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Comparison of crack growth rate of 316L steel in axial/torsional in-phase and out-of-phase cyclic loading mode

Ladislav Poczklán[a,b], Tomáš Kruml[a]

[a] *Institute of Physics of Materials, The Czech Academy of Sciences, Žižkova 22, 616 62 Brno, Czech Republic*

[b] *Central European Institute of Technology, Brno University of Technology, Purkyňova 123, 621 00 Brno, Czech Republic*

[a] *poczklan@ipm.cz*

The aim of this study was to compare fatigue crack growth rate of two multiaxial (axial/torsional) cyclic loading modes: in-phase and 90° out-of-phase. All tests were done at room temperature with constant strain rate. Tests were performed on hollow cylindrical specimens manufactured from austenitic stainless steel 316L. Specimen surface was mechanically and electrolytically polished and an artificial crack starter made by spark erosion was fabricated in the middle of the gauge length. The crack path and the dependences of the crack length on the number of cycles were determined from photos taken by light microscope Navitar. Results from fatigue tests with the same ratio between axial and torsional amplitude and with different equivalent amplitude (calculated by von Mises equation) indicate that in-phase mode led to higher crack growth rate in case of small equivalent amplitudes. On the contrary in case of higher equivalent amplitudes, the growth of fatigue cracks was faster in out-of-phase mode. Series of tests with the same equivalent amplitude and different ratio between axial and torsional amplitude were also carried out. It was found out that increasing torsional amplitude led to lower crack growth rate. Such a behavior is probably caused by a phase transformation from austenite to deformation induced α´ martensite. Results of magnetic measurements indicate that the phase transformation is more intense in case of tests with prevailing torsional amplitude.

Keywords: fatigue crack growth rate, deformation induced martensite, austenitic stainless steel 316L, multiaxial loading