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Thermal-hydraulic analysis of low temperature superconducting CFETR Central Solenoid Model Coil

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The China Fusion Engineering Test Reactor (CFETR) is the next device in the roadmap for the realization of fusion energy in China, aiming at bridging the gap between the fusion experimental reactor ITER and the demonstration reactor (DEMO).
CFETR will operate in two phases: steady state operation and self-sufficiency will be the two key issues for Phase I, with a fusion power of up to 200 MW, while Phase II will aim at DEMO validation with a fusion power over 1 GW. For saving the cost of construction and meeting both Phase I and Phase II targets with achievable technical solutions, a new design has been made by choosing a larger machine with R = 6.6 m, a = 1.8 m, BT = 6-7 T. Over 1 GW fusion power can be achieved technically and it is easy to go from Phase I to Phase II with the same machine. In order to obtain the maximum magnetic flux of 224 Wb from the CS coil in Phase II, the use of high temperature superconductors (HTS) made of Bi2212 is envisaged.
In order to test the manufacturing and performance of the superconducting coils for the CFETR in relevant operating conditions, a Central Solenoid Model Coil (CSMC) is being designed, as already done for, e.g., ITER, operating at the nominal current of ˜48 kA and at the peak magnetic field of ˜12 T. It will be composed by two pancake-wound sub-coils: the inner one, in turn divided into inner and outer module, adopting Nb3Sn Cable-in-Conduit Conductors (CICCs), and the outer one, built assembling three NbTi modules in the vertical direction. All the CICCs are cooled by supercritical He and feature two hydraulic paths, namely the bundle and a central pressure relief channel delimited by a spiral.
In this paper, the 4C code is employed to analyze the thermal-hydraulic behavior of the CFETR CSMC in nominal operating conditions, including the effects of the inter-turn and inter-pancake thermal-coupling across the insulation layers. Moreover, the temperature margin of the different CSMC modules during the reference current scenario is computed adopting the design values for the stands and conductor parameters.

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