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Effect of Grain Size and Stress Parameters on Ratcheting Behaviour of Two Different Single Phase FCC Metals

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Abstract : Ratcheting is one of the most important phenomena to be considered for design and safety assessment of structural components subjected to stress controlled asymmetric cyclic loading in the elasto-plastic domain. In the present study uniaxial ratcheting behavior of commercially pure annealed OFHC copper and aluminium with two different grain sizes has been investigated. Stress-controlled tests have been conducted at various combinations of stress amplitude and mean stress. These stresses were selected in such a way that the ratio of equivalent stress amplitude ($\sigma_a$eq) to ultimate tensile strength (σUTS) of the selected materials remains constant. It is found that irrespective of grain size the ratcheting fatigue lives decrease with the increase of both stress amplitude and mean stress following power relationships. However, the effect of stress amplitude on ratcheting lives is observed higher as compared to mean stress for both the FCC metals. It is also found that for both FCC metals ratcheting fatigue lives at a constant ratio of equivalent stress amplitude ($\sigma_a$eq) to ultimate tensile strength (σUTS) are more in case fine grain size. So far ratcheting strain rate is concerned, it decreases rapidly within first few cycles and then a steady state is reached. Finally, the ratcheting strain rate increases up to the complete failure of the specimens due to a very large increase of true stress for a substantial reduction in cross-sectional area. The steady state ratcheting strain rate increases with the increase in both stress amplitude and mean stress. Interestingly, a unique perfectly power relationship between steady state ratcheting strain rate and cycles to failure has been found irrespective of stress combination for both FCC metals. Similar to ratcheting strain rate, the strain energy density decreases rapidly within first few cycles followed by steady state and then increases up to a failure of the specimens irrespective of stress combinations for both FCC metals; but strain energy density at steady state decreases with increase in mean stress and increases with the increase of stress amplitude. From the fractography study, it is found that the void density increases with the increase of maximum stress, but the void size and void density are almost same for any combination of stress parameters considering constant maximum stress.

Keywords : ratcheting phenomena, grain size, stress parameter, ratcheting lives, ratcheting strain rate
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