Dynamic Modelling of a Solid Energy Storage Concept for pulsed operation DEMO fusion power plant (Direct Cycle)

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The Demonstration Fusion Power Plant (DEMO) project aims to construct and successfully operate an industrial size fusion power plant. In order to succeed in this task, several challenges in the current fusion technologies have to be overcome. One key challenge is related to the pulsed operation of the Tokamak-fusion reactor. It is estimated that the tokamak reactor can run only in pulsed mode introducing challenges to conventional power conversion systems, which are commonly designed for continuous operation. The DEMO power conversion system has to be designed to manage a periodical drop in fusion heat production during the dwell period. The DEMO-project work packages Plant Level System Engineering (PMI) and Balance of Plant (BOP) aim to design a thermal- and cost-effective Primary Heat Transfer System (PHTS) and Power Conversion System (PCS) for the DEMO fusion reactor. As part of these work packages, modelling studies were done by KIT, VTT and Fortum during 2018. Personnel in KIT performed a steady-state balance analysis of several PCS concepts directly thermally connected to the Helium Cooled Pebble Bed PHTS (Direct Cycle) both during normal pulse (power) operation and during 10 minutes dwell time operation with the Ebsilon simulation tool. Ebsilon results were used to dimension and construct a dynamic 1-D Apros model for a solid energy storage concept analyzed by VTT and Fortum. In the solid energy storage concept, thermal accumulators and a steam drum are used to store heat during operation and are unloaded during the dwell period. The solid energy storage system succeeded in keeping turbine power around 50% during the dwell period; however the Apros model also showed strong transients in process parameters, which could be problematic when considering plant safety and process component wear.

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

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