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An approach to lifetime prediction for a wrought Ni-base alloy under thermo-mechanical fatigue with various phase angles between temperature and mechanical strain

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Abstract

The damage and lifetime behaviour of Ni-base alloy NiCr22Co12Mo9 (comparable to Inconel Alloy 617) under thermo-mechanical fatigue (TMF) loading with varying phase angles between strain and temperature and optional dwell times at the maximum temperature was studied. Based on the results, a new lifetime prediction approach is proposed.

Strain controlled TMF tests with a temperature range of 100 – 850 °C were conducted in air. Phase angles between temperature and mechanical strain were 0° (in-phase, IP), 180° (out-of-phase, OP), +90° (clockwise diamond, CD) and -90° (counter clockwise diamond, CCD). In some tests, optional dwell times of 2, 5 or 30 minutes were introduced at 850 °C. The TMF-lifetime depends significantly on the phase angle and increases in the sequence IP < CCD < OP < CD. While for IP and CCD loading intergranular damage dominates, the damage in OP and CD tests is mainly transgranular. For all phase angles, wedge-type cracks at grain boundary triple points could be found. The orientation of these wedge type cracks is perpendicular to the loading axis for IP and CCD loading and parallel to the loading axis for OP and CD loading. This behaviour could be explained by phase angle dependent grain boundary sliding. Introducing dwell times leads to lower stress amplitudes and higher plastic strain amplitudes compared to tests without dwells. For OP and CD loading the two effects apparently compensate each other and the overall effect of dwell times on the lifetime is