

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

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1) Introduction
An upgrade of the tokamak TCABR (6.7 m diameter, 0.55 MA, 5.13 T) is being carried out to study the impact of RMP fields on ELMs. For that, 18 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 18 coils located on the low field side. Each group is composed of three sets containing 18 coils. This will allow to apply RMP fields with toroidal mode number $n=5, 9$.



Fig. 1. 3D model of the in-vessel RMP coils and photograph of the physical coils.

- 2) Mechanical design**
The mechanical design of the in-vessel RMP coils must meet the following criteria:
- Operate with up to 2.5 kV and 4.1 kV;
 - Withstand temperatures as high as 250 °C and the associated temperature gradients;
 - Materials compatible with $p < 1 \times 10^{-10}$ 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 315 MPa (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. Cross-sectional diagram of the in-vessel RMP coil.

4) Results
The following results were obtained using the Ansys software models: Maxwell 3D, transient thermal, and mechanical static structural.

4.1) Maxwell 3D analyses

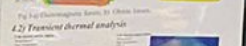


Fig. 3. Electromagnetic forces, \vec{F} , (Newton) and force density, \vec{f} , (N/m³).

4.2) Transient thermal analysis



Fig. 4. Temperature after the 1st shot at conductors, in Call string, at 100 ms.

4.3) Electromagnetic-thermal structural analysis



Fig. 5. The structural analysis takes into account electromagnetic forces and temperature distribution at 100 ms, in Call string, at 100 ms.

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

ACKNOWLEDGMENTS
This work was supported by the project PTDC/CTP/140288/2018, funded by the Portuguese Government through the FCT.

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