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Preliminary investigation on W foams as protection strategy for advanced FW PFCs

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Among the eight core missions towards the realization of nuclear fusion, a future reactor must ensure efficient and safe power exhaust through the divertor and First Wall (FW). The greatest challenges arise from the occurrence of plasma transients. A simulation of a DEMO-like FW Plasma Facing Component (PFC) was carried out assuming Vertical Displacement Event (VDE) and ramp-up limiter conditions. The results highlighted an extreme heat flux impinging the thin tungsten (W) armour produced by Plasma Vapour Deposition (PVD). As a consequence, localized surface vaporization, melting and re-solidification may occur. Vapour shielding and surface melting play an important role in terms of heat flux reduction, but the failure of the component may occur owing to the high thermal stress and cracking developed, which can compromise safety and prompt return to normal operation. A possible protection strategy is to provide the plasma a sacrificial structure able to promote the flux reduction while preventing the substrate from the failure. W-based refractory foams are a viable solution owing to their peculiar mechanical and thermal management capabilities, that can be tailored by choosing an optimum value of relative density and porosity. However, a proper FE modelling is challenging due to their complexity and anisotropy. Nevertheless, a recent study confirmed that the mechanical behaviour of an existing open cell foam is achievable through the calibration of an equivalent FE model. The present investigation aims to verify the feasibility of W based open cell foams as a possible sacrificial material for FW protection strategy. Thermo-mechanical analyses have been carried on the equivalent FE model of foam exposed to heat loads expected in VDE and limiter conditions. As a consequence, optimal values of relative density and porosity of foam are proposed to achieve the required protection capabilities.

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