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Investigation of Process Parameters on Strength of Welding Joint in GMAW

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Abstract: *The strength value most desired in any welding process is an excellent Ultimate Tensile Strength (UTS) of the weld, compared with the parent metal. Process parameters applied during the welding process ought to be subjected to continuous scrutiny and assessment because of the ever increasing demand for structural and industrial materials with weld joints possessing higher strength values. This study is intended to investigate the inadequacies of existing GMAW welding process parameters utilized by the investigated industrial firm in its signature welding protocol, by suggesting alternative, uniquely crafted, and improved process parameters to replace its existing signature welding protocol, thereby improving the weld results by attaining higher UTS. These suggested process parameters were thereafter subjected to reported literature, following which optimization was achieved by employing the Taguchi Method. Then in future work we will study the strength on universal testing machine and calculating the results.*

Keywords: GMAW.

I. Introduction

Metal Inert Gas welding as the name suggests, is a 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 is an arc welding process where in coalescence is obtained by heating the job with an electric arc produced between work piece and metal electrode feed continuously. A metal inert gas (MIG) welding process 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 joint between the parent metals. Gas metal arc welding is a gas shielded process that can be effectively used in all positions.

GMAW can be done in three different ways

1. **Semiautomatic Welding** - equipment controls only the electrode wire feeding. Movement of welding gun is controlled by hand. This may be called hand-held welding.
2. **Machine Welding** - uses a gun that is connected to a manipulator of some kind (not hand-held). An operator has to constantly set and adjust controls that move the manipulator.
3. **Automatic Welding** - uses equipment which welds without the constant adjusting of controls by a welder or operator. On some equipment, automatic sensing devices control the correct gun alignment in a weld joint.

1.1 Working Principle of MIG Welding

As shown in fig. the electrode in this process is in the form of coil and continuously fed towards the work during the process. At the same time inert gas (e.g. argon, helium, or CCCC) is passed around electrode from the same torch. Inert gas usually argon, helium, or a suitable mixture of these is used to prevent the atmosphere from contacting the molten metal and HAZ. When gas is supplied, it gets ionized and an arc is initiated in between electrode and work piece. Heat is therefore produced. Electrode melts due to the heat and molten filler metal falls on the heated joint.

The arc may be produced between a continuously fed wire and the work. Continuous welding with coiled wire helps high metal depositions rate and high welding speed. The filler wire is generally connected to the positive polarity of DC source forming one of the electrodes. The work piece is connected to the negative polarity. The power source could be constant voltage DC power source, with electrode positive and it yields a stable arc and smooth metal transfer with least spatter for the entire current range.

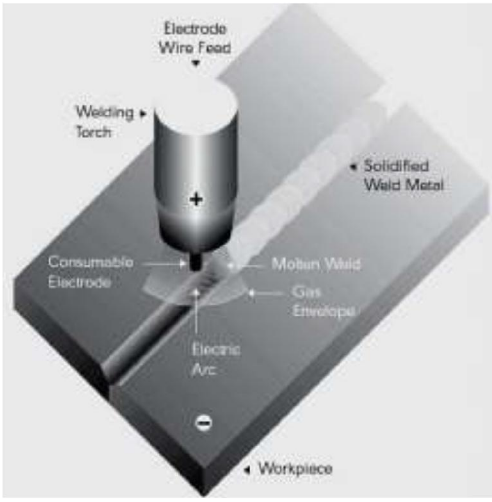


Figure 1: Basic working principle

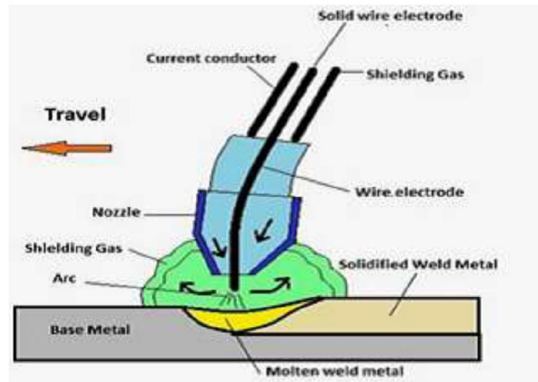


Figure 2: Schematic of GMAW

The gas shield around it does not ionized, which prevents weld against atmospheric co contamination and surface oxidation. Some torch has water cooling systems. MIG welding is also called Gas Metal Arc Welding. The filler metal is transmitted from electrode to joint by different methods. It is dependent on the current passing through the electrode and voltage.

1.2 GMAW / MIG Welding Applications

MIG may be operated in semiautomatic, machine, or automatic modes. All commercially important applicable metals such as carbon steel, high-strength, low-alloy steel, and stainless steel, aluminum, copper, titanium, and nickel alloys can be welded in all positions with this process by choosing the appropriate shielding gas, electrode, and welding variables.

1.3 MIG Welding Effecting Parameters

Weld quality and weld deposition rate both are influenced very much by the various welding parameters and joint geometry. Essentially a welded joint can be produced by various combinations of welding parameters as well as joint geometries. These parameters are the process variables which control the weld deposition rate and weld quality. The weld bead geometry, depth of penetration and overall weld quality depends on the following operating variables.

- Electrode size, Welding current, Arc voltage
- Arc travel speed, Welding position
- Gas Flow rate, Shielding Gas composition
- Electrode extension (length of stick out)

1.4 Electrode Size

The electrode diameter influences the weld bead configuration (such as the size), the depth of penetration, bead width and has a consequent effect on the travel speed of welding. As a general rule, for the same welding current (wire feed speed setting) the arc becomes more penetrating as the electrode diameter decreases. To get the maximum deposition rate at a given current, one should have the smallest wire possible that provides the necessary penetration of the weld. The larger electrode diameters create weld with less penetration but welder in width. The choice of the wire electrode diameter depends on the thickness of the work piece to be welded, the required weld penetration, the desired weld profile and deposition rate, the position of welding and the cost of electrode wire. Commonly used electrode sizes are (mm): 0.8, 1.0, 1.2, 1.6 and 2.4. Each size has a usable current range depending on wire composition and spray- type arc or short- circuiting arc is used. [7]

1.5 Welding Current

The value of welding current used in MIG has the greatest effect on the deposition rate, the weld bead size, shape and penetration. In MIG welding, metals are generally welded with direct current polarity electrode positive (DCEP, opposite to TIG welding), because it provides the maximum heat input to the work and therefore a relatively deep penetration can be obtained. When all the other welding parameters are held constant, increasing the current will increase the depth and the width of the weld penetration and the size of the weld bead.

1.6 Welding Voltage

The arc length (arc voltage) is one of the most important variables in MIG that must be held under control. When all the variables such as the electrode composition and sizes, the type of shielding gas and the welding technique are held constant, the arc length is directly related to the arc voltage. High and low voltages cause an unstable arc. Excessive voltage causes the formation of excessive spatter and porosity, in fillet welds it increases undercut and produces narrower beads with greater convexity, but an excessive low voltage may cause porosity and overlapping at the edges of the weld bead. And with constant voltage power source, the welding current increase when the electrode feeding rate is increased and decreased as the electrode speed is decreased, other factors remaining constant. This is a very important variable in MIG welding, mainly because it determines the type o metal transfer by influencing the rate of droplet transfer across the arc. The arc voltage to be used depends on base metal thickness, type of joint, electrode composition and size, shielding gas composition, welding position, type of weld and other factors.

1.7 Shielding Gas

The primary function of shielding gas is to protect the arc and molten weld, pool from atmosphere oxygen and nitrogen. If not properly protected it forms oxides and nitrites and result in weld deficiencies such as porosity, slag inclusion and weld embrittlement. Thus the shielding gas and its flow rate have a substantial effect on the following: Arc characteristics, Mode of metal transfer, penetration and weld bead profile, speed of welding, cleaning of action, weld metal mechanical properties. Argon, helium and argon-helium mixtures are used in many applications for welding non-ferrous metals and alloys. Argon and Carbon dioxide are used in Carbon steel. [7]

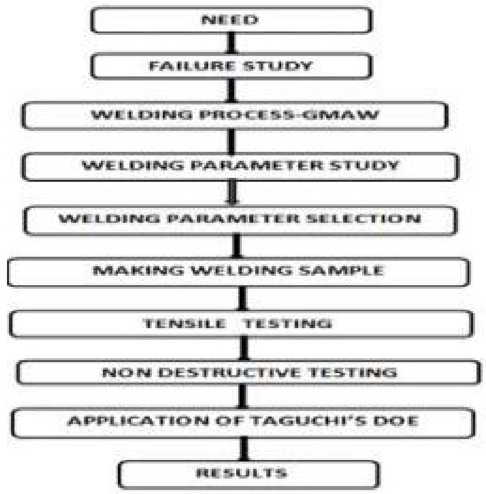
1.8 Arc Travel Speed

The travel speed is the rate at which the arc travels along the work- piece. It is controlled by the welder in semiautomatic welding and by the machine in automatic welding. The effects of the travel speed are just about similar to the effects of the arc voltage. The penetration is maximum at a certain value and decreases as the arc speed is varied. For a constant given current, slower travel speeds proportionally provide larger bead and higher heat input to the base metal because of the longer heating time. The high input increases the weld penetration and the weld metal deposit per unit length and consequently results in a wider bead contour. If the travel speed is too slow, unusual weld build-up occurs, which causes poor fusion, lower penetration, porosity, slag inclusions and a rough uneven bead. The travel speed, which is an important variable in MIG, just like the wire speed (current) and the arc voltage, is chosen by the operator according to the thickness of the metal being welded, the joint fit-up and welding position.

II. Objective

- By selecting optimized welding parameter, improving the tensile strength of pipe joints welded by using Gas metal arc welding
- To reduce the cracking
- To reduce the porosity due to improper welding parameter
- To improve welding fusion
- To avoid oxidation
- To improve appearance
- To improve welding quality

III. Experimental Procedure



3.1 Material

The material used for Gas metal arc welding (GMAW) is EN8 steel. The entire specimens were machined into the dimensions of 200mm long x 75mm x 10 mm thick. This metal had very good welding characteristics and could be welded by all of the common welding techniques.

Mechanical Properties

Tensile Strength -465 (N/mm2)

% Elongation-16% min

Hardness(HV) -201-255 BHN

3.2 Welding Machine

This sections provides the important specifications of the tool used in the welding process

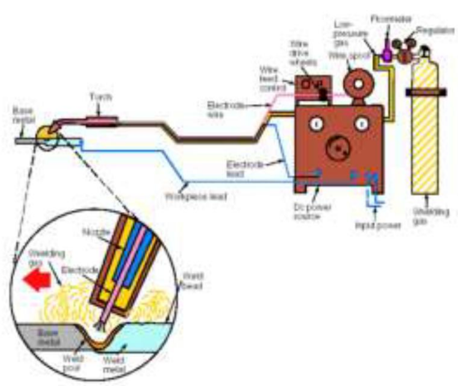


Figure 3: Gas Metal Arc Welding M/C

3.3 Welding Process Parameter Selection

Based on literature review following is the range selected for three process parameter

TABLE I

Process parameter	**Process Designation**	**Level 1**	**Level 2**	**Level 3**
Welding Current(Amp)	A	180	210	240
Arc Voltage (volts)	B	24	27	30
Wire Feed Rate (m/min)	C	2	3	4

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IV. Results and Discussion

Microscopic Study

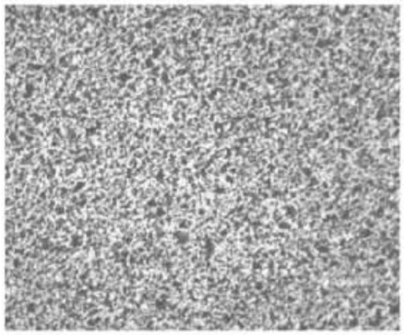

Figure 4: Microstructure of base metal

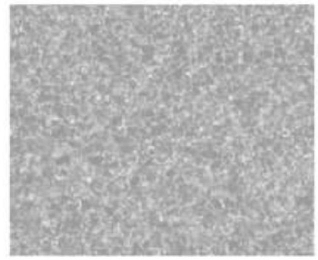

Figure 5: Microstructure of Heat Affected Zone

TABLE II: Experimental result for UTS and S/N ratio

Welding current (amp)	Arc voltage (voltage)	wire feed rate (M/min)	Tensile strength (Mpa)	S/N ratio
180	24	2	255.500	48.1478
180	27	3	2693270	48.6038
180	30	4	375.130	51.4836
210	24	3	358.000	51.0777
210	27	4	395.750	51.9484
210	30	2	455.250	53.1650
240	24	4	218.875	46.8039
240	27	2	363.625	51.2131
240	30	3	470.740	52.0145

TABLE III: S/N response table for UTS

Level	Welding current (amp)	Arc voltage (voltage)	Wire feed rate (M/min)
1	49.41	48.68	50.81
2	52.06	50.59	50.84
3	50.28	52.49	50.08
Delta	2.62	3.82	0.76
Rank	2	1	3

TABLE IV: Result of annova for UTS

Symbol	Parameter	DOF	Sum of sq.	Mean	F	%
A	I	2	10.965	5.483	2.11	32.26
B	V	2	21.841	10.920	4.21	64.37
C	W	2	1.157	0.597	0.22	3.36
Error		2	5.191	2.595		0.01
Total		8	39.154			100

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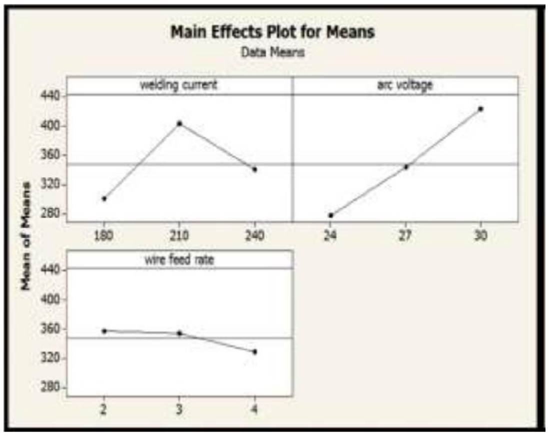

Figure 6: Main effect plot for means

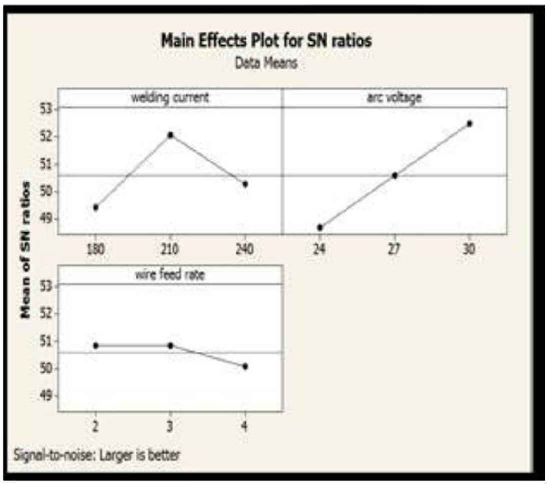

Figure 7: Main effect plot for SN ratios

V. Conclusion

The following conclusions, from the experiential investigation can be made about the welding parameter and their influence on strength of weld and its quality From results of present experimental investigation and by doing Taguchi analysis the following conclusions are drawn

Optimal Parameter are- A2B3C2 that are as follows
Level 2 welding current 210 amp
Level 3 arc voltage 30 volt
Level 2 wire feed rate 3 m/min
From Annova analysis for UTS It is found that arc voltage has 64.37 % influence on tensile strength of welded joint

VI. Future Scope

This study does not indicate for the other types of welding process as well as other types of welding process parameter. However one can pay attention to different material, filler material and applications in different areas.

VII. Acknowledgment

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