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The Effect of Process Parameters on Clad Bead Geometry with GMAW

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Abstract: The Present work aims to study the same during surface hardening of a mild steel with that stainless steel. Process parameters are liable to produce unwanted effects in the job during the welding operation. Aim of this paper is to study the effects of Welding Speed. Cladding is a process of depositing a thick layer of corrosion resistant material over carbon steel plate. The engineering applications require wear resistance, high strength and corrosion resistant materials for long term reliability and performance. In the cladding Material properties can be improved and achieved with minimum cost. The main problem faced on cladding is the selection of optimum combinations of process parameters for achieving quality clad and hence good clad bead geometry. This paper highlights an experimental study to predict various input process parameters. The effect of gas metal arc welding process parameters on the weld bead geometry in cladding mild steel with 304L stainless steel was studied. The full factorial method was used, to number of experiments run were carried out to know the effect of wire feed rate, welding speed, welding voltage, welding current of welding on weld bead geometry. The gas metal arc welding process is increasingly employed for fabrication in many industries. The effect of all the four parameters on various samples has been individually explained.
Keywords: MIG Welding, Parameter optimization process, Mild Steel Plate, 304 stainless steel electrode, process parameters.

I. INTRODUCTION

Surface modification process is used to improve quality and life of engineering part and components. Wear and corrosion is a major problem in industries. Even though it cannot be eliminated completely, but it can be reduced to some extent. Cladding process is made of mild steel substrate to less wear and corrosion resistant by a protective layer on it. This technique is also used to reduce cost of industrial products and process. This process is mainly used in industries such as chemical, textiles, nuclear, steam power plants, food processing, and petro-chemical industries.
Gas metal arc welding is the most accepted method in weld cladding. It has got the following advantages.

A. High reliability
B. All position capability
C. Ease to use
D. Low cost
E. High productivity
F. Suitable for both ferrous and Nonferrous metals
G. High deposition rate;

The mechanical strength of clad metal is highly influenced by the composition of metal but also by clad bead shape. This is an indication of bead geometry. Figure 1 shows the clad bead geometry. It mainly depends on wire feed rate, welding speed, arc voltage, and so forth. Therefore it is necessary to study the relationship between in process parameters and bead parameters to study clad bead geometry. This paper highlights the study carried out to develop models to optimize clad bead geometry, in stainless steel cladding deposited by gas metal arc welding. The experiments were conducted based on four factor three level central composite rotatable designs with full replication technique .The developed models have been checked for their adequacy and significance. The bead parameters were optimized.

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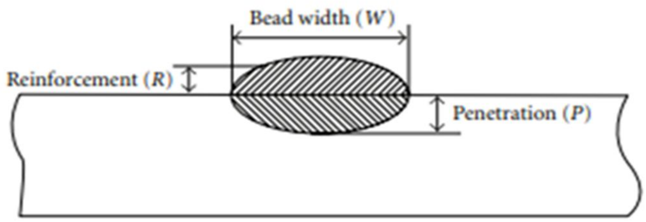

Fig:- 1 weld bead geometry

Table 1: Chemical composition of filler wire of ss304

mtrl	C	MN	P	Si	Cu	Ni	Cr	Mb	V	Tu	Al	Fe
%	0.019	1.709	0.028	0.287	0.173	9.13	19.281	0.078	0.119	0.037	0.06	68.912

Table 2: Composition of M.S. being used (wt%)

Mtrl	C	Si	Mn	P	S	Ni	Cr	Al	Fe
MS	0.15	0.17	0.59	0.026	0.023	0.021	0.045	0.029	balance

II. EXPERIMENTAL SET UP

The following machines and consumables were used for the purpose of conducting experiments.

A. A constant current gas metal arc welding machine
B. Welding manipulator
C. Wire feeder
D. Filler material Stainless Steel wire of 1.2 mm diameter (ER-304 L).
E. Gas cylinder containing a mixture of 98% argon and 2% of carbon dioxide
F. Mild steel plate (MS).

Test plates of size 150 × 75 × 10(mm) were cut from mild steel plate and one of the surfaces is cleaned to remove oxide and dirt before cladding. 304L stainless steel wire of 1.2 mm diameter was used for depositing the clad beads through the feeder. Argon gas at a constant flow rate was used for shielding. The properties of base metal and filler wire are shown in Table 1, Table 2. The important and most difficult parameter found from trial run is wire feed rate. The wire feed rate is proportional to current. The selection of the welding electrode wire based on the matching the mechanical properties and physical characteristics of the base metal, weld size, and existing electrode inventory A candidate material for cladding which has excellent wear and corrosion resistance and weld ability is stainless steel. These have chloride stress corrosion cracking resistance and strength significantly greater than other materials. These have good surface appearance, good radiographic standard quality, and minimum electrode wastage. Experimental design procedure used for this study and important steps are briefly explained.

III. DESIGN OF EXPRIMENTS

The research work was planned to be carried out in the following steps.

A. Identification of process parameters and responses
B. Finding range of process parameters.
C. Development of design matrix
D. Conducting experiments run
E. Recording the responses in design matrix
F. Checking the adequacy of developed models
G. Conducting conformity tests.

Table:-3 welding parameters with factor level

Process parameters	unit	Factor level		
		-1	0	1
Welding current(I)	Amp	150	160	170
Welding voltage(V)	Volt	28	30	32
Welding speed(S)	Cm/min	40	60	80
Wire feed rate(F)	m/min	6	8	10

IV. PREDICTION OF CLAD BEAD GEOMETRY

The controllable process parameters were found to be affecting output parameters. These are wire feed rate (F), welding speed (S), welding current(I), welding voltage(V), the responses chosen were clad bead depth of Penetration (P), and percentage of dilution (D). The responses were chosen based on the impact of parameters on final model. The basic difference between welding and cladding is the percentage of dilution. The properties of the cladding is the significantly influenced by dilution obtained. Hence control of dilution is important in cladding where a low dilution is highly desirable. The final deposit Composition will be closer to that of filler material and hence corrosion resistant properties of cladding will be greatly improved. The chosen factors have been selected on the basis to get minimal dilution and optimal clad bead geometry. Few significant research works have been conducted in these areas using these process parameters and so these parameters were used for experimental study. Working ranges of all selected factors are fixed by conducting trial runs. Working range of each process parameters was decided upon by inspecting the bead for smooth appearance without any visible defects. The chosen level of the parameters with their units and notation are given in Table 3. Design matrix chosen to conduct the experiments was central composite rotatable design. All welding parameters in the intermediate levels (o) constitute the central points and combination of each welding parameters at either is highest value (+1) or lowest value (−1) with other parameters of intermediate levels (0) constitute star points. 15 experimental trails were conducted that make the estimation of linear quadratic and two way interactive effects of process parameters on clad geometry. At each run settings for all parameters were disturbed and reset for next deposit. This is very essential to introduce variability caused by errors in experimental set up. In order to measure clad bead geometry of transverse section of each weld overlays were cut using band saw from mid length. Position of the weld and end faces were machined and grinded. The specimen and faces were polished and etched using a 5% nital solution to display bead dimensions. Then the bead dimension such as depth of penetration height of reinforcement and clad bead width were measured. The traced bead profiles were scanned in order to find various clad parameters and the percentage of dilution with help of AUTOCAD software. The measured clad bead dimension and percentage of dilution is shown in Table 4.

Table: 4 Design Matrix

Trial No	Process Parameters				Bead Parameters	
	I	V	S	F	P	D%
1	-1	-1	-1	-1	1.243	8.620
2	1	-1	-1	1	1.315	10.741
3	0	1	-1	1	1.286	10.167
4	-1	1	1	-1	1.439	8.807
5	1	0	1	1	2.290	14.693
6	0	0	1	1	2.167	13.673
7	-1	-1	0	-1	1.154	8.549
8	1	-1	0	0	1.289	8.438
9	0	1	0	0	1.674	10.493
10	-1	1	-1	-1	2.174	14.926
11	1	0	-1	1	2.329	13.876
12	0	0	-1	1	2.511	12.987
13	-1	-1	1	-1	1.382	10.873
14	1	-1	1	0	1.279	8.342
15	0	1	1	0	1.861	10.783

I=current, V=voltage, S=welding speed, F=wire feed rate, p= penetration; D%=dilution

V. RESULT AND DISCUSION

Test results for the first sample include three different current values (150A, 160 A and 117 A), three different voltage values (28V, 30V & 32 V) and three different welding speeds (40cm/min, 60cm/min and 80cm/min). Three different variables were combined in 15 patterns. The effect of changing the welding current keeping the other parameters constant can be explained on basis of following graphs as shown in fig: 2. The above graphs reveal that for speed of 40cm/min, the increase in penetration for 28V is 1.66mm, for 30V it is 1.67mm and for 32V, the increase is 1.68mm when the current value increases from 150A to 160A (increase of 10A). Similar effect is observed for the speed of 60cm/min and 80cm/min. Hence, depth of penetration increases almost linearly with increase in welding current. Also the higher increase is observed when current is increased from 150A to 160A than increase from 160A to 170A. To understand the effect of welding speed on penetration, the following graphs are provided as shown in fig. 2. The above graphs suggest that as the welding speed increases, the depth of penetration increases in all the three cases. However, the it decreases as the speed is increased beyond 60cm/min. this means that for any welding condition, there is a optimum value of welding speed, beyond which if the speed is increased, the depth of penetration decreases.

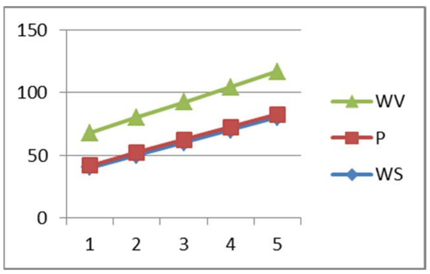

Fig:2 penetration vs welding speed

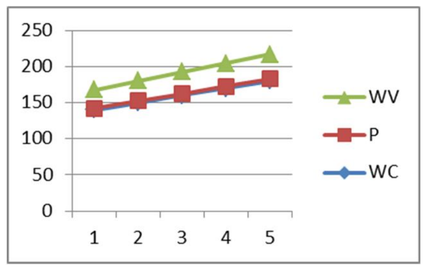

Fig:3 penetration vs welding current

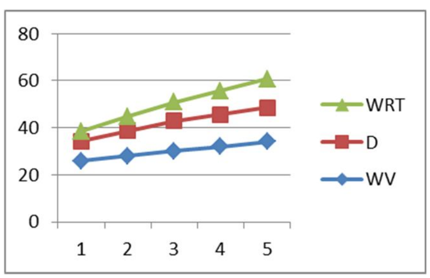

Fig:4 dilution vs wire feed rate

Wire feed rate must be greater than critical wire feed rate to achieve pulsed metal transfer. The relationship found from trial run is shown. The selection of the welding electrode wire based on the matching the mechanical properties and physical characteristics of the base metal, weld size, and existing electrode and minimum electrode wastage. According to Fig.4, dilution (D) increases with increasing both wire feed rate and welding voltage. In both situations, it seems that quantity of heat that affected the base metal or in the other words, arc power increases leading to the melting of more base metals.

VI. CONCLUSION

The developed models are able to optimize process parameters required to achieve the desired clad bead geometry of stainless steel cladding deposited by gas metal arc welding with reasonable accuracy. In this study, the following steps were applied for prediction of stainless steel clad bead geometry using gas metal arc welding: (a) data collection using experimental studies, (b) analyzing and processing of data, These optimized values can be directly used in automatic cladding in the forms of programs and for real time quality control and for the entire cladding process control application to improve bead geometry.

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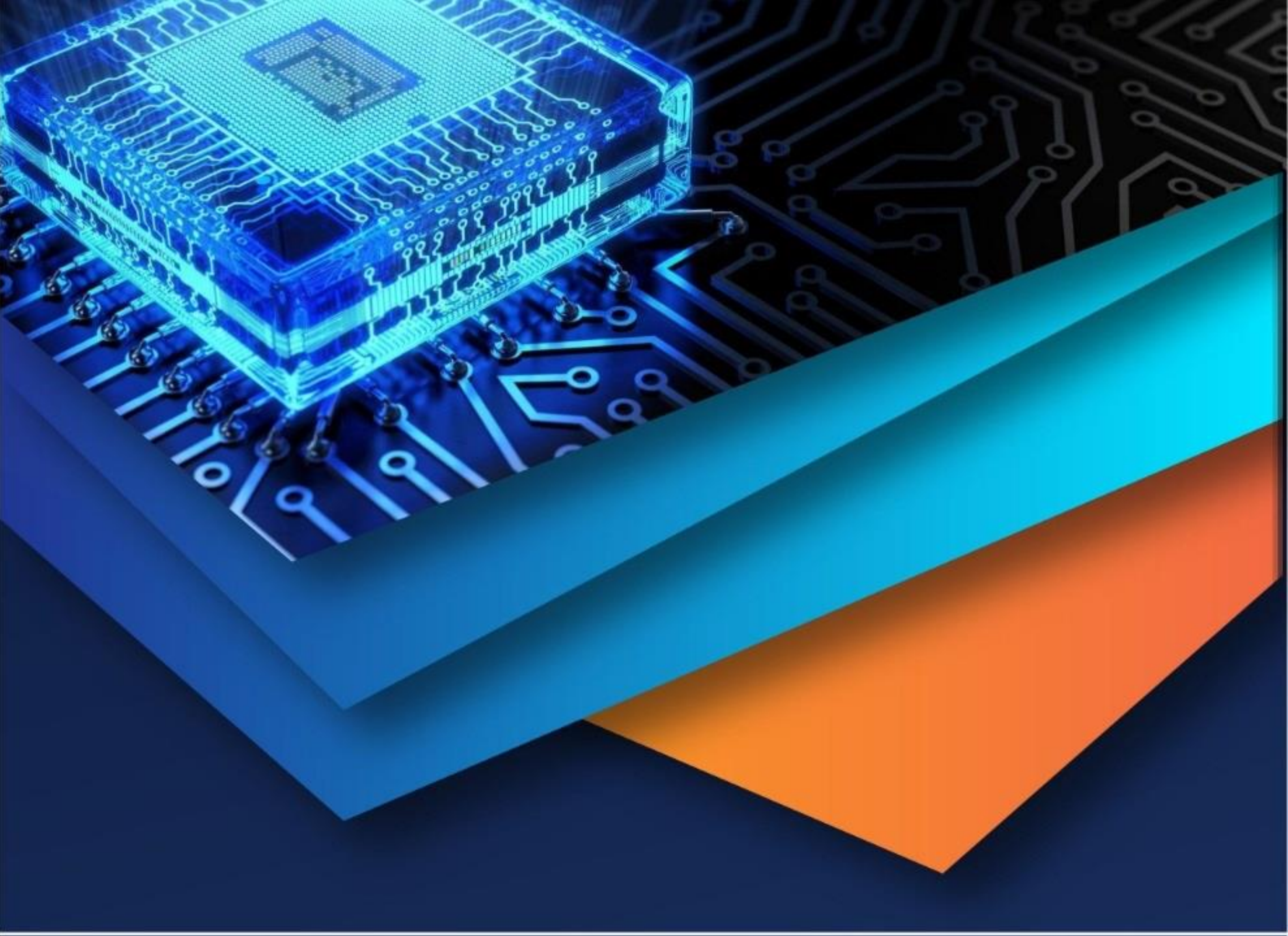

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