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Technologies for Plasma-Facing Wall Protection in EU DEMO

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The plasma-facing wall of the main chamber in DEMO will be unlike any current tokamak. The blanket first wall (FW) is to be actively-cooled reduced-activation steel (Eurofer) under a thin plasma-facing tungsten armour. To help control cost, modest misalignment of this wall must be tolerable at least with respect to a relatively quiescent divertor plasma flat-top equilibrium. However, with present knowledge it is not possible to exclude normal or off-normal plasma transient phases, and during some of these transients the blanket FW will not be sufficient in terms of the engineering heat flux limit of the plasma-facing technology. Particularly challenging are transients during which the plasma is limited, for example during plasma start-up or vertical displacement events (VDEs). In EU-DEMO we propose discrete limiters, with large gaps between them, which serve to protect the blanket FW from these plasma transients. In this work, two proposed protection components are presented: an equatorial port limiter which receives power during the start-up phase, and an upper wall "dump"panel which is intended to sacrificially protect the blanket system in the event of an upward-VDE.

The plasma-facing component (PFC) engineering designs, although an evolution of the ITER W/CuCrZr divertor monoblock technology, are tailored according to their respective transient loading requirements. For the start-up limiter designed for 30-60 second ramp-up phase, we show by thermal-structural finite element analyses that the heat sink properties of tungsten can be exploited to improve the component heat flux limit. This equatorial limiter features a water-cooled Eurofer plug behind the PFCs for neutron shielding and connection to the stainless steel port plug. The manufacturing and assembly proposal for the limiter is described and the effect of the limiter on reactor tritium breeding ratio is shown. In the case of the upper dump PFC, the huge amount of energy deposited during the VDE could lead to extensive melt damage of the tungsten armour. However, the PFC described here has features to deliberately channel the heat flux to the sides and rear of the coolant pipe, and we show by transient engineering analyses that this technique can markedly increase the heat load at which structural failure of the coolant pipe occurs, reducing the likelihood of a loss of coolant accident.

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