PROCEEDINGS PAPER

ESTIMATION OF THE FATIGUE LIFE IN LCF REGIME OF 316L NOTCHED SPECIMENS USING THE THEORY OF CRITICAL DISTANCES

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Proceedings of the ASME 2025 Pressure Vessels & Piping Conference (PVP2025)
July 20-25, 2025, Montreal, Quebec, Canada

Paper No.: **PVP2025-155730**; 7 pages
DOI: 10.1115/PVP2025-155730
Published Online: October, 2025 (*expected*)
URL: https://asmedigitalcollection.asme.org/

Abstract:

This work evaluates the fatigue life of notched specimens in elastic-plastic conditions using the Theory of Critical Distances (TCD). Notches, often present in structural components, can significantly influence the fatigue behavior of materials. The localized stress concentration at the notch tip can accelerate crack initiation and propagation, leading to premature failure. It is then necessary to study the fatigue phenomenon in the presence of notches in order to better understand how structural components may behave under real conditions in a nuclear power plant. In this research, austenitic stainless steel 316L was analyzed, which is a common material in pressurized water reactor (PWR) plants. Cylindrical specimens containing U-notches with distinct radii (0.5 mm and 2.0 mm) were made to represent typical geometric features found in structures. The specimens were subjected to control load fatigue tests with stress ratio (R) equal to -1 in the low-cycle fatigue (LCF) regime.

In order to analyze the fatigue behavior of the notched specimens, we combined the Manson–Coffin approach with the TCD. The Manson–Coffin approach relates the fatigue life to the plastic strain range, while the TCD introduces the concept of a critical distance (L) to determine failure conditions. The critical distance is a material-specific parameter, which may be considered to be independent of the notch geometry and the cycles to failure. Moreover, the TCD comprises several failure criteria, among which the Point Method (PM) provide a good balance between accuracy and simplicity. To assess the precision and reliability of the proposed methodology, the predictions of the TCD are compared to the experimental results obtained from the notched specimens. In this regard, elastic-plastic finite element analyses (FEA) were performed to define the corresponding stress-strain fields ahead of the different notch tips.

Our findings demonstrate that the TCD, in conjunction with the Manson–Coffin approach and FEA, can provide accurate predictions of the fatigue life for notched specimens made of stainless steel 316L. The predicted lifetimes were in reasonable agreement with the experimental data, suggesting that the TCD is a valuable tool for assessing the fatigue performance of nuclear components.

Keywords: Theory of Critical Distances, notch, cyclic plasticity, low-cycle fatigue

This project has received funding from the Euratom Research & Training programme 2019-2020 under grant agreement N^{o} 945300