



Analysis of Thermal Stresses Produced on TCABR Tokamak Vacuum Vessel due to Baking Process

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Background
 Plasma-wall interactions inside a tokamak vacuum vessel may cause erosion and deposition of particles in its inner walls, reducing the plasma confinement. A baking (heating) system is planned to be installed on the TCABR tokamak and would allow the deposited particles to be removed by heating the vacuum vessel's inner walls to 250 °C. However, this baking system could produce large levels of thermal stresses and produce structural damage if designed poorly.



Fig. 1 - 3D model of the vacuum vessel.

- Objectives**
- Obtain temperature field produced by baking process
 - Evaluate the stresses produced by temperature field and other loadings (gravity, pressure difference)
 - Check if the stresses are large enough to damage the vacuum vessel or its support structure

Methodology

- Finite Element Method (FEM) to obtain numerical solution for differential equations governing the problem

Heat conduction differential equation

$$\frac{\partial}{\partial t} \left(\rho c \frac{\partial T}{\partial t} \right) + \nabla \cdot \left(-k \nabla T \right) = \dot{q}$$

FEM

$$[K][T] = [Q]$$

System of algebraic equations

One way coupling of thermal and structural FEM models

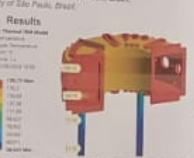
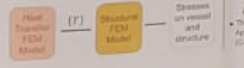


Fig. 2 - Temperature distribution on the vacuum vessel during the baking process.



Fig. 3 - Equivalent stress distribution on the vacuum vessel during the baking process.

- Conclusions**
- Supports act as heat sink, thermal insulation required
 - Thermal radiation has a strong impact on results, helps to reduce temperature differences across the vessel
 - Stresses below yield strength for 316L stainless steel
 - Thermal stresses are function of temperature gradient, supports analysis required

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