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Strategy of an integrated limiter design for EU-DEMO first wall protection from plasma transient events

This work presents the integrated strategy aimed at the protection of the first wall (FW) from plasma transients, developed for the EU-DEMO design. The proposed strategy foresees the use of discrete limiters to protect the breeding blanket (BB) FW from direct contact with the plasma. The present FW design include the use of Eurofer coolant channels, able to withstand steady state heat fluxes up to ≈1-1.5 MW/m². A design process is developed to systematically evaluate the impact of design changes, or new physics input, on the FW protection strategy and integration issues. The first phase includes the collection of a list, as complete as possible, of all the physics nominal and off normal events originating from transport simulations (e.g. using the ASTRA/Simulink suite [1] or experimental multi-machine database of DEMO relevant perturbations. The resulting plasma internal parameter variations (e.g. plasma current, βpol and li) are then used as input to run electromagnetic simulations (using the CARMA0NL 3D code [2], and the 2D CREATE-NL [3] and MAXFEA [4] codes) to individuate the poloidal position of plasma-FW impact. The resulting flux maps are used to evaluate the heat flux (HF) on the limiters and the FW surface, due both to the charged particles (using 3D field-line tracing codes PFCflux [5] and SMARDDA [6]) and to the radiation loads (employing the CHERAB code [7]) from the core and SOL sources, determined respectively with ASTRA and SOLPS[8]. This phase is iterated until the design and the required number of limiters fulfill the function of protection of the FW. All the resulting HF are used to evaluate the thermo-hydraulic behavior of the FW and the limiters, using both simplified 1D RACLETTE [9], and 3D FEM codes, to estimate lifespan of these structures, also including innovative materials. Preliminary estimation of the possible tungsten vapor shielding effects during disruptions are also evaluated, using the TOKES code, and experiments are being proposed to validate the model. Finally, initial calculations on the Runaway Electrons (REs) are considered, using the FLUKA [10] code, to evaluate the electrons energy deposition profile for different PFC, coupled with FEM for the thermo-hydraulic analysis. This FW protection strategy will be assessed in 2020 in a gate review by a panel of external experts.

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