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Effect of Process Parameters on Weldability of the Material

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ABSTRACT: *In this study, the effect of various welding process parameters on the weld ability of Mild Steel specimens having dimensions 50mm× 50mm× 6 mm welded by metal arc welding will be investigated. The welding current, arc voltage, welding speed, heat input rate are chosen as welding parameters. The depth of penetrations are to be calculated 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 will be estimated and then investigated by applying optimization and regression modelling*

Key Words : *Welding Current, Heat Input, Depth of penetration,optimization*

I. INTRODUCTION

1.1. Arc Welding:

Electrical arc is used as the main source of heat in arc welding. Electrical arc is produced when two conductors i.e. Anode and cathode of an electric circuit are brought together and then separated slightly so that an air gap is established such that the current continues to flow through the gaseous medium. This arc produces temperatures of about 6000-7000 degrees.

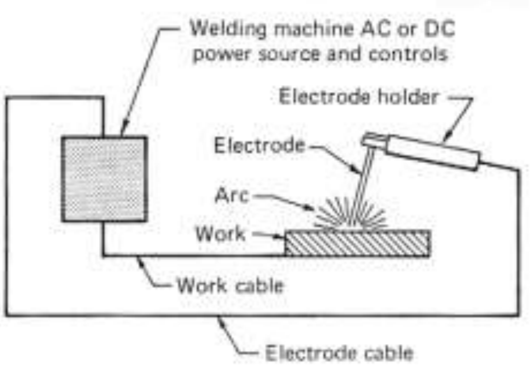


Fig.1. Schematic diagram of arc welding

Figure 1 shows schematic diagram of an arc welding process. Either from an A.C or a D.C source supply electric current. With A.C due to the reversal of the current, the heat generated at each pole is the same and hence changing over the connections to the electrode does not have any effect.

But the polarity of D.C has greater effect on electrode performance. With a D.C source, if the work piece is connected to the positive terminal and the electrode holder is connected to the negative terminal of a welding machine, then the welding set up is said to have straight polarity.

Usually D.C. Arc welding machines are D.C generators which are driven by electric motors where as A.C. Welding machines are transformers.

Both consumable and non consumable electrodes are used in arc welding. In the past bare electrodes were used but with bare electrodes it was found difficult to control the arc and to protect the molten metal from atmospheric oxygen and nitrogen which produces oxides and nitrides and makes the weld bead brittle and weak.

Therefore modern electrodes are mostly coated. During welding the coatings on the electrode burns as the electrode melts and covers the molten metal from contamination.

Various arc welding processes are as follows:

a) Metal arc welding
b) Carbon arc welding
c) TIG welding
d) MIG welding
e) Submerged arc welding

1.2. Metal arc Welding:

This is conventional welding process where metal rod is used as electrode (consumable) and the work piece is used as another electrode. Figure 2 shows the conventional metal arc when the electric arc is struck between the electrodes, the base metal melts due to the heat of the arc. The consumable metal electrode will also melts and enters in to the molten metal.

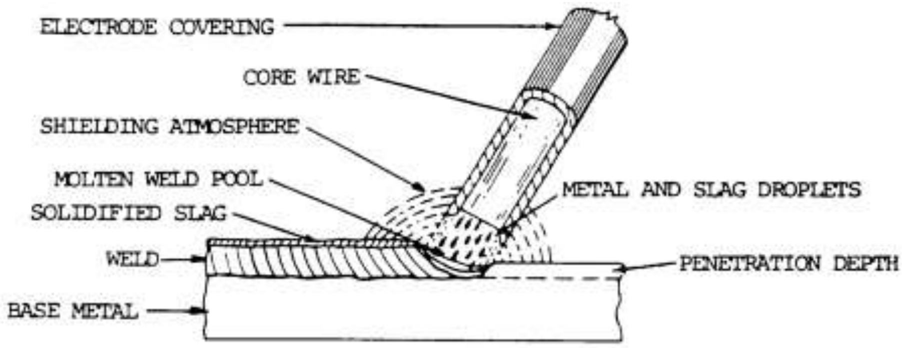


Figure 6-7. Shielded metal arc welding.

Fig.2. Metal arc welding

The depth to which the base metal is melted and deposited is called the penetration of the joint. The amount of penetration depends upon the cross sectional area of the weld bead, the current and the voltage. Penetration increases with increase in current.

A crater (small depression in the base metal) is formation due to the action of the electric arc. This arc crater should be avoided always otherwise it will become the weak point in the welded structure.

This process is also called as shielded metal arc welding (SMAW) because as the electrode coating burns it gives off an inert or protective gas which shields the arc and the molten metal from the atmospheric oxygen and nitrogen. Both A.C. And D.C. Current source may be employed in this method.

Overall Classification of Welding processes are further classified as shown in Fig. 3.

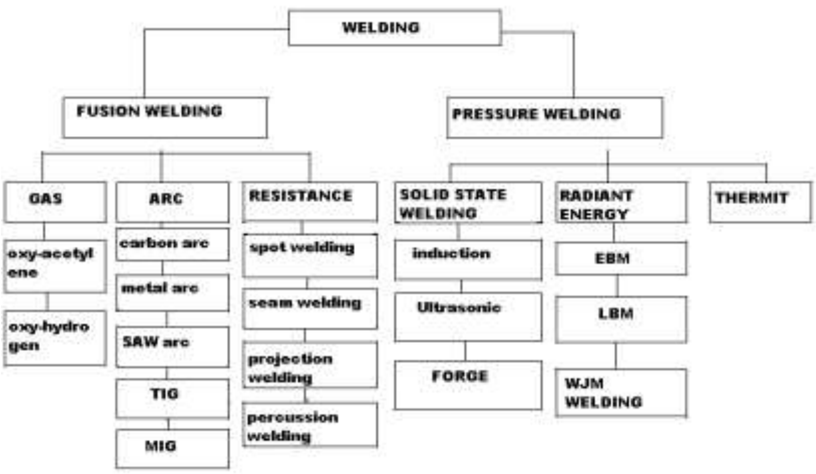


Fig.3 Classification of welding processes

II. LITERATURE SURVEY IN WELDING DOMAIN

Welding process is an important domain of activity of to-day industry, especially in the sector where a lot of assembly of structures has to be done. Generally, the initial design of industrial parts requires revisions, because unpredictable changes occur in the shape or the performance of a component when it is welded because its metallurgical structure was modified by the process. The re-design is very costly since that happen late in the development cycle of the product. It is now possible to avoid this by anticipating the undesirable effects of the manufacturing process early in the design stage, by using numerical simulation, numerical optimization and AI tools. This shows how much virtual welding
process can be important in the development of a new component. Welding simulation utilize to optimize process parameters during the earlier stages of a new design cycle avoiding expensive errors that could occur later. The industrial benefits of using welding simulation and optimization are:

i) Minimize distortions: Simulation allows to predict the distortions and to minimize them by optimization. The effects are of increasing the overall quality of the product and of reducing the costs. Increase in heat input during welding can cause the problems of fracture resistance and deformations. The welding cost increases with the increase of welding volume.

ii) Residual stresses: The goal is to minimize the gradient and to have a smooth distribution of the residual stresses resulting from the welding process. By acting on the welding process, one can have compressive stresses on the surface of the component, which improves its quality and avoids corrosion due to tensile stresses. Residual stresses can be optimized by applying design of experiments and simulations.

iii**)** Knowledge of welding process: Welding analysis by ANOVA and simulation allows to define the best welding sequence and to control all the parameters of the welding process. It is important to optimize the amount of heat input brought by the heat source during the process to maximize the weld strength and minimize the deformations. By mastering the process involved, one can use the right parameters to achieve the desired response, and the productivity is improved by applying process knowledge base.

III. EXPERIMENTAL METHODOLOGY

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 workpiece. 20 specimens of dimensions 150mm × 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.

During the welding process, following data are chosen:

M.S. (Mild Steel) Workpiece
Electrode (E 6011) of 3mm & 4mm diameter
Current (3mm electrode) =120-180 Amp
Current (4mm electrode) =160-240 Amp
Terminal voltage = 440 V

Chemical Composition of M.S.Plate are shown in the following sequence:

Chemical composition of Workpiece :

Mild steel plate.

C %	**Si%**	**Mn%**	**P %**	**S %**	**Cr%**	**Ni%**	**Mo%**	**Al%**
(0.250)	(0.035)	(0.95)	(0.014)	(0.0081)	(0.019)	(0.019)	(0.012)	(0.00)

Only arc time was varied during the welding. Welding speed is calculated for each welded specimen. After finishing the welding processes, in view of measuring the depth of penetration, weld pieces 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.

Different values of Depth of Penetration are tabulated with input parameters like Welding Current, Welding speed and Heat Input as shown in Table 1 for 3 mm electrode and Table 2 for 4 mm electrode

TABLE 1: Process parameters of Depth of Penetration for 3 mm electrode

S.NO	**Welding voltage (v)**	**Welding current (A)**	**Welding speed (mm/min)**	**Heat input (J/mm)**	**Penetration ratio (mm)**
1.	440	120	101.07	31344.61	1.96

2.	440	130	101.60	33779.52	2.01
3.	440	140	102.22	36157.30	2.22
4.	440	150	101.71	38934.22	2.66
5.	440	160	103.85	40674.04	2.58
6.	440	170	104.28	43037.97	2.09
7.	440	180	104.92	45291.65	1.85
8.	440	180	109.01	43592.33	1.45

TABLE 2: Process Parameters of Depth of Penetration for 4 mm Electrode

S.No	Welding voltage (v)	Welding current (A)	Welding speed (mm/min)	Heat input (J/mm)	Penetration ratio (mm)
1.	440	160	101.19	41743.25	1.98
2.	440	170	101.76	44103.77	5.66
3.	440	180	102.34	46433.45	2.96
4.	440	190	101.86	49244.06	3.28
5.	440	200	103.86	50837.66	3.19
6.	440	220	104.19	55744.31	2.85
7.	440	230	104.85	57911.30	2.34
8.	440	240	109.19	58027.29	1.42

IV. RESULTS AND DISCUSSIONS

4.1.Effect of welding speed on depth of penetration:

Readings of depth of penetration obtained through measuring instrument after cutting all the welded specimens perpendicular to the direction of welding are shown in the table 1 and 2.Penetration Ratios are analyzed with the help of graph which is plotted between Welding current, Welding Speed and penetration as shown in Fig 4 and 5

It can be seen from Fig 4, As Welding Current increases, Penetration Ratio also increases slightly then it shows rapid growth with Welding Current. Further increase in welding current, a maximum value of 150 amps shows the maximum value of Depth of Penetration 2.66 mm. Afterwards, increase of Welding current decreases Depth of Penetration.

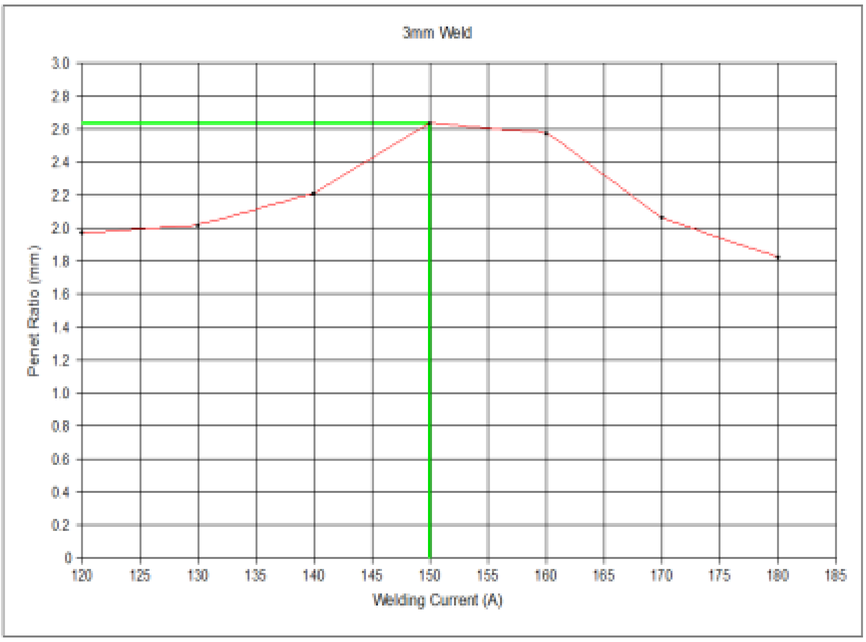


Fig 4. Relationship between Welding Current and Penetration Ratio

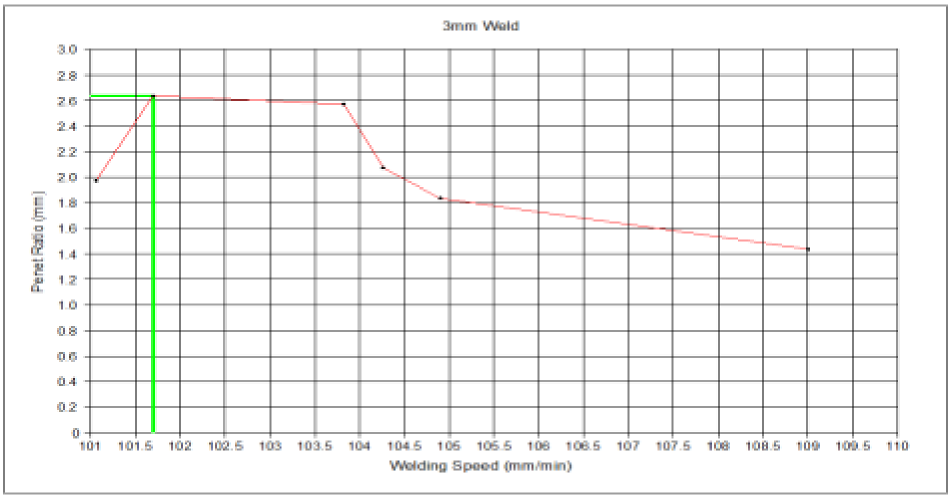


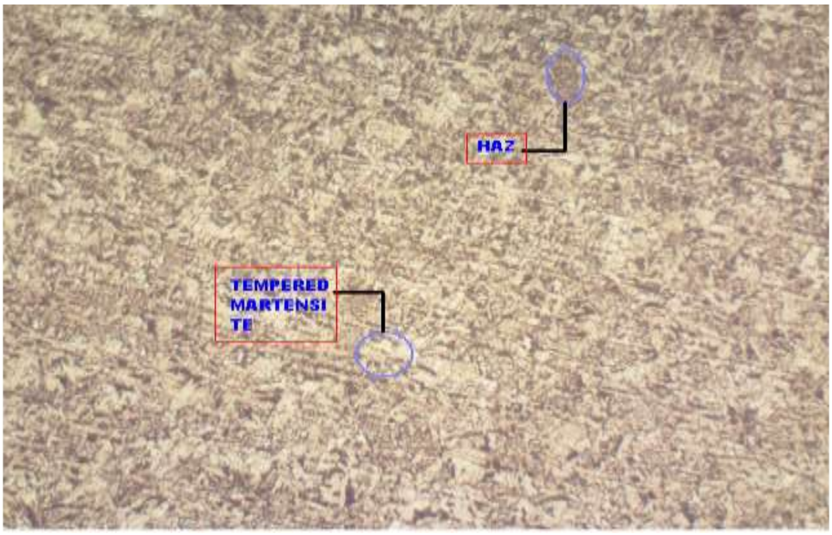
Fig 5 . Relationship between Welding Speed and Penetration Ratio

From the graph it can be found that the increase in Welding speed first increases depth of penetration then further increase in speed , penetration ratio will not change much. Instead it decreases enormously. Hence an Optimum value of 2.66mm Depth of Penetration is recorded at 101.71 mm/min of Welding speed.

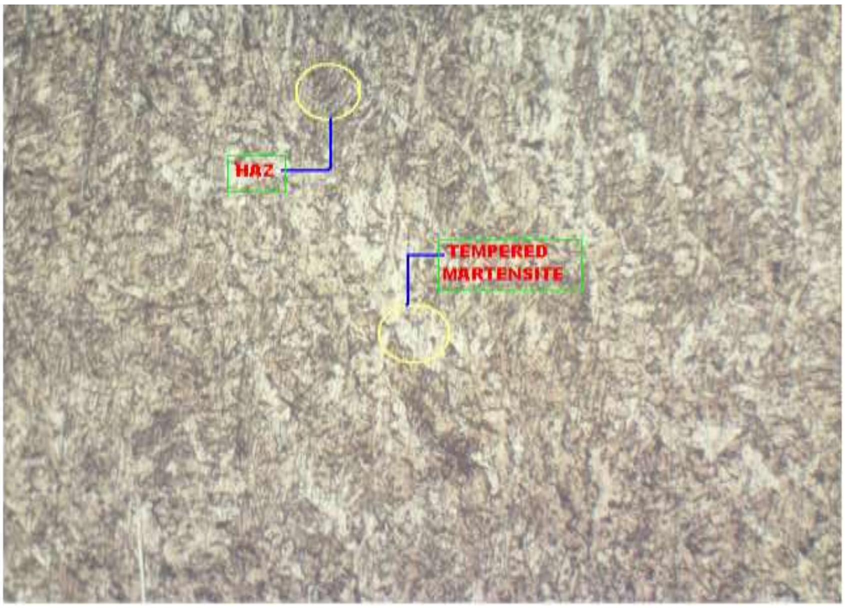
4.2.Microstructural analysis:

Microstructure for 3mm

3mm HAZ@100x



3mm PM@100x



3mm WELD@100x

V. CONCLUSIONS

1. Depth of Penetration can be achieved by considering the welding parameters as welding speed, 101.71 mm/min with current 150 Amp, arc voltage 440V which is taken as constant with size of the electrode(E 6011) diameter 3mm.
2. Microstructure consists of tempered martensite in the matrix.
3.HAZ is well fused and consists of tempered and needle martensite in the matrix.
4. Maximum Depth of Penetration of 2.66mm is possible at optimum values of Welding Current 150 amp with welding speed of 101.71mm/min is possible which clearly indicated that the weldability is maximum at this point. It is due to the weldability of any material is proportional to Depth of Penetration.

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