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Experimental and numerical investigations for the operation of large scale helium supercritical loops subjected to pulsed heat loads in tokamaks

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Strategies for smoothing pulsed heat loads are of great interest for future operation of large refrigeration systems for tokamaks, such as JT-60SA or ITER as their superconducting magnets are cooled by independent supercritical helium loops. Numerical and experimental process studies have been conducted at CEA Grenoble to validate and optimize the control of such large scale refrigeration circuits. At the cryo-distribution level, in the auxiliary cold box, pulsed heat loads effects have been analysed on a scaled down loop of supercritical helium driven by a cold circulator. Variation of pressure and mass flow can be significant is depending on the pulsed load scenario and on the volume distribution between the heat sources and extractions along the loops. Extensive experimental tests have been performed on the HELIOS test facility during the past three years and the present article aims at summarizing the pulsed load strategies and the understanding of the thermodynamics along the supercritical loop. Dynamics modelling on EcosimPro and the CRYOLIB library is a relevant tool to validate and to compare possible future process controls.
The HELIOS loop has offered the possibility to test several configurations: the supercritical loop can be either completely closed (isochoric) or regulated in pressure (isobaric). The article addresses a comparative study of the two configurations. The observations and outcomes of this study can be used for preparing the operation of future cryogenic installations, which main new feature will be the pulsed heat load control resulting from the cycling operation of the tokamak.

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