PROCEEDINGS PAPER

EVALUATION OF THE DIFFERENCES ON FATIGUE LIFE BETWEEN HOLLOW AND SOLID SPECIMENS ON A 316L STAINLESS STEEL IN THE FRAME OF INCEFA-SCALE PROJECT

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Abstract:

Two main specimen geometries are historically used to perform fatigue testing in Light Water Reactor (LWR) environments: solid and hollow specimens. With a solid specimen design, an autoclave contains the environment around the specimen but the strain has generally to be controlled between the specimen's shoulders while with a hollow specimen, the strain is controlled directly on the gage length but the coolant environment passes only through the bore of the specimen. It is not yet clearly established to which extend the fatigue lives obtained by both geometries differ. This can be a source of conservatism in environmental assisted fatigue analyses since it could generate a potential important scatter of fatigue curves using both designs. In addition, the NUREG/CR-6909 is using the reference ANL curve, which is mostly based on hollow specimens. In the frame of EU INCEFA-SCALE project, fatigue tests on hollow specimens were conducted in the aim to evaluate the influence of specimen geometry on the fatigue life of a 316L stainless steel.
INCEFA-SCALE is a five-year project supported by the European Commission HORIZON2020 program. It aims to address the gap between the good Operational Experience of Nuclear Pressurized Water Reactor (PWR) plant and the difficulty in obtaining an acceptable environmental assisted fatigue assessment result. A reason for this discrepancy is that the assessment procedures described in codes and standards are based on laboratory test results that simplify and idealize the real conditions that plant components are subjected to. The study on the effect of specimen geometry was identified as a bridge to fulfill that gap.
This paper will give an overview of the test program carried out to date. Three test matrices were designed to evaluate the following hypotheses. The first one is that for hollow specimens tested in LWR environments, the radial and hoop stresses generated by internal pressure contribute to the increase in the Von Mises strain and promote crack initiation. The second hypothesis is that there are differences on the crack propagation stage between solid and hollow specimens. The wall thickness of hollow specimens is generally lower than the diameter of solid specimen that leads to a shorter crack propagation stage. Finally, the last hypothesis is that the hoop stresses that are dependent of the hollow specimen geometry and the internal pressure could explain the differences on the fatigue lives between several hollow specimen geometries. Experimental results are supported by Finite Element Analysis and fractographic observations to assist the analyses. Results obtained so far are in good agreement with the expected effect of internal pressure/hoop stresses.
Keywords: hollow and solid specimens, environmentally assisted fatigue, PWR

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