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Quench of ITER poloidal field coils: influence of some initiation parameters on thermo-hydraulic detection signals and main impact on cryogenic system

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The 6 ITER Poloidal Field Coils are wound in double pancakes (DP) using two-in-hand large NbTi Cable-In-Conduit Conductors (CICC) with a central channel. All pancakes are cooled in parallel. The helium inlets are located at the innermost turns whereas the helium outlet (in the electrical joints) are locate at the outer radius. For a each PF coil winding, a simplified rectangular cross-section is assumed in the modeling, considering an integer number of turns in the radial (Nr) direction and an integer number of pancakes vertically (Nz).

In case of a magnet quench, the primary quench detection system is classically based on voltage detection. In addition, a safety related secondary quench detection is required and this could rely on signals of thermo-hydraulic nature.

A model based on the coupled GANDALF and FLOWER codes already partly presented in a previous papers for Central Solenoid and Toroidal Field Coils have been developed: This model represents one pancake of one PF coil modeled by Gandalf and the other pancakes and other PF coils modeled with Flower with compressible heated channels (as well as the inlet and outlet channel in the feeders).

This study focuses on two PF Coils, namely PF3 and PF5:
- PF3 has the longest hydraulic length and a relative high temperature margin (of nearly 2 K); there is very little difference in the temperature margin between the top, middle or bottom pancake. For the median pancake (with a conductor temperature of 5.1 K), one short heated zone of between 1 m and 10 m, at the middle of conductor, will be the most difficult to detect, except with the signal difference of mass flow rates (i.e. inlet – outlet) in the feeder at the Cold Termination Box (CTB), where the sensors are located.
- PF5 has the higher magnetic field value along the conductor, and a high nuclear heat load (during plasma) on the top pancake (due also to the steady state support heat loads). The top pancake has then the lowest temperature margin, and for this case the study of a "big quench"is performed, that means with all the pancakes quenching at the same time, at the inlet and outlet of the coil. In this case the cryogenic consequences are presented, specially the pressure inside the conductor and upstream the relief valves.

Results of some parametric studies are presented and the influence of the initiation parameters of the quench (specially quench energy, location and length of heat deposition,, and time duration). The possibility of a secondary thermohydraulical detection and the main impact on cryogenic system are analyzed and discussed.

Author: NICOLLET, Sylvie (CEA/IRFM Saint-Paul-lez-Durance 13108 France)

Co-authors: LACROIX, Benoit (CEA/IRFM Saint-Paul-lez-Durance 13108 France); CIAZYNSKI, Daniel (CEA/IRFM Saint-Paul-lez-Durance 13108 France); BESSETTE, Denis (ITER International Organization, Saint Paul lez Durance, France); RODRIGUEZ-MATEOS, Felix (ITER International Organization, Saint Paul lez Durance, France); DUCHATEAU, Jean-Luc (CEA/IRFM Saint-Paul-lez-Durance 13108 France); COATANEA-GOUACHET, Marc (CEA/IRFM Saint--Paul-lez-Durance 13108 France)

Presenter: NICOLLET, Sylvie (CEA/IRFM Saint-Paul-lez-Durance 13108 France)

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