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A REVIEW ON MECHANICAL PROPERTIES OF ALUMINUM AND STEEL ALLOYS USING MIG WELDING

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ABSTRACT

Metal Inert Gas welding (MIG) also known as Gas Metal Arc welding (GMAW) is used for joining ferrous and non ferrous metals. Its quality and productivity depends on many welding parameters like welding current, welding speed and arc voltage. This paper presents the effect of welding parameters on mechanical properties such as hardness, tensile strength and fatigue life of aluminum and alloy steels. Also we considered various output parameters like depth of penetration, weld bead geometry and microstructure.

Keywords- *MIG welding, parameters of welding, mechanical properties, aluminum and alloy steel..*

I. INTRODUCTION

In metal inert gas welding (MIG) an arc is formed between a consumable metal electrode and the work piece in an inert gas atmosphere. The coiled electrode wire is fed by drive rolls at constant rate as filler material. Normally except for aluminum, DC arc welding machine is used for MIG welding with electrode positive (DCEP). The DCEP increases the metal deposition rate and also provides a stable arc and smooth electrode metal transfer.

The shielding gases commonly used are helium (He), argon (Ar), carbon dioxide (CO_2) and their mixtures. Helium is the most expensive of all the shielding gases. It has a better thermal conductivity and hence is useful for thicker sheets and for metals having higher thermal conductivity such as copper and aluminum. Argon has better electrical properties than helium. It provides a superior oxide cleaning action with AC power source. It is made suitable for thin sheets because of less penetration. Carbon dioxide is cheaper than helium and argon. But it produces more spatter and poorer bead shape when used alone. So it is usually conjunction with argon (80% Ar, 20% CO_2).

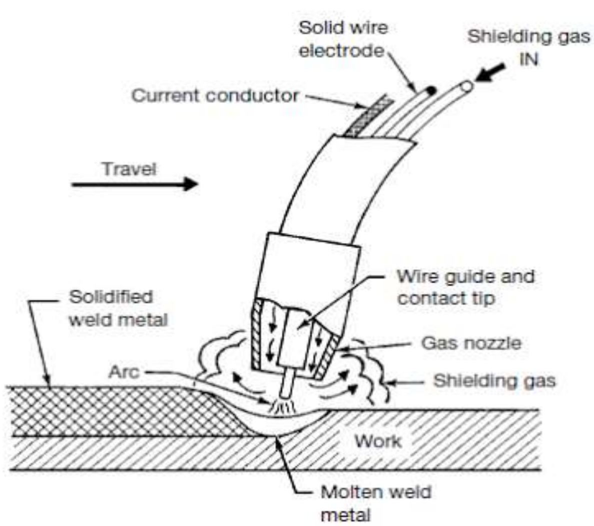

Fig.1. Working of GMAW.

Gas meal arc welding (GMAW) is a versatile process because of high deposition rates, ease of welding in all positions, requirement of less operator skill and adaptability to weld almost all metals. But it has inherent disadvantages. The welding equipment is more complex, costly and less portable. It is difficult to weld in small corners or difficult to reach places. The metallurgical and mechanical properties of the joint may be affected due to high cooling rate.

II. LITERATURE REVIEW

M.Bala Chennaiah et al. [1] worked on dissimilar metals of mildsteel and EN8 joined by MIG welding. The work heat input was varied from low to high with input parameters such as voltage, current and welding speed. Different parameters like tensile strength, hardness, impact were taken for the analysis. The microstructure and mechanical properties at different weldment zones were analyzed with or without post weld heat treatment. The properties are better when the joint was subjected to heat treatment.

Hee-Keun Lee et al. [2] investigated the effect of the wire feeding speed (WFS) and nozzle diameter on surface defects of aluminum plasma hybrid MIG welded joint using high speed imaging and metallurgical analysis. They observed that as WFS increased, the undercut size decreased and the surface defects can be completely controlled by controlling the nozzle diameter.

Peng Jignan et al. [3] studied MIG welding molten pool characteristics by using 2D mathematical model of Gaussian heat source distribution to find the effect of groove angle, groove depth and welding speed on the molten pool. The results showed that with the increase in the groove angle and groove depth, the molten pool became wider and it became narrower when the welding speed was increased.

Joseph Achebo et al. [4] employed multi objective optimization technique based on ratio analysis (MOORA) and standard deviation to optimize welding parameters. Mild steel plates were joined using MIG welding. It was found that welding current of 350A, welding voltage of 22 V, and an electrode diameter of 3.2 mm and welding speed of 100 mm /s produced the weldment with the best properties.

Issam Bendauod et al. [5] investigated the simulation of heat transfer in hybrid laser MIG welding of high thickness duplex steel UR2507Cu by using COSMOL multiphysics software. Using the numerical experimental designs method the equivalent heat source methods were estimated and adjusted to reproduce the characteristics of the melted zone. The results obtained were used to choose the equivalent heat sources for heat supply in hybrid welding and to solve thermo mechanical problem.

Xiagmeng Meng et al. [6] compared MIG welding and laser MIG hybrid welding methods to obtain the best method to overcome the poor weldability of invar36 alloy. They used Gauss and Cone combined heat source for estimation. It can be concluded that laser MIG hybrid welding is better than that of MIG welding for invar36 alloy.

A. Abouarkoub et al. [7] studied the influence of heating cycle during plasma MIG welding on the microstructure and corrosion properties of the AA5754 alloy using silicon- rich filler wire as electrode. Results showed that the high heat input during welding causes severe galvanized corrosion along the partially melted zone of the AA5754 during exposure to aqueous corrosion environments.

Americo Scotti et al. [8] worked on metal transfer in solid wire MIG welding using laser shadowgraph system with synchronized electrical signals and high speed filming to obtain several metal transfer modes with particular characteristics. The modes were independent of the type of shielding gas and welding power source.

Ivan Bunaziv et al. [9] investigated the joining of aluminum alloys using high power fiber laser MIG welding to eliminate difficulty in welding of aluminum alloys to improve overall productivity. In this study they considered the different factors effecting weld quality such as torch arrangement, distance between heat sources and shielding gas composition. They observed that the main welding defect was internal porosity due to short separation distance between heat sources and leading torch arrangement. Trailing torch set up provided higher quality weldments than leading set up and the weld quality did not depend on the shielding gas used.

Sudipto Chaki et al. [10] used combination of Artificial Neural Networks (ANN), Genetic Algorithm (GA), Simulated Annealing (SA) and Quasi Newton line search techniques for optimizing welding strength of hybrid CO_2 laser MIG welded joints of aluminum alloy. Laser power, welding speeds and wires feed rate were considered as controllable input parameters. During optimization ANN-GA was the best method compared to other methods. This method produced maximum weld strength 119.299MPa for laser power 2.01KW, welding speed 2.03m/min and wire feed rate 4.405m/min.

Vahid Farajkhah et al. [11] investigated the effect of a 3D simulated MIG welding induced heat affected zone, residual stress and distortion fields on the behavior of aluminum stiffened plates under compressive loading. A thermo-structural finite element model was developed for the simulation of the welding process. The post buckling behavior and buckling mode were analyzed with respect to welding induced imperfections. It was found that welding induced tensile and compressive residual stresses ranged from 72 to 77% and 18 to 36% of the base metal yield stress.

Sharmistha Singh et al. [12] worked on dissimilar welded joints of stainless steel 304 and mild steel using MIG with the filler wire of stainless steel in presence of argon as shielded gas. The difference in the properties such as melting point, thermal conductivity and carbon content difference makes austenite stainless steel and mild steel difficult to weld. The welding joint has more strength than mild steel (parent metal) and fracture takes place in the mild steel during tensile testing. The optimum values of current 250 A, voltage 25 V, wire feed rate 12.5 m/min and welding speed 15 cm/min are found to develop weld joint of maximum hardness.

Omar Btaineh et al. [13] The authors investigated the effect of input factors like arc voltage, filler feed rate, gas flow rate, specimen edge angle and preheat temperature on 1070 aluminum alloy using MIG welding taking argon as inert gas and ER1100 filler wire with was used as consumable electrode. Results of factorial design experiments and the analysis of variance (ANOVA) showed that arc voltage and filler feed rate are the only significant factors of the five. Optimal settings of arc voltage and filler feed rate are reached using regression analysis at 24 V and 7 in/s respectively at which the mean weld strength is maximum.

Diganta Kalita et al. [14] MIG welding has been carried on C20 carbon steel using ER70S4 electrodes. An experiment has been designed using Taguchi's Orthogonal Array taking welding current, voltage and shielding gas flow rate as factors with three levels of each. The experiments were conducted using TORNADO MIG 400 welding machine with three repetitions. ANOVA analysis of the experiment results showed that welding voltage has significant effect both on mean and variation of the tensile strength of the weld having 87.019% and 85.398% contribution respectively, whereas welding current has significant effect on mean only having 10.807% contribution. Shielded gas flow rate has insignificant effect on the tensile strength of the weld. From analysis of experimental data the optimal setting is found as welding current 200 A, welding voltage 30 V and shielding gas floe rate (CO_2) 8 lit/min.

D.Sindhu et al. [15] presented the effect of welding parameters like welding speed, plate thickness, pulse frequency, pulse current magnitude and welding voltage on weld bead geometry of stainless steel SS grade 410. In this study the mathematical model predicting depth of penetration and convexity index has been formulated using multi regression with reasonable accuracy. Taguchi methods were carried out to optimize pulsed parameters. The bead geometry is mainly influenced by plate thickness and welding speed ratio in pulsed GMAW. The depth of penetration is better at intermediate pulsed frequency level of 101 Hz compared to other pulsed frequency levels. Convexity is high at intermediate level frequency of 75 Hz and low at lower level pulse frequency of 40 Hz.

S.Brumm et al. [16] investigated the various modern GMAW process such as cold MIG, cold metal transfer and short arc, with the pulsed GMAW using AC current for welding aluminum. The welding tests were performed using different arc characteristics. The aluminum alloy AlMg4.5Mn (ENAW-5083) is selected as base material, AlMg5 as electrode wire and pure argon as shielded gas. The parameters penetration and heat input were considered for investigation. It was found that reversing the current driving the phase of the base current leads to lower heat input into the work piece. This provides the advantage of minimizing the deformation as well as increasing the rate of deposition at constant heat input.

Ghosh Nabendu et al. [17] worked on butt welding of AISI 409 ferretic stainless steels under three levels of current, gas flow rate and wire extension/stick out based on L9 Taguchi's Orthogonal Array Design of experiment. They studied the effect of current, gas flow rate, filler wire rate on ferritic stainless steel. They used X-ray radiographic tests and visual inspection to indicate lack of penetration, lack of fusion, weld depressions and uneven deposition. The optimum values for maximum strength of the joint are current 124 A, gas flow rate 15 lit/min, wire extension/stick-out 9 mm.

Mohd. Shoeb et al. [18] the various welding parameters such as welding speed, voltage and gas flow rate were varied on IS304 HSLA steel and the effects of these parameters on weld bead geometry such as penetration, width and height have been studied. Mathematical equations have been developed using factorial technique. In MIG welding of steel , it was observed that penetration increases with the increase of wire feed rate, arc voltage, welding speed and nozzle to plate distance and decrease with increase in electrode to work angle whereas gas flow rate has no effect on penetration. It was also observed that in spray mode of metal transfer, increased voltage produced increased bead width but decreased bead height. As travel speed increases, the weld width decreases. Increase in arc voltage results in a longer arc, which in turn, causes a wider bead.

Nawres Jabar Nasser [19] studied the effects of MIG welding process on the mechanical properties and fatigue life of AA6061T6. A series of experiments has been conducted on single and double V groove (at 70°) and square using ER-5356 as a filler metal and argon as a shielding gas. The fatigue test of the welds and base alloy were examined o obtain the S-N curve. Results showed a general decay of mechanical properties of MIG weld joint that is due to heat input during the welding process and low cooling rate. Fatigue strength of the butt joint with single V groove has a reduction percentage of 36% comparing with the base alloy while double V gives a reduction of 28%. In most of the cases, fracture in tensile tests was located in heat affected zone and in fatigue tests fracture was occurred in weldment in all cases.

Amit kumar et al. [20] worked on dissimilar welded joints of stainless steel of grade 304 and 316 using MIG. Three input parameters welding voltage, current and welding speed and one output parameter ultimate tensile strength were taken for the study. Experimental data was classified by using Artificial Neural Networks (ANN) and the welding parameters were optimized by genetic algorithm (GA).

Reiichi Suuki et al. [21] developed the arc stabilization mechanism and general characteristics of the MX-MIG process as well as the mechanism for improving corrosion toughness and fatigue strength of the carbon steel MM-1S weld joint. It was found that the MX-MIG process has the potential for raising the quality of GMAW. The use of MM-1S steels produce extremely low spatter and fume, as well as less susceptibility to bead shape failure and a higher welding speed.

Vineeta kanwal et al. [22] parametric optimization of MIG welding for hardness has been performed on aluminum alloys of grades 6061 and 5083 by using Taguchi method. Welding speed, welding current and welding voltage were chosen as welding parameters. A Taguchi orthogonal array, the signal-to-noise (S/N) ratio and analysis of variance (ANOVA) were used for the optimization of welding parameters. It was found that welding current has major influence on hardness of welded joints.

Amit Pal et al. [23] presented the effect of different welding parameters like welding voltage, filler wire rate and v-butt angle on the strength of the weld joint and elongation produced during the tensile test on medium carbon steels. To optimize these parameters for better weld quality Taguchi Orthogonal array has been used. The ANOVA was used to predict the percentage effect of each parameter on results.

S.Utkarsh et al. [13] worked on Gas Metal Arc Welding (GMAW) show the effect of current, voltage and speed on Ultimate Tensile Strength (UTS) of ST-37 low alloy steel material. In this experiment he employed L9 orthogonal Array to find out UTS and also performed confirmatory experiment to find out optimal run set of current, voltage speed and gas flow rate.

Ajit Hooda et al. [25] developed a response surface model to obtain tensile strength of GMAW welded AISI 1040 medium carbon steel joints. The process input parameters have been chosen as welding voltage, current, wire speed and gas flow rate. They applied Response Surface Methodology (RSM) to optimize the MIG welding process parameters to attain the maximum yield strength of the joint.

III. CONCLUSION

From the above literature we find that many researchers worked on the effect of different welding parameters on mechanical properties of aluminum and steel alloys using MIG welding. But wide research has to be done on other parameters like usage of various shielded gases, gap between metal and torch, angle of torch and feed wire diameter in MIG welding of aluminum and steel alloys.

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