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Fri-Af-Po.03-06: Could the parasitic heat load from the supports jeopardize the operation of the superconducting feeder of the Divertor Tokamak Test facility?

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The superconducting (SC) magnets of the Divertor Tokamak Test (DTT) facility, a fusion experiment under construction at the ENEA Research Center in Frascati, Italy, require several tens of kA, necessitating the use of SC feeders. These feeders are based on the Cable-in-Conduit Conductor (CICC) concept, where a bundle of twisted NbTi strands is encased in a stainless-steel jacket and cooled by a forced flow of supercritical helium passing through the strands. The DTT magnet system includes feeders for the Central Solenoid (CS), the Poloidal Field (PF) Coils, and the Toroidal Field (TF) Coils, along with additional "jumpers"to connect the TF coils in series. Each feeder has its own path within the machine, with specific lengths, magnetic fields, and operating current scenarios.
The design of the feeder CICCs, including their sizing and the evaluation of the required coolant mass flow rates, has been completed and is now finalized. The design ensures a minimum temperature margin for the SC strands to counteract thermal loads, including Joule heating at the joints, AC losses from current or field variations, and parasitic loads from radiation emitted by the environment, which consists of a cryostat equipped with a thermal shield at liquid nitrogen temperature. Additionally, the heating due to the nuclear flux escaping the plasma has been accounted for. However, parasitic heat loads introduced by conduction through thermal bridges, caused by the mechanical support of the feeders, were not included since the mechanical design of the component is not yet available. Such contributions may significantly reduce the temperature margin, as indicated by experiences from other tokamaks.
This paper aims to address the issue of parasitic heat loads from the supports through a parametric analysis, evaluating the maximum tolerable heat load under the nominal operating mass flow rate, assuming a reasonable spatial distribution of the supports. The study, conducted using the OPENSC2 software, is performed under steady-state conditions for all CS, PS, TS, and jumper feeders, considering a reference plasma scenario and an environment temperature of 80 K. For the most critical feeders, a transient analysis is also performed, incorporating AC losses calculated using the Ogasawara equation. The results of this analysis support the projects with guidelines and constraints for the thermal design of the feeder supports.

Authors: PLACIDO, Daniele (Politecnico di Torino); Dr DE MARZI, Gianluca (ENEA); Prof. SAVOLDI, Laura (Politecnico di Torino)

Co-authors: Dr POLLI, Gian Mario (DTT); Dr RAMOGIDA, Giuseppe (ENEA DTT)

Presenter: Dr DE MARZI, Gianluca (ENEA)

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