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Research Article

EFFECTS OF WELDING PARAMETERS ON PERCENTAGE DILUTION IN 316L GMAW CLADDING

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ABSTRACT

The welding is the well-known metallurgical sculptural process for the fusion of metals and also to increase the surface properties in the case of cladding. The Gas metal arc welding (GMAW) is implemented to achieve the improvement in the surface properties of the base metal. The deposition of 316L stainless steel onto the structural steel is presented in this paper. This cladding gives the weld bead geometry which shows how far the electrode material has influenced the work piece. The extent of dilution of the electrode material or the stool over the base material is to be minimized. At the same time the weld quality has to be increased. The control parameters for this cladding process are the welding voltage (V), wire feed rate (WF), welding torch speed (S), gas flow rate etc. This is to predict the well suiting parameter that satisfies the weld quality and the desired results. These parameters affect the outcome responses such as welding geometry, reinforcement height, penetration depth, percentage dilution, height and width of the weld bead and the ferrite number. The weld bead geometry is constructed using the AutoCAD for predicting the desired parameter. It shows the levels of percentage on which the dilution has been resulted.

INTRODUCTION

Welding is the most popularly used sculptural process that is used for the joining of the materials that is mainly the metals. The metal's temperature is being raised or increased in order to melt the metals and then they are fused together. There are many types of welding processes that are being used all over the world. Some of them are oxy-fuel welding, shielded metal arc welding (SMAW), gas metal arc welding (GMAW), gas tungsten arc welding (GTAW), submerged arc welding (SAW), friction welding etc. This report is based on the project that is carried out using the GMAW welding processes that is being used to perform the cladding processes (Murugan and Parmar, 1994; Palani and Muugan, 2007; Murugan, *et al*., 1993; Parmar, 1992).

Cladding is the metallurgical process of coating a surface of the material or a component of any material. It may be a plastic or metal or any kind of materials. The main purpose of the cladding is that the improvement of the surface properties.

The quality of the cladded components depend upon the weld bead geometry, the coefficients of the shape of welds and dilution. The mechanical strength of the cladded metals depends up on the composition of the metals and also the bead geometry.

Gas metal arc welding (GMAW) is the welding process in which the electric arc forms between the welding electrode and the base metal. The electric arc which is being formed melts the metals and makes them melt so that they are joined together. In the anode is the welding electrode which is the stool metal which is wound over a wheel and made to flow over the base metal and the cathode is that the base metal over which the welding has to be done. The GMA welding is otherwise known as the Metal Inert Gas(MIG) welding or Metal active gas

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(MAG) welding (Houldcroft, 1989; Alam, *et al*., 2002; Murugan and Parmar, 1997).

The input parameters of the GMA welding are the wire feed rate, welding speed, welding voltage, standoff distance or the distance between the base plate and the electrode. The standoff distance also plays an important role in the weld bead geometry and in the dilution of the metals. The output variables of the process are the results that are measured. They are weld bead geometry, dilution level, penetration area, percentage dilution, and reinforcement area and ferrite number. There are also many other results that could be measured from this process (Fig. 1).

The dilution in the welding is that the combining or the mixing of the electrode metal with the base metal in a certain range. The dilution is influenced by the welding voltage, standoff distance, welding speed, wire feed rate and the gas flow rate. The weld metal deposited over the surface of the base metal shows the reinforcement height and the penetration area is inside the base metal. The percentage dilution is that the percentage of the electrode material diluted in the base metal of affected in the base metal by the electrode material. The higher the voltage the higher is the percentage dilution. The lower wire feed rate gives the lower penetration area and leads to the lower percentage of the dilution.

EXPERIMENTAL SETUP

As mentioned above the cladding process is to be done with the gas metal arc welding process. The machine required for the process is to be set up and checked for the working condition. Before the process that is done over the main work piece, the process is to be done over the testing plate to check the working condition of the machine and also the torch in all desired the parameters (David, 2005; Tarun, *et al*., 2014; Ernst, *et al*., 2016).

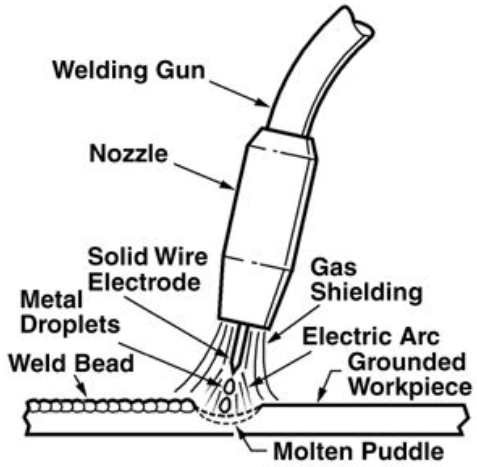

Fig. 1 Gas Metal Arc Welding (GMAW).

The plates for the running of the trial runs are to be prepared for the conducting of experiments over it. The rusts over the plate has to be cleaned either by using the emery sheet (paper) or by the process of grinding over the surface. This is to avoid the contamination in the dilution and to improve the dilution level of the stool and the base material.

The inert gas combination used for the process is the combination of carbon-di-oxide and argon. This prevents the atmospheric gasses coming in contact during welding. The welding without gasses leads to the porosity and cracking of the weld bead and the work piece.

The welding torch in the setup is fixed in a mount and made stationary the work piece is mounted over the manipulator which moves the plate with a fixed amount of speed. The speed of the table of the manipulator is the speed of the welding torch (Rooyen, *et al*., 2009; Vipin, *et al*., 2012).

SELECTION OF PROCESS PARAMETERS

The parameters for the gas metal arc welding are to be decided prior to the conduction of the welding. The electrode material has to be deposited over the work piece so that the level of dilution should be minimized as possible. Here the process parameters are decided with the help of design of experiments. The Taguchi method is applied to construct the control measures.

Before the conduction of the main experiment, there are also some of the steps to be followed. The trial run has to be done over the test plates in prior to the main experiments. The parameters are also to be set for the analyzing of the control measures. It also helps in ensuring the working condition of the welding machine. The parameters of the trial run are tabulated below (Table 1).

The design of experiments was used to obtain the parameters to be employed during the welding. With the help of Taguchi method the welding control parameters are tabulated as follows (Table 2).

CONDUCTING AND COLLECTING RESPONSES

The welding is done with the obtained parameters accordingly. The constant gas flow rate of twenty liters per minute is used for the welding. The welding process is properly shielded for the safety purposes. The electrode material used for the welding is the stainless steel 316L. The diameter of the electrode

Table 1. Parameters of the trial run

S. No	X1	X2	X3
1	28	300	100
2	28	350	100
3	28	400	100
4	28	400	150

X1 – Welding Voltage in V
X2 – Wire Feed Rate in ipm
X3 – Welding speed in mm/min

Table 2. Welding control parameters using Taguchi method

S. No	X1	X2	X3	X4
1	26	300	125	5
2	26	350	150	10
3	26	400	175	15
4	28	300	150	15
5	28	350	175	5
6	28	400	125	10
7	30	300	175	10
8	30	350	125	15
9	30	400	150	5

X1 – Welding Voltage in V
X2 – Wire Feed Rate in ipm
X3 – Welding speed in mm/min
X4 – Oscillation Width

material is 0.8 mm. The base metal or the work piece is the mild steel or the structural steel. The base plate is connected to the earth to close the circuit. The voltage is set to the given value. The welding electrode flow is checked for the uninterrupted flow as the interruption causes improper beads. The proper bead gives the proper dilution and the weld geometry for the measurement.

The total of nine experiments was conducted with the time left in between for the cooling of the plates. The immediate cooling may lead to the change in microstructure of the material.

The weld beads were then sectioned in the equal dimensions for the further steps. The sectioned weld beads were then polished for getting the even surfaces for the analysis purposes. The polished weld beads should be etched to find the level of dilution. The level of dilution is the dilution percentage on which the electrode material is diluted with the base material.

The specimens are etched with the solution of nitric acid and ethanol. It is then scanned for the measurement of weld bead geometry. The scanned images are used to construct the weld bead geometry. The AutoCAD software is used for the construction of weld bead geometry. The scale is set for the measurement of the values. The measured values of the geometry are tabulated below (Table 3).

The weld bead geometries of the weld beads are measured for the values of height, width and penetration depth of the weld beads with the different parameters.

The percentage dilution has to be measured flowingly. For that the reinforcement area and the penetration area has to found which is measured in the same software which is used to measure the weld bead geometry. From the measured values the percentage dilution is calculated. The percentage of dilution varies with varying parameters. The dilution percentage increases with increase in welding voltage and heat input. The oscillation width also has the effect on the percentage dilution. The percentage dilution of the weld beads are tabulated below (Table 4).

RESULTS AND DISCUSSION

The values obtained from the processes performed shows the responses of the weld bead from the gas metal arc welding at the different parameters. The various parameters give the corresponding results. The greater voltage results in the higher dilution and penetration area. The voltage is made constant for the each bead throughout and the current is not controlled and it becomes a limitation. The diameter of the welding electrode material also plays an important role in the weld bead geometry and the

Table 3. The measured values of the geometry

Specimen No.	Height (mm)	Width (mm)	Penetration depth (mm)
1	3.965	11.39	0.592
2	3.168	14.82	0.729
3	2.711	19.36	0.778
4	3.178	19.81	0.765
5	3.355	10.95	3.119
6	3.576	16.54	3.018
7	3.011	16.14	0.757
8	3.501	14.33	0.792
9	4.048	21.25	1.023

Table 4. The percentage dilution of the weld beads

Specimen No.	Percentage Dilution (%)
1	10.03
2	9.67
3	14.55
4	9.24
5	10.79
6	7.02
7	6.64
8	16.07
9	9.93

percentage dilution. The greater diameter of the electrode material gives the higher penetration depth which leads to the more percentage dilution.

CONCLUSION

1. The gas metal arc welding gives the better results in the case of cladding.

2. As it is to improve the surface properties the level of electrode material affecting the work piece should be minimized.

3. From the above mentioned processes it is evident that the better chosen control parameter gives the better outcome of the results.

4. The control parameters are the welding voltage, wire feed rate, welding speed and the oscillation width.

5. The outcomes are welded bead geometry, reinforcement height, penetration depth and percentage of dilution.

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