Microanalysis of Fatigue Cracks in IN706 and IN718

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Fatigue crack propagation samples of IN706 and IN718 tested in air at 593°C are being studied to understand the mechanism of crack growth under hold-time conditions. Microanalysis of the oxidized fracture surfaces and of the metal ahead of the crack tip in these samples was done to help characterize this phenomenon. For IN706, transmission electron microscopy (TEM) of the layers in the fatigue cracks showed that the one closest to the matrix was a mixture of Cr_2FeO_4 (spinel) plus a second phase. A $NiFe_2O_4$ layer was present on top if the two-phase zone, and there was a (Ni, Fe, Cr) oxide as the outermost layer. High resolution scanning electron microscopy (SEM) on a metallographic sample through the fracture surface showed that discontinuous regions of Ni-rich austenite were present between in the inner two-phase layer and the middle Ni_2FeO_4 layer. Analysis of the crack propagation rate data for this sample indicated that there may be a damage zone ahead of the growing intergranular crack. Examination of the microstructure ahead of the crack tip using transmission electron microscopy showed no features that could be correlated with a damage mechanism, such as oxidation of grain boundary phases or of the adjacent metal, or cavitation on the grain boundaries. For IN718, Auger profiles on the fracture surface at various positions showed Ni and Fe as the major constituents in the outermost oxide layer, with an increase in Nb and Cr in the layer detected beneath it. SEM on a metallographic sample through the fracture surface detected the presence of discontinuous Ni-rich austenite regions between the inner and outer layers, as was seen for IN706. The composition of the layers on the fracture surface was markedly different from what was detected on the sides of the compact tension sample, for which the outermost layer was a Cr-rich oxide, probably Cr_2O_3. This difference may represent a response to the presence of stress during oxidation in the crack, or to the presence of a different environment in the crack relative to the surface.

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