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Experimental quantification of the effect of crack closure on residual fatigue strength

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ABSTRACT

Based on experimental tests, the influence of loading history on residual fatigue strength and crack propagation is examined. The experimental tests consist of ultrasonic fatigue (USF) tests [1] of QT steel specimens with artificial defects. Crack growth is monitored intermittently with a scanning electron microscope (SEM) from the specimen surface.

Prior to testing, several micro-scale artificial defects are machined to each of the USF test specimens. The specimens are then pre-cracked with the USF testing machine at a load level considerably above the expected fatigue limit at a stress ratio of R=-1 or R=0. The fatigue test load amplitude (R=-1) is then selected based on the largest observed pre-crack size and applied stress ratio. The goal in selecting the load level is to obtain both runout observations with arrested crack growth as well as failure observations. The obtained results are compared against Murakami's $\sqrt{area}$ -model [2], and Murakami's $\sqrt{area}$ -based crack growth model [3] to assess the influence of loading history. Focus is put on analysing the crack closure mechanisms, mainly the plasticity induced crack closure. The effects of microstructure and residual stresses are also discussed.

The presented results give some insight into the effect of loading history on fatigue limit for surface defects, such as soft non-metallic inclusions or small surface dents. Even though the crack growth is not monitored in-situ, the high number of test cycles per test (1e9 cycles) and intermittent SEM inspections can give reliable results, especially when fatigue limit or non-propagating cracks are of interest.

Keywords: crack arrest, ultrasonic fatigue testing, loading history, crack closure

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