Quench Propagation in YBCO Rotor Winding,

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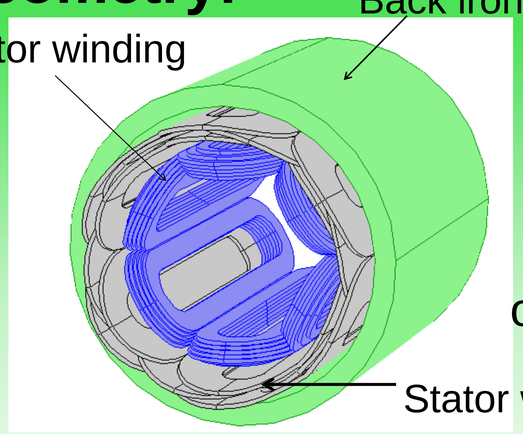
Introduction: The next generation of aircraft are expected to use electric machines with superconducting material. The superconducting state only exists under a critical surface defined in the (J,T,B) space. Quench is the process by which a current carrying superconductor locally changes from the superconducting state to the non-superconducting state thus leading to propagation of a normal zone in which heat is generated. The COMSOL model presented aims at simulating quench propagation in YBCO coated conductor wound coils.

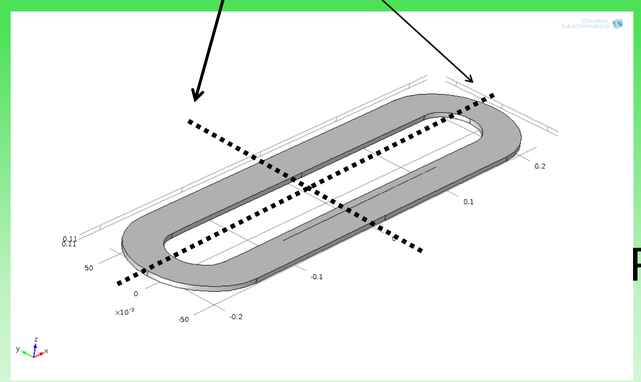
Study: multiphysics purpose: **Heat transfer** (temperature distribution), **Magnetic field** and **Global ODE** (detection).

Geometry:



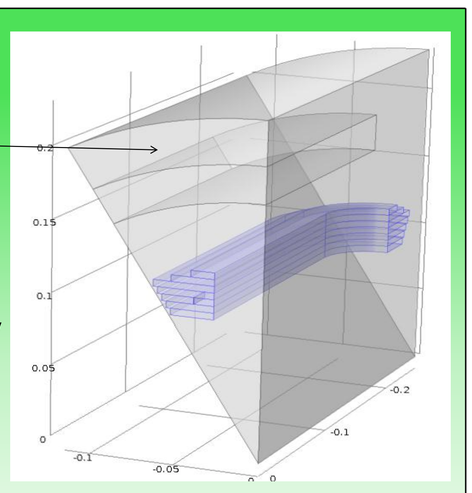
Machine geometry

Study performed on the rotor winding



Rotor winding and symmetry

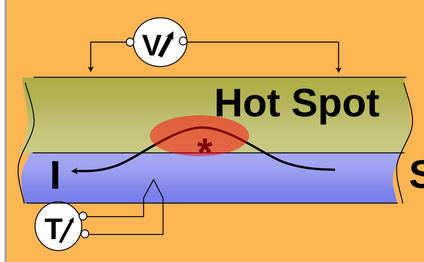
Final geometry



Studied Geometry

Quench Phenomenon

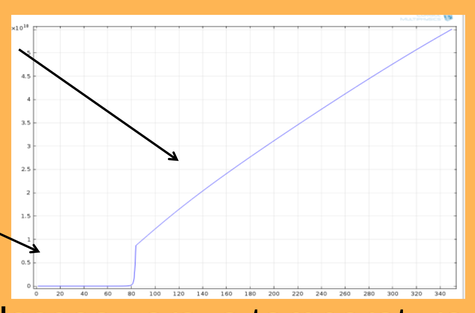
- Change locally of the state of the superconducting coil



- In superconducting state (sc) the YBCO tape dissipates no Joule losses, in normal state, the current flowing into the stabilizing layer dissipates high Joule losses, increasing the temperature locally.

Normal state

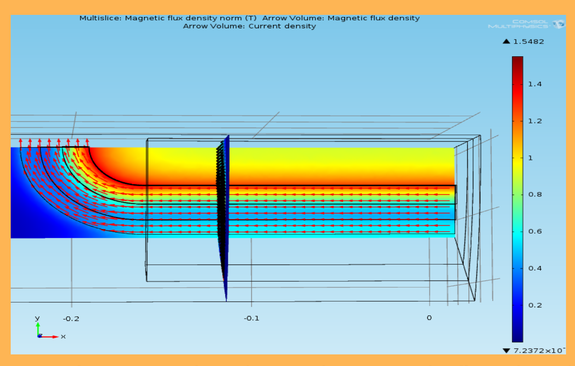
sc



Joule losses versus temperature

Magnetic field

- The joule losses are magnetic field dependent
- an external current density is set in the winding



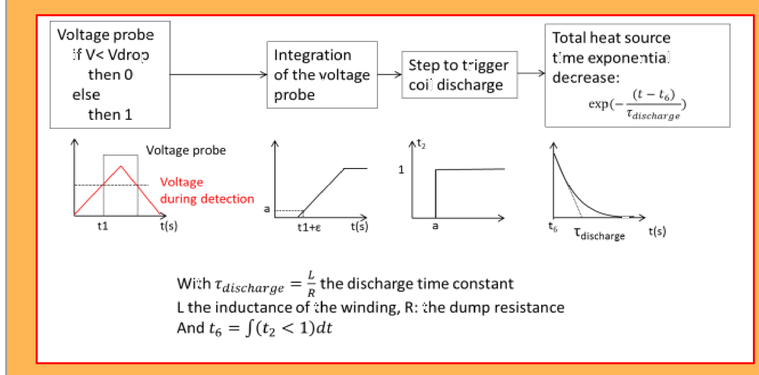
External current density and magnetic flux density

Heat transfer

- An **homogenous model** is created based on **equivalent anisotropic thermal and electrical properties** of the winding

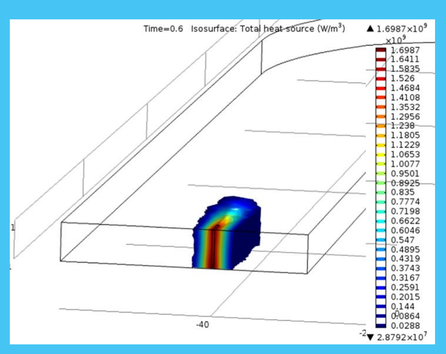
Quench Detection (global ODE)

- During the quench, the voltage across the coil rises. At a threshold value, the energy stored in the coil is discharged in an external dump resistor
- COMSOL implementation:
  - Initiate discharge when the voltage crosses the threshold value
  - intermediate variables and ODE equations were used

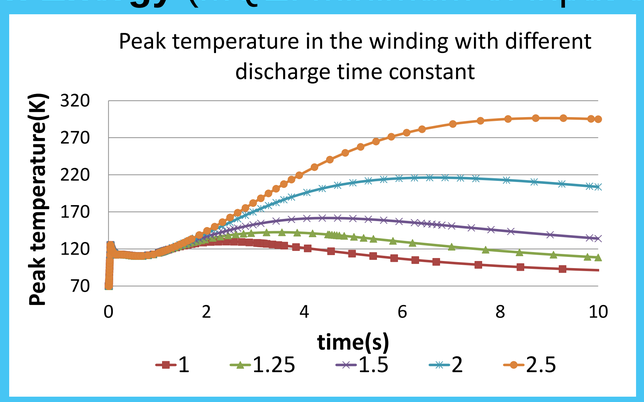


Detection set implementation

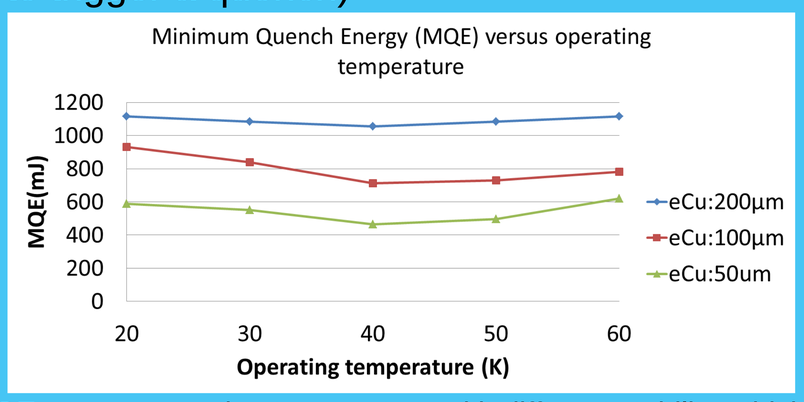
- **Studies** performed include: changes in geometry, detection set. Sweep in the range of operation
- Results obtained : - **Peak temperature** in the winding, temperature and voltage distribution
  - **Quench propagation velocities**
  - **Minimum Quench Energy** (MQE: minimum of input energy to trigger a quench)



Normal zone propagation



Peak temperature versus discharge time constant



MQE versus operating temperature with different stabilizer thickness

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