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Parametric study and optimization of the cryo-magnetic system for EU DEMO at the pre-conceptual design phase

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The pre-conceptual design phase of the EU DEMO magnet system relies on mechanical, electromagnetic and thermal-hydraulic analyses of different conductor designs for the Toroidal Field (TF) coils, the Poloidal Field coils and the Central Solenoid magnet. The cryo-magnetic system includes the superconducting magnets cooled by forced flow of supercritical helium at about 4.5 K, the cryo-distribution lines and valve boxes, and the cryogenic system with several cold boxes. The present analysis focuses on the cooling capacity of the TF coils with three winding pack options for the cable in conduit conductors (based on 2015 DEMO baseline), featuring pancake or layer winding approaches. Parametric studies on the cold source temperature and on the supercritical helium mass flow rate, are performed on the three conductor designs in order to identify for each one the impact of the cooling conditions onto the temperature margin with respect to the current sharing temperature. In addition, Simcryogenics, a dynamic modelling tool developed by CEA, is used to model supercritical helium loops for cooling different conductor designs. An algorithm has been developed to optimize the cold source temperature and the supercritical helium mass flow, in order to minimize the refrigeration power for each conductor design. Both parametric and optimization studies are analyzed and compared in order to estimate for each TF winding pack design the impact on the refrigeration power. The interest of such quick cross-check analyses is to identify design improvements for the conductors and the cryo-distribution, keeping acceptable temperature margins and minimizing the refrigeration power.

Category

Multi-scale and multi physics design methods

Keywords

Primary author: HOA, Christine (CEA - Commissariat à l'énergie atomique et aux énergies alternatives)

Co-authors: BONNE, François (CEA - Commissariat à l'énergie atomique et aux énergies alternatives); LE COZ, Quentin (ASSYSTEM); ZANI, Louis (CEA - Commissariat à l'énergie atomique et aux énergies alternatives); LACROIX, Benoît (CEA - Commissariat à l'énergie atomique et aux énergies alternatives); LEWANDOWSKA, Monika (ZUT - West Pomeranian University of Technology); Prof. SEDLAK, Kamil (EPFL - École polytechnique fédérale de Lausanne); Dr CORATO, Valentina (ENEA - Energia Nucleare ed Energie Alternative)

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