Abstract

Welding has been one of the important and crucial manufacturing processes in the present industrial scenario. It is being practiced in various leading sectors such as the railways, ship building, automobiles, construction, aerospace etc. The wide application of the welding process as an operation indicates its importance. The welded structures would be deployed in various equipment, some of them being operated on the floor, some being the parts of an aircraft, rail wagons etc. The point to be stressed upon is the life of these structures upon whom the daily life of the human is dependent, and also serves the need of the industry. Thus, the welding technique being employed in an industry and also the type of material under the experiment are imperative. In the present research, one such welding technology has been adopted and a light metal has been taken into account to benefit the industries breakthrough in a more defined path.

The welding technique explored here is Friction Stir Welding (FSW) which based on the concept of solid state joining technique. This novel joining technique was first implemented for aluminium alloys, which has now expanded its application to a wide range of materials. Patented by TWI, UK, FSW is the most promising welding technology for joining a range of metals which are difficult to join by the conventional fusion welding techniques. Heat produced by a non-consumable and rotating tool helps to join two mating surfaces. As the tool is the most vital part of FSW, various divergent tools have been developed to increase the potential of the process.

Based on the available theories and concepts provided by TWI, "The inventor of FSW", a novel tool design titled *"Counter-rotating twin tool"* has been developed, fabricated and employed to weld aluminium alloy in the present work. The present work provides an advancement to repair the voids and defects arising particularly in aluminium FSW process, termed re-welding technique or MP-FSW. Rather to throw an expensive piece as scrap, repairing of defective portion will be desirable by conventional means. To overcome this traditional technique, Twin-stir can be a cost-effective technique. Hence, a wide range of process parameters and variants of the welding process have been taken into account to visualize the different aspects of this novel technique. Mechanical as well as metallurgical properties of the weld such as tensile strength, micro-hardness, surface roughness, fractograph, microstructure have been quantified to determine the effect of the developed tool. Further, residual stresses in the welded samples, corrosion analysis, and weld defects produced in the samples have also been analyzed. The temperature and power prevailing during the process of welding have also been evaluated. The obtained results have been compared and analyzed with those obtained with the traditional single-tool. In addition, a case study, also showing the temperature and power consumption with different gaps between the leading and follower tool, has also been analyzed.

Keywords: Friction stir welding, friction stir processing, twin-tool, single-tool, multi-pass