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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, HAZ, Welding Speed

1. 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.

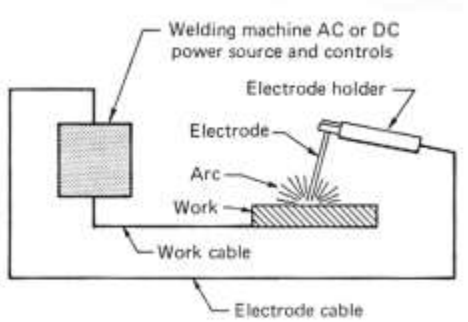

Fig.1 Schematic diagram of arc welding

A Schematic diagram of an arc welding process is shown in Fig 1[7].

2. Literature Review:

Manual metal arc welding was first invented in Russia in 1888. It involved a bare metal rod with no flux coating to give a protective gas shield. The development of coated electrodes did not occur until the early 1900s when the Kjellberg process was invented in Sweden and the Quasi-arc method was introduced in the UK. It is worth noting that coated electrodes were slow to be adopted because of their high cost.

However, it was inevitable that as the demand for sound welds grew, manual metal arc became synonymous with coated electrodes. When an arc is struck between the metal rod (electrode) and the work piece, both the rod and work piece surface melt to form a weld pool. Simultaneous melting of the flux coating on the rod will form gas and slag which protects the weld pool from the surrounding atmosphere. The slag will solidify and cool and must be chipped off the weld bead once the weld run is complete (or before the next weld pass is deposited).

Welding is an efficient and economical method for joining of metals. Welding has made significant impact on the large number of industry by raising their operational efficiency, productivity & service life the plant and relevant equipment.

Welding is one of the most common fabrication techniques which is extensively used to obtained good quality weld joints for various structural components. The present trend in the fabrication industries is to automate welding processes to obtained high production rate[1].

Arc welding, which is heat-type welding, is one of the most important manufacturing operations for the joining of structural elements for a wide range of applications, including guide way for trains, ships, bridges, building structures,

automobiles, and nuclear reactors, to name a few. It requires a continuous supply of either direct or alternating electric current, which create an electric arc to generate enough heat to melt the metal and form a weld.

The arc welding process is a remarkably complex operation involving extremely high temperatures, which produces severe distortions and high levels of residual stresses. These extreme phenomena tend to reduce the strength of a structure,

Which becomes vulnerable to fracture, buckling, corrosion and other type of failures.

Hardness is very important mechanical property of material but during welding high heating and rapid cooling influence the hardness of the weld as well as the Heat affected zone (HAZ)[2]. Also the optimum hardness of weld and heat affected zone (HAZ) at minimal heat input rate for 60and 70bevelangle weldments have been investigated.

A mathematical model was developed to study the effects of process variable and heat input on the heat effected zone (HAZ) of submerged arc weld in structural pipes.

High deposition rate welding process which can produced a smooth bead with deep penetration at a faster travel speed also welding input parameters plays a very significant role in determining the quality of the weld joint have been investigated.

A numerical model of fluid flow and temperature field in GMAW was established according to the new model arc heat flux distribution. By using a numerical simulation technique, the effects of welding heat input on microstructure and hardness in HAZ of HQ130 steel were studied.

The effect of welding parameters on the size of the heat affected zone (HAZ) and its relative size as compared to the weld bead of submerged arc welding [3]. It is discovered that the welding parameters influences the size of weld bead and HAZ differently which can be relate to the effect of welding parameters on the various melting efficiencies. This difference in behavior of HAZ and weld bead can be explored to minimize the harmful effect of HAZ in future welds.

In this study, the effect of various welding parameters on the weld ability of Mild Steel specimens having dimensions 125mm× 75mm× 5 mm welded by manual metal arc welding (MMAW) for single V-Butt joint were investigated. The welding current, arc voltage, welding speed, heat input rate are chosen as welding parameters. The effect of these parameters on the size of heat affected zone is investigated [8].

3. **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[4].

A 3D Model of a Closed Butt joint of Mild Steel specimen is shown in Fig 2.

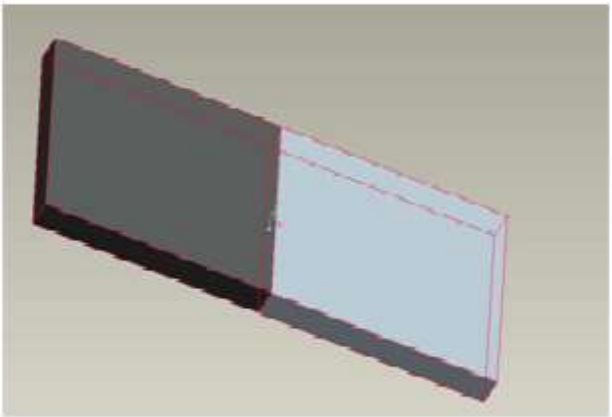

Fig: 2. A 3d Model Of a Closed Butt Joint

3.a. Experimental Data:

During the welding process, following data are chosen:
M.S. (Mild Steel) Work piece
Electrode (E 6011) of 3mm & 4mm diameter
Current (3mm electrode) =120-180 Amp
Current (4mm electrode) =160-240 Amp
Terminal voltage = 440 V
3. b. Chemical Composition of M.S. Plate are shown in the following Table 1.

Table 1 Chemical Composition of Mild steel plate:

C %	**Si%**	**Mn%**	**P %**	**S %**	**Cr%**	**Ni%**	**Mo%**	**Al%**
(0.2 50)	(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 [6].
Different values of Depth of Penetration are tabulated with input parameters like Welding Current, Welding speed and Heat Input as shown in Table 2 for 3 mm electrode and Table 3 for 4 mm electrode

Table 2: 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 3: 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

1.8 RESULTS AND DISCUSSIONS

a. 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 3 and 4

It can be seen from Fig 3, 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 [5].

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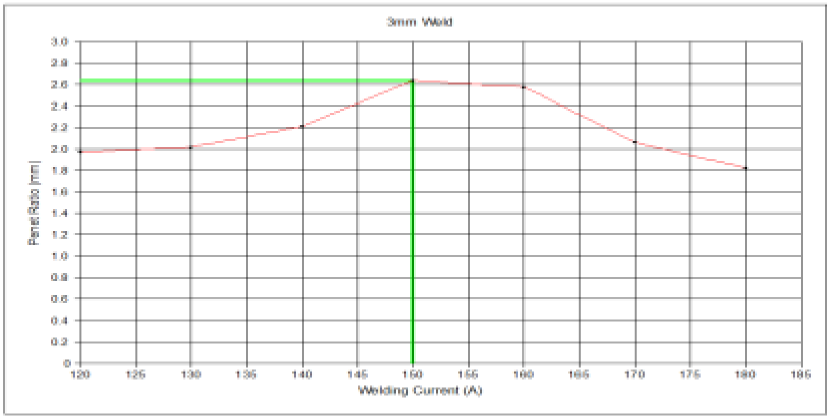

Fig 3: Relationship between Welding Current and Penetration Ratio

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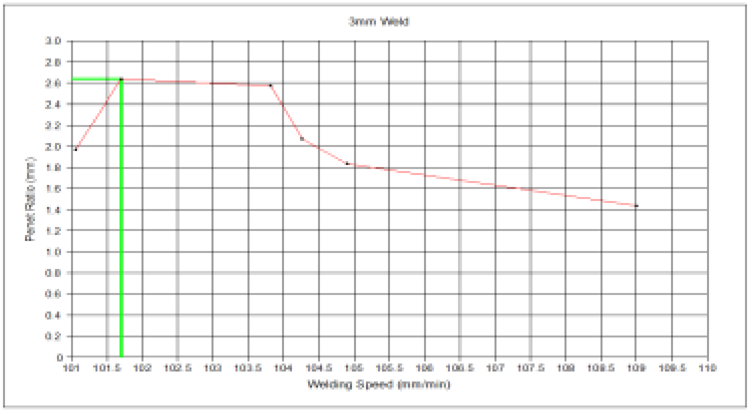

Fig 4 Relationship between Welding Speed and Penetration Ratio

From the Fig 4, 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.

b. Micro structural analysis

Further investigations of Closed butt joint were analyzed using Metallurgical Microscope. The Microscopic images of welded joint for 3mm electrode Microstructure for 3mm HAZ is shown in Fig 5 and 4 mm in Fig 6 at Magnification 100 X. Tempered Martensite in form of spherical craters are identified in images.

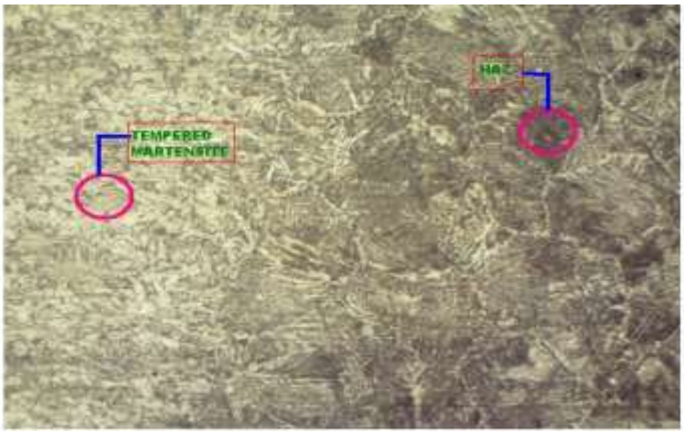

Figure 5: 3mm HAZ@100x

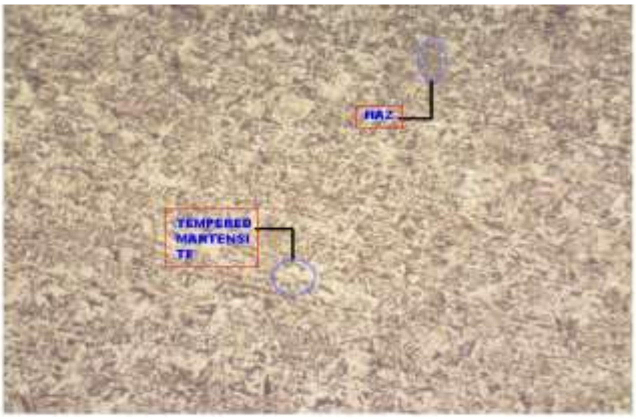

Figure 6: 4mm HAZ@100x

4. 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 for 3mm and 4mm electrode images consist of tempered martensite in the matrix which are in form of spherical globules indicate the formation of Heat Affected Zone (HAZ).

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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