ME – PhD Thesis Defense

Mechanisms and mechanics of mixed-mode (I/II) fracture of magnesium alloys

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ABSTRACT

Magnesium alloys are considered as a desirable substitute for aluminium alloys in automotive structural components due to their high strength-to-weight ratio which is crucial for improving vehicle performance and fuel efficiency. However, they possess lower ductility and fracture toughness at room temperature than aluminium alloys. The present thesis is aimed at understanding the mechanisms and mechanics of mixed-mode fracture of basal textured rolled magnesium alloys.

The effect of notch acuity and temperature on the mixed-mode (I/II) fracture behaviour of above alloys is studied by conducting four-point bend fracture tests at room temperature (RT) and 100°C. It is found that the fracture mechanism involves twin-induced quasi-brittle cracking in fatigue pre-cracked (FPC) samples at RT, whereas ductile void growth and coalescence is perceived at 100°C. Notched samples tested at RT display hybrid fracture surface features. The fracture toughness J_c is much higher for notched samples than FPC specimens. Also, it enhances strongly over the above range of temperature, irrespective of mode mixity. In all cases, changing the loading from mode I to II leads to pronounced drop in J_c. These trends are rationalized from microstructural observations pertaining to tensile twin evolution near the tip and the texture changes occurring in the far-edge of the ligament.

Crystal plasticity-based finite element (CPFE) analyses are conducted to study the 3D nature of stationary mixed-mode (I/II) notch tip fields in a rolled AZ31 Mg alloy. The analyses are carried out using four-point bend fracture test specimens with three levels of mode-mixity and two notch orientations. The simulation results are validated by comparing against experiments for one of the notch orientations. The spatial distribution of stresses, plastic strain and slip / twin activities are systematically studied. The growth of spherical and cylindrical voids ahead of a notch tip in above Mg alloys under plane strain, mixed-mode, small scale yielding conditions are contrasted by conducting CPFE simulations. A simple criterion is applied to predict the stage of coalescence of the void with the notch. Results show pronounced effect of void shape and mode mixity on its growth as well as the value of J at coalescence. The behavior is explained from spatial distribution and evolution of hydrostatic stress and plastic strain in the voided cell.

ABOUT THE SPEAKER

Dhrubjyoti Baruah is a PhD student in the Dept. of Mechanical Engineering, IISc Bangalore. He obtained his B. Tech degree in Mechanical Engineering from Tezpur University, Sonitpur in 2013 and M. Tech degree in Mechanical Engineering (Automobile Engineering) from NIT Warangal in 2016. After M. Tech, he worked as Assistant Professor in Vignan's Foundation for Science, Technology & Research, Guntur. His research interests are broadly in mechanical behaviour of engineering materials.