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Cyclic plastic deformation behaviour of a directionally solidified nickel base superalloy at 850°C: Damage micromechanisms

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Dislocation based deformation micromechanisms during low cycle fatigue deformation of nickel base superalloy CM 247 DS LC at 850°C was investigated by conducting fatigue tests employing constant strain amplitudes for strain ratio (R) values of 0, -1 and carrying out extensive SEM and TEM examinations. Cyclic life of the alloy reduces for all fatigue tests conducted employing R=0 in comparison with R=-1 owing to sustained mean stress developed during fatigue at R=0. TEM examinations confirmed that sustained mean stress developed during low strain amplitude fatigue test ($\Delta\varepsilon/2$=0.5%) using R = 0 condition prevented slip transfer from γ-channels to γ′-precipitates and resulted in the formation of dislocation substructures such as networks, nodes etc. and also promoted dislocation looping around γ′-precipitates. Lower fatigue life at R = 0 is mainly attributed to the development of these types of substructures, which promotes strain localization in both intra as well intergranular regions. Whereas, in specimen fatigue tested ($\Delta\varepsilon/2$=0.5%) using R = -1 condition, shearing of γ′-precipitates by APB coupled dislocation and formation of stacking faults were observed. The formation and nature of stacking faults were analysed using weak beam imaging technique. Stacking fault formed during fatigue tests using R=-1 condition matures to micro-twins when $\Delta\varepsilon/2$ value was increased to 0.8%. The mechanism of formation of these microtwins is discussed in detail. SEM based microstructural and fractographic examinations revealed that mean stress induced creep effect resulted in intergranular crack initiation and grain boundary cavitation during fatigue tests under R=0 condition and therefore verified the facts revealed in TEM studies.

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