CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Welding is one of the most important secondary manufacturing processes that has been and will continue to be more essential for the survival, comfort and advancement of human race. It is the foremost used and realistic joining method within the manufacturing industries. Its traces are found nearly in all the sectors of production at present. The buildings, bridges, streets, sewer and transportation systems, petroleum pipelines, aerospace, defensive industries and most of the everyday use stuffs are produced by a variety of welding processes. From the day the welding process has been discovered, this has widen the standard of life and has allowed us to make our world (Messler, 1999). Welding means the construction of continuous solid body from two or more separate pieces of materials. The description of welding can be stated as: forming an atomic bonding between materials by putting their surfaces close enough so that a new atomic arrangement can be created through inter atomic or inter molecular forces by having a common electron configuration (Erturk, 2011; Messler, 2004). Among numerous welding methods, mankind has found gas metal arc (GMA) welding to be the most effective one. The materials to be joined are melted by the heat of an electric arc. The filler material is deposited between the work pieces. Upon solidification of the molten bath, atomic bonds and continual surface are produced (Blondeau, 2013; Erturk, 2011).

Aluminium (Al) and magnesium (Mg) alloys are the most promising materials for manufacturing industries at present. This two alloys have been continously and extensively researched during the past decades for their practical industrial applications.

In fact, various Al and Mg alloys will be counted as the fundamental materials in almost all structures in near future. In most of the land, water and air transportation systems; especially in the automotive industries, both Al and Mg alloys will be used in the same structure. In such cases, a successful welding technique is of utmost necessity to combine these two alloys together. The main problems in welding of these two alloys are the difference in physical and chemical properties between them. Moreover, Al-Mg reaction causes formation of very brittle and fragile Al_mMg_n type intermetallic compounds (IMCs). Therefore; the joint possesses very low strength and can be very easily fractured even by bare hand. In order to achieve a joint with good mechanical and metallurgical properties by reducing or avoiding the formation of Al_mMg_n IMCs at the welding joint, an appropriate welding technique should be introduced.

The welding parameters play an important role in the performance of welding joints. GMA welding parameters and their appropriate settings can produce better quality joints. The selection of welding parameters and their ranges are provided by the machine manufacturers, which are only applicable for the common materials in similar welding. The parameter settings for welding of dissimilar Al and Mg alloys need to be optimized experimentally. Modeling is an effective way to solve the welding problems by relating the process parameters to the responses. It was revealed from the study of previous researchers that it is difficult to develop a universal mathematical model for almost any kind of material and welding method to predict the responses. Therefore, it is not acceptable to use existing models when advanced dissimilar materials are welded. From this viewpoint, mechanical properties of the welding joints have been investigated and development of mathematical models have been attempted in order to correlate the welding process parameters to certain responses. The validation of the models by conformation experiments was attempted. The metallurgical properties of the joints have also been studied.

This research work was carried out in three major steps. Primarily, the most important parameters such as welding voltage, current, gas flow rate and tip to work distance were selected as process parameters. For that, the behavior of the materials to different welding process parameters was investigated. Then, joints with good welding appearances and with no visible defects were produced. The mechanical properties of the welding joints were investigated. Secondly, mathematical models were developed through statistical analysis to relate the process variables to the responses. Validation experiments were conducted to verify the models. The effects of the variable process parameters on the responses were also studied. Finally, metallurgical properties of the welding joints and fracture surface morphology after mechanical testing were investigated. To accomplish these processes; *Box-Behnken* design of experiment (DOE), GMA lap plug welding of Al and Mg alloys, tensile and charpy impact toughness tests for the joints, statistical analysis, mathematical modeling and validation, macro and micro structural examinations of welding cross sections, fracture surface morphology study, and elements analysis at the welding cross were carried out step by step. The technical aim of this research was to create a lap welding joint between A7075-T651 aluminium and AZ31B magnesium alloys by new technique of GMA plug welding method with better joint performance. Production of lighter and more fuel efficient vehicle structures for automobiles, aviation, aerospace and marine industries was aimed by such joint.

1.2 PROBLEM STATEMENT

A variety of attempts have been taken so far to find out the best method to join Al to Mg alloys such as arc, metal inert gas (MIG), tungsten inert gas (TIG), friction stir welding (FSW), diffusion, laser, laser-TIG hybrid, laser and electron beam welding (Hayat, 2011, Zhang and Song, 2011). But, most of these methods particularly gas metal arc welding method failed to come up with complete satisfactory outcomes (Yan et al., 2005). When two dissimilar alloys like Al and Mg are used in the same product, it is very important to have a proper bonding between them so that significant mechanical proppeties of the joint can be obtained (Liu et al., 2008). But due to the difference in physicochemical properties between Al and Mg alloys, it is very difficult to obtain a sound joint through conventional welding methods as large amount of extremely brittle Al_mMg_n type IMCs like $Mg_{17}Al_{12}$ and Mg_2Al_3 etc., cracks, defects, pores, oxide, cavities, coarse grains are always formed at the interface of these alloys. Most importantly, Al_mMg_n IMCs have a strong negative, unacceptable deteriorative effects on the mechanical and metallurgical properties of the welding joints (Zhang and Song, 2011). Even in high energy density laser welding, harmful Al_mMg_n IMCs can form