Contribution ID: **10** Type: **not specified**

TACTICS: overview of a multi-physic analysis tool for fusion magnet design and application to DEMO TF coil

Tuesday, 21 September 2021 13:50 (25 minutes)

In the context of the different fusion machines using superconducting magnets that are currently in development or exploitation phase (DEMO, JT-60SA, ITER…), reliable numerical models are required to perform analyses of the magnet design performances. In the design phase, after a conductor and associated magnet structured is proposed, extensive analyses are carried out to verify the compliance of the design with imposed design criteria (i.e. temperature margin, hotspot temperature). These calculations are also performed during commissioning and exploitation of the machine to ensure that a given scenario will not put the magnet at risk.
To meet the need for accurate, fast, and easily usable numerical models for the analysis of magnet systems, the TACTICS code was developed. It consists of a code coupling methodology to perform a pseudo-3D transient co-simulation of coupled physics by linking different codes: THEA for the modeling of the conductors, Cast3M for the magnet structures and Simcryogenics for the cryodistribution simulation.
In this paper, the structure of TACTICS is described, detailing the different links and coupling between the codes. The latest developments will be presented, mainly regarding the numerical stability when dealing fast transients (optimization of the coupling time-step, of the meshing of the structures…). Details will be given on the generation of inputs for the different codes (electromagnetic, thermic, thermo-hydraulics, cryodistribution) and the post-processing of the results.
The last part of the paper presents the application of the tool on the latest CEA design proposals for EU-DEMO TF magnets. The design considered is WP#4 for DEMO 2018. It is an "ITER-like" design, based on the double-pancake concept, with the use of radial plates. In burn studies, the minimal temperature margin of the design will be calculated, using a model accounting for the conductors, the magnet structures and the cryodistribution by coupling the three codes included in TACTICS. The same exercise will be conducted considering a detachment of the winding pack from the casing due to the electro-mechanical forces. A fast safety discharge of the magnet will be performed, and it will be checked whether or not a quench is initiated on such scenario. Then quench simulations will be performed in order to verify if the hotspot temperature criterion is met.

Keywords

CICC, code coupling, DEMO, magnet, quench

Category

Multi-scale and multi physics design methods

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Session Classification: Multi-scale D2