DEVELOPMENT OF MODELING TOOLS FOR THERMO-HYDRAULIC ANALYSES AND DESIGN OF JT-60SA TF COILS

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In the framework of the EU participation to the JT-60SA project, the Toroidal Field (TF) coils design has required to address reliably the choice between multiple design options and to calculate the temperature margin central criterion. This has involved a thermo-hydraulic analysis for the He flow along each conductor, and a thermal analysis to compute the transverse heat diffusion between the casing and the winding pack, thus leading to a 3D problem.

For this purpose, a tool has been developed in order to interface the finite elements ANSYS code for modeling the 2D transverse heat diffusion, with the GANDALF code [1] which is designed for solving the 1D thermo-hydraulics inside the conductors. This tool has been used in a two steps approach. In a first step, the ANSYS model has been configured for integrating a simplified 1D thermo-hydraulic analysis in the conductors, in addition to the 2D thermal model. This approach has provided a pseudo-3D model of a whole TF coil, in order to compute He temperature in conductors as well as transverse heat flux from case to conductors. In a second step, the thermal fluxes have been injected into the GANDALF code, for an accurate calculation of the temperature margin on each conductor.

Several validation calculations have been performed, for the reference operation scenario, notably by comparison with the VINCENTA code [2]. Results have shown a satisfying consistency between the different models.

The use of the tool interfacing ANSYS and GANDALF has then allowed to evaluate the impact of TF coils design choices in the framework of cost and feasibility optimization. Pros and cons of coil features such as geometry, case cooling channels layout or winding pack insulation material have been evaluated. The replacement of He inlets at high field on the inner side of the coil by inlets at electrical connections level has also been analyzed. Finally, definitive choices have been consolidated for an optimized TF design with respect to feasibility, cost and risk.

[1] L. Bottura, “A Numerical Model for the Simulation of Quench in the ITER Magnets,” J. Comput. Phys. 125, 1996, pp. 26-41

[2] N. Shatil et al., “The First Experimental Observation of the Helium Mass Exchange between Cable Space and Central Channel in CICC Obtained by SHF Method during QUELL,” Proceedings of the 20th SOFT, Fusion Technology 1, 1998, pp. 715-718