

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter presents the details of experimental works and methods that were implemented to achieve the objectives of this research. These include research framework, materials and sample preparation, GMA lap plug welding method, details of experimental setup, design of experiments, methods of mechanical testing and calculation of fracture toughness. The method for mathematical modeling and analysis in RSM including analysis of variances is also explored. Methods for metallurgical investigation (macro and micro structural observation by microscope, fracture surface and elements analysis at welding joints by SEM and EDX spectroscopy) were also discussed.

3.2 RESEARCH FRAME WORK

In this research, GMA plug welding method in lap configuration was used to achieve significant mechanical properties of joint between A7075-T651 and AZ31B dissimilar alloys using ER308L-Si SS and ER5356 Al fillers. Welding was performed according to the parameters' combination designed by *Box-Behnken* experimental design technique in RSM. Statistical analysis was also worked out with a view to check the validity of the results and to find the significance of variable parameters. Mathematical models were developed and conformation tests were carried out for models validity. Metallurgical investigation was also carried out at fractures surface and welding cross sections. Figure 3.1 illustrates the detail structure of research plan.

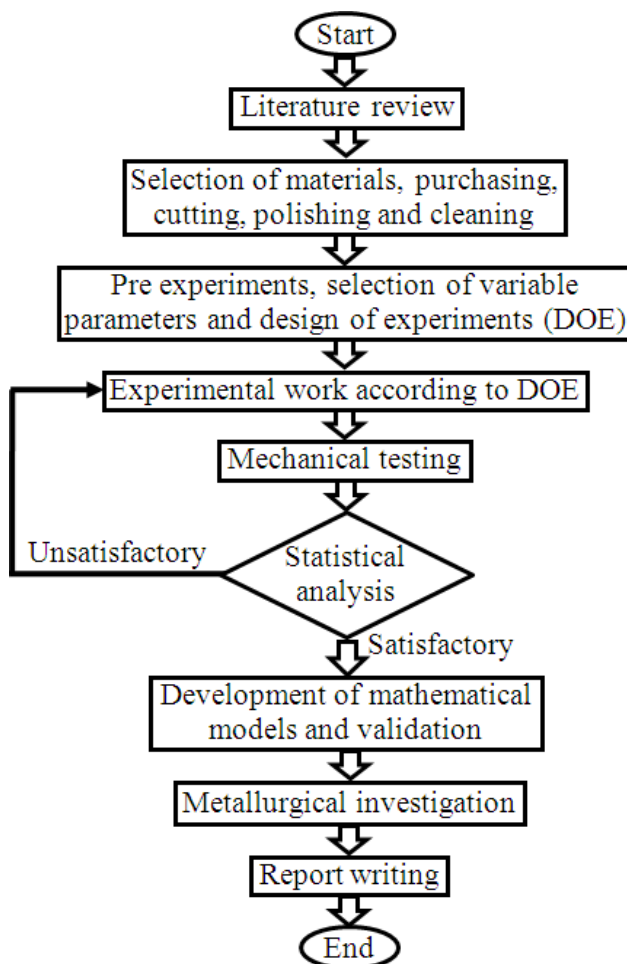


Figure 3.1: Structure of research plan.

3.3 MATERIALS

Four types of materials have been chosen; two parent metals and two filler wires. A7075-T651 Al and AZ31B Mg alloys were chosen as parent metals, ER308L-Si SS and ER5356 Al wires were chosen as fillers. These two alloys were lap joined by new technique of GMA plug welding method using SS and Al fillers. The chemical compositions of these four materials are given in Table 3.1 (Das et al., 2009; Lean et al., 2003; Liu et al., 2012; Srinivasan and Balasubramanian, 2011; Wu and Wang, 2010). Chemical composition of A7075-T651 was provided upon delivery of the material, verified in chemical analyzer and cross checked with literature. The chemical compositions of AZ31B alloy was determined by chemical analyzer and cross checked with the data from other related literature studies (Chang and Kim, 2011; Kostka et al.,

2009; Liu and Ren, 2011). The results from tests and data from literature have shown the same features. The SS and Al filler wires compositions were taken from literature (Das et al., 2009). The microstructures of the parent metals were examined and taken into account to be used as the state of reference for comparison after welding.

Table 3.1: Chemical compositions of A7075-T651, AZ31B alloys and ER308L-Si SS, ER5356 Al fillers (wt %).

Element	A7075-T651	AZ31B	ER 308L-Si	ER5356
Al	Balance	2.5-3.5	-	Balance
C	-	-	<0.02	-
Ca	-	0.04	-	-
Co	-	-	0.06	-
Cr	0.23	-	20.0	0.06
Cu	1.6-1.8	-	0.18	0.011
Fe	0.50	-	Balance	0.20
Mg	2.5-2.7	Balance	-	4.6-5.0
Mn	0.30	<1.0	1.40	0.15
Mo	-	-	<0.17	-
Ni	-	-	12.6	-
Si	0.40	<0.20	0.40	0.20
Ti	0.20	-	<0.10	>0.05
Zn	5.6	0.5-2.0	-	>0.10

3.4 GMA LAP PLUG WELDING PROCESS

In a metallic structure, there are high and low stress components. As Al has better mechanical properties than Mg (in terms of strength and toughness), Al can be used in high stress components and Mg can be used at low stress components. Therefore, to gain benefits from the significant properties of Al and Mg alloys through compound structures, it is necessary to find out a better welding technique. GMA plug welding method is considered to serve that purpose effectively. GMA plug welding is similar to normal gas metal arc welding process but the welding takes place in a single point without any movement of the welding gun or the work piece. This method welds through holes between upper and lower sheets in lap configuration. The lap joint is one of the most common joining configurations in automotive and aviation industries, typically using the RSW method. However, if RSW is used to weld any Al alloy to any Mg alloy, the two alloys come in direct contact to each other and the formation of Al_mMg_n type IMCs exist which deteriorate the essential mechanical properties of the