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ITR/P5-22: Experimental Assessment of Materials Exposed to Coolant Water under ITER Relevant Operational Conditions

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The ITER Vacuum Vessel materials that are exposed to the coolant water consist of mechanically strained structural materials, joints and bolts along with non-loaded parts. The complex geometries result in high amount of crevices. Therefore, it is important to map the formation of corrosion products (impurities) susceptibility to stress corrosion cracking and surface effects such as pitting to determine the engineering margins and the operational lifetime. Taking into account highlighted corrosion issues along with results from initial activities and presently ongoing work it was possible to setup exposure experiments simulating ITER relevant operational conditions comprising exposure, drainage and drying cycles. The drying step was performed with hot nitrogen and superheated steam in two separate test systems. Studsvik performed the presented work organized by F4E via a task agreement with ITER IO. The exposure was repeated during 38 cycles to allow for accumulation of impurities. The water chemistry, using degassed ultrapure water, was maintained at 1 ppm hydrogen peroxide and 10 ppb chloride. Material specimens were manufactured from the steel grades 316L(N)-IG, 304B4, 304B6, 304B7, 430, 304 and XM-19. The susceptibility to crevice corrosion was evaluated using crevice corrosion specimens. The susceptibility to stress corrosion cracking was evaluated using the Crevice Bent Beam (CBB) method with graphite wool as crevice former. A purpose-built conductivity cell to simulate capillary condensation in crevices was employed to register the progress of drying. The results show that impurities are concentrated in the creviced area after each cycle. The ferritic stainless steel Type 430 showed the lowest corrosion resistance, followed by the borated stainless steels 304BX. Welded 316L(N)-IG also showed lower resistance. The 316L(N)-IG and reference material type 304 were the most resistant. Microscopy of the loaded CBB specimens revealed short surface cracks for both XM-19 and 316L(N)-IG. Short straight cracks with a depth less than 6 μm evolved in a crackled surface zone and the cracks stopped when reaching the unaffected base material. In summary, during the test conditions used, the crevice corrosion attacks were relatively small in both drying environments. The CBB method on XM-19 and 316L(N)-IG only exhibited short surface cracks in both drying environments

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Collaboration (if applicable, e.g., International Tokamak Physics Activities)

Assessment of Vacuum Vessel Materials Properties

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