International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-2 Issue-5, June 2013

Influences of the Welding Process Parameters on the Weldability of Material

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Abstract— In this study, influence of the welding process parameters on the weldability of material, low carbon alloy steel (0.14% C) specification having the dimensions 75 mm X 50 mm X 6mm welded by metal arc welding were investigated. The welding current, arc voltage, welding speed, heat input rate are chosen as welding parameters. The depth of penetrations were measured for each specimen after the welding operation on closed butt joint and the effects of welding speed and heat input rate parameters on depth of penetration were investigated.

Index Terms— Low Carbon Steel, Manual Metal Arc Welding, Welding Bead Penetration, Welding Process Parameters, Welding Speed.

I. INTRODUCTION

Welding technology has obtained access virtually to every branch of manufacturing; to name a few, ships, rail road equipments, building construction, boilers, launch vehicles, pipelines, nuclear power plants, aircrafts, automobiles, pipelines. Welding technology needs constant upgrading and with the widespread applications of welding [1].Welding is a fabrication or sculptural process that joins materials, usually metals, or thermoplastics, by causing coalescence. This is often done by melting the workpieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. The important process variables in manual arc welding are: welding current, arc voltage, welding speed. The effects of these process variables are determined through their effects on weld bead penetration. Many efforts have been made to develop a mathematical model to study these relationships and best way to solve this problem is by using experimental model. Investigation into the Relationship between the welding process parameters and bead geometry began in the mid 1900s and regression analysis was applied to welding geometry research by Lee and Raveendra [2, 3]. A multiple regression technique has been utilized to establish the models for various welding processes [4, 5]. Renwick [6] studied the characteristics of the weld bead penetration, melting rate under variable operating current conditions and found that these parameters increased with the increase in current. Gunaraj and Murugan [7] proposed a mathematical model to relate the process parameters with the weld bead quality parameters including total volume of the weld bead.

Manuscript published on 30 June 2013.
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The mathematical models thus developed were capable of predicting the weld bead quality parameters and setting the process parameters at optimal values to achieve preferable weld quality and at the same time high productivity.
Chandel [8] first applied this technique to the GMA welding process and investigated relationship between process variables and bead geometry. These results showed that arc current has the greatest influence on bead geometry, and that mathematical models derived from experimental results can be used to predict bead geometry accurately.

II. WELDING PARAMETERS

Welding Current and Arc voltage

It controls the melting rate of the electrode and thereby the weld deposition rate. It also controls the depth of penetration and thereby the extent of dilution of the weld metal by the base metal. Arc voltage, also called welding voltage, means the electrical potential difference between the electrode wire tip and the surface of the molten weld puddle. It hardly affects the electrode melting rate.

Welding Speed and Heat input

Welding speed is the linear rate at which the arc moves with respect to plate along the weld joint. Welding speed generally conforms to a given combination of welding current and are voltage. If welding speed is more than required

1. Heat input to the joint decreases.
2. Less filler metal is deposited than requires , less weld reinforcement

If welding speed is slow

1. Heat input rate increases.
2. Weld width increases and reinforcement height also increases more convexity [9].

$$\text{HEAT INPUT RATE} = \frac{V \times I \times 60}{v} \quad \text{J/mm}$$

V=arc voltage in volts
I=welding current in ampere,
v =speed of welding in mm/min.

III. EXPERIMENTAL SETUP

In this analysis, metal arc welding is used. It is a process which yields coalescence of metals by heating with a welding arc between a continuous filler metal electrode and the work piece. 20 specimens of dimensions 75mm× 50mm× 6 mm are prepared, then closed butt joint are made by these specimens. Before welding, edges of the work pieces are suitably prepared. The edges and the area adjoining them is cleared of dust using wire brush and cloths.
Afterwards, the work pieces to be welded were positioned with respect to each other and welding process was performed.

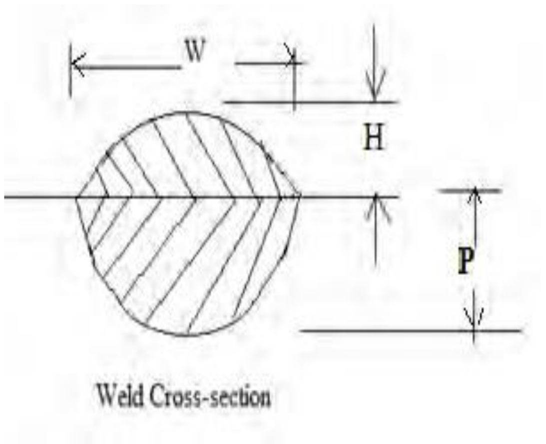


Fig No. 1

W- Weld Width, P- Penetration & H- Reinforcement

During the welding process, following data are chosen:

M.S. (Mild Steel) electrode (E 6013) of 3.15 mm diameter was used.

Current = 250 Amp

Terminal voltage = 18 V

Only arc time was varied during the welding. Welding speed was calculated for each welded specimen. Having finished the welding processes, in order to measure the depth of penetration, welds were cut perpendicular to the direction of welding on power hacksaw. Then with the help of measuring instrument, depth of penetration of welded specimens was measured.

IV. CALCULATION

Table No. 1

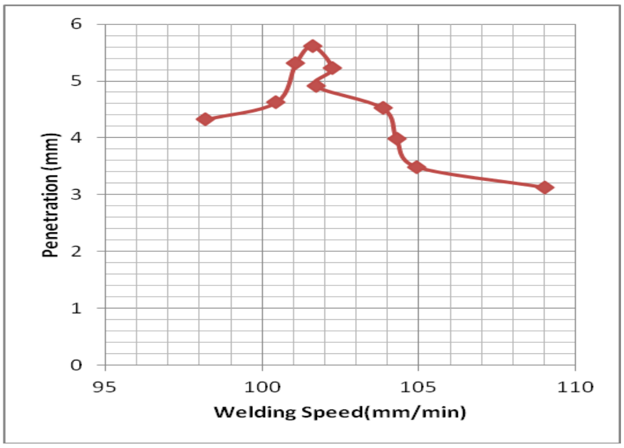
S. N.	Welding Voltage (V)	Welding Current (A)	Welding Time (sec)	Welding Speed (mm/min)	Heat Input j/mm	Penetration (mm)
1	18	250	45.83	98.18	2749.80	4.32
2	18	250	44.81	100.44	2688.01	4.62
3	18	250	44.52	101.07	2671.20	5.31
4	18	250	44.29	101.60	2657.40	5.62
5	18	250	44.24	102.22	2654.40	5.22
6	18	250	44.02	101.71	2641.20	4.91
7	18	250	43.33	103.85	2599.80	4.52
8	18	250	43.15	104.28	2589.00	3.98
9	18	250	42.89	104.92	2573.40	3.48
10	18	250	41.28	109.01	2476.80	3.12

IV. RESULTS AND DISCUSSION

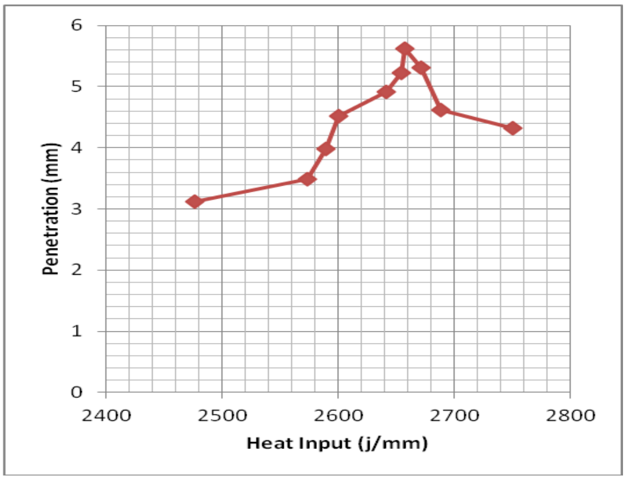
Depth of penetration measured from sectional cross cutting of weld beads through measuring instrument after cutting all the welded specimens perpendicular to the direction of welding are shown in the table and variations in the penetration are analyzed with the help of graph as shown in graph no. 1&2.

The depth of penetration increases with increasing welding speed up to 101.60 mm/min which was optimum value to obtain maximum penetration, because it begins to decrease linearly after this point. Increasing the speed of travel and maintaining constant arc voltage and current increases penetration until an optimum speed is reached at which penetration is maximum. Increasing the speed beyond this optimum result in decreased penetration and maximum depth of penetration occurs at heat input rate of 2657.40 J/mm. Greater the depth of penetration, better is the weldability. So, Optimum weld ability can be obtained with heat input rate as 2657.40 J/mm.

So it can be concluded from experimental analysis that for the mild steel specimen having dimension 75mm× 50mm× 6 mm, optimum weldability can be achieved by considering the welding parameters as welding speed, 101.60 mm/min with current 250 Amp, arc voltage 18 V and electrode E6013 diameter 3.15mm.



Graph No. 1 Penetration Vs Welding speed



Graph No.2 Penetration Vs Heat Input

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

ISSN: 2249-8958 (Online), Volume-2 Issue-5, June 2013

V. CONCLUSIONS

Maximum depth of penetration (i.e. 5.41 mm) was obtained at welding speed 101.60 mm/min and heat input rate 2657.40 J/mm, with current is 250 amp, arc voltage is 18 V and electrode chosen is E6013, diameter 3.15mm.

Hence it can be concluded that increasing the speed of travel and maintaining constant arc voltage and current will increase penetration until an optimum speed is reached at which penetration will be maximum. Increasing the speed beyond this optimum value will result in decreasing penetration.

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