ABSTRACT

Although welding is considered a relatively developing process day-by-day, its origins can be traced to ancient times, around 1000 B.C. At the turn of the 19th century, welding had become a popular commercial process for joining of many engineering metals. Of late, the arc welding technology has been appreciably improved and proposed for various industrial applications. Now, arc welding process is dominant as a joining process among the world's welding fabricators, especially gas metal arc welding. About 40% of the production with help of welding in country (like India) is accomplished by this process

In Gas Metal Arc Welding (GMAW), maintaining quality remains a challenging task. Recent investigations have shown that the parameters of electrode geometry such as change in electrode diameter, different electrode tip geometry, flat tip electrode, sharpened electrode, and twin-wire electrode influence the weld quality. In this work, a flat wire electrode has been proposed for GMAW. The main objective of this thesis is to develop flat wire electrode for improving the dimensional quality and the mechanical properties of the weld in GMAW process.

In order to fulfill the objective, the conventional GMAW has been tailored into a promising method to enhance the performance using flat wire electrode. The proposed flat wire electrode is used under the same process conditions as those applicable to cylindrical wire electrode. The experimental setup developed consists of three main components viz. Modified Wire Feeder (MWF) mechanism, Support Wire Feeder (SWF) system, and new welding torch for the continuous formation of flat wire electrode online during GMAW process. The main function of the MWF mechanism is to

form the flat shaped wire electrode throughout the process. Followed by, SWF system which is used to regulate the feed of flat wire electrode in to the fusion zone. A new straight head welding torch is developed with optimal design for the investigation.

After developing a FW-GMAW (Gas metal Arc Welding using Flat wire electrode) experimental setup, the geometry of the formed flat electrode and process parameters are optimized by conducting preliminary study. The investigation involved testing of 1.2 mm diameter conventional electrodes made of two different materials viz. AWS/ASTM A5.10: Al Si/5 Er4043 and AWS/SFA-5.20: E70T1 flux cored. The various geometrical sizes of flat wire electrode have been formed with the help of MWF mechanism. Electrode geometry which is extremely close to the cross sectional area of regular electrode is preferred for further investigation. The perimeter of the formed flat wire electrodes are 27.5 % and 26% more than that of regular wire electrode made of Er4043 and E70T1, respectively. In addition to that, a numerical model has been developed to analyse the electrical influences of formed flat wire electrode geometry by using High Frequency Structure Simulator (HFSS). From the result, it is evident that electric and magnetic field is increased with increasing perimeter of the flat wire electrode. However, bead-on-plate welds are performed as a preliminary study. From the characterization results, it is observed that there is weld bead profile improved dimensionally with better mechanical properties.

Detailed investigation has been performed with three different orientations of formed flat wire electrode namely 0°, 45°, and 90° with respect to welding direction. The butt joint and T-joint weld have been studied with the formed flat wire electrode based on L_9 orthogonal array experimental design. The welding current *(I),* welding speed *(WS),* and orientation of flat wire electrode *(θ)* were considered as input parameters.

The welding characterization studies of formed Er 4043 flat wire electrode infers that 7.75 % of Depth to Weight (D/W) ratio has improved reasonably. However, higher penetration depth was observed with 0°, 45°, and 90° orientations than that with regular electrode in GMAW. Similarly for formed Er 70T1 flat wire electrode, at constant welding current and at constant orientation the penetration area has improved compared to that in regular electrode used in FCAW process. In addition to that, the transient temperature distribution at the top surface of weld zone during the FW-GMAW process has been captured by using thermal imager. This shows an increased temperature distribution than that of R-GMAW process by 7.31%. Moreover, yield strength and hardness tests are conducted and it is evident that the values are greater at fusion zone and HAZ zone in FW-GMAW process. The microstructural examinations reveals prominent grain growth in the fusion zone and fine elongated grains in the HAZ zone in FW-GMAW weld.

A fuzzy logic model is established to predict the effects of the use of flat wire electrode on GMAW with varying input parameters. The predictions of the model are compared with the experimental results which show good agreement. Furthermore, finite element model is developed to predict the temperature distribution caused by flat wire electrode. The predicted temperature distribution is founded to be in close agreement with the experimental results obtained by thermal imager. Also, numerical study confirmed that the initial arc and steady state temperature are higher for FW-GMAW process.