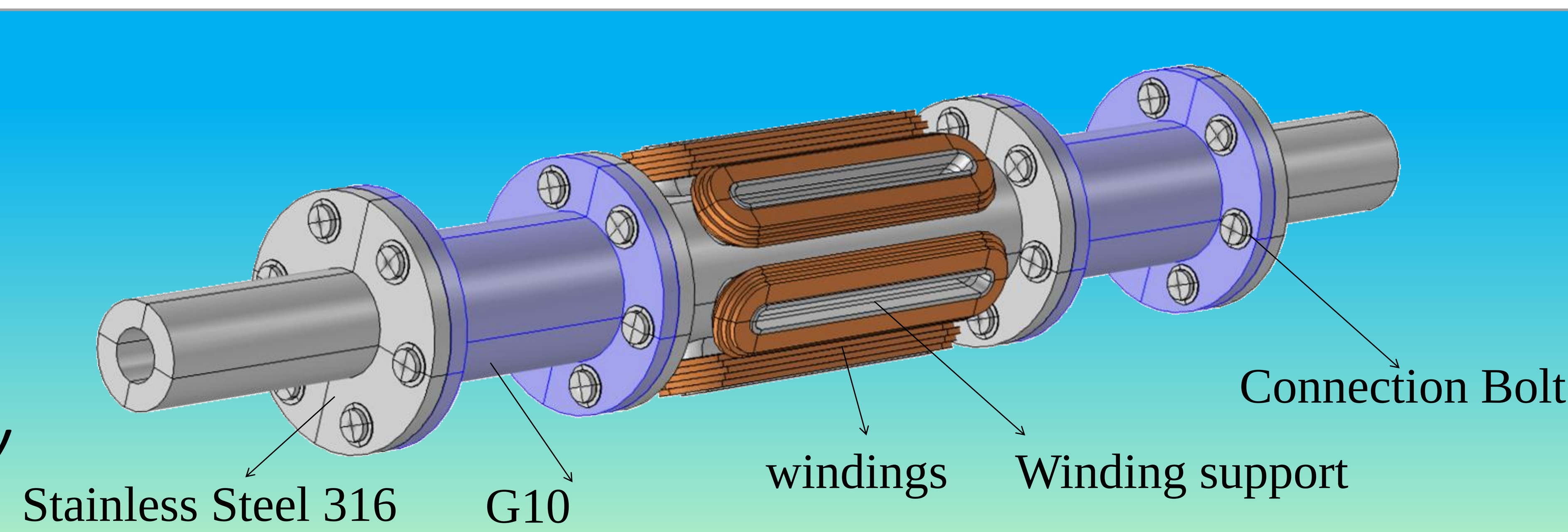
Introduction: Future generations of aircraft are expected to use superconducting machines for power generation and potentially propulsion. Superconductive motors require operation at cryogenic temperature and mechanical torque transfer between cryogenic and room temperature. Large temperature gradients and thermal stress are created. The COMSOL model presented aims at simulating temperature and stress distribution in the torque transfer components of superconducting machines.

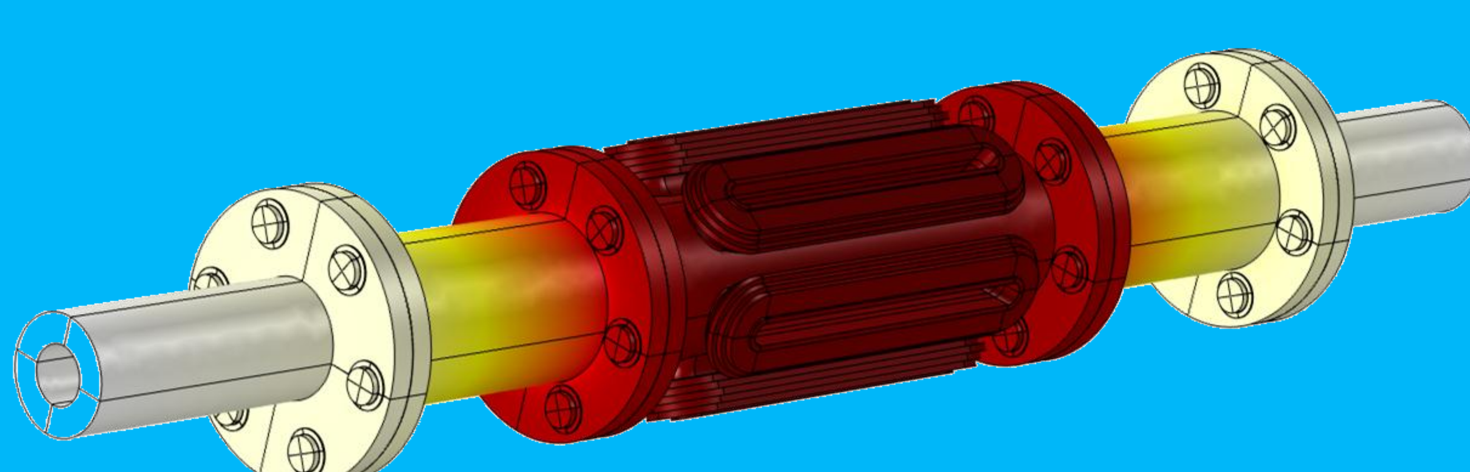
Study: Multiphysics: **Heat transfer** (temperature distribution), **Solid Mechanics** (stress analysis).

Geometry:

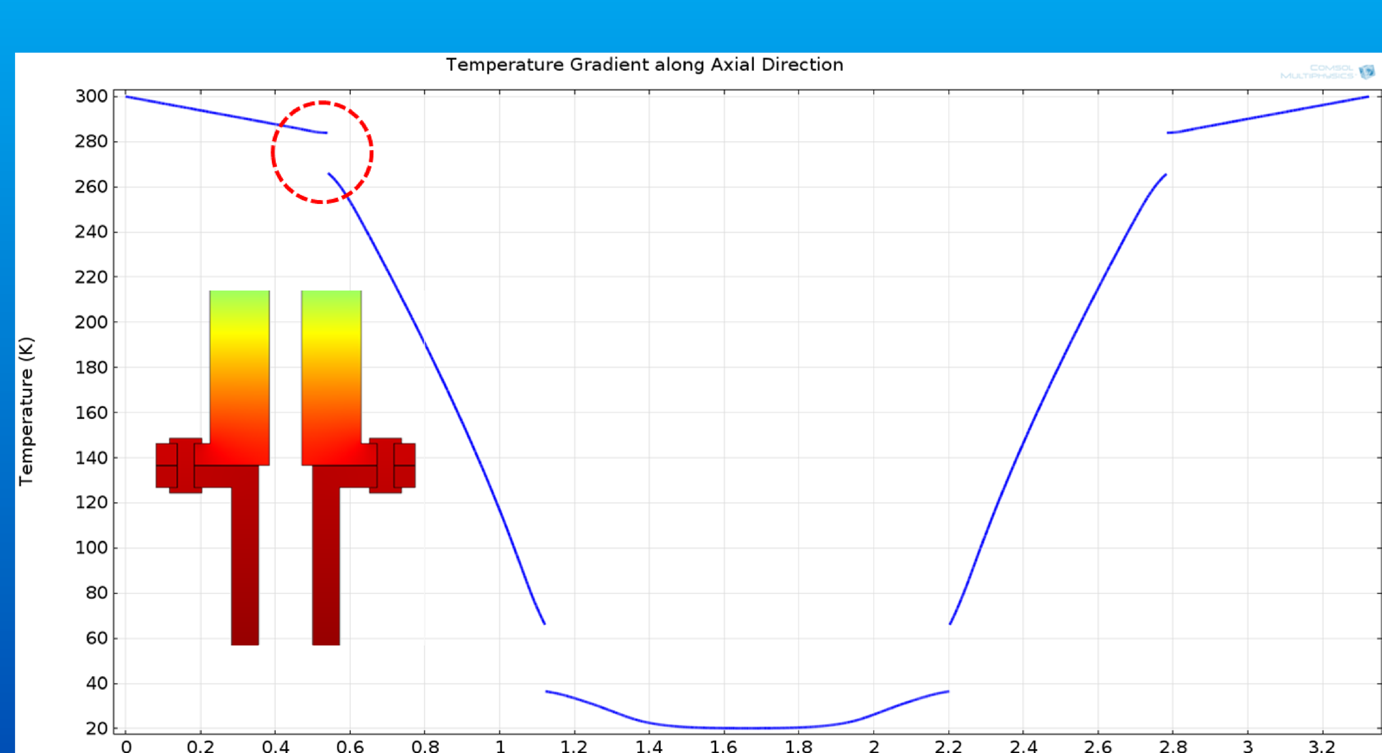
- ✓ *Fully Parametric Design Model*
- ✓ *Allows for Easy Parametric Sweep*
- ✓ *High-fidelity simulation of assembly*



Temperature Distribution

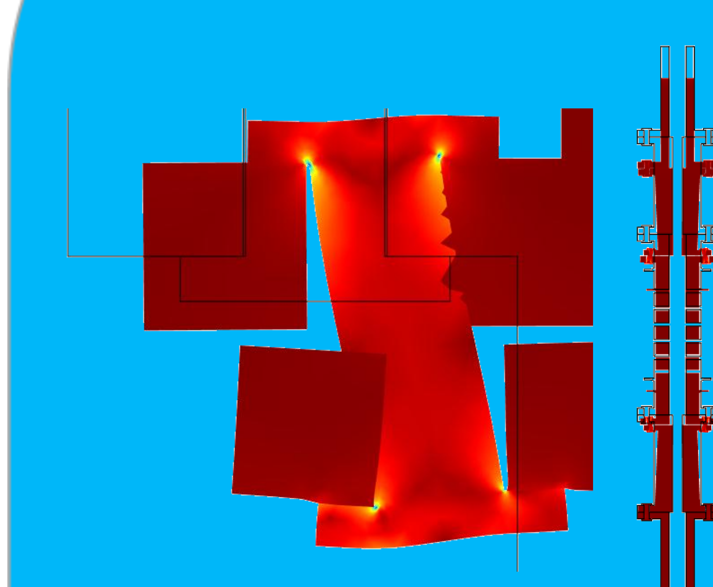


- G10 components take most of the temperature gradient
- Bolts connect G10 and stainless steel parts
- Thermal contact resistance implemented to represent rough surfaces of connected parts

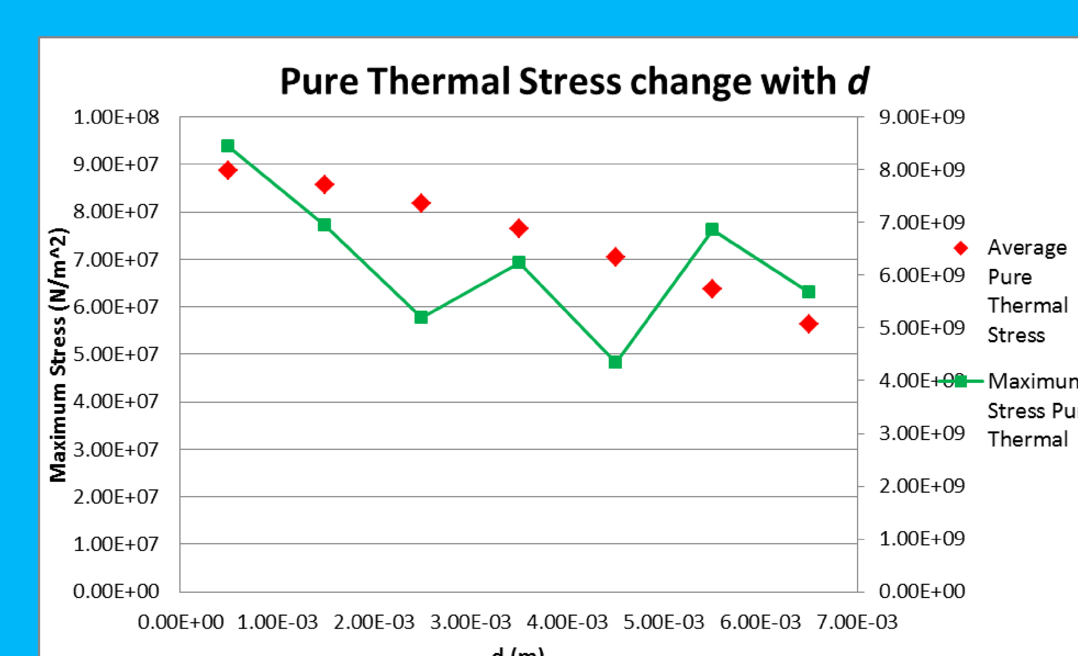


Temperature Gradient along Axial Direction

Stress Analysis



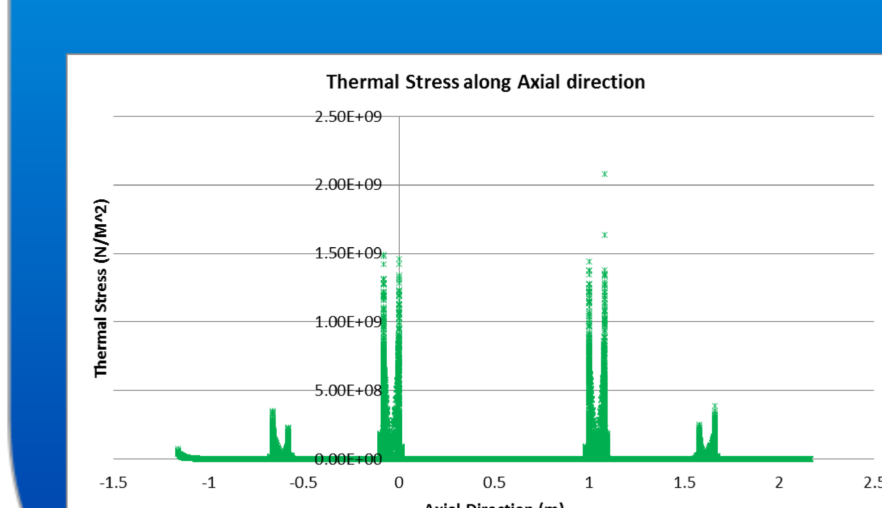
Stress and Deformation of bolt area



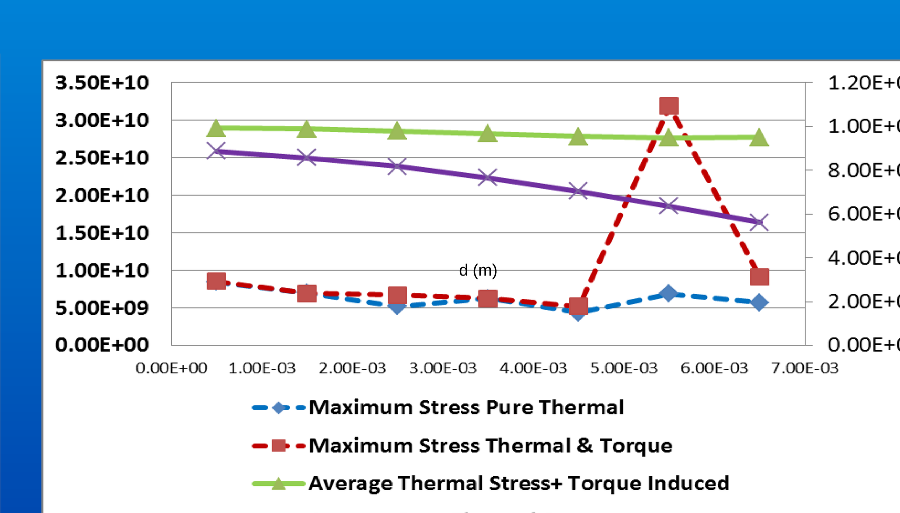
- Thermal stress is dominating
- Peak stress is in the connection bolts
- Influence of number of bolts and bolt cross-section area on peak stress was investigated

Torque(Nm)	Max Stress(N/m^2)	Thermal Stress ONLY(N/m^2)	Torque induced stress ONLY(N/m^2)
3000	4.44E+10	4.44E+10	3.0200E+07
4000	4.44E+10	4.44E+10	6.6900E+07
5000	4.45E+10	4.44E+10	1.0350E+08
6000	4.45E+10	4.44E+10	1.4030E+08
7000	4.45E+10	4.44E+10	1.7700E+08
8000	4.46E+10	4.44E+10	2.1390E+08
9000	4.46E+10	4.44E+10	2.5070E+08
10000	4.46E+10	4.44E+10	2.8770E+08
11000	4.47E+10	4.44E+10	3.2460E+08
12000	4.47E+10	4.44E+10	3.6160E+08

Thermal stress and Torque induced Stress



Stress Distribution



Stress Sweep

References:

1. Yifan Chen, Research on Thermal Contact Resistance of Bolt-Jointed Interface and Heat Conduction Characteristics of Aluminum Honeycombs (2002)
2. R.A. Jones, Mechanical shimming of resistive or superconductive magnets for magnetic resonance imaging, Magnetic Resonance Imaging (1985)
3. Marco Cavenago and Giovanni Bisoffi, Optimization studies of a 14.4 GHz ECR ion source for the superconductive linac at Legnaro, Nuclear Instruments and Methods in Physics Research (1991)
4. B. J. Maddock, G. B. James, and W. T. Norris, Superconductive composites Heat transfer and steady state stabilization, CRYOGENICS (1969)

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