Investigation of fretting wear damage in the cooling channel of Europe's Demonstration Fusion Reactor DEMO: effect of normal force fluctuation

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Abstract

Nuclear fusion is predicted to be a promising renewable clean energy source as it would provide a large-scale sustainable and predictable energy which is indispensable for reducing carbon footprint. DEMO (Europe's Demonstration Fusion Reactor DEMO) is the most ambitious nuclear fusion project aiming at assessing the applicability and the economic viability of thermonuclear fusion. The divertor targets in DEMO, sustaining a heat flux up to 20 MW/m^2, are made of pure tungsten armouring actively water-cooled CuCrZr pipes. The cooling capacity of the divertor targets can be improved by adding a Cu-OFHC swirl tape in the cooling channel. Under DEMO cooling conditions, the insertion of the swirl tapes in the pipes triggers fretting wear damage due to flow-induced vibrations of the swirl tape within the hosting pipe which may reduce the lifetime of the divertor components and their thermal efficiency. Hence, the objective of this study is to compare the fretting wear response of CuCrZr/Cu-OFHC contact under constant and fluctuating normal forces involving contact detachment. Surface damage evolution is followed by using different analysis techniques as 3D profilometry and SEM-EDS. Wear kinetics is quantified using energy wear rate (α) which is the ratio of the wear volume (V) and the accumulated dissipated friction energy ($\sum$Ed). Results show that under constant normal force the main damage is a mixed abrasive-adhesive wear mechanism is detected leading to a relatively high coefficient of friction, with an average value of 1.5. The evolution of friction coefficient as a function of fretting cycles reveal increase followed by decrease of friction coefficient suggesting a continuous process of formation and destruction of adhesive junctions. These results will be compared to tests under fluctuating normal force to assess its impact on wear response.

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