PhD Thesis Colloquium

Name of the Student: Subrahmanya Prasad Narla
Title: Experimental and numerical studies on Mode-I ductile fracture behavior of Magnesium.
Date: 10-July-2017
Time: 11 AM to 12 AM
Venue: ME Lecture Hall

Abstract

In recent years, weight reduction of automobiles is being achieved by using light weight metals like magnesium (Mg) in the form of cast or wrought products. However, the structural application of Mg and its alloys is limited due to low ductility and fracture toughness at room temperature. Thus understanding how microstructure affects the above properties is vital to circumvent these barriers. To this end, Mode-I fracture experiments are conducted using notched compact tension specimens of rolled Mg AZ31 alloy. Fractography and EBSD analysis, show that tensile twins (TTs) play a dual role in imparting fracture resistance through significant dissipation in the background plastic zone and retardation of micro-void growth and coalescence. Also, the effect of notch acuity on fracture initiation toughness is studied by conducting fracture experiments using four point bend specimens with different notch root radii. The fracture surface shows combination of large number of small dimples and twin induced quasi-brittle features for acute notches whereas it is dominated by ductile fracture features for blunt notches. Twin volume fraction near the crack tip is found to increase with notch acuity or stress triaxiality. The mechanics of void growth and coalescence corresponding to various stress states in Mg single crystals is studied using plane strain finite element simulations. Two lattice orientations are analysed with c-axis along the thickness direction in one and along the major principal stress direction in the other. It is concluded that tensile twinning retards void growth considerably and also changes the mode of failure from internal ligament necking at high biaxial stress ratios to one involving inclined shear localization bands at low stress ratios. The interaction between a notch tip and void is examined by analysing Mg single crystal fracture specimens with vastly differing crack tip constraint levels. The fracture process zone is modelled with an array of cylindrical voids. It is found that in the orientation where TT is suppressed, void growth and coalescence take place directly ahead of the tip and fracture resistance enhances with reduction in constraint. By contrast, in the orientation where TT is active, void growth is retarded and coalescence happens by shear bands, resulting in higher fracture toughness.