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Thu-Af-Po.07-04: Validation of the 4C code against data from the cooldown of the EAST TF magnets

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After the first plasma in 2006, the Experimental Advanced Superconducting Tokamak (EAST) is approaching now 20 years of operation. It has been the first tokamak featuring both toroidal and poloidal superconducting coils. In particular, its toroidal field (TF) magnet system is composed by 16 coils with an height of about 4 m. The superconducting coils are operated at a temperature of 4.5 K, being cooled by supercritical He (SHe) at 3.76 bar. To reach the nominal operating conditions, the magnet system undergoes a transient (the cooldown) during which its temperature is slowly reduced from room temperature to the operating (cryogenic) one.
The Cryogenic Circuit, Conductor and Coil ("4C") code is a numerical tool developed more than 15 years ago at Politecnico di Torino to perform the thermal-hydraulic analysis of superconducting magnets for fusion applications. It has been validated against several transients (from the fast quench to the slow cooldown) and is now being applied to simulate the same transients to support the design of the magnet systems of future tokamaks.
In this work, the 4C code is used to model the cooldown of the EAST TF coils, aiming at its first validation in the case of a magnet cooldown in a tokamak. The measured boundary conditions (inlet temperature and inlet and outlet pressures) will be applied to the 4C magnet model, and the evolution of the computed outlet temperature will be compared with the experimental data to quantify the accuracy of the model.
As the actual cooldown process of the EAST TF coil is controlled by the temperature difference between the SHe outlet and inlet, but the maximum temperature difference inside the coil cannot be measured because it location is not known a priori, the 4C simulation will also support the optimization of the cooldown: the possibility to accelerate the cooldown without exceeding the maximum allowed temperature difference will be investigated.
This validation exercise will move a step forward in the qualification of the 4C code in perspective of its application to future machines, also in view of the licensing requirements, as (to the best of our knowledge) currently there is not any tool qualified for this. In particular, the 4C code is already being applied to the CFETR TF coil cooldown simulation.

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