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EXPERIMENTAL STUDY ON PRODUCTIVITY OF THE GAS METAL ARC WELDING (GMAW)

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Abstract

GMAW welding parameters are the most important factor affecting the quality and productivity. Cost of welded product, weld bead size, shape and penetration depend upon various parameters. Lots of research work has been done regarding the effect of variables on the process. In order to increase the productivity of any ferm, which is the very first objective of any organisation. So, studying the various input parameters affecting the productivity will greatly influence the development of organization. welding process parameter on the weldablity of mild steel having dimension 150mm X 40mm X 5mm, welded by metal inert gas welding were investigated. The quality of the welded joint are directly influenced by input parameter that's why specifically three input parameter which are welding current, welding voltage, gas flow rate. Each parameter is varied simultaneously keeping the others constant. The amount of filler metal deposited at the welded portion is examined after complete process. Time required for welding in also recorded for each sample. Maximum metal deposition in minimum time gives the maximum productivity.

Index Terms: GMAW**,** welding current, welding voltage, gas flow rate.

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1. INTRODUCTION

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 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.

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. A wide range of materials may be joined by Gas metal arc welding, similar Metals, dissimilar metals, alloys, and non-metals. GMAW welding is used because of its advantages over other welding techniques like high welding speeds. Less distortion, no slag removal required, high weld metal deposition rate, high weld quality, precise operation, etc.

The research on parameter optimization of different types of welding for obtaining various responses in output have been done by a number of researchers using a wide range of materials. They make use of various types of methods, techniques and mathematical models for evaluating and obtaining results. Many researches' have been done research work on different materials for obtaining maximum yield strength and tensile strength.

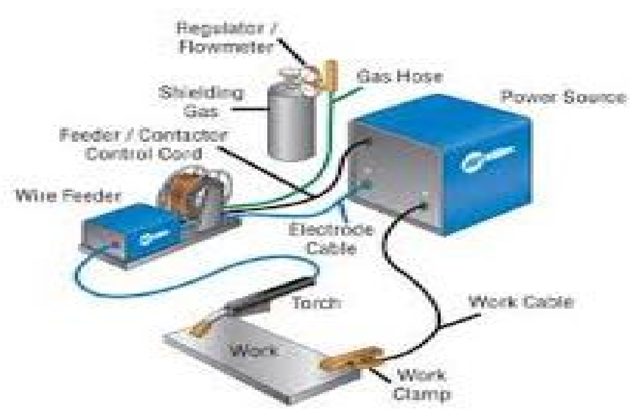

Fig1: GMAW equipment

Nearly 90% of welding in world is carried out by one or the other arc welding process; therefore it is imperative to discuss the effects of welding parameters on the weldability of the materials during the arc welding. Mild steel is the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. The variables affecting weld quality in arc welding are classified into the following groups.

1.1 Process Parameters

Welding current
Welding current is the most influential variable in arc welding process which controls the electrode burn off rate, the depth of fusion and geometry of the weldments.

Welding voltage:- This is the electrical potential difference between the tip of the welding wire and the surface of the molten weld pool. It determines the shape of the fusion zone and weld reinforcement. High welding voltage produces wider, flatter and less deeply penetrating welds than low welding voltages. Depth of penetration is maximum at optimum arc voltage.

Gas flow rate:- Gas flow rate is defined as the rate at which the gas is being supplied at the welding zone to provide shielding. Metal transfer during the welding takes place in two ways:-

Spray transfer mode:- the metal transfer takes place in the form of very small finite droplets of metal which is being sprayed to the welding zone. It takes place at high welding current and is more desirable than globular metal transfer mode.

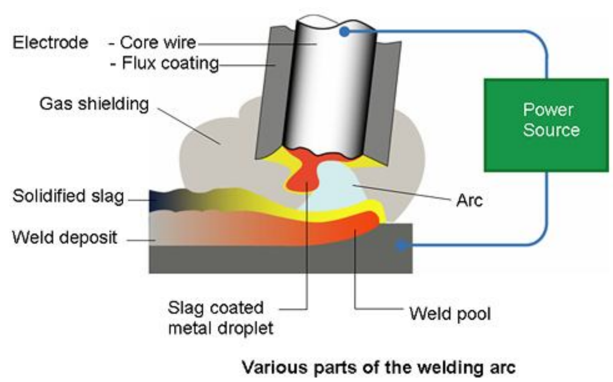

Fig-2: GMAW Process

Globular transfer mode: **-** the metal transfer takes place in the form of comparatively larger droplets of metal. It takes place due to low welding current. For shifting the globular metal transfer mode to the spray metal transfer mode we need to supply higher value of current. The value of current at which this transfer takes place is known as transient current. The value of this transient current gets affected on using shielding gas the value of current. The value of this transient current gets affected on using shielding gas. The value of current gets increased on using CO_2 on the other hand when argon is used as the shielding gas.

1.2 Risk Analysis

Inclusion of slag
Inclusions of slag in welding take place due to flux employed and electrode coating. In multilayer welding process, it is impossible to remove slag between layers results inclusion in these zone other causes are slow speed less electrode angle.

Inadequate penetration
It exists in groove weld when the deposited metal and base metal are not fused at the root of the weld. This condition occurs when the root fence has not reached fusion temperature along its entire depth. Inadequate penetration may lead to cracking.

Incomplete fusion This is defined as the failure of two weld metal layer to fuse together. It is caused by failure to reach the base metal at its melting point.

Under cut
It is the melting or burning away of base metal at the toe of the weld, in multilayer weld it may occur at the puncture of weld layer and the wall of the groove. Undercut due to excessive weaving speed, big electrode, and incorrect electrode angle.

Spatter
Spatter refers to particles of metal scattered around the vicinity of the weld along its length. It occurs due to excessive current & too high arc voltage.

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1.3 Objectives of the work

To find the effect of process parameters on the Gas Metal Arc Welding productivity.

1.4 Scope of the work

A better understanding of the GMAW welding through a variety of parameters and the defects encountered upon welding; leads to a better productivity of the product which is based on this experiment. The defects can be encountered prior to the welding by selecting a particular set of parameters selected.

2. LITERATURE REVIEW

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 0020 Arc welding process in which a continuous and consumable wire electrode and a shielding gas are fed through a welding gun[1].

High productive arc welding is basically an adaptation of a standard method to achieve a higher production rate. The improvement can be utilised either as an increase in welding speed or as a higher deposition rate. . At present, High Speed Welding with MIG/MAG is performed with travel speeds between 1 and 6 m/min. Factors influencing the possible increase in productivity are: the material type and thickness, the welding position, quality demands on the welded joint, and the welding equipment used[2].

It is found that a stable GMAW process can be obtained through a balance between the wire-feed-speed (WFS) and the dynamic electrode melting rate due to the transient behaviour of plasma arc[3].

An excessively long distance causes an unstable arc, much spatter generation, irregular bead appearance, less weld penetration, and lack of shielding thereby causing porosity. In contrast, an excessively short distance causes an unstable arc, too. Gas metal arc welding (GMAW) uses direct currents of electrode positive (DCEP) for most applications. This is because the DCEP connection provides stable melting rates for welding wires and facilitates the use of the advantages of several droplet transfer modes, by choosing the size of wire, levels of current and voltage, and type of shielding gas. If the voltage is set too low, the welding wire sticks onto the base metal making crackling sounds with an irregular arc. If the voltage is set too high, the arc becomes a long flame causing much spatter generation. When the arc voltage is properly adjusted, the arc is stable with little spatter generation [4].

Shielding gases are inert or semi-inert gases that are commonly used in several welding processes, most notably gas metal arc welding. Their purpose is to protect the weld area from oxygen, and water vapours. Depending on the materials being welded, these atmospheric gases can reduce the quality of the weld or make the welding more difficult. Improper choice of a welding gas can lead to a porous and weak weld, or to excessive spatter; the latter, while not affecting the weld itself, causes loss of productivity due to the labour needed to remove the scattered drops [5].

In addition, as defined as
$H = I2\ R \times T$
(Where H: Joule heat, I: current, R: internal resistance, and T: duty cycle), heat of a power source is affected by the internal resistance of the power source, in addition to by current and duty cycle. This suggests that joints between the components must sufficiently be fastened
through maintenance activities to minimize the resistance; if not, a loose joint can cause more heat than the estimated, which may cause overheating of the power source even if the duty cycle and welding current is within the specified[6].

In order to prevent overheating, duty cycle is specified for welding torches, too, in the same way as for power sources as discussed above. However, unlike power sources, the rated duty cycle of welding torches varies depending on how to use the welding torch: e.g. 80% for CO2 welding, 60% for MAG welding, and 50% for pulse-MAG welding in use of the same welding torch. This is because radiant heat from the arc to the tip of the torch varies affected by the welding process. The radiant heat becomes higher in CO2 welding, MAG welding, and pulsed-MAG welding in this order, when other welding parameters are kept constant. Specifications of welding torches indicate the rated duty cycle when used in CO2 welding, unless otherwise specified [7].

3. METHODOLOGY

3.1 Preparation of specimens

The metal used was mild steel of size 150 mm x40 mmx8 mm for welding. As for proper bead formation v-butt joint are used and up to a depth of 7 mm at an angle of 30 degrees. 1 mm at the bottom of the weld was left flat to provide proper metal fusion. A total of eight pair of specimens were prepared in this project.

Fig-3: Edge Preparation (Single V butt Joint)

3.2 Selection of welding parameters

The GMAW consists of a number uncertainty in parameters. So a proper mathematical table was constructed in the form of observation table so that variation in welding bed can be studied. Instead of selecting any random values of parameter, the variation in values set by welder were used. The observation set was based on three sets of magnitude of each of the parameters used namely low level ,middle level, and high level.

Fig4: Mild steel Specimen

Fig5: Single V Butt Joint before welding

3.3 Equipment specification

The work is carried out at the GMAW machine of central workshop of O P Jindal Institute of Technology, Raigarh. The specification of machine is given below:

Types of power sources: - Alternating current (AC)
Current level: - 45 AMP (min.) to 400 AMP (max.)
Voltage level: - 25 V (min.) to 34 V (max.)
Gas used: - CO_2 gas
Gas pressure level: - 20 FT3/hrs. (min.) to 100 FT3/hrs. (Max.)
Cooling type: - Forced air cooling

Temperature: - 3000'C
Feed wire dia.:- 1.2mm

3.4 Process parameter

The observation set was based on three sets of magnitude of each of the parameters used namely low level ,middle level, and high level.

Table-1: Input Parameters levels

Input Parameter	Level 1	Level 2	Level 3
Voltage (Volt)	28	30	32
Current (Amp)	160	200	240
Gas Flow Rate(Ft^3/hr)	60	70	80

3.5 Experimental work

A systematic arrangement of all the samples was controlled during welding by proper fixtures. Weight of all the specimens were taken before welding on electronic weighing machine. The voltage and current were varied by the knob on the remote and gas flow rate was controlled by knob on the CO_2 cylinder. An electronic stopwatch was to determine the welding time. There after the metal deposition rate can be calculated by

Metal deposition rate = weight of the metal added / welding time

Weight of the metal added (gm.) = weight of the sample before welding - Weight of the sample after welding

Fig6: GMAW welding Machine

4. RESULT AND DISCUSSION

4.1 Data obtained during welding operation

The study is carried out under real operating conditions to investigate the amount of filler material deposited at the welded portion in minimum time; which further increases the productivity of the product. As the voltage decreases

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the filler metal will not melt easily. In order to compensate this, we need to increase the current. Now as the current increases welding speed will increase, due to this gas flow rate (to increase the shielding rate) will also increase.

This will lead to minimum time required for welding and enhance the productivity. Below, the table shows the magnitude of current, voltage and gas flow rate under varying conditions. The time required for welding in each sample is recorded and the weight of the deposit is calculated simply by weighing the sample before and after welding. Metal deposition rate is then calculated and then tabulated in the table for each sample.

4.2 Observational study

From the above study we have concluded that the metal deposition rate mainly depends upon the current.

Higher the value of current higher will be the heat generation and as a result higher will be the deposition rate.

We have the relation between heat generation and current as,

$$H = I^2 RT \qquad \text{..........(i)}$$

WHERE,

H= heat generated; I = current

R= resistance of the material; T= Time

Table-2: Experimental Results

SAMPLE NO.	VOLTAGE (V)	CURRENT (AMP)	GAS FLOW RATE (Ft3/Hr.)	WT. OF SAMPLE BEFORE WELDING	WT. OF SAMPLE AFTER WELDING	WT.OF DEPOSIT ON (Gm)	TIME (SEC)	METAL DEPOSITION RATE (Gm/sec)
1	28	200	60	935	950	15	150	0.1
2	28	160	60	937	945	8	200	0.04
3	28	225	60	930	960	30	138	0.217
4	28	200	80	932	960	28	162	0.172
5	32	200	60	935	970	35	126	0.277
6	30	240	60	933	955	62	114	0.543
7	28	170	70	936	960	24	150	0.160
8	31	200	55	935	985	60	120	0.50

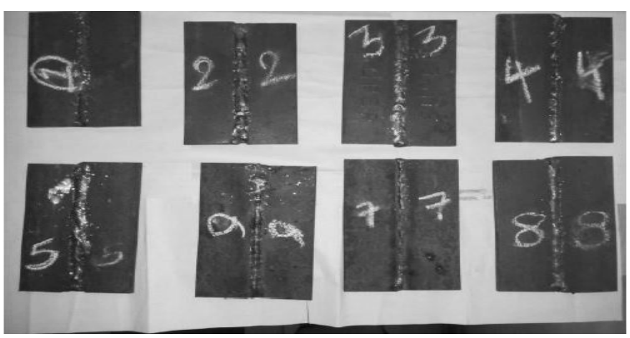
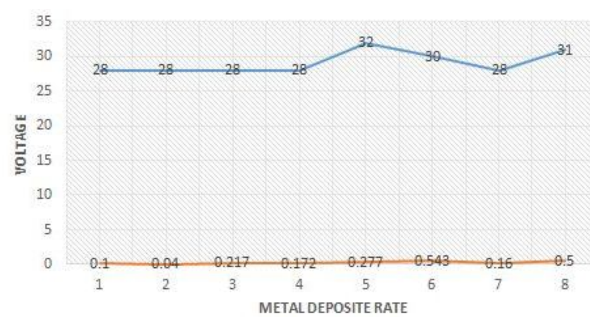
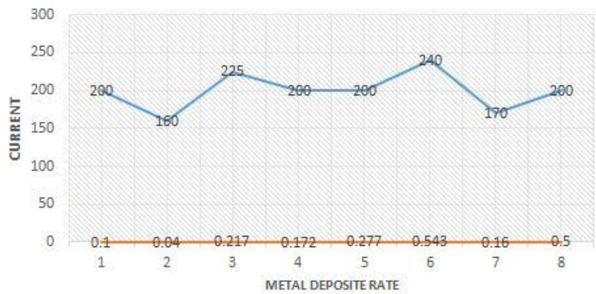


Fig7: Specimen after welding operation

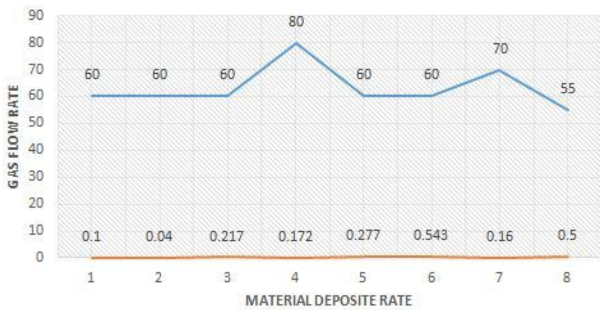


Graph-1: Voltage vs. MDR

After performing the welding MDR is calculated using given formula for each specimen. It can be seen that the maximum MDR is for sample number 6. It is obvious that the maximum MDR will be for maximum for the higher current value which is true according to formula (i). The effect of selected parameters on the MRR is shown below in the graph.



Graph-2: Current vs. MDR



Graph-3: Gas Flow rate vs. MDR

5. CONCLUSION

This study has discussed the effect of voltage, current and gas flow rate on the material deposition rate of gas metal arc welding of mild steel plates. The productivity is mainly depends upon the amount of metal deposited per unit. For sample no. 6 current is higher, so the metal deposition rate is also maximum leading to lower time consumption and will result in "higher productivity".

As the time required for welding decreases the productivity of the product increases which will reduce the overall Manufacturing time of the product.

The work can be extended for optimizing the process parameters using optimization techniques for more than one output performance.

REFERENCES

[1] Ajit Hooda, Ashwani Dhingra and Satpal Sharma (2012) Optimization of Mig welding process parameters to predict maximum yield strength in aisi 1040

[2] J HEDEGARD (2006) , Improving productivity in MIG/MAG methods Corrosion & Metals Research Institute, Sweden

[3] Z.H. Rao, J. Zhou, H.L. Tsai, (2012) Determination of equilibrium wire-feed-speeds for stable gas metal arc welding

[4] Kobe Steel, Ltd., "How to Use Solid Wires in Gas Metal Arc Welding," 1995

[5] Internet (Wikipedia) the free encyclopaedia.

[6] American Welding Society, "Welding Handbook," 1991

[7] KOBE STEEL, LTD. The Japan Welding Society, "CO2 Semi-automatic Arc Welding," 1986, Sanpo Publications Inc.

[8] Dr Swadesh Singh, A text book on production technology (Made Easy publication)

[9] Welding handbook (4th edition) section 2, "Gas, arc and resistance welding processes", published by American welding society.

[10] OP Khanna, a text book of welding technology, Dhanpat Rai Publications Ltd., 2006.

[11] The Japan Welding Society, "CO2 Semi-automatic Arc Welding,"1986,Sanpo Publications Inc.

[12] The Japan Welding Society, "Q&A on MAG/MIG Arc Welding," 1999, Publications Inc.

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