Serrated flow in carbide strengthened cobalt base superalloy

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Wrought carbide strengthened cobalt-base superalloys have been extensively used as a sheet material for high temperature components in gas turbine engines due their high temperature strength and enhanced corrosion resistance. Therefore, understanding the deformation behaviour of these alloys over a wide range of temperatures and strain rates is essential. Curiously, in quasi-static regime, literature reports suggest inherent low stacking fault energy (SFE) and presence of significant fraction of stacking faults leading to a distinct mechanical behavior in carbide strengthened cobalt-base superalloys alloys as compared to the wrought Ni-base superalloys. Intriguingly, these alloys have shown dynamic strain aging (DSA) as a major deformation mechanism in quasi-static regime. However, there is an equivocal understanding in connection with the rate controlling solute and influence of substructure in the DSA regime. Thus, the present study aimed at addressing the origin of DSA in wrought carbide strengthened Co-base superalloy Co-22Cr-22Ni-14W-2Fe-0.1C.

To ascertain the DSA regime, tensile tests were carried out at a constant crosshead velocity in the strain rate range of 10^{-5} – 10^{-1} s^{-1} and in the temperature range of 200 –1000°C. Strain rate sensitivity was measured from the strain rate jump tests in the DSA regime to estimate the PLC regime. Transmission electron microscopic studies illustrated the pervasive presence of stacking faults, array of dislocation dipoles and multipoles on (111) planes. Further attempt was made to identify the solute segregation using atom probe tomography while analyzing the substructure using TEM. Besides, theoretical models were used to estimate the drift velocities of solute atoms across tested regime. Thus, by correlating the present results with existing DSA models, the complex mechanism responsible for DSA in cobalt-base superalloys is discussed.

Keywords: Cobalt-base superalloys, Dynamic strain aging, Dislocation dipoles, Stacking faults, Substructure.