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EU-DEMO Fuel Cycle Operation Modelling and Design

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The fuel cycle of future demonstration and fusion power plants is a complex and highly dynamic system by nature, resulting from the pulsed operation of the tokamak as well as from a number of cyclic operations employed within its processing systems. The fuel cycle nevertheless has to guarantee the availability of fuel in the right quantities and composition to the plasma fueling systems, while continuously removing ash and unburnt fuel. Next to these tasks directly servicing the plasma chamber, the fuel cycle also processes tritium extracted from the breeding blankets or recovered in detritiation systems.
The strongest design driver hereby is the minimization of tritium inventories in the employed processing systems to allow safe operation of the plant and due to its limited availability. Next to design tools based on in-depth, steady state modeling, integrated process simulation of the full fuel cycle is also required to investigate and ultimately confirm its dynamic operability.
A holistic, transient process simulation of the EU-DEMO fuel cycle is therefore under development within the work package Tritium –Matter Injection –Vacuum of the European Fusion Programme. This talk gives an introduction to the EU-DEMO Fuel Cycle Simulator, outlining the modeling approach and simulation methodology, as well as presenting simulation results for the dynamic characteristics of the inner fuel cycle. It is found that transients in the inner fuel cycle are driven by the time dependent fueling requirements to the plasma in its different phases (ramp-up, flattop, ramp-down), as well as the dwell pumping phase. This sequence of different operation modes leads to pressure oscillations in the gas distribution system, which have to be buffered against to ensure the continuous fuel supply to all systems. A design study showcasing how dwell bypasses can be used to minimize the required size of buffer vessels will be presented.

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