A Review on an Effect of Process Parameters on Mechanical and Metallurgical Properties of Aluminium Weld Joints using Gas Metal Arc Welding (GMAW) Process

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Abstract— This Paper Presents an Effect of Process Parameters On mechanical and metallurgical properties of aluminium weld joints using Gas Metal Arc Welding (GMAW). We considered aluminium alloys which widely used in marine, aerospace, pipe industries etc. Aluminium alloys are light in weight comparably less density with better mechanical properties with mild steel. So we considered Aluminium alloys for study. Due to the affinity of aluminium for oxygen, it cannot successfully be arc welded in an air environment. If fusion welded in a normal atmosphere oxidisation readily occurs and this results in both slag inclusion and porosity in the weld, greatly reducing its strength. To overcome these problems one of the most common ways of welding aluminium has been to use the electric arc process whilst shielding the weld pool with an inert gas in Gas Metal Arc Welding process. we select AA-6063 Aluminium alloy for investigation. The variables that choose in this study are welding current and welding feed and Gas flow rate. The Ultimate Tensile strength, microstructure and hardness were measured for each specimen after the welding process and the effect of it was studied.

Key words: GMAW, AA-6063, Ultimate Tensile Strength, Microstructure, Hardness, Design of Experiment

I. INTRODUCTION

Gas Metal Arc Welding (GMAW), sometimes referred to by its subtypes Metal Inert Gas (MIG) welding or Metal Active Gas (MAG) welding, is a semi-automatic or automatic Arc welding process in which a continuous and consumable wire electrode and a shielding gas are fed through a welding gun. A constant voltage, direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used. There are four primary methods of metal transfer in GMAW, called globular, Short-circuiting, spray, and pulsed-spray, each of which has distinct properties and corresponding advantages and limitations. In the present study the welding of 250mmx75mmx6mm thick plate of AA-6063 aluminium alloy was carried out using Gas Metal Arc welding (GMAW) process.

Design of Experiment (DOE) and statistical techniques are widely used for optimization of process parameters. In the present study the welding process parameters of GMAW can be optimized to maximize the Ultimate Tensile strength of the work piece also reducing the number of experiments without affecting the results. The optimization of process parameters can improve quality of the product and minimize the cost of performing lots of experiments and also reduces the wastage of the resources. The optimal combination of the process parameters can be predicted. This work was concerned with the effects of welding process parameters on the Ultimate Tensile strength of AA-6063 aluminium alloy weld Joint.

II. GAS METAL ARC WELDING

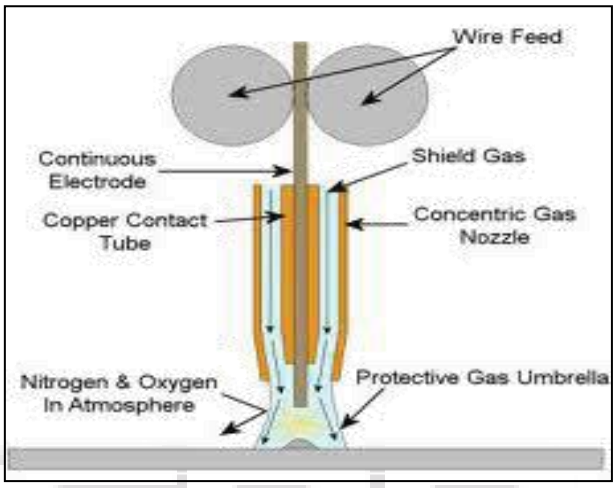

Fig. 1: Gas metal arc welding Principle

A Metal Inert Gas (MIG) also called GMAW is the process that included of heating, melting and solidification of parents metals and a wire electrode material in restricted fusion zone by transient heat source to form a joint between the parent's metals. The continuous wire electrode from an automatic wire feeder and fed through the contact tip inside the welding torch is melted by the internal resistive power and heat transferred from the welding arc. Heat determined from the end of the melting electrode to molten weld pools and by the molten metal that transferred to weld pools. [5]

III. RESEARCH METHODOLOGY

The aim of the study is to explore the optimum values of process parameters in the Gas Metal Arc Welding. AA-6063 aluminum alloy used as base metal which dimensions are 250mmx75mmx6mm. Input parameters are current (I) Voltage (V) and weld Speed (S) and response parameters are Ultimate tensile strength and Microstructure and weld strength The input parameters having three different levels. In this research work L9 orthogonal array is used to design the experimental runs and find the optimal process parameter combination by using Response Surface Methodology. After the number of experiments ANOVA and MINITAB 16.0 used to generate validate the optimum values.

IV. LITERATURE REVIEW

Many of investigators have suggested various methods to explain the process parameters effecting on mechanical and metallurgical properties of weld metal of aluminium alloys.

SHEIKH IRFAN AND PROF. VISHAL ACHWAL. 2014 [1] Investigated that the influence of process parameters optimum value to achieve the maximum weld bead width and depth of penetration. In this review he observe that for maximum depth of penetration and maximum weld bead width main process parameters are current, voltage, and welding speed. In this experiment current and voltage taken as constant parameter whereas arc time varied during the welding of specimens. The paper conclude that depth of penetration increases with increasing welding speed, which was optimum value to obtain maximum penetration, because it begins to decrease linearly after this point. Increasing the speed of travel and maintaining constant arc voltage and current increases penetration until an optimum speed is reached at which penetration is maximum. Increasing the speed beyond this optimum results in decreased penetration.

S.UTKARSH ET AL. 2014 [2] Studied In this research work of Gas Metal Arc Welding (GMAW) show the effect of Current ,Voltage ,Gas Flow rate and welding Speed on Ultimate Tensile Strength of material. In this Experiment L9 orthogonal Array used to find out maximum UTS and also perform confirmatory Experiment to find out optimal run set of current voltage welding speed and gas flow rate. Taguchi technique is used to increase the output and reduce the cost of products of gas metal arc welding. After the experimental investigation paper conclude that current voltage and welding speed are the effective process parameters whereas gas flow rate is less effective during the weld.

RAKESH B PRAJAPATI ET AL. 2014 [3] In this study, the effects of various welding parameters on welding strength in AISI 1045 medium carbon steel having dimensions 200mmx75 mmx6mm with V-groove of specimen, welded by gas metal arc welding were investigated. The welding current, arc voltage and welding speed and gas flow rate were chosen as variable parameters. Ultimate tensile strength was measured for each specimen after the welding operations and the effects of these parameters on strength were researched. Experiments concluded based on D.O.E method that current has a significant effect on the Ultimate tensile strength**.**

ESSAM AHAMAD M.A ET AL. 2014 [4] in this experiment AA 7075-T6 aluminum alloy has been researched with manually operated Gas Metal arc welding process for improving its tensile strength. Argon is used as shielding gas. The process parameters used are current (I), Voltage (V), Welding Speed (WS) and Gas flow (GS) predictors and tensile strength response parameter. So that multiple regression as chosen and validated this model SPSS 16 and formulated the transfer function with interaction between predictors reported by Minitab 15. After the experiment and regression model the result is done that tensile strength decreases when welding speed increases without change all the input parameters.

RAJESH P VERMA AND K. N. PANDEY 2012 [5] conducted two different welding process manual metal arcs (MMA) on 6061-T6 aluminium alloy and metal inert gas (MIG) on 5083-O aluminium alloy. Plates of 6061-T6 and 5083-O aluminium alloys with dimensions of 250mm×100mm× 8mm were joined by means of MMA welding and MIG welding with same parameters. Square butt joint for MMA welding (b) Single V-groove for MIG welding. AA5356 grade filler wire is used for MIG welding process. Argon used as shielding gas in MIG welding. The Fatigue test of weld joints carried out where the MIG weld joint shows greater life than the MMA weld joint. Investigation concluded that Grain size influences the fatigue life of welded material. Increased fatigue life is obtained in fine grained structure. MMA welding is not an alternate option for MIG welding of Aluminium Alloy.

IZZATUL AINI IBRAHIM1 ET AL. 2012 [6] In this study, the effects of different parameters on welding penetration, micro structural and hardness measurement in mild steel that having the 6mm thickness of base metal by using the robotic gas metal arc welding are investigated. The variables that choose in this study are arc voltage, welding current and welding speed. For the experimental studies, mild steel having the 100mmx 100mmx6mm sizes were used as the base metal. The penetration, microstructure and hardness were measured for each specimen after the welding process and the effect of it was studied. As a result, it obvious that increasing the parameters value of welding current increased the value of depth of penetration. Other than that, arc voltage and welding speed is another factor that influenced the value of depth of penetration. The microstructure showed the different grain boundaries of each parameter that affected of the welding parameters.

GAUTAM KOCHER ET AL. 2012 [7] Performed MIG butt welds of IS 2062 E250 mild steel plates to be welded using CO 2 as shielding gas. Welding speed is select as process variable while arc voltage, welding current, wire feed rate distance between the nozzle and the plates are fixed in this experiment. Experiment is done on Mild steel plates IS2062 E 250A with the dimensions of 5mmx40mmx70mm. After Experiments analysis shows an increase in welding speed at constant wire speed rate and constant arc voltage and welding current, results decrease in the heat input and hence, decrease in the depth of penetration and the width of the weld bead in the single pass weld. Penetration area increases with increase in the value of welds speed at constant wire speed rate and constant arc voltage and welding current and finally it reaches to its maximum value and then it again start decreases with increases in the weld speed in the single pass weld.

AJIT HOODA ET AL. 2012 [8] In This investigation attempt to develop a response surface model to predict tensile strength of inert gas metal arc welded AISI 1040 medium carbon steel joints. Experiment done on Plate which dimensions are 300mmx150mmx08mm. The process parameters such as welding voltage, current, wire speed and gas flow rate were studied. The experiments were conducted based on a four-factor, three-level, and face centered composite design matrix. Response Surface Methodology (RSM) was applied to optimizing the MIG welding process parameters to attain the maximum yield strength of the joint. Results conclude that at the optimum values of process parameters longitudinal yield strength of weld joint is greater than the transverse yield strength of weld joint.

SIVASHANMUGAM M. ET AL. 2009 [9] in this Investigation an attempt has been made in this paper to weld AA-7075

Aluminium alloy using GTAW and GMAW with argon as a shielding gas. Mechanical properties of the joint like tensile strength, Hardness and impact strength have been reported a constant current AC power source with a continuous high frequency is used with water or air-cooled GMAW torch and an externally supplied inert shielding gas as experimental setup. After successfully done experiments results show that Welded joints fabricated by GMAW process have lower strength comparatively GTAW.

I.O. OLADELE ET AL. 2009 [**10]** this work was carried out to investigate the effect of welded joints on the mechanical properties of wrought (6063) aluminium alloy. The alloy samples were welded at varying values of current and voltage after which mechanical tests were performed on the welded samples. Post Experimental tests are hardness test impact test metallographic test. The micro structural examination of the various fusion zones obtained was carried out various parameters which are affected on different types and impact test carried out. concluded that As the voltage increases from 25V to 30V, the ultimate tensile strengths and hardness values increases while the impact strengths decreases.

M.ST. WEGLOWSKI ET AL. 2008 [11] The Experiment is exploring influence of current on metal transfer in Gas metal arc welding process. A high speed Video camera is used to capture the metal transfer rate of gas metal arc welding. Results from high resolution camera shows droplet diameter is smaller when argon is used as shielding gas.

V. EXPERIMENTAL SET UP.

Fig. 2: Gas metal arc welding Set up

VI. CONCLUSION

From the literature survey, it can be concluded that Gas Metal Arc Welding has a high production rate. Input variables can make an effect on the response parameters. Review shows current has a maximum effect over the response. Voltage and welding speed also has an effect on response but not as current. Design of experiment method has used to design and performs the experiments, which gives an optimum combination of input parameters set for GMAW process. Response parameters for study are ultimate tensile strength and weld micro structure.

From all the above detailed analysis of various process parameters of GMAW process, the following points have been observed.

- The main effects of process parameters such as current, voltage, welding speed and gas flow rate for weld structure and weld strength would be carried out in the study
- Other variables are shielding gas, angle of torch and gas pressure are the constant parameters.
- Response parameters for the study are ultimate tensile strength and weld microstructure.

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