ABSTRACT

Ratcheting deformation of materials which occurs under asymmetric cyclic loading, by now is a well-known phenomenon, as it usually deteriorates the fatigue life of critical engineering components and limits the predictive capability of the Coffin-Manson relation. The mechanistic aspects of this phenomenon concerned with the effect of test parameters like maximum stress, mean stress, stress amplitude, stress ratio and temperature on the accumulation of ratcheting strain have been dealt with by several investigators. This investigation primarily aims to examine the influence of material parameters like the effect of crystal structure, stacking fault energy, substructure etc. on the ratcheting strain accumulation in several polycrystalline single phase materials.

Four materials viz. AISI 304LN stainless steel, interstitial free steel, aluminum alloy and $\alpha-$brass have been selected for this investigation. Ratcheting behavior of these materials have been studied using cylindrical specimens at ambient temperature (298 K) under various combinations of mean stress (σ_m) and stress amplitude (σ_a). These primary experiments have been supplemented by characterization of their chemistry, microstructure, grain size, macrohardness, microhardness and tensile properties. Substructural variations due to ratcheting have been assessed using transmission electron microscopy (TEM). In addition, tensile properties of ratcheted specimens (subjected to 100 fatigue cycles) have been studied together with fractographic examination.

The highlights of this investigation are: (i) accumulation of ratcheting strain in the investigated materials is dependent on the respective crystal structures and stacking fault energy values, (ii) strain accumulation increases with increase in σ_m at constant σ_a. Similarly, it increases when σ_a increases at constant σ_m. Increase in strain accumulation is correlated with the dislocation substructure of the investigated materials, (iii) it is shown that ratcheting deformation increases tensile properties of the materials and austenitic stainless steel shows martensitic transformation during ratcheting deformation as evidenced by TEM and X-ray diffraction studies. Increase in strength values has been attributed to accumulation of plastic strain during ratcheting similar to that like in pre-strained materials.

Keywords: ratcheting; stacking fault energy; dislocation substructure; deformation induced martensite; post-ratcheting tensile properties.