Abstract

The stress response of spot-welded joints on sheets of interstitial free steels has been examined using tensile-shear, pure-shear and cross-tension specimens to acquire in-depth knowledge about the performance of these joints in various simulated service conditions. The factors considered to simulate the service conditions are related to the history of the material (e.g. chemistry, pre-straining, and bake hardening), environment (e.g. ambient and corrosive), weld (e.g. different nugget diameters) and test conditions (e.g. different modes of loading, strain rates). A series of supplementary experiments have been carried out to understand the various underlying phenomena responsible for the deformation behaviour and consequently the failure of these joints. The supplementary experiments consisted of characterization of the microstructures and sub-structures of the base metals and weldments by optical, scanning and transmission electron microscopes, determination of micro-hardness profiles along the spot-welds and fractographic examination of the failed spot-welds.

The major inferences drawn from the analyses of the obtained results are: (a) while load bearing capacity of spot-welds increases with increasing nugget size for a specific mode of loading, their strength remains independent of nugget diameter, (b) the strength under sliding mode is higher than that under opening mode, but the ratio of these strength values remains constant; this has been explained using Von Mises' criterion of yielding, (c) the strength of spot-welds increases with increasing pre-strain of the sheets due to increased dislocation density at the HAZ-base metal interface, (d) hardness profiles along the spot-welds on un-strained and pre-strained sheets are different owing to partial removal of dislocation density by weld heat input, (e) baking treatment after spot-welding appears to have negligible effect on strength of spot-welds, (f) impact tensile energy of spot-weld is found to be higher than its quasi-static energy and it increases with increasing pre-strain of base metal, (g) the strength of spot-welds decreases with increased duration of immersion in 3.5% NaCl solution; this phenomenon has been attributed to reduction in sheet thickness as well as easy crack initiation due to corrosive attack, and (h) under cathodic hydrogen charging, spot-welds on pre-strained sheets exhibit considerable decrease in strength unlike that of as-received sheets; this has been explained using increased dislocation density, and higher vacancy concentration in pre-strained sheets, which act as hydrogen trapping sites.

Key words: Spot-weld, Interstitial free steel, Strength, Toughness, Pre-strain, Baking, Corrosion, Impact load