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P4.099 Optimization of the cooling capacity of the cryo-magnetic system for EU DEMO at the pre-conceptual design phase

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The thermal hydraulic analysis of the DEMO cryo-magnetic system has the main objective to minimize the refrigeration power. The cryo-magnetic system includes the superconducting magnets cooled by forced flow supercritical helium at about 4.4 K, the cryo-distribution lines and valve boxes, and the cryogenic system with several cold boxes. The DEMO cryogenic system is at the pre-conceptional phase design, with the identification of the heat loads requirements of the main cryogenic users. The analysis will focus on the cooling capacity of the superconducting magnets, which are the main contributors of the 4.4 K heat loads. Simcryogenics, a dynamic modelling tool developed by CEA, has been used to model a supercritical helium loop for cooling superconducting magnets, driven by a cold circulator and exchanging the heat loads with a liquid helium phase separator (cold source) pumped down with a cold compressor. An optimization algorithm has been developed to optimize the cold source temperature and the supercritical helium mass flow, in order to minimize the refrigeration power. The refrigeration power covers the cooling capacity to absorb the heat loads of the superconducting magnets (nuclear heating, thermal radiation and conduction) but also the pumping powers from the cold circulator and the cold compressor. The optimization problem is subject to the requirement of keeping a temperature margin of 1.5 K with respect to the critical temperature of the superconducting material. The optimization has been applied on one cable in conduit designed by CEA, but could be relevant for comparing different designs and their cooling requirements. At this pre-conceptional design phase, the interest of such analysis is to contribute to the optimization of both the cryogenic system and the superconducting magnets to minimize the refrigeration power, one of the important investment and operation costs for the future tokamak.

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