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Self-consistent modelling of a liquid metal pool-type divertor

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The steady-state power exhaust problem in future fusion reactors (e.g, DEMO) is considered as a major challenge along the path towards fusion electricity. Dedicated work packages are being devoted to this problem within EUROfusion and a dedicated facility (the Italian Divertor Tokamak Test –IDTT) is being designed in Italy. Among the possible solutions for this problem, a liquid metal (LM) divertor has been proposed. The particularly attractive feature of this solution is the absence of damage to the wall, even in the case of high heat fluxes, thanks to the high latent heat of evaporation and to the liquid nature of the wall, which can be constantly replenished.

In this work a closed, LM divertor with pool-type configuration is proposed for a reference single-null (SN) scenario, for both the EU DEMO and the IDTT. The assessment of the divertor performance is achieved by means of a newly developed model which self-consistently accounts for the most relevant physics, including plasma-vapor interactions. Self-consistency is achieved by coupling three modules: a 0D thermodynamic module for the LM/vapor system -benchmarked against 2D CFD calculations performed in OpenFOAM-, a 1D module for the SOL plasma and a 2D FEM module for the divertor walls. The resulting model is applied to the comparison between Li and Sn as possible LM choices, in terms of mitigation of the parallel heat flux to the target and of contamination of the main/core plasma. An assessment of the representativity of the IDTT in view of the EU DEMO in terms of the performance of a closed box divertor using Li is finally performed.

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