**20th European Mechanics of Materials Conference - EMMC20**
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

# Corrosion fatigue of 304L stainless steel in simulated LWR water environment

**Mustafa Subasic[1], Carl F. O. Dahlberg[2], Pål Efsing[3]**

[1] KTH Royal Institute of Technology, Sweden. msubasic@kth.se
[2] KTH Royal Institute of Technology, Sweden. carldahl@kth.se
[3] Ringhals AB, Sweden. pal.efsing@vattenfall.com

*Paper ID: 497*
*Symposium S9: Fatigue evaluation: modelling and characterisation at different length scales*

## Abstract

Corrosion fatigue is a critical degradation mechanism for austenitic stainless steel components in light water reactor (LWR) nuclear power plants, where the combined action of cyclic loading and high-temperature water environments significantly accelerates fatigue crack initiation. This work aims to improve life prediction methodologies for corrosion fatigue in reactor piping systems by integrating experimental observations with physics-based modeling. Corrosion fatigue experiments were conducted on 304L stainless steel under simulated pressurized water reactor (PWR) and boiling water reactor (BWR) conditions using hollow specimens. Tests were performed under cyclic loading in pressurized water at 300 °C and 12 MPa. For reference, S–N curves obtained from standard solid specimens tested in air were compared with corrosion fatigue results from hollow specimens exposed to reactor water environments. Crack initiation and early crack growth were monitored in situ using the direct current potential drop (DCPD) technique, enabling the separation of initiation and propagation phases. Post-test fracture surface and microstructural analyses were carried out using scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD) to identify crack initiation sites, environmentally assisted damage features and anodic dissolution mechanisms. Based on the experimental findings, a continuum damage mechanics (CDM) corrosion model was proposed to describe corrosion-assisted fatigue crack initiation. The model incorporates electrochemical kinetics through Faraday's law and accounts for mechanically driven oxide film rupture and corrosion activation. The formulation is implemented within a crystal plasticity framework, where Voronoi tessellations represent the polycrystalline grain structure. Numerical simulations of a representative section of the hollow specimen are performed to estimate crack initiation, providing a mechanistic link between microstructure, environment and fatigue damage accumulation.

**Keywords:**

Corrosion fatigue Mechanical-electrochemical degradation Stainless steel Crystal plasticity