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Design of the cryogenic loops for the superconducting magnets of the Divertor Tokamak Test

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The Divertor Tokamak Test (DTT) facility is being built at ENEA Frascati (Italy), to address the development of a power exhaust system capable to handle the large heat fluxes expected to be deposited in fusion reactors on the plasma facing components.
DTT will be a compact and flexible fusion experiment relying on low-temperature superconducting magnets for the plasma confinement. The magnets will be cooled to their operating temperature by supercritical He at 4.5 K and ˜0.6 MPa, distributed by at least two cryogenic circuits (one for the AC and one for the DC coils) composed by supply and return cryolines, heat exchangers, control valves and a cold circulator. These circuits need to be designed to handle both the pulsed heat loads deposited in the coils by AC losses and nuclear particles during the operation of the tokamak and the static heat transferred by conduction/radiation from the cryostat to the magnets. To decouple the circuits from the refrigerator, that should operate as much as possible at a constant thermal load, the heat will be transferred to a thermal buffer (a saturated liquid He bath).
The validated thermal-hydraulic code 4C is used here to support the design of the DTT cryogenic system. Different operative phases are simulated, comparing the evolution and peak values of the heat load transferred from the cryogenic circuits to the thermal buffer in different plasma configurations and for different circuit layouts.
To drive the selection of the best layout, suitable figures of merit are identified, such as the number and volume of the buffers and the amplitude of the variation of the power transferred to the refrigerator during the plasma pulses. In case the buffer is not sufficient, some additional mitigation strategies for the smoothing of the power transferred to the refrigerator, involving suitable controls, will be investigated.

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