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Characterization of Oxide Layer Developed during Tribo-Interaction of Zircaloys

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Abstract : Zirconium alloys are used as core components of nuclear reactors due to their high wear resistance, good corrosion properties, and good mechanical stability at high temperatures. The present work simulates the contact between the calandria tube and the liquid injection shutdown system (LISS) nozzle. The Calandria tube is the outer covering of the pressure tube. Water flows inside the pressure tube through fuel claddings which produces vibration in the pressure tube along with vibration in the calandria tube. Fretting wear takes place at the point of contact between the calandria tube and the LISS nozzle. Fretting tests were performed under different conditions, such as; varying fretting duration (i.e., 1 to 4 hours), varying frequency (i.e., 5 to 6.5 Hz), and varying amplitude (100 to 400 µm). The formation of the oxide layer was observed during the fretting wear test; as a result, the worn product. The worn surfaces were analyzed with scanning electron microscopy (SEM) to analyze the wear mechanism involved in the fretting test, and Energy dispersive x-ray spectroscopy (EDS) and Raman spectroscopy were used to confirm the presence of an oxide layer on the worn surface. The oxide layer becomes more uniform with fretting duration in case of water submerged condition as compared to dry contact condition. The oxide layer is deeply removed at high amplitude due to the change of wear mechanism from adhesion to abrasion, as confirmed by the presence of micro ploughing and micro cutting. Low amplitude fretting favors the formation of the tribo-oxide layer.

Keywords : tribo-oxide layer, wear, mechanically mixed layer, zircaloy
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