Dynamic Modelling of the Helium-cooled DEMO Fusion Power Plant with an Intermediate Loop and Energy Storage System (Indirect Cycle)

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The Demonstration Fusion Power Plant (DEMO) project aims to construct and successfully operate an industrial size tokamak fusion power plant generating electricity to the grid. One key challenge, among many, relates to the pulsed operation of the machine and adopting conventional power conversion systems, which are commonly designed for continuous operation. The DEMO balance-of-plant systems have to be designed to manage a periodical drop in fusion heat production during the dwell period.

A concept utilizing a molten salt Intermediate Heat Storage System (IHTS) equipped by an Energy Storage System (ESS) between the helium-cooled Primary Heat Transfer System (PHTS) and the Power Conversion System (PCS) – Indirect Cycle – have been studied over the course of several years within the EUROfusion Balance of Plant (BOP) workpackage, with the aim to smooth the transition between pulse and dwell. KIT has, with the support from the industrial turbine manufacturer Siemens, developed and optimized the PCS scheme and performed steady-state balance analysis for power and dwell operations with the simulation tool Ebsilon. To complement the static analyses VTT has made a model of the same configuration with the system code Apros. Dynamic analyses including pulse and dwell transitions have been performed to verify that the developed balance-of-plant concept is feasible. Further, a plausible control strategy has been developed and optimized, which minimizes cyclic temperature and pressure loads on components, potentially induced by the pulsation of the low temperature DEMO heat sources (e.g. divertor and vacuum vessel), whose Heat Exchangers (HXs) are integrated in the feedwater train. With the increasing maturity of the design related to the key areas of the DEMO fusion power plant, during the last years also a higher accuracy of the models have been achieved.

Keywords: DEMO fusion power plant, Apros, dynamic modelling, tokamak, energy storage

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