Effects of single overload/underload on fatigue life of 350WT steel using FE-simulation of PICC

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In present work, fatigue life of center cracked 350WT steel specimen subjected to single overload/underload(OV/UN) predicted by simulating plasticity induced crack closure(PICC) method. Finite element method is used for crack growth simulation and results are compared with Rushton and Taheri's experiments.

Many structural materials are subjected to variable-amplitude fatigue loading rather than constant amplitude fatigue loading. Sudden changes in the cyclic loading patterns during fatigue deformation could result in a considerable acceleration or retardation in the crack growth rate. There have been numerous efforts to account for the crack growth retardation phenomena. Among them, the plasticity-induced crack closure concept has been supported by many investigations. In present study, effects of single OV and single OV following by UN, on crack growth retardation of center-cracked specimen of 350WT steel is studied. A two-dimensional finite element model is built using four node plane stress elements, with one quarter of the specimen modeled because of symmetry. Mesh refinement procedure used around crack tip region to approach predefined convergence. Fatigue crack growth was modeled by repeatedly applying two loading-unloading cycles then advancing crack front. During each increment of loading, the nodal displacement of first node before crack tip was monitored. The purpose of the analysis is the computation of crack opening stress Sop and the corresponding stress intensity factor Kop. Calculating effective stress intensity factor and using base metal Paris parameters express the number of fatigue cycles which would cause one element length of crack growth. Using the same procedure at each step would result in calculating total fatigue life and determining effect of single OV/UN on crack growth retardation/ acceleration. The results are in good agreement with Rushton and Taheri's laboratory experiments on 350WT steel.

Single OV abruptly accelerates the crack growth immediately after overloading; however, crack retardation is the dominant effect following this acceleration period. Higher overload ratios (OVR) results in higher crack growth retardation which leads to increase in fatigue life of the specimen. UN would decrease the effect of OV but couldn't totally eliminate it. PICC is a reliable technique for fatigue life prediction under OV/UN conditions when the following criteria are satisfied.

-PICC should be the dominant mechanism of crack closure.

-Optimum mesh refinement is used.

-Crack advance scheme and exact crack growth data are available.