Abstract:

An important issue in the automotive industry is to investigate the effectiveness of laser welding and, in particular, the efficacy of high-speed laser welding for enhancing productivity. The present work explores achieving the same with respect to several attributes such as weld bead geometry, microstructure, hardness, tensile and fatigue properties, fatigue crack propagation, residual increased stress, texture etc. Appropriate treatments are developed in this work to explain and correlate the virtues of these attributes chapter wise.

The parent material used for this study is cold rolled closed annealed dual phase (CRCA DP 600) steel sheet having 600 MPa tensile strength and thickness of 1.2 mm which is a popular AHSS genre material used in the automotive industry. It is primarily observed that although microstructures of different parts of fusion zone and heat affected zone remain almost the same from low speed to a typical high speed, there are visible changes in weld bead geometry. At the same time, higher welding speed above a critical limit leads to high residual stresses, resulting in longitudinal crack and distortion. Additionally, it is witnessed that laser speed has a strong relationship with formation of γ-fiber texture, rotated cube $\{001\}\langle 110\rangle$ and cube $\{001\}\langle 010\rangle$ orientations. With increased welding speed, the enhancement of columnar nature of the austenite grains at FZ or HAZ corroborates with the cube texture formation and deterioration in the formability of the welded material. It is also seen that the laser welding at low speed or medium speed does not have any significant effect on the fatigue property. However, the endurance limit has exhibited a significant reduction of 28% compared to parent material at higher speed.

In summary, it is experimentally established in this work that even if an optimum heat input is maintained while increasing the speed of the laser welding, one can find a critical value of speed, beyond which welding is not recommended because it leads to poor mechanical property of weld bead in terms of certain factors such as high residual stress generation, chance of crack formation or distortion, poor formability and decreased tensile and fatigue property.