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Influence of Welding Parameters on Weld Joint Using SASMAW Machine

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Abstract—*Material characteristics and welding parameters play a very important role in determining the quality of a weld bead. Factors like heat source characteristics, nature of deposition of filler material, heat flow characteristics in the joint, cooling of the fusion zone with associated contractions, residual stresses and metallurgical changes. Different welding processes are used with the aim of obtaining a best welding joint with the desired input parameters, good mechanical properties with minimum defects. So there is a need for the study on these input characteristics for obtaining good mechanical properties of the weld joint. We have designed an automated machine performing the arc welding using rack and pinion mechanism and an rps for converting the rotating to linear motion and speed control respectively for obtaining constant parameters like weld velocity, feed rate and arc length, so that the study would be more precise. An attempt is made the study of input parameters of shielded metal arc welding using a SASMAW(Semi Automated Shielded Metal Arc Welding) machine with the case study of performing the welding operation on an MS-sheet and finding the corresponding welding speed.*

1. INTRODUCTION

The most common quality problems associated with SMAW include weld spatter, porosity, poor fusion, shallow penetration, and cracking. Weld spatter, while not affecting the integrity of the weld, damages its appearance and increases cleaning costs. It can be caused by excessively high current, a long arc, or arc blow, a condition associated with direct current characterized by the electric arc being deflected away from the weld pool by magnetic forces. Arc blow can also cause porosity in the weld, as can joint contamination, high welding speed, and a long welding arc, especially when low-hydrogen electrodes are used. Porosity, often not visible without the use of advance non destructive methods, is a serious concern because it can potentially weaken the weld. Another defect affecting the strength of the weld is poor fusion, though it is often easily visible. It is caused by low current, contaminated joint surfaces, or the use of an improper electrode. Shallow penetration, another detriment to weld strength, can be addressed by decreasing welding speed, increasing the current or using a smaller electrode. Any of these weld-strength-related defects can make the weld prone to cracking, but other factors are involved as well. High carbon, alloy or sulfur content in the base material can lead to cracking, especially if low-hydrogen electrodes and preheating are not employed. Furthermore, the work pieces should not be excessively restrained, as this introduces residual stresses into the weld and can cause cracking as the weld cools and contracts. An attempt is made in this work, to make the operation semi automatic, keeping in view of the economy and accuracy. The experimental setup ensures that the automation reduces the lacunae occurred due to manual handling of the electrode and the flow of the current is in controlled manner. A proper alignment of the electrode and electrode angle, makes the weld non defective.

2. EFFECTS OF WELDING PARAMETERS :

The effects of the variables are somewhat dependent on the welding process being employed, but general trends apply to all the processes. It is important to distinguish the difference between constant current (CC) and constant voltage (CV) electrical welding systems. Shielded metal arc welding is always done with a CC system, while flux cored welding and gas metal arc welding generally are performed with CV systems. Submerged arc may utilize either primary variable in determining heat input. Generally, an increase in amperage means higher deposition rates, deeper penetration, and more admixtures. The amperage flowing through an electrical circuit is the same, regardless of where it is measured. It may be measured with a tong meter or with the use of an electrical shunt. The role of amperage is best understood in the context of heat input and current density considerations. For CV welding, an increase in wire feed speed will directly increase amperage. For SMAW on CC systems, the machine setting determines the basic amperage, although changes in the arc length (controlled by the welder) will further change amperage. Longer arc lengths reduce amperage.

Arc voltage is directly related to arc length. As the voltage increases, the arc length increases, as does the demand for arc shielding. For CV welding, the voltage is determined primarily by the machine setting, so the arc length is relatively fixed in CV welding. For SMAW on CC systems, however, the arc voltage is determined by the arc length, which is manipulated by the welder. As arc lengths are increased with SMAW, the arc voltage will increase, and the amperage will decrease. Arc also controls the width of the weld bead, with higher voltages generating wider beads. Arc voltage has a direct effect on the heat input computation.

The voltage in a welding is not constant, but is composed of a series of voltage drops. The most accurate way to determine arc voltage is to measure the voltage drop between the contact tip and the work piece. However, this may not be practical for semiautomatic welding, so voltage is typically read from a point on the wire feeder (where the gun and cable connection is made),to the work piece. For SMAW welding, voltage is not usually monitored, since it is constantly changing and cannot be controlled except by the welder. Skilled welders hold short arc lengths to deliver the best weld quality.

2.1: Travel speed

It is measured in inches per minute, is the rate at which the electrode is moved relative to the joint. All other variables being equal, travel speed has an inverse effect on the size of the weld beads. As the travel speed increases, the weld size will decrease. Extremely low travel speeds may result in reduced penetration, as the arc impinges on a thick layer of molten metal and the weld puddle rolls a head of the arc. Travel speed is a key variable used in computing heat input (reducing travel speed increases heat input).

2.2: Wire feed speed

It is a measure of the rate at which the electrode is passed through the welding gun and delivered to the arc. Typically measured in inches per minute (ipm), the deposition rates are directly proportional to wire feed speed and directly related to amperage. When all other welding conditions are maintained constant, an increase in wire feed speed will directly lead to an increase in amperage. For slower wire feed speeds, the ratio of wire feed speed to amperage is relatively constant and linear. For higher wire feed speeds, this ratio may increase, resulting in a higher deposition rate per amp, but at the expense of penetration. Wire feed speed is the preferred method of maintaining welding procedures for constant voltage wire feed processes. The wire feed speed can be independently adjusted and measured directly, regardless of the other welding conditions. It is possible to utilize amperage as an alternative to wire feed speed although the resultant amperage for a given wire feed speed may vary, depending on polarity, electrode diameter, electrode type and electrode extension. Although equipment has been available for two decades that monitor wire feed speed, many codes such as AWS D1.1 continue to acknowledge amperage as the primary method for procedure documentation. D1.1 does permit the use of wire feed speed control instead of amperage, providing a wire feed speed-amperage relationship chart is available for comparison. Specification sheets supplied by the filler metal manufacturer provide data that support these relationships.

2.3: Electrode diameter

It is another critical variable. Larger electrodes can carry higher welding currents. For fixed amperage, however, smaller electrodes result in higher deposition rates. This is because of the effect on current density.

2.4: Heat input

Its is proportional to the welding amperage, times the arc voltage, divided by the travel speed. Higher heat inputs relate to larger weld cross sectional areas, and larger heat affected zones, which may negatively affect mechanical properties in that region. Higher heat input generally results in slightly decreased yield and tensile strength in the weld metal, and generally lower notch toughness because of the interaction of bead size and heat input.

3. ELECTRODE ANGLE

As the angle between the electrode and the plate determines the point of impingement and direction of the arc force, it has a critical effect on the weld bead profile and depth of penetration. Welding can be carried out with the electrode wire leading, trailing and normal to the plate surface and the effects on weld shape, penetration and undercut .For most applications it is usual to weld with the electrode wire pointing forwards, i.e. leading by 10°, in order to obtain the best combination of bead shape, penetration and resistance to undercut.

The effect of the electrode angle on horizontal-vertical fillet welds. Penetration into the root of the joint can be increased by reducing the electrode angle whilst also aiming the arc more onto the vertical rather than the horizontal plate.

4. DESIGN OF SEMI AUTOMATED SMAW MACHINE

This model is designed for performing the welding operation with pre calculated weld parameters like weld speed, feed rate and arc length. It has the features for setting the different parameters according to the requirement. The main elements of the machine consist of a rack and pinion, an electric motor, adjusting table, supporting plates and RPS. The rack and pinion mechanism is used to convert the rotary motion into linear motion which is required for linear velocity of weld torch. The welding torch is fixed at one extreme end of the pinion carries the electrode. As the rack passes the linear motion which is being transmitted through pinion, the weld torch and electrode have the same linear velocity of the rack.

The pinion shaft is coupled to an electric motor for its drive .the motor is given power supply through an RPS. This is used for the purpose of getting different linear velocities of the rack by regulating the power supply through RPS .a varied RPM of the motor shaft can be achieved thus getting different linear velocities. The supporting plates have been provided with two supporting bars, where one is fixed at its position and the other one is provided with long slot where it can be slide from top to bottom fixing it at various positions. The position of the second supporting bar decides the angle of the rack.

The angle of the rack and pinion both in combine decides the feed rate and weld velocity. Thus for the different combinations of angle of the rack and RPM of the motor shaft, we can achieve the wide range of weld velocities and feed rates. As we are changing the angle of the rack, the distance between the electrode and the table is also changed, so there is requirement of adjustable table for maintaining the required distance between the electrode and the weldment.

A DC motor uses electrical energy to produce mechanical energy. The DC motor has two basic parts: the rotating part that is called the armature and the stationary part that includes coils of wire called the field coils. The stationary part is also called the stator. Figure shows a picture of a typical DC motor, Figure shows a picture of a DC armature, and Fig shows a picture of a typical stator. From the picture you can see the armature is made of coils of wire wrapped around the core, and the core has an extended shaft that rotates on bearings. You should also notice that the ends of each coil of wire on the armature are terminated at one end of the armature. The termination points are called the commutator, and this is where the brushes make electrical contact to bring electrical current from the stationary part to the rotating part of the machine.

And all other equipment is in common with generally performed Shielded Metal Arc Welding.

5. METHODOLOGY

The welding equipment selected is to have the following specifications for carrying out the performance of the welding parameters. The DC supply: 4 to 12V, Total length: 46mm, Motor diameter: 36mm, Motor length: 25mm, Brush type: Precious metal, Output shaft: Centered, Gear assembly: Spur

Although motor gives 10 RPM at 12V but motor runs smoothly from 4V to 12V and gives wide range of RPM, and torque. Tables below gives fairly good idea of the motor's performance in terms of RPM and no load current as a function of voltage and stall torque, stall current as a function of voltage.

Table 3.1: RPM of motor with varying input

S. No	Voltage	RPM
1	5	5
2	6	6
3	7	7
4	8	8
5	9	9
6	10	10

With the adjusting table, we can vary the work piece height from the ground level so as to compensate the changes in the angle of rack which makes the changes in distance of electrode from base level as shown in Figure 3.2

This has been provided for supporting the whole rack and pinion and motor set up. There are two horizontal supports provided on the plates, one is fixed at its point and the other can be moved vertically up and down for achieving different angles of the rack according to the requirement.

Fig. 3.2: View of angular positions

5.1 Performance of welding operation on MS sheet using different parameters

Performance is calculated using the Selection of base material and filler material: Mild steel sheet, Filler material/Electrode type: E6013, Type of current: Direct current electrode positive (DCEP) and Selection of welding process parameters:

Feed Volume rate of electrode by experimental study:

Table 3.2: List of feed volume rates

S.NO.	Current (amps)	Length of consumption (cm)	Time	Length/ time (Vf) (cm/sec)	F=Feed/sec (m3/sec) (X*10-6)
1	20	4.3	18	0.2388	X=0.018609
2	30	4.1	15	0.2733	X=0.021298
3	40	4.1	12	0.3416	X=0.021432
4	50	3.8	8	0.4750	X=0.029802
5	80	5.9	10	0.5900	X=0.037017
6	100	7.4	10	0.7400	X=0.046428

5.2 Calculations of Weld Speed and Feed Volume Rate for given Power Input

Weld Volume/sec(F)= π/4* d2 *(Length/Time) (d=3.15mm)

- Area of cross section of weld bead, $\mathbf{A} = (\frac{\sqrt{3}}{4}(\frac{2}{\sqrt{3}}t)^2 + \mathbf{x})$
- Where x is the cross sectional area of crown, assume to be 20% of the fillet area
- therefore, $\mathbf{A_c} = 1.2(\frac{\sqrt{3}}{4}(\frac{2}{\sqrt{3}}t)^2)$

- Volume of the weld bead, $V_C = 1.2(\frac{\sqrt{3}}{4}(\frac{2}{\sqrt{3}}t)^2) * l$
- Time required for welding, $\mathbf{T = V_c/F}$
- Rate of filling of weld bead volume at crown, $\mathbf{V}^* = \frac{Vc}{T}$
  (T is time required for welding)
  $= \frac{(Ac)*l}{T}$
  $\mathbf{= (A_c)*V}$ **--- (1)** [As l /T =V(weld velocity)]

This rate of filling of weld bead is equal to the feed rate of electrode which we have calculated experimentally, Thus equating these two, we get

$(A_c)*V$ = FEED VOLUME RATE

Therefore,

Welding velocity, V= FEED VOLUME RATE/ (A_c) --- (2)

V_1 is the linear velocity along the rack $V_1\cos\theta = V$ --- (3)

$V_1 \sin\theta = V_f$ --- (4) (V_f - feed velocity)

Therefore $V_1 = V \sec\theta$ or $V_f \operatorname{cosec}\theta$

From (3) & (4)

$V/V_f = \cot\theta$

$\theta = \cot^{-}(V/V_f)$ --- (5)

Also, $V_1 = \pi DN/60$ --- (6)

From (3) & (6)

Required RPM of motor, $N = \frac{V}{(\frac{\pi D}{60}.\cos\theta)}$ **--- (7)**

Area of cross section for selected metal is,

$A_c = 17.3205 * 10^{-6}\ m^2$ (for t=5mm)

For $v_f = 23.88*10^{-4}$ m/sec,

$v = 3.0008*10^{-6}/17.3205 * 10^{-6}$

$= 1.0743 * 10^{-3}$ m/sec

Therefore, $\theta = \cot^{-}(1.0743*10^{-3}/23.88*10^{-4}) = 65.706$

And, $v_1 = 1.0743*10^{-3} * [\sec(65.706)] = 2.6112 * 10^{-3}$ m/sec

6. RESULTS

This paper has presented an investigation on the effect of welding parameters on the strength, elongation, brinell hardness and welding speed for such strength of welding operation on MS Plate. The following values were obtained after the welded specimen of MS was tested on UTM

Yield strength – 61.15 MPa, % Elongation – 3.1%, Brinell Hardness Number – 80 BHN, and optimum welding speed-2.6 mm/sec. Based on this test on tensile shear strength, the effective parameters were found as welding current and electrode force, whereas electrode diameter and welding time were less effective factors. The results showed that welding current was about two times more important than the second ranking factor (electrode force) for controlling the tensile shear strength.

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