TUE-AF-Po2

Mechanical Stability Study of the MICE Spectrometer Solenoids

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Abstract—The Muon Ionization Cooling Experiment's (MICE) purpose is to design and engineer a section of a cooling channel capable of giving the desired performance for a Neutrino Factory. Two spectrometer solenoids in the MICE cooling channel provide a uniform magnetic field for two five-plane scintillating fiber trackers to analyze the evolution of the muon beam emittance in the cooling channel. Each spectrometer contains five superconducting solenoids with different structural parameters. The five coils are wound on a single 6061- aluminum mandrel that forms the cold mass. A series finite element models were developed to analyze the thermal-mechanical behaviors of the cold mass: A 2D finite element structural model is created in ANSYS to analyze the static stresses development of the cold mass over the steps of winding to excitation; a 3D Opera model is used to evaluate the quench protection performance. The paper systematically investigates the static mechanical behaviors and the dynamic stress evolution in a quench event.

➢ *The magnets configuration*

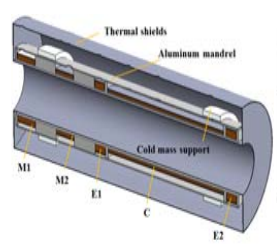
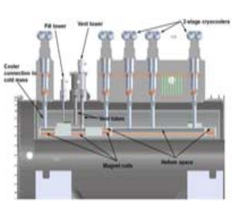
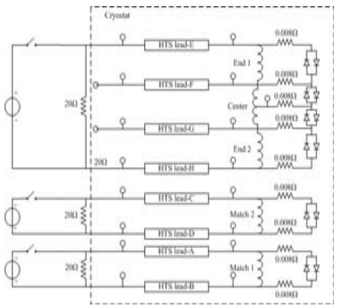


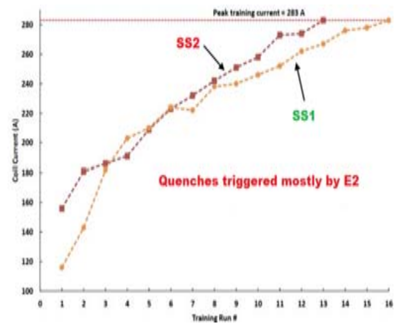
TABLE I PARAMETERS OF EACH COIL

Parameter	M1	M2	E1	C	E2
No. turns/layer	120	119	66	784	62
No. layers	42	28	56	20	66
Inner radius (mm)	258	258	258	258	258
Outer radius (mm)	303	288	318	279	324
Axial coil build (mm)	201	199	111	1314	111
Nominal current (A)	261	280	210	275	230



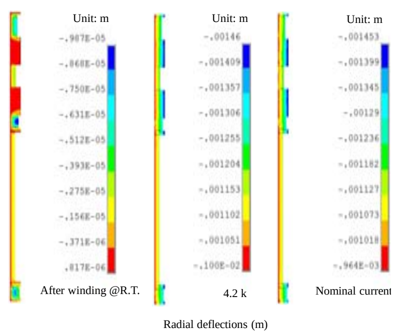
➢ *Training history*

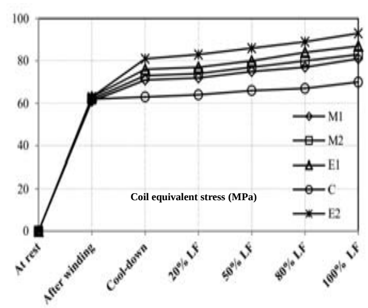




➢ *Static mechanical behavior*

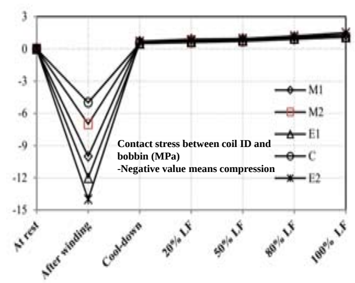
❖ ANSYS 2D axisymmetric model incorporate with Opera3D model is used to simulate mechanical behaviors over magnet life cycles.





AXIAL LORENTZ FORCES IN COILS AT NOMINAL CURRENT

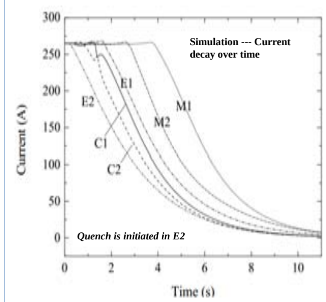
Item	M1	M2	E1	C	E2
Forces (kN)	305	159.2	831.5	-16.7	-1279.3

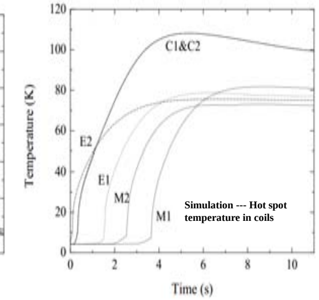


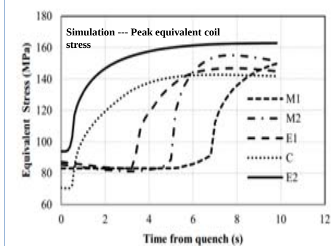
❖ The coil stress is in a safe range for an impregnated NbTi coil.

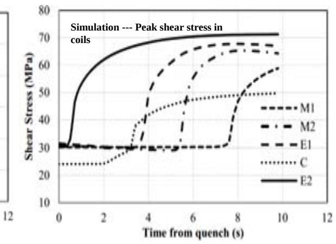
❖ Relatively high stress and high body force on E2, which may lead to high likelihood of epoxy cracking or break-away.

➢ *Mechanical behavior under dynamic loads*









❖ The highest quench temperature occurs in coil C, but the stress level in coil C is not high due to the thin coil thickness.

❖ E2 shows the highest equivalent stress and shear stress (which located around coil corners and coil/bobbin interfaces).

➢ *Conclusion*

The static and time-dependent thermal, electrical, and mechanical quench response of the MICE spectrometer solenoids was studied. A series of finite element model were used to calculate magnet stress components over winding to excitations. Unbalanced quenches have been simulated, and coil peak temperatures and dynamic stresses were computed incorporate with Opera3D and ANSYS codes. The overall mechanical analysis shows the E2 coil behaves differently with the other coils. It is proposed that high shear stress and tension may introduce mechanical instabilities at the coil/bobbin interfaces.