Optimization of Parameters for Gas Metal Arc Welding on Mild Steel by using Taguchi's Method

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Abstract— Gas metal arc welding can be defined as a fusion welding process having wide range of applications in the industry. In this process proper selection of input welding parameters are necessary in order to obtain good quality of weld with good tensile strength and increase the productivity of the process. In order to obtain a good quality of weld of high tensile strength, it is necessary to control the input welding parameters. In this research work, experiments were carried out on mild steel plates using gas metal arc welding process. Taguchi method is used to formulate the experimental design. The exhaustive survey suggests that some control factors viz. arc voltage, welding current and Root Gap. Finally the conformations tests have been carried out to and experimental and predicted values are compared. A series of experiments based on Taguchi technique has been used to acquire the data. An Orthogonal array, signal to noise (S/N) ratio are employed to investigate the welding characteristics of Mild steel of material & optimize the welding parameters.

Key words: Gas Metal Arc Welding, Welding Electrode, MIG Welding, Optimization, Welding Current, Root Gap, Arc Voltage, S/N Ratio

I. Introduction

Gas metal arc welding is the process in which the source of heat is an arc formed between a consumable metal electrode and the work piece, and the arc and the molten puddle are protected from contamination by the atmosphere (i.e. oxygen and nitrogen) with an externally supplied gaseous shield of inert gas such as argon, helium or an argon-helium mixture. No external filler metal is necessary, because the metallic electrode provides the arc as well as the filler metal. It is often referred to in abbreviated form as MIG welding.MIG welding was primarily developed as a high current density, smaller diameter metal electrode process with argon shielding for welding aluminum. Hence the term MIG was appropriate, and the process was equally applicable to deoxidized copper and silicon bronze. But when it was extended to the welding of ferritec and austenitic steels, addition of 1-2% oxygen to argon was found necessary to get smooth metal transfer. Later it was established that mild steel could be welded using 100% carbon dioxide (CO_2) or argon - CO_2 mixture as a shielding gas. Since these gases are not the inert, the process came to be termed as MIG/ CO_2 or of metal active gas, in which active gas refers to argon-oxygen, carbon dioxide and argon-CO_2 mixture, which are chemically reactive and not inert.The American Welding Society refers to the process as Gas Metal Arc Welding and has given it the letter designation GMAW. This term appears simpler because it covers inert as well as active shielding.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. Originally developed for welding aluminum and other non-ferrous materials in the 1940s, GMAW was soon applied to steels because it allowed for lower welding time compared to other welding processes. The cost of inert gas limited its use in steels until several years later, when the use of semi-inert gases such as carbon dioxide became common.

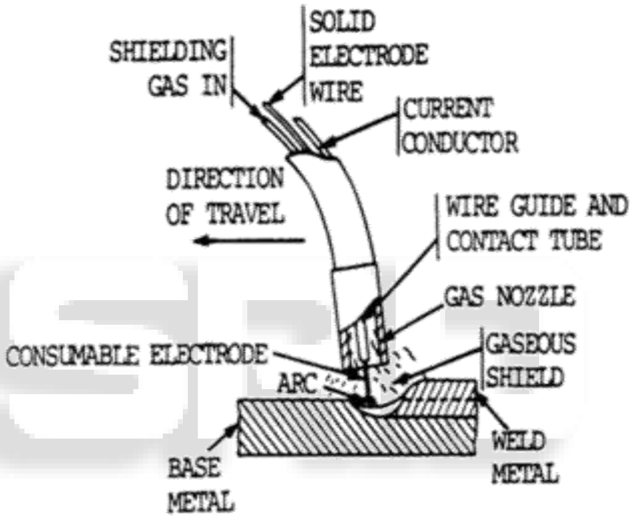

Fig 1: Basic diagram of Gas Metal Arc Welding

Further developments during the 1950s and 1960s gave the process more versatility and as a result, it became a highly used industrial process. Today, GMAW is the most common industrial welding process, preferred for its versatility, speed and the relative ease of adapting the process to robotic automation. The automobile industry in particular uses GMAW welding almost exclusively. Unlike welding processes that do not employ a shielding gas, such as shielded metal arc welding, it is rarely used outdoors or in other areas of air volatility. A related process, flux cored arc welding, often does not utilize a shielding gas, instead employing a hollow electrode wire that is filled with flux on the inside. Welding is the most common method used for joining materials. When compared to other joining processes, such as riveting or bolting, welded structures tend to be stronger, lighter-weight and cheaper to produce. There are over 80 different welding processes that can be employed, but GMA welding is the most commonly used process today.

The initial development of GMA welding during the late 1940s focused on joining reactive metals such as aluminum and magnesium. These metals were difficult to join with the standard Shielded Metal Arc (SMA) welding process of the time because they oxidized readily with the

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decomposition products of the flux that coated the finite-length metal electrodes. The GMA welding process differed significantly with its use of continuously fed spools of electrode wire and argon gas as shielding to protect the molten metal from chemical reactions. High production rates, ease of use, and good weld quality became apparent quickly, and soon it was being used for the joining of mild steel. As the popularity of the process grew, so did finding ways to improve it. One of the first critical steps involved refining the electrical power supply characteristics for self-regulating arc characteristics unique to this process.

The process is known by different names, such as MIG (metallic inert gas), CO2 welding (when a carbon dioxide gas shield is employed), metal active gas welding and, in the USA, gas metal-arc welding. In the UK, the most widely accepted name is MAGS (metal arc gas-shielded welding) because this term covers shielding gases other than inert gases, and also gas mixtures.

MIG welding is operated in semiautomatic, machine, and automatic modes. It is utilized particularly in high production welding operations. All commercially important metals such as carbon steel, stainless steel, aluminum, and copper can be welded with this process in all positions by choosing the appropriate shielding gas, electrode, and welding conditions.

II. PROCESS

The key pieces of equipment are the power source, the wire feeding mechanism, the welding torch, and the work piece. The process uses a continuous metal wire electrode coiled on a spool that is fed through the wire feeder to the welding torch. At this point, the electrical current from the power source is transferred to the electrode through the contact tip. The wire then encounters the electric arc. The arc is maintained between the electrode and the work piece and is controlled by the welding power source. The heat produced from the arc melts both the work piece and the electrode, creating a molten weld pool. Because the process is travelling along the work piece, the weld pool solidifies once it is out of the heating influence of the arc. This describes a bead-on-plate weld, used extensively in research to analyze certain aspects of the process and resulting microstructure. In real applications, however, welding is overwhelming used to join two or more separate pieces of metal to form one continuous structure. Completed Weld Gas Shielding Nozzle Contact Tip Work piece Arc Droplets Power Supply Weld pool Wire Feeder Electrode Wire Travel Direction Welding Torch Electrode Spool Gas Shielding Looking closer at the arc region, molten drops produced at the end of the electrode are transferred across the arc into the weld pool. The droplets can be transferred in a variety of ways and this detail of GMA welding is of primary importance in the current study.

A. *Process Parameters*

1) Welding Current: On a standard GMA welding machine, voltage and arc length are often used interchangeably, but they are different. For a given welding setup, voltage and arc length vary in similar ways. However, for a given voltage, the arc length will change with shielding gas, current, and electrode extension. If all other variables remain constant, an increase the voltage setting will increase arc length. Voltage is a key element during process monitoring. Voltage does not play a significant role in the forces acting on droplets.
2) Arc Voltage: During GMA welding, current is roughly proportional to the wire feed speed (WFS). It is one of the main inputs for current density and has a large influence on the magnitude of Lorentz forces. Current also contributes significantly to the resistive heating of the electrode extension
3) Root gap: the gap between the tourch and the workpiece is root gap

III. TAGUCHI'S EXPERIMENTAL DESIGN METHOD

Taguchi's comprehensive system of quality engineering is one of the great engineering achievements of the 20^{th} century. His methods focus on the effective application of engineering strategies rather than advanced statistical techniques. It includes both upstream and shop-floor quality engineering. Upstream methods efficiently use small-scale experiments to reduce variability and remain cost-effective, and robust designs for large-scale production and marketplace. Shop-floor techniques provide cost-based, real time methods for monitoring and maintaining quality in production. The a quality method is applied, the greater leverages it produces on the improvement, and the more it reduces the cost and time. Taguchi's philosophy is founded on the following three very simple and fundamental concepts.

– Quality should be designed into the product and not inspect into it. Quality is the best achieved by minimizing the deviations from the target. The product or process should be so designed that it is immune to uncontrollable environmental variables.
– The cost of quality should be measured as a function of deviation from the standard and the losses should be measured system-wide.

Taguchi's proposes an "off-line" strategy for quality improvement as an alternative to an attempt to inspect quality into a product on the production line. He observes that poor quality cannot be improved by the process of inspection, screening and salvaging. No amount of inspection can put quality back into the product. Taguchi recommends a three-stage process: system design, parameter design and tolerance design. In the present work Taguchi's parameter design approach is used to study the effect of process parameters on the surface roughness of CNC turning process.

IV. RESULTS

In this experimental work, the specimen is welded at three different levels of welding parameter i.e. current, voltage and root gap as shown in table 1.

Parameters	Welding Current(A)	Arc Voltage (B)	Root Gap (C)
Unit	Amp	Volt	mm
Level 1	140	35	2
Level 2	160	40	3
Level 3	180	45	4

Table 1: Welding parameter and their levels

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The working ranges of welding parameter were fined by conducting trial run and satisfactory values obtained are used to conduct the experimental work. L9 orthogonal array is used for analysis purpose and standard table of three variables with three different levels of input parameters is shown in table 3 and actual value of selected input parameter arc shown in table 4.

Experiment Number	Welding Current (Amp.)	Arc Voltage (Volt.)	Root Gap (mm)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 3: L9 Orthogonal Array Design Matrix

Exp. no	Welding current (AMP.)	Arc voltage	Root gap(mm)	Tensile strength (mpa)	s/n ratio
1	140	35	2	347.9	50.8291
2	140	40	3	335.4	50.5113
3	140	45	4	429.0	52.6491
4	160	35	3	341.8	50.6754
5	160	40	4	328.0	50.3175
6	160	45	2	339.4	50.6142
7	180	35	4	482.2	50.6645
8	180	40	2	375.6	50.4945
9	180	45	3	351.1	50.9086

Table 4: tensile strength and s/n ratio

V. CONCLUSIONS

The mild steel 1018 was used for the present study to explore the different input process parameters on the tensile strength and hardness of the weld samples. The L9 orthogonal has been used to assign the identified parameters. ANOVA analysis was performed for the analysis purpose which shows that current is the most significant parameters that influenced the tensile strength and hardness of the weld. The highest tensile strength obtained in the research is 482.2 at current (180 amp), voltage (35 volt) and root gap (4 mm) at a welding current of 210 amp, The maximum hardness is obtained at a welding current (180 amp), arc voltage (40 volt) and root gap (3 mm). The results of the structures of microstructure of weld metal of mild steel represents a fine grains of Ferrite and Pearlite. No formation of Martensite takes place. So according our results we can conclude that our weldments have lower hardness because both pearlite are soft constituents.

REFERENCES

[1] Juang SC, Tarng YS.(2002), "Process parameter selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel". J Mater Process Technol 122, 33-37.
[2] G. Taguchi(1990), "Introduction to quality Engineering", Asian Productivity Organisation, Tokyo.
[3] G.S.Peace(1993), "Taguchi Methods: A hand-on Aproach, Assison- Wesley", Reading, M.A.
[4] K. Suresh Kumar, G. Phani Kumar, P. Dutta, K. Chattopadhyay(2002), "Microstructural development of Dissimilar Weldments: Case of MIG Welding of Cu with Fe filler", Journal of Materials Science, Vol. 37, pp. 2345-2349.
[5] G.Haragopal, PVR Ravindra Reddy, G Chandra Mohan Reddy, J V Subrahmanyam(2011), "Parametric design for MIG welding of Al- 65032 alloy using Tagauchi Method" Journal of Scientific and Industrial Research, Vol. 70, pp.844 – 850.
[6] S.V.Sapakal, M.T. Telsang(2012), "Parametric Optimization of MIG Welding Using Taguchi Design Method", International Journal of Advanced Engineering Research and Study, Vol. 1, pp.28-30.
[7] "Welding Process and technology" R.S.Parmar, Khanna Publishers, ISBN No. 81-7409-126-2.
[8] "A Course in workshop technology", B.S. Raghuwanshi, Dhanpat Rai & Co. 2008 Edition.
[9] "A Text book of Welding Technology", O.P.Khanna, Dhanpat Rai Publications, Edition 2005.