ABSTRACT

The present study focus towards understanding the mechanical response of AA2014-T6 alloy under static, dynamic, and impact loading conditions. Fracture behavior of any materials can be described by the characteristics like fracture initiation toughness and propagation toughness, which in turn depends on the strain rate and temperature. Research effort in this study can be summarized in the following steps. First, the material was characterized under tension and compression at different strain rates (10^{-4} to 10^{3} s^{-1}) and temperatures (25 to 250 ^{o}C). Tensile and compression experiments at low strain rates (10^{-4} to 10^{-1} s^{-1}) were performed on conventional UTM equipped with the thermal heating chamber. High strain rate (>10^{3} s^{-1}) experiments were carried out on SHPB (compression) and TSHPB (tension). Material was found to exhibit positive strain rate sensitivity and negative thermal rate softening for the considered strain rates and temperatures. Also, the strain hardening rate under compressive ultimate stress was observed to be higher when compared with the strain hardening rate under compressive yield stress. However, tensile yield and ultimate stress followed similar profile of strain hardening rate. Constitutive and fracture model parameters were evaluated to predict the plastic flow and fracture behavior of this alloy. In the considered constitutive model, plastic flow stress is the function of strain, strain rate, and temperature while the fracture strain is the function of stress triaxiality, strain rate and temperature. These parameters predicted flow stress with minimal error under both tension and compression loading. Secondly, the fracture initiation and propagation toughness under static and dynamic loading were determined at a wide temperature range. Static fracture initiation toughness was evaluated as per the ASTM E399 standard, while the modified Hopkinson pressure bar (MHPB) approach was used for dynamic fracture toughness. Identical pre-cracked three-point bend specimens were used for both static and dynamic experiments. A non-contact technique, 3D digital image correlation (DIC), was also used in this study to calculate the crack initiation time and crack mouth opening displacements, which were then used in determining the fracture characteristics. From experimental results, it was observed that the values of both dynamic fracture initiation and propagation toughness are higher as compared to static fracture initiation and propagation toughness. It was also found that the static fracture initiation toughness decreases continuously whereas propagation toughness increases with increase in temperature. Although, dynamic fracture initiation toughness attains the highest value at room temperature while the dynamic propagation toughness continuously increases with the increasing temperature. Further, a FE model was developed to incorporate the material constants and predict the fracture behavior of 3-point bend specimen under dynamic loading conditions. Numerical results of dynamic experiments found to be quite similar to the experiment results.

Lastly, the projectile impact experiments were performed on two different thickness monolithic plates (1 mm and 2 mm thick) and one homo-stacked configuration of 1_1 mm thick plate under blunt and hemispherical impacts. A single-stage gas gun coupled with ultra-high-speed synchronized cameras were used for this study. Captured images by the cameras were processed in Vic-3D software to get full-field deformation profile of the target plates. The experimental study reveals that the perforation of the plate is strongly influenced by the shape of the projectiles and plate thickness. Radial cracks were observed around the circumference of perforation hole

when impacted by the hemispherical projectile, while the shear failure was observed in case of the blunt projectile impact. A numerical simulation of projectile impact experiments was also performed using Johnson-Cook damage criteria to validate the experiment results. After comparison it was observed that both the experimental as well as simulations results are in good agreement with each other.