Structural analyses of the in-vessel RMP coils of the TCABR tokamak

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1) Introduction

An upgrade of the Brazilian tokamak TCABR ($R_0 = 0.62m, a \leq 0.2m, I_P \leq 120kA, B_0 \leq 1.5T$) is being carried out to study the impact of RMP fields on ELMs. For that, 108 independently powered in-vessel RMP coils will be installed. These coils are divided into two groups: the CP-coils, located on the high field side, and the I-coils, located on the low field side. Each group is composed of three rows containing 18 coils. This will allow to apply RPM fields with toroidal mode number $n_{tor} \leq 9$.

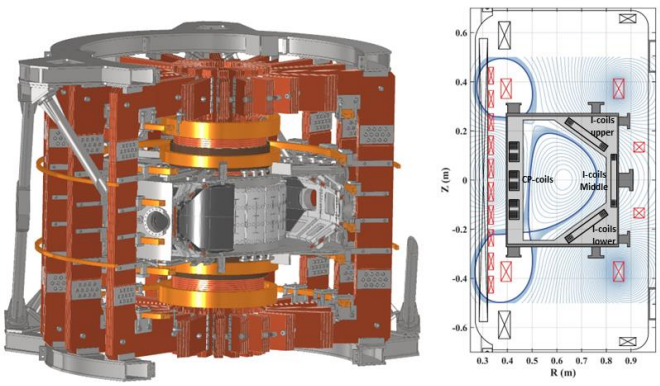

Fig 1-a) 3D CAD model of the TCABR tokamak; b)The physical model.

2) Objectives

This work aims to perform structural analyses of the mechanical components of the IM-coils set. The IM-coils must meet the following criteria:

- Operate with up to 2 kA and 4 kV;
- Withstand temperatures as high as 250 ºC and the associated temperature gradients;
- Materials compatible with p $\leq 1 \times 10^{-7}$mbar;
- To occupy a reduced space to allow the installation of graphite protection tiles;
- Maximum deflection of 0.1 mm;
- The equivalent von Mises stresses must be less than 73MPa (1/3 of the yield stress of 316L).

3) Methodology

Simulations using multiphysics finite element models in Ansys were performed to evaluate the IM-coil design.

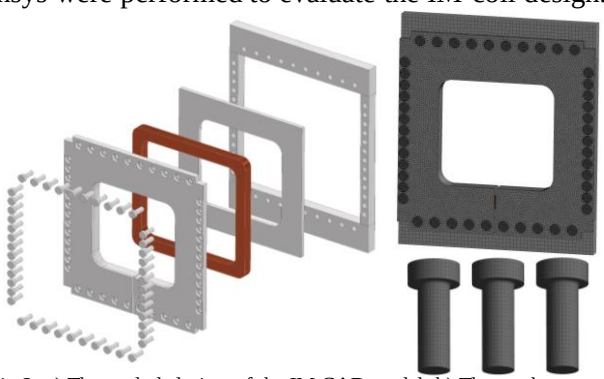

Fig 2- a) The exploded view of the IM CAD model; b) The mesh.

4) Results

The following results were obtained using the Ansys software moduli Maxwell 3D, transient thermal, and mechanical static structural.

4.1) Maxwell 3D analyses

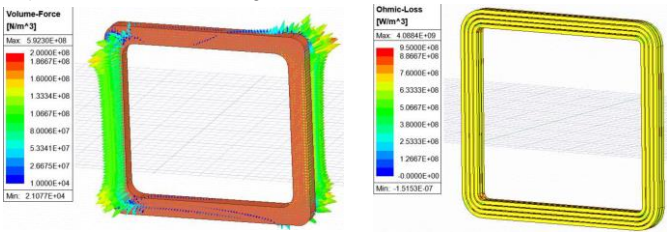

Fig 3-a) Electromagnetic forces; b) Ohmic losses.

4.2) Transient thermal analysis

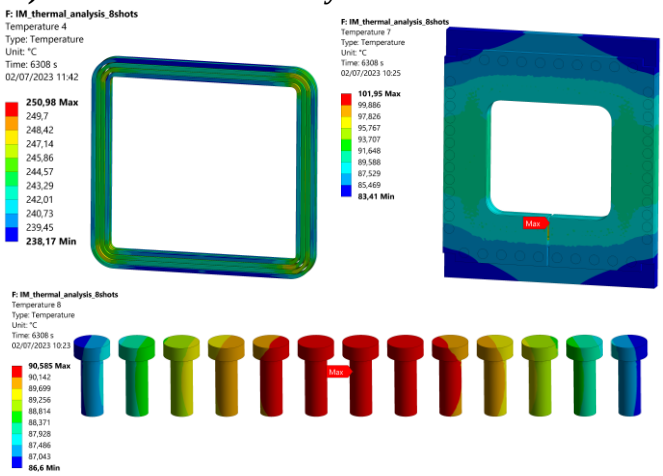

Fig4-Temperature after the 8th shot: a) Conductors; b) Coil casing; c) Bolts.

4.3) Electromagnetic-thermal structural analysis

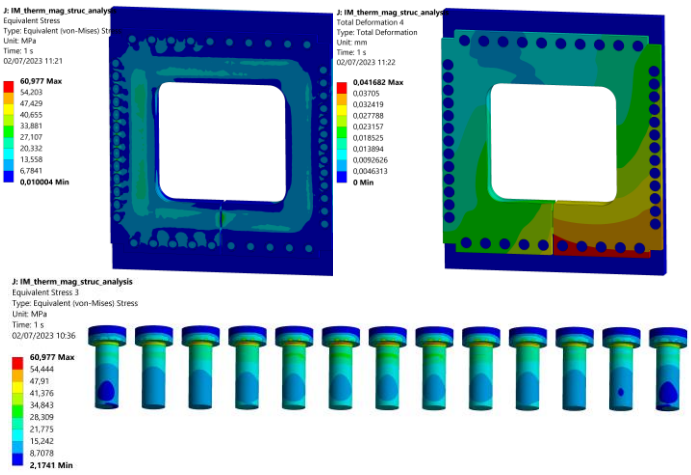

Fig 5- The structural analysis takes into account electromagnetic forces and temperature distribution: a) Stress; b) Deformation; c) Stress in the bolts.

5) Conclusion

The IM-coil design proposed meets the deflection and stress criteria, showing that it can be safely installed on TCABR.

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