OPTIMIZATION OF WELDING PARAMETERS AND PROPERTIES OF ALUMINUM ALLOY ON THE WELD BEAD GEOMETRY

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Abstract
The present investigation is done effect of welding input parameters on weldbead geometry and mechanical properties. The main objective of present work is to study the effects of MIG process parameters such as Welding current, speed, wire feedrate, angle of torch and stand-off distance in welding Al 6061 alloy material and to optimize these parameters along with hardness property. Further, to investigation was done through design of experiments and to develop prediction model of bead geometry and hardness using regression and Artificial neural network methods. A comparative study.

From the present research work it can be concluded that developed models can be effectively used to predict the weld bead geometry and property within the range of parameters used. The parameters like torch angle, wire feedrate have got significant over front height where as other parameters has got more influence over back height. And the Front width and back width increases with increase in feedrate and welding current whereas when other parameter increases both widths of bead geometry decreases. The parameters angle of torch and standoff distance doesn't have effect over depth of penetration whereas depth of penetration increases has increase in wire feedrate and welding current and it declines when incline in welding speed. The hardness of weld bead is influenced by welding speed with greater extent and angle of torch has got less effect over hardness.

Keywords: MIG welding, Taguchi Technique, Response surface methodology, Forward Computing, Backward Computing, Welding inputparameters, Weld bead Characteristics.

INTRODUCTION

The industries like manufacturing, aeronautical, marine industries using various methods to join metals during repairing, production or fabrication process. But most commonly used method is welding, since its rapid availability and economic feasibility. Welding refers to joining of two metals of similar or dissimilar kind by heating up to melting point and allowing flow of molten metal of each to undergo integration and solidification process. During industrial revolution, a welding was in the form forge welding, later due to development of technology a various methods of welding was emerged to meet the challenges. Today, many methods of welding are available to name, Arc welding, Gas welding, Tungsten inert gas welding, Metal inert gas welding etc.

Overview of Metal Inert Gas Welding

In Metal inert-gas welding (MIG) an arc is generated between solid or flux cored wire electrodes and the base metal with protected shielding gas or gas mixture around a weld spot. Shielding gas protects weldbead from contaminated atmosphere which in turn affects properties of weld bead. Generally, a mixture of argon and carbon dioxide is usually used as shielding gas. The electrode wire is feed automatically from wire roll to work piece to generate a heat required for metal to undergo melting. The MIG welding is preferred over other due to following reasons;

- Due to continuous supply electrode a quality of weldbead can be produced.
- It can be used for both thin and thick work pieces in effective manner.
- It produces smooth, splatter free welded surfaces.
- It can be easily mechanized and can be adopted at higher speed with high-productivity, with low cost welding process, thus it can be used commercially for metals and as well as alloys.
- Deep weld penetration can be obtained which permits the use of small weld sizes for equivalent weld strengths in certain applications. It minimizes the post weld operations such cleaning slag of weld bead.

LITERATURE REVIEW

Zhang et al., [1,2] used dual torch welding method for Al 6061 to investigate cracking parameter by varying welding speed and reported that welding speed is effective towards centre of weld bead and increase of the welding speed a weld bead shows porous which results in decreasedstrength of material. The author made further effort to investigate crack sensitivity by carrying outexperiments using plasma arc welding one side and tungsten gas arc welding on other side of welding specimen. Finally, concluded that there is an improvement in crack sensitivity as compared to dual torch method. Further, author reported that using above welding methods a fine equiaxed grain structure are obtained which would increase some of the mechanical properties of weld bead. Themicrostructure of weld specimen in the welding resulted in a cast columnar at boundary and growthof nucleation structure is more towards centre of weld bead.

Z. Sterjovski et al., [3] Pulsed tandem gas metal arc welding is used for the fabrication of ship panels which produces minimum distortion with increase in productivity. From nondestructive test it was analyzed that solidification crackingoccurs at all levels of thickness and this is due to factors like depth to width ratio, plate thickness,and also reported that with nickel in weld pool crack sensitivity can be reduced.

M Dziuba-Kaluza et al., [4] made an effort to evaluate mechanical properties of 13CrMo4-5 and 14MoV6-3 steel welded joints after long-term service under creep conditions beyond the design worktime of 100,000 hours and their suitability for further service. and reported that the influence of long-term service on strength and plastic properties and on impact strength of tested material after long- term service under creep conditions beyond the design work time was determined and results are used in creation of materials characteristics that allow prediction of the life time of tested steels and their welded joints.

J Zhang et al., [5] studied the effect of temporal pulse shaping on the crack of the solidified welded joint in case Nd: YAG pulsed LASER weld for Al 6061-T6 aluminum alloy and it was predicated thatthe decrease in the ramp – down gradient of laser pulse cracking can be eliminated, further the author reported that a intermittent solidification cracking reoccurred when the gradient was further decreased. The solidification cracking susceptibility was also found to

increase with increasing peak power density of the main welding sector. Authors further stated that the width of the initial planar grain growth layer at the fusion boundaries, dendrites and cell spacing increased with decreasing ramp-down gradient.

Linga Raju and Narasa Raju [6] made an investigation to know effect of rotating electrode wire, voltage and current using pulsed MIG welding on weld bead geometry and reported that there is improvement in weld bead geometry and mechanical properties due to rotation of electrode, however it was noticed that there is decrease in depth of penetration. The further illustrated stated that by increasing voltage and current, the deposition of electrode wire increased.

K. Abbasi et al., [7, 8] has focused on weld bead geometrical changes and its shape factor as a result of changes in welding parameters. In his study reported that there is an increase in heat generated which intern increases the depth of penetration until the optimum welding speed and then the heat generated declines which in turn results in decreasing penetration due to further increase in welding speed. Author also mentioned that it improved in shape factor at higher welding speed and heat input. The author also worked on metal inert gas welding to study the effect of welding parameters on mechanical properties of Al 6061 material and reported that increasing inert gas flow rate pressure along with voltage simultaneously at constant gas pressure (230 bars) resulted in good weldbead and increase in strength of weld bead.

Sagar et al., [9, 10] made an effort to study influence of current, voltage and welding speed on Al 6061 on depth of penetration and tensile strength and reported that welding current is most significant factor compared to welding voltage and speed on tensile strength, depth of penetration and toughness. The author further stated that grain size has significant effect on material properties whereas the larger size of grain obtained caused loss in mechanical properties,with increase in hardness

Objective of the Study

The literature survey revealed that the various welding parameter are responsible for quality weldbead quality. The important parameters influencing the quality of weldbead are welding current, welding voltage, welding speed, wire feed rate, standoff distance, torch angle, gas flow rate, diameter of wire. Current and voltage have major influence on mechanical properties of weldbead in any metals or alloys. The Aluminum alloys have its own applications due its physical and mechanical properties. Now days, aluminum and its alloys are replacing conventional materials used in manufacturing mechanical components and there is a necessary to investigate further its metallurgical and mechanical properties along with weldbead geometry under various welding conditions. The most widely adapted method of welding aluminum is metal inert gas welding, where the weldbead can be protected from contaminants of air which could increases strength of material by shielding gas. So in this regard aluminum alloy Al 6061 had been considered for the investigation using MIG welding and the present research work is focused on following objectives.

- An investigation of the properties of metal inert gas welded element of aluminum alloy Al 6061-T6.

- Experimental investigation for welding aspects by design of experiments.
- Experimental investigation for effect of welding parameters such as Angle of torch, wire feedrate, standoff distance, welding speed and Current on hardness using design of experiments
- To investigate effect of welding parameters on weldbead geometry and hardness using. Taguchi and Response surface methodologies by adopting MIG welding technique.
- To optimization of welding parameters to achieve optimum bead quality.
- To develop input-output model relationship to predict optimized model.

METHODOLOGY

The present work conducted according to following phases to accomplishment the above mentioned objectives in the following paragraphs.

PHASE – I:

Step 1: Identification of all controlling parameters of MIG welding process which influence quality of the weld bead and investigating the behavior of these process parameters by conducting the experiments based on literature survey.

Step 2: Identification of acceptable working range of all MIG welding process parameters through literature survey and trial and error method and identified process parameters are:

1. Angle of torch (A)
2. Wire feedrate (W)
3. Standoff distance (SD)
4. Welding speed (S)
5. Welding current (I)

Step 3: Identification of output responses which are actually effect quality of weldbead of the MIG are

1. Back width (BW)
2. Back height (BH)
3. Front width (FW)
4. Front height (FH)
5. Depth of penetration (DOP)
6. Hardness (H)

PHASE – II:

Step 1: planning experiments by use of Taguchi technique for the design matrix for have been performed with selected parameters according design L32 suitable for 2 levels and 5 parameters.

Step 2: The conduction of experiments through RSM to measure accuracy using 3 levels 5 parameters for output responses

Step 3: Investigation of effect of each parameter along with interaction of each parameter in MIG welding responses.

Step 4: Optimization of MIG process parameters for enhanced weld bead quality. Prediction of optimal setting of MIG process parameters, prediction of optimal values of weld bead quality and to see these predictions are within±5% accuracy and a confidence level of 95%.

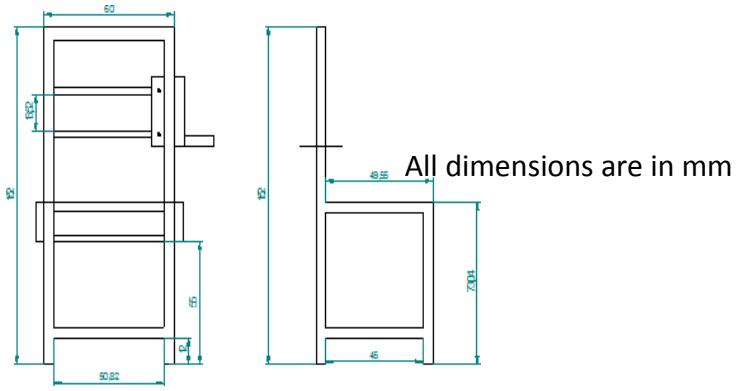
PHASE – III:

Step 1: Development of mathematical models of all weld bead geometry parameters and hardness using regression analysis.

Step 2: Development of mathematical models of all weld bead geometry parameters using artificial neural network.

EXPERIMENTAL SETUP

The literature revealed the MIG welding process parameters such as Angle of torch, wirefeedrate, diameter of wire, type of gas used, gas flow rate, welding speed, standoff distance and welding current and it was also noticed that wire diameter, gas flow rate and composition of gas doesn't have significance effect on weldbead geometry and mechanical properties. So, to vary allinput parameters are determined from objective an experimental fixture was fabricated. The main frame is the main chassis [Fig] and enhances the parameter control. This frame keeps the entire structure stable and provide welding gun guiding machine track for movement. which intern facilitates for welding speed and ang



torch adjustment. Below working table calibrated screw jack is provided for height adjustment along vertical direction of work piece

Fig - Design of main frame

The fixture [Fig. 6.2] is plate consisting of slots used to clamp the work piece A 15mm slots are provided in the work table in which strap clamp is assembled. The work table is capable of holding different sizes of work piece.

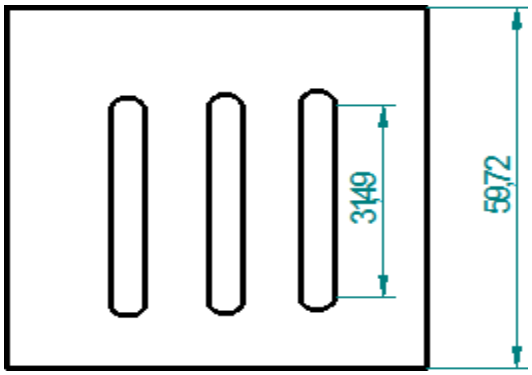


Fig - Work holding Fixture

RESULTS AND DISCCUSION

The main effect plot for S/N ratio based on data mean of Back height (Fig. 7.1) shows that a torch angle plays a significant role in decreasing of back height comparing to feed rate as their level increases, where as other welding parameters shows increase in back height as there level increases. The decrease in back height is because of torch angle increases because there is wide deposition of material compared to narrow direction. Increase in back height is due to fact that asstandoff distance increases there is sufficient gap for filler material to deposits more on base material, even as velocity and current increases the direction of welding makes more filler material to deposit in narrow Contour. From Table it clearly exhibits that angle of torch has got significant effect over back height and wire feedrate is least responsible for output.

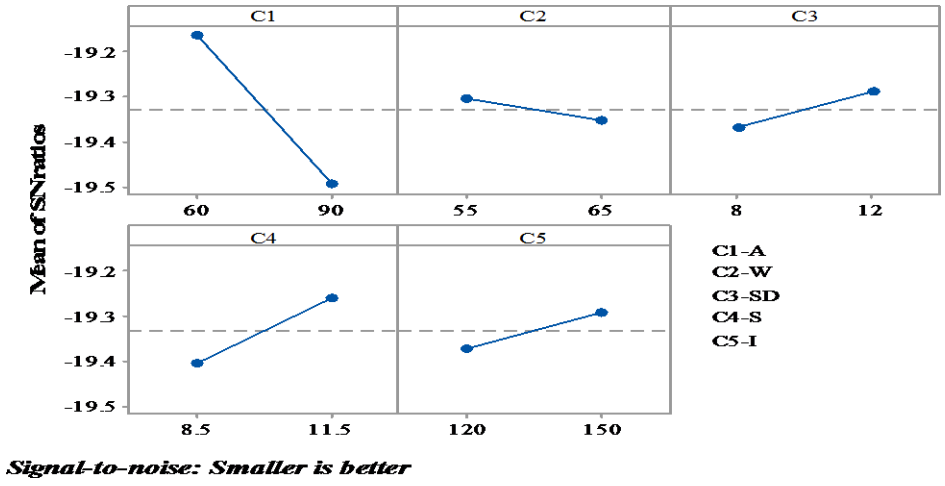


Fig - Main effect plot of S/N ratio of Back height

Table- Response table of Back height

Level	A	W	SD	S	I
1	-19.16	-19.31	-19.37	-19.40	-19.37
2	-19.50	-19.35	-19.29	-19.26	-19.29
Delta	0.33	0.05	0.08	0.14	0.08
Rank	1	5	4	2	3

CONCLUSION

The objective of present study is to develop a better understanding of the effect of MIG welding parameters on Weld bead and Mechanical properties. So in this regard a research in two above mentioned areas has been carried out to achieve following objectives:

- An investigation of the properties of metal inert gas welded element of aluminum alloy Al 6061-T6.
- Experimental investigation for welding aspects by design of experiments.
- Experimental investigation for effect of welding parameters such as Angle of torch, wire feedrate, standoff distance, welding speed and Current on hardness using design of experiments
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