Abstract

Thin-walled tubular components of aluminium alloys, fabricated by friction stir welding (FSW) process can be utilized in body-in-white for structural applications over extruded tubes due to its cost-effectiveness and no dimensional restrictions. However, FSW of tubular components is complex due to its curvature which makes it challenging to get the desired quality of the tube. In the present study, an attempt was made to fabricate longitudinal FSWed tubes of AA5083-O alloy. A novel parameter window highlighting their effects on the weld quality was presented, and the significant process parameters such as rotational speed, transverse speed and concavity of tool shoulder were optimized to get a defect free good quality welded tube. The joint efficiency obtained was 87% along with comparable hardness value, suggesting homogeneity of the weld zone (WZ). The performance of these welded tubes was evaluated in terms of end expansion and crushing experiment. Finite element (FE) model was developed for both these processes incorporating WZ properties, material anisotropy, and two theoretical fracture models. In end expansion, the FE model developed was utilized in designing the punch and die setup so that the welded tube could be expanded with significant plastic deformation before the onset of instabilities such as buckling and fracture. Failure mechanism along with the microscopic damage initiation characteristic during expansion was studied. Failure of these samples took place in the WZ, and three types of void nucleation mechanisms viz., inclusion cracking, inclusion-matrix debonding, and matrix debonding were found to be present. In crushing test, the performance of the welded tubes was assessed in axial and lateral loading conditions to get insight into the effect of WZ. The FSWed tubes deformed in progressive concertina mode during the axial crushing and by forming plastic hinges from the WZ during lateral crushing. The crushing performance of the welded tube, in terms of specific energy absorption (SEA) exhibited them to be comparable with the extruded tubes. Based on the findings, it was inferred that FSW can be applied to fabricate affordable lightweight tubular components of aluminium alloys with excellent formability as well as energy absorption capability.

Keywords: Crushing; End expansion; FE modelling; Fracture; FSW; Tubular components