ABSTRACT

Common welding processes that are used for cladding face challenges like dilution, spatter control, distortion, thickness control, superficial bonding, and cost effectiveness. Therefore, there is a need to explore new processes for cladding. The deposition of copper on top of a steel substrate combines the advantages of the corrosion resistance of copper with the high tensile strength of steel. Due to their diverse properties, it is challenging to deposit copper on steel. In this work, the friction stir welding (FSW) process has been used to successfully clad a 3 mm thick copper sheet on a 6 mm thick mild steel substrate. The process is different from lap welding, not only because of its intended purpose but also because several repetitive passes are required with a suitable tool offset to cover the entire plate effectively. To optimise the tool offset distance, a series of trial experiments with offset values of 6, 8, 10 and 12 mm were carried out. Metallography examination, along with X-ray radiography, was carried out on the prepared cladded samples. The average grain size of the steel substrate below the clad layer showed refined grains with a size of 5 μm, indicating an improvement of more than 60% over the base steel. SEM and EDS map analysis revealed proper bonding of the cladded material with the substrate. Uniaxial tensile tests on flat specimens were carried out for base copper, base steel, and copper clad steel samples. The copper cladded steel has a yield strength (YS) of 261 MPa and an ultimate tensile strength (UTS) of 359 MPa in comparison to base copper, with a YS of 131 MPa and a UTS of 227 MPa. Fractography analysis revealed stretching marks between copper and steel due to the difference in elongation rates of both materials. A guided bend test for the face bend, root bend and side bend revealed no delamination or crack initiation along the convex surface. Microhardness testing was carried out

across the interface from copper to steel, where a maximum hardness value of 226 HV was recorded near the interface close to the steel region. Corrosion behaviour for as-received copper, the top surface of friction stir cladded plate, and cladded plate after 1.5 mm removal has been carried out in a 3.5% NaCl solution through the potentiodynamic polarisation method. SEM and XRD examinations of the corroded clad layer depict oxide layer formation. Atomic force microscopy reveals the presence of pits and valleys in the corroded, clad copper top. The experimental results suggest FSW does not significantly degrade the corrosion properties of copper, and the corrosion results are comparable to those of base copper.