NSTX

Thermal Stresses on the OH-TF Coils

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Executive Summary

The objective of this analysis was to estimate the anticipated hoop stresses in the OH coil during the unusual occurrence of the TF at its peak temperature from a normal pulse, and a cold un-energized CS. The CS was to have been assumed wound on the TF with no gap in-between. This fault condition is expected to be the worst loading consequence of having no gap between the coils. Stresses were found to be acceptable, supporting the "no gap" design choice.

The OH coil is cooled to 12 C (53.6 F) and the TF coil is heated up to 100 C (212 F). Both the coils are made up of Copper and there is Epoxy glass insulation in between the OH and TF coils, and also between each of the TF coils. A stress pass is then run on this model that showed a maximum Von-Mises stress of approximately 22 ksi on the inner diameter of the OH coil. Also, the stresses due to stress concentration near the cooling holes on the TF coil were found to be near 24 ksi. Although the maximum stress in the model is 35 ksi, this region is near the ends and the high stresses could be attributed to the relative deformation between the insulation and the coils. Symmetry is taken advantage of, and a 90 degree solid is modeled and appropriate boundary conditions are applied. The mesh has 47583 nodes and 7696 elements. When the mesh is refined and the nodes are increased to 64907, the stress rise is with in 3%. This shows that the mesh is adequate.

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Modeling:

The solid model of the coil assembly has no insulation and the gaps between the coils were filled with insulation. The 360 degree model is cut into 90 degree model and imported into workbench. The model is then meshed (workbench automatically chooses the element type depending on the analysis) and appropriate boundary conditions are applied.

Figure1: FE model of the OH-TF coil assembly

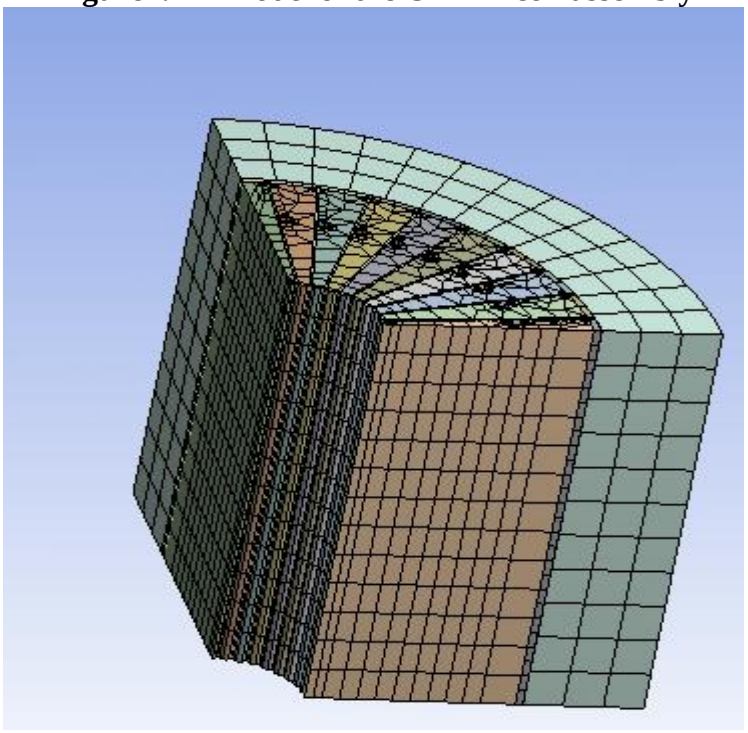


TABLE 1
Model > Mesh

Relevance	0
Element Size	Default
Nodes	47583
Elements	7696

The OH and TF coils are made up of Copper and the insulation is made up of Epoxy glass.

TABLE 2
Copper Alloy > Constants

Young's Modulus	1.5954e+007 psi
Poisson's Ratio	0.34
Thermal Expansion	1.e-005 1/°F
Thermal Conductivity	5.3633e-003 BTU/s·in·°F

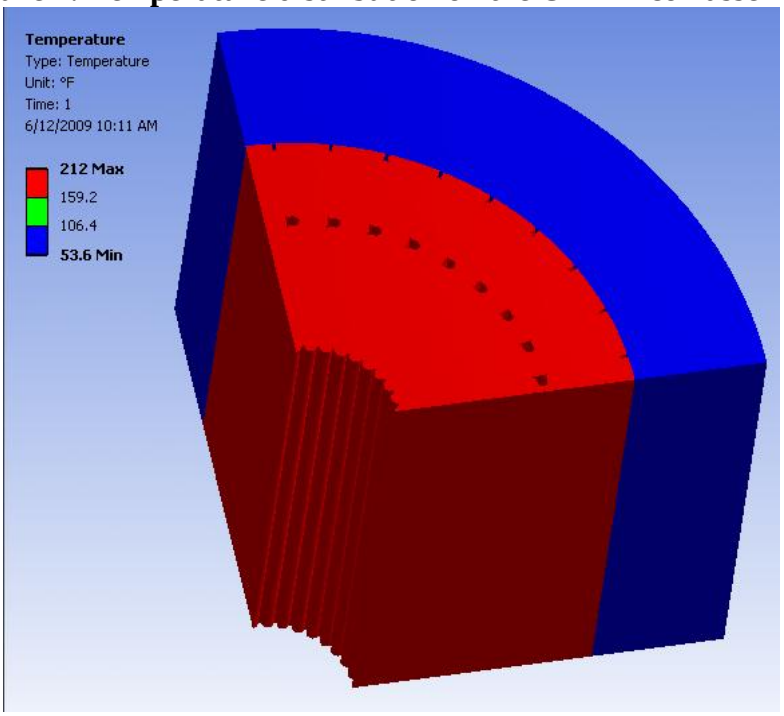
TABLE 3
Epoxy Glass > Constants

Young's Modulus	1.e+006 psi
Poisson's Ratio	0.3
Thermal Expansion	1.6667e-005 1/°F
Thermal Conductivity	6.6874e-005 BTU/s·in·°F

Boundary Conditions for Steady State Thermal Analysis:

The OH coil was held at 12 C and the TF coils are held at 100 C and the results were trivial. The results were then input as a thermal condition in the analysis.

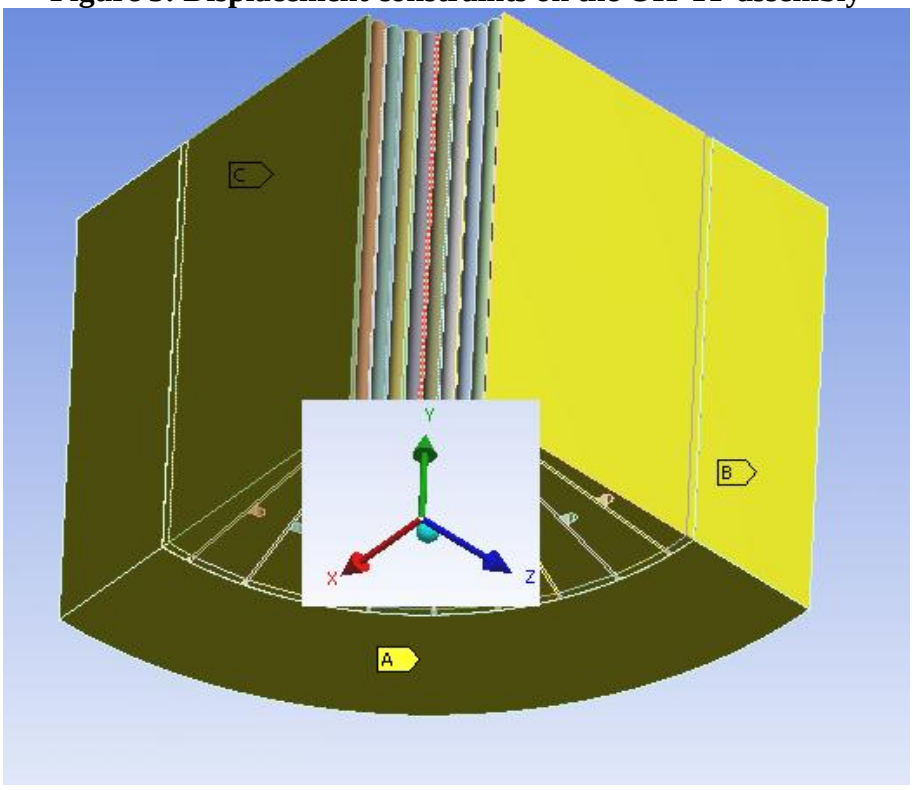
Figure 2: Temperature distribution on the OH-TF coil assembly



Boundary Conditions for Structural Analysis:

The bottom of the OH-TF coil is constrained vertically (Y) the two faces are constrained in X and Z direction as shown in the following figure.

Figure 3: Displacement constraints on the OH-TF assembly



Results:

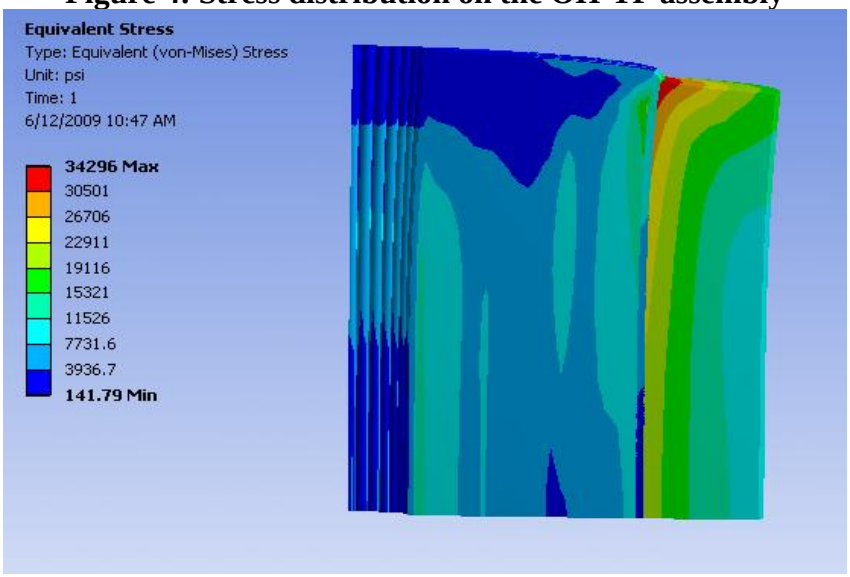
A stress pass is run and the results are as follows.

TABLE 4

Model > Static Structural > Solution > Results

Object Name	*Equivalent Stress*	*Total Deformation*
State	Solved	
Type	Equivalent (von-Mises) Stress	Total Deformation
Display Time	End Time	
Results		
Minimum	141.79 psi	4.4794e-005 in
Maximum	34296 psi	1.9603e-002 in

Figure 4: Stress distribution on the OH-TF assembly

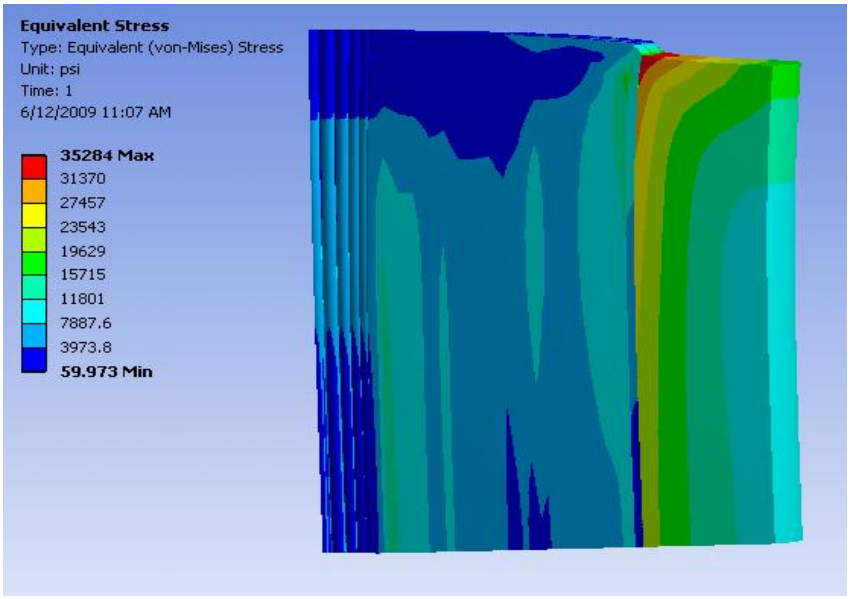


The max stress occurs at the interface between the insulation and the OH coil. This is due to the bonded contact between the two surfaces and can be ignored. Therefore, the maximum hoop stress in the model is found to be around 22 ksi. To validate the results, the mesh was refined and no appreciable rise in stresses was found.

TABLE 5
Model > Mesh (Refined)

Relevance	40
Element Size	Default
Nodes	64907
Elements	10736

Figure 5: Stress distribution on the OH-TF assembly with refined mesh


Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: psi
Time: 1
6/12/2009 11:07 AM
35284 Max
31370
27457
23543
19629
15715
11801
7887.6
3973.8
59.973 Min