Abstract

Aluminium alloys are used in different applications e.g. marine, aerospace, railways for their superior weight to strength ratio, physical properties, mechanical properties and its corrosion resistance. It is also used for electrical contacts as bus bar for additional advantage of good electrical conductivity comparable with copper. Till the date aluminum alloys were welded by Gas Tungsten Arc Welding (GTAW) and Gas Metal Arc Welding (GMAW). But this leads to vast reduction in strength compared to base metal. Also arc welding leads to excessive distortion and defects like voids, porosity, etc. To avoid these problems friction stir welding (FSW) is being explored.

The main benefits of friction stir welding over conventional thermal welding processes are minimization of energy usage, no need for consumables, potential for good weld quality without porosity, no fumes, minimal adverse environmental effects (green), minimal waste (lean), and reduced threats to personal health and safety.

FSW is a solid-state process, which means that the base materials to be joined do not melt during the joining process. In FSW, a cylindrical shouldered tool with a profiled pin is rotated and plunged into the joining area between two pieces of sheet or plate material. The parts have to be securely clamped in a manner that prevents the joint faces from being forced apart and also should not get displaced by tool traverse. Frictional heat between the wear resistant, non consumable rotating tool and the work pieces causes the latter to soften without reaching the melting point and allows traversing of the tool along the weld line. The plasticized material is transferred from leading edge to the trailing edge of the tool pin and is forged by the intimate contact of the tool shoulder and pin. On cooling down, it leaves a solid phase bond between the two pieces.

Factors such as tool and substrate fixation compliance and machine types emerge as variables that need to be given attention in the selection of process parameters. Hence weightage is given in design and fabrication of fixture and tool. A jig type fixture is fabricated which can accommodate different substrate size and thickness.

In this research work precipitation hardening alloy (AA6101 and AA6082) is welded using FSW. The weld is subjected to tensile, bend, hardness, corrosion and conductivity tests. After testing results are compared and analyzed for different parameters. The micrographs showing the microstructure of base material and all the welded joints are presented. SEM fractographs of the fractured surface of the tensile test specimens of the welded joints are presented to know the behavior of fractured surface.

FSW of these alloys resulted in fine recrystallized grains in the weld nugget which has been attributed to frictional heating and plastic flow. The process also produced a soften region in the weld nugget which may be due to dissolution and growth of possible precipitates. The corrosion tests of base metal and welded joints were carried out in 3.5% NaCl solution at room temperature. Corrosion current and potential were determined using potentiostatic polarization measurements. It was found that the corrosion rates of welded joints were higher than that of base alloy.

The experiment was extended from conventional to bobbin FSW. Looking to the requirement a special fixture was designed and fabricated for bobbin friction stir welding (BFSW) also. The novel BFSW tool was designed and manufactured to get defect free weld joint.

An attempt was made to explore Infrared Thermography an innovative technique, to understand the welding behavior and weld quality.

Keywords: Friction Stir Welding, Mechanical properties, Conductivity, Microstructure, Scanning Electron Microscopy, Fractograph, Corrosion, Infrared Thermography, Bobbin tool.