CREEP AND OXIDATION EFFECTS ON HIGH TEMPERATURE FATIGUE CRACK GROWTH OF A SINGLE CRYSTAL NICKEL BASE SUPERALLOY

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Studies of high temperature fatigue crack growth (FCG) behaviour of <001> axially oriented single edge notch tension specimens (R = 0.05) in CMSX-2 single crystal alloy were performed within linear elastic fracture mechanics frame. A marked dependence of crack growth direction in the (001) plane was observed, as shown in Fig. 1.

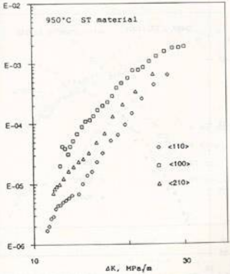

Fig. 1 - Influence of secondary orientation on FCG rates.

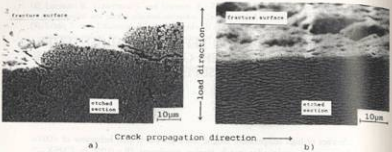

Fig. 2 - Crack path of <100> oriented specimens at 950°C: a) ST material and b) TMT material.

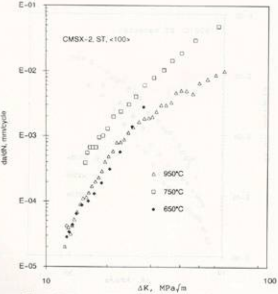

Fig. 3 - Temperature effect on 4 Hz FCG rates of ST material.

The influence of γ' morphology on FCG at 750 and 950°C was determined comparing standard heat treatment material (ST) fatigue crack growth properties with thermomechanically treated material (TMT) that had been produced to simulate the microstructure in a gas turbine blade after short high temperature service. Higher FCG rates at 950°C for "serviced" material were related to fracture surface morphology, Fig. 2.

The increasing of the test temperature in air environment from 750 to 950°C lowered the FCG rates, as illustrated in Fig. 3.

The time dependent creep and oxidation effects on FCG mechanisms were explored at 950°C by performing continuous cycle (triangular wave form of loading) and hold time tests, in air and vacuum, as shown in Fig. 4. Tests at low ΔK in air had much slower FCG rates than tests in vacuum, especially when hold time was applied at peak load. Oxide-induced closure at crack tip can explain the drastic environmental effect on FCG rates at low ΔK values while creep mechanisms can explain the acceleration at high ΔK when hold time is added in vacuum.

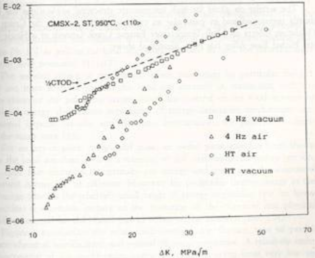

Fig. 4 - Hold time (HT) and environment effects on FCG rates in ST material (<110> secondary orientation).

REFERENCES

Lupinc V., Onofrio G. and Vimercati G., *Superalloys 1992*, ed. S.D. Antolovich et al., TMS Warrendale PA, 1992.
Ai S.H., Lupinc V. and Onofrio G., «Scripta Metall. et Materialia», 29, 1385 (1993).

Few words about CNR-ITM

At ITM, Istituto per la tecnologia dei materiali metallici non tradizionali of the National Research Council (technical personnel ca. 30) research of new and advanced metallic materials is performed studying material production processes and correlation between microstructure and properties.

The main research activity of the Institute is focused on:
— Superconducting materials
— Alloys for high temperature structural applications
— Alloys for aggressive environment applications
— Shape memory alloys

The activity on alloys for high temperature structural applications has been shortly mentioned and in particular an example of this activity, the Creep and Oxidation Effects on High Temperature Fatigue Crack Growth of a Single Crystal Nickel Base Alloy has been illustrated above.