International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor (2018): 7.426

A Review on the Parametric Optimization in MIG Welding using Taguchi Method

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Abstract: ***In the contemporary, MIG welding has wide industrial applications. Parameters utilized in MIG plays a significant role in overall quality, productivity, duration as well as cost of welding. This paper throws light on the influence of welding parameters like welding current, welding voltage, gas flow rate, wire feed rate etc. on the weld strength of Medium Carbon Steel material during welding. By the use of DOE method, the parameters can be optimized to ascertain the best possible combination to achieve desirable quality. Taguchi technique has been used to plan the set of experiments and acquiring the data. An orthogonal array, Signal to Noise Ratio(S/N) and ANOVA is utilized to investigate the welding characteristics of Steel and thereby attaining the welding parameters which gives out desirable result. The confirmation test compares the predicted values with the experimental values to confirm the effectiveness in the analysis of weld strength.***

Keywords: MIG welding, Welding parameters, Taguchi technique, ANOVA, Steel

1. Introduction

Metal Inert Gas (MIG) welding is a process in which metal electrode is continuously fed from the welding gun, joining two base materials together. It is to be noted that a shielding gas is used which prevents the weld pool from contamination by the atmosphere. There is no requirement of filler metal, as the metal electrode in wire form itself provides the subsequent arc as well as filler metal. MIG welding consists of heating, melting and solidification of parent metals and a filler material in localized fusion zone by a transient heat source to form a weld joint between the parent metal [1].

MIG welding can be done in three different ways

1) Semi-Automatic Welding - The gun is controlled by the operator, while the equipment monitors the electrode wire feed.
2) Machine Welding - The gun is connected to a manipulator, and the operator sets and adjusts the control which moves the manipulator.
3) Automatic Welding - It consists of the equipment which performs welding without constant adjustment of the operator, as it utilizes sensing devices which automatically monitors the correct gun alignment.

1.1 Working Principle

As shown in fig. the electrode is used in the form of coil which is continuously fed towards the work, and there is subsequent supply of inert gas to prevent atmospheric contamination. The gas supplied gets ionized to form an arc between electrode and work piece, resulting in smooth welding.

Continuous welding results in higher metal deposition rate as well as high welding speed. The filler wire is connected to positive polarity while work piece is connected to negative polarity.

The power source is generally constant voltage DC source, with electrode positive which yields quite stable arc and smooth metal transfer with minimum least spatter for the entire current range. It is to be noted that the gas shield around the weld pool does not get ionized, hence preventing weld against surface oxidation and further contamination. [2]

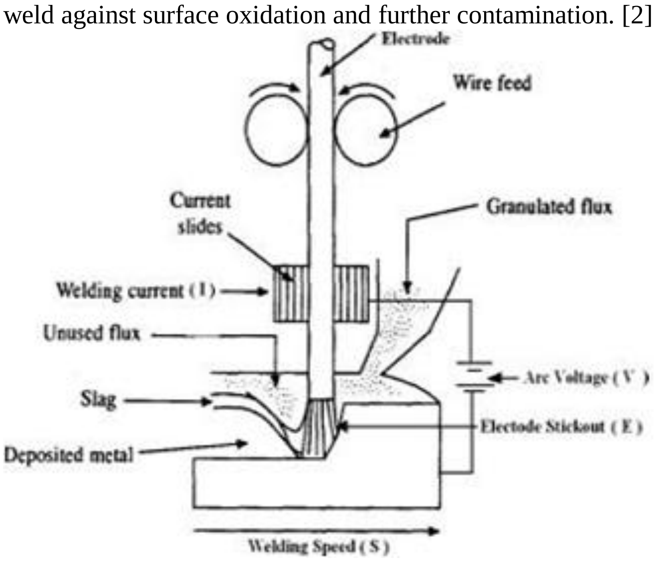

Figure 1: MIG Welding

1.2 MIG Welding Parameters

1. Welding Voltage - It is one of the most dominant parameter which determines the welding. Keeping all the process parameters constant, arc length is directly related to arc voltage. Moreover, high as well as low voltage causes unstable arc. Excessive voltage causes the formation of spatter while low voltage causes overlapping at the edges of the weld bead. Voltage to be used depends upon the base metal thickness, type of weld joint etc.

2. Welding Current - The value of welding current greatly determines deposition rate, weld bead size as well as degree of penetration. Generally, metals are welded with direct

current polarity electrode (DCEP, opposite to TIG welding), as it provides to the work piece, thereby providing desirable penetration. Keeping all other parameters constant, increasing the current will increase the width as well of depth of weld penetration.[3]

3. Gas Flow Rate - GFR is also an important factor which determines the welding obtained in MIG. Depending upon material to be welding, gas flow rate is adjusted.

4. Welding Speed - It is the rate at which the arc travels along the work piece. It is controlled by the welder in semiautomatic welding. It is to be noted that the effects of welding speed is similar to voltage. The penetration is maximum (depends upon base metal) at a particular value and decreases as the speed is varied. For a constant current, slower speed provides larger bead and higher heat input to the base metal due to higher heating time.

5. Electrode Size - It influences the weld bead configuration, bead width, and has a significant effect on travel speed of welding. To attain maximum deposition rate at a given current, wire with less diameter ensures necessary penetration, while larger diameter electrodes results in weld with less penetration (but more thick welds).[4]

2. Literature Review

Izzatul aini Ibrahim, et.al performed various experiments in the effects of different parameters on welding penetration, hardness measurement. The variable parameters are voltage, current and welding speed. In the experiment, AISI 1045 was used, ER70S wire electrode with work distance of 12 mm. In the fig, effect of welding current on penetration was present in welding speed as 20 cm/min and the value was increased by increasing the value of welding current. The highest penetration was observed 2.98mm at 22V and 210A. For constant speed of 40 cm/min, penetration of 3.26 mm is observed at 22V and 210A.[5]

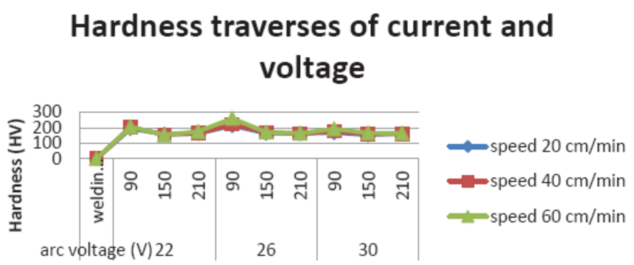

Figure 2: Penetration versus welding current and voltage

Omar Bataineh, et.al identified and optimized the main factors that have significant effect on weld joint strength through factorial design experiments. Welding experiments were carried out using MIG welding , Aluminum 1070 was used and ER1100 filler wire 1.2mm diameter was selected with argon gas. The size of specimen was 100mm*50mm*8mm.

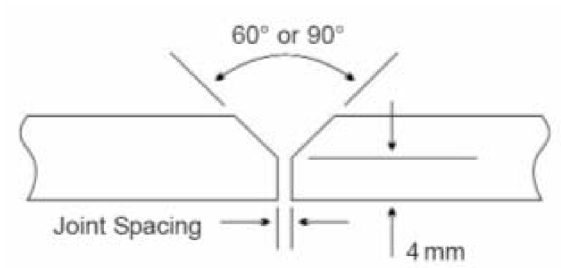

Figure 3: Joint geometry for the welded specimens

Results by factorial design experiment and ANOVA revealed that voltage and filler feed rate are most significant factors of the observed parameters. Optimal setting of arc voltage and filler feed rate were obtained using regression analysis at 24V, 7in/s at which weld bead strength is maximum.[6]

G.Haragopal , et.al optimized the mechanical properties of weld specimen for aluminum alloy (Al-65032) , which is generally used for construction of aerospace wings. The process parameters which were used for the experiments were gas pressure, current, groove angle and preheat temperature. L9 orthogonal array was used to conduct experiments to ascertain the most favorable parametric combination. Signal to noise ratio for each quality(S/N) ratio for each quality characteristic was calculated, and thus optimum input parameters for each run are obtained. A confirmation test was also conducted at optimum conditions to ensure correctness of analysis.[7]

Salawadagi sushant , et al, investigated the effects of welding parameters like current, voltage, speed and weld plate angle of stress occurring in mild steel plates during the process of welding. FEM analysis in Butt Welding was found out with ANSYS software. The optimum conditions were found out by different combination of welding parameters. The welding parameters of specimen for minimum residual stress(327MPa) were current 180A, voltage 23V, welding speed 428.4mm/min, weld plate angle 90 obtained. The impact strength of the weld specimens were checked by Charpy test. The impact strength of weld was improved by 31.42%.[8]

K.Srinivasulu Reddy investigated the weld parameters in submerged arc welding, concluding that weld quality affected by parameters are closely related to the geometry of the weld bead, a relationship which is thought to be complicated due to non-linear characteristics. Semi-automatic SAW machine was used to carry out welding on mild steel 1060 plates. Input parameters were current, voltage, electrode stick out, while output response being penetration and hardness. By this, an attempt was made to minimize the weld bead width and maximize the penetration, and developing artificial neutral network (ANN) models to predict the weld bead properties accurately along with sensitivity analysis was also one of the major objectives to determine optimal parameters. The optimized results were compared to the experimental results. Modular network model accurately predicts and depicts that current, weld reinforcement and bead hardness are sensitive to electrode stick out, while depth of penetration is sensitive to welding speed.[9]

3. Design of Experiment (DOE)

DOE is a technique introduced by R.A. Fisher in 1920. It is basically used to study the effects of multiple variables simultaneously. The collaboration of DOE with Taguchi proves to be efficient to ensure desired optimization. By this technique, scientists and researchers significantly reduced the time required for experimental investigations. DOR is also efficient to combine the factors at distinct levels, each with respective range, and yet ascertain minimum variation around the optimized results.

ANOVA stands for Analysis for Variance, and is used for the analysis for assessment of each input parameter on response parameter.[10]

Table 1: L9 Orthogonal Array

experiment	parameter 1	parameter 2	parameter 3
1	L1	L1	L1
2	L1	L2	L2
3	L1	L3	L3
4	L2	L1	L2
5	L2	L2	L3
6	L2	L3	L1
7	L3	L1	L3
8	L3	L2	L1
9	L3	L3	L2

4. Conclusion

There are many research conducted on MIG welding, and accessing the optimal process parameters can take a lot of time of a researcher, but with the collaboration of DOE and Taguchi, the most significant process parameters can easily be identified and hence optimal response parameters can be achieved. Welding current, voltage, gas flow rate, wire feed rate, diameter of electrode etc. are some of the important process parameters in MIG welding, in which welding current and voltage being the most significant. They affect the weld quality in terms of mechanical properties and weld bead geometry. Welding current is directly propotional to the depth of penetration. The Taguchi method is an influential tool for improving the output response during research and development, resulting in better quality products in minimum time and cost. We can say the collaboration of DOE with optimization of control parameter to find the best results is achieved in this method. Moreover, the purpose of ANOVA is to determine which input parameters significantly affect the quality as well to estimate optimum results.

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Author Profile

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