PRELIMINARY RESULTS OF THE EXPERIMENTAL STUDY OF PFCS EXPOSURE TO ELMS-LIKE TRANSIENT LOADS FOLLOWED BY HIGH HEAT FLUX THERMAL FATIGUE

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The damage mechanism of the plasma facing components (PFCs) under transient events, such as type I edge localized modes (ELMs) and disruptions, is expected to play a major role in the lifetime of PFCs themselves and the amount of erosion products deposited in the form of dust, particles and films. Moreover, the PFCs must withstand high heat flux (HHF) thermal fatigue due to thermal loads during ITER normal operations and slow transient events. To obtain data for the empirical evaluation of the PFC lifetime, dedicated experiments are in progress in the in frame of an EU/RF collaboration. In this work a presentation of the results of the first campaign of exposure to ELMs-like load and high heat flux (HHF) thermal fatigue is given.

The erosion behaviour of carbon fibre composite (CFC) and the tungsten melt layer modeling, droplet ejection and microstructural changes were investigated during earlier studies. The objective of this study was to expose EU-manufactured CFC and W-armoured actively cooled mock ups to both ELM-like heat loads and high heat flux cyclic loads in a sequence resembling that expected during ITER operations. This is achieved by alternating the exposure of the mock ups to ELM-like loads at the QSPA facility of the TRINITI Institute (RF) with the high heat flux (HHF) cycling at the Efremov TSEFEY electron beam facility (RF). In particular, the full testing sequence includes a total of two ELMs campaign exposure alternated with two HHF thermal fatigue testing.

The PFCs monoblock samples, which have similar specifications to those proposed for the ITER divertor, were manufactured by Ansaldo Ricerche SpA (Italy). The CFC samples and tungsten monoblock samples were repeatedly (500 pulses) exposed to hydrogen plasma stream with an absorbed energy density of 0.5 MJ/m^2 (at the axis of the plasma stream) and plasma pulse duration of 0.5 ms with a plasma incidence angle of 60 degrees.

Under ELM loads the CFC erosion was mainly due to PAN-fiber damage. The measured PAN-fiber erosion rate was in the range 0.01 μm/pulse to 0.15 μm/pulse. These data confirm earlier results [2] and give also indication for energy densities lower than 0.5 MJ/m^2. Concerning W, the main damage mechanism resulted to be edge melting and smoothing. After the plasma treatment the surfaces of all tungsten monoblock were covered with cracks and the surface morphology appeared porous.

Afterward, the CFC and W samples were high heat flux tested under 2000 cycles at 10 MW/m^2 and 300 cycles at 20 MW/m^2 (17 MW/m2 on the CFC due to surface temperature limitations). The cycle duration was 30 seconds (15 seconds power on, 15 seconds dwell time); the water cooling parameters were: 40°C inlet temperature, 10 m/s, 3.5 MPa inlet pressure (twisted tapes with a twist ratio of 2 were installed before tests). After the first thermal fatigue testing at 10 and 17 MW/m^2 on CFC mock ups no further damage was observed. Slight difference in the surface temperature was detected but this difference was stable and did not change before and after cycling. Conversely, the W mock ups showed, after testing at 20 MW/m^2, deep cracks parallel to the cooling channels and slight additional surface melting but with no influence on the mockup reliability. As a preliminary conclusion, one can say that, notwithstanding the structural change produced in the armour, the mockups survived to the first HHF testing campaign without degradation of their power handling capability.