Contribution ID: **67** Type: **Oral**

Numerical Simulation of the Initial Phase of Unipolar Arcing in Fusion Relevant Conditions

Wednesday 18 September 2019 11:15 (30 minutes)

NUMERICAL SIMULATION OF THE INITIAL PHASE OF UNIPOLAR ARCING IN FUSION RELEVANT CONDITIONS

The results of experimental works on unipolar arcs, e.g. [1], suggest that there are two phases of unipolar arcing. An intense external energy flux, i.e., the laser pulse (or ELM), causes significant heating of a wide region of the surface of an isolated plate, current transfer is initiated and the potential difference between the plasma and the plate is reduced. The laser beam is then switched off, however the potential difference remains the same and small bright spots are seen moving away from the impact site; the second phase.

A model for the initial phase of unipolar arcing has been developed on the basis of the detailed numerical model of plasma-cathode interaction in vacuum arcs [2]. The model takes into account an external heating which triggers the arc spot, the vaporization of the atoms from the heated surface, the ions and electrons produced by ionization of the vapor, the electron emission from the metal surface, and relevant hydrodynamic phenomena, including convection and surface deformation. Current transfer outside the arc attachment is taken into account and the potential difference between the plasma and the metal surface (the plate) is evaluated from the condition that the net current transferred to the plate is zero at each moment.

The developed model is used for simulation of the interaction of an external energy load (laser beam) with and current transfer to a tungsten plate immersed in a helium background plasma in conditions similar to those of the experiment [1]. Simulations were performed for different dimensions of the plate and laser beam radii. The results revealed the formation of a crater, but no jet formation or droplet detachment. If the plate is large (R = 100mm), the peak temperature attained is 5200K, and the plate potential remains below the plasma potential. If the plate is small (R = 10mm), a peak temperature of 7500K is reached, the potential of the plate surpasses the plasma potential, circulation of the melt at the pool periphery occurs, and the erosion (which is mainly due to the vaporization of the metal atoms in the spot) reaches the value of 37 micrograms.

Acknowledgments The work was supported by FCT - Fundação para a Ciência e a Tecnologia of Portugal (the project Pest-OE/UID/FIS/50010/2019). The work at Universidade da Madeira was supported by the project PlasMa - M1420-01-0145-FEDER-000016, co-financed by the Operational Program of the Autonomous Region of Madeira 2014-2020.

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Session Classification: Experiment and Diagnostics - Applications

Track Classification: Modeling and Simulations