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MODELING OF TUNGSTEN ARMOUR DAMAGE UNDER ITER-LIKE TRANSIENT HEAT LOADS

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ABSTRACT: Tungsten (W) is now foreseen as most promising armour material for plasma facing components (PFCs) in the ITER divertor, baffle and the dome. During the expected transients (disruptions, ELMs (Edge Localized Modes, and VDE (Vertical Displacement Events)) in ITER the armour will be exposed to hot plasma streams. The expected fluxes on the ITER divertor during transients are: Type I ELM energy fluxes of 0.5–6 MJ/m^2 during τ=0.3-0.6 ms, and thermal quench energy fluxes (disruptions) of 2-25 MJ/m^2, τ=1-5 ms [1]. The heat fluxes are expected to be so high that they can cause severe erosion of PFCs thereby limiting their lifetime. During intense transients the melting, melt motion, melt splashing and surface evaporation are seen as the main mechanisms of metallic armour erosion.

The plasma loads of ITER transients are not directly achieved in the existing tokamaks. Therefore other plasma devices such as powerful plasma guns (in particular the quasi-stationary plasma accelerators (QSPA)) are applied for armour testing. However, parameters of the plasma guns facilities do not cover diapason of ITER transients. To obtain adequate information on the expected damage to ITER PFCs under the transient energy loads the experiments must be supported by numerical simulations using the codes validated against experimental target erosion measured on the powerful plasma guns facilities and tokamaks. For modeling of PFCs damage caused by different types of heat loads the fluid dynamic code MEMOS in 2D and 3D versions was developed. Interaction of the plasma with metalic armour is calculated with taking into account formation of the plasma shield in front of the turget formed from evaporated material. A 3D thermal transport solver to the Stefan problem and a 2D melt motion model based on the “shallow water” approximation with the surface tension and the viscosity of molten metal are implemented into the code. Plasma pressure, tangential pressure of inclined impact, and the **J**x**B** force caused by the current crossing the target surface in a strong magnetic field considered as the driving forces are also adjusted to the 2D algorithm as well as the real macrobrush peculiarities of ITER-like armours. The code was successfully validated against short pulse target erosion experiments on plasma gun facilities.

In this work MEMOS modeling of the TEXTOR experiments [2] on W targets damage under long time plasma heat loads up to several seconds with heat fluxes up to 40 MW/m^2 in a strong magnetic field are performed. Good agreement between numerical simulations and experimental results on tungsten target erosion is demonstrated. The code MEMOS is also apply to investigate the consequences for W material damage as a result of plasma heat loads on vertical faces of misaligned leading edges between divertor cassettes due to downwards VDE expected on ITER. Melt layer damage is estimated for single plasma loads in the range 100 → 300 MJ/m^2, with pulse durations between 0.5 → 3 ms, and edge misalignments up to several mm. The Tecplot 360 package is used for the result visualization.

References

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