Analysis of Various Parameters of ARC Welding

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Abstract : Arc-welding is the most commonly and widely used welding technique for variety of purposes. Welded joint may not be very reliable unless the weld is of reasonably good quality. Improving the weld quality is of prime concern. The aim is to study the effect of welding parameters and to use magnetic field advantageously to improve the weld qualities and properties (such as strength and hardness).

However there is lack of information for optimum parameters, very little work has been reported in this direction. A magnetic field externally applied to the welding arc, deflects the arc by electromagnetic force in the plane normal to the field lines. The magnetic field exerts force on the electrons and ions within the arc, which causes the arc to be deflected away from the normal arc path. The welding arc can be deflected forward, backward, or sideways with respect to electrode and welding direction depending upon the direction of an external magnetic field

The objective of this work is to study effect of magnetic field on the weld quality and geometry when the field is applied longitudinal to the electrode travel

I. INTRODUCTION

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[1]. 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[2]. 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[3]. 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. 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[4].

II. OBJECTIVE

The objective of this work is to study effect of magnetic field on the weld quality and geometry when the field is applied longitudinal to the electrode travel

With this objective the work is divided in 3 modules as:

- Concept Designing
- Fabrication and Assembly
- Testing the weld - pieces

2.1 CONCEPT DESIGNING

An arc welding machine supplies electric current to an electrode wire. The electric current travels through the air gap between the end of the electrode wire and the base metal. As the electric current flows through this air gap, an electric arc is formed. The electric arc produces heat that heats the base metal to its melting temperature. The heat from the base metal produces a shielding gas that protects the base metal, arc, electrode, and weld from the atmosphere during the welding process. As the flux covering on the electrode wire melts, a shielding gas is created.

When the flux cools, it solidifies and forms a protective slag over the weld bead. As the electrode wire melts, it becomes the filler metal to the weld[5].

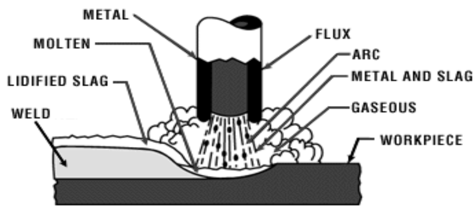

Fig 1: Schematic of Arc welding

Application of external magnetic field has been reported in the literature to affect the characteristics of the welding arc and the weld properties. Magnetic field can be applied to the welding arc in three different modes. If magnetic field is in the direction of electrode travel, it is considered to be a longitudinal magnetic field[6]. If the field is perpendicular to the direction of electrode travel and electrode axis, it is referred to as a transverse field.

Factors which affect the arc behavior during the application of a magnetic field are as follows:

1. Distance between the electrodes
2. Magnetic field intensity
3. Arc current
4. Weld material

A magnetic force acts on the arc, in this system when the angle between the direction of the electron stream and magnetic lines of force are not zero. As the arc has a conical shape and the current carrying electrons also moves along the surface of the arc, their motions can be resolved in two components, one along the axis of the arc and other perpendicular to it. The component along the arc does not contribute to the magnetic movement[7]. The component perpendicular to arc exerts a force on the arc causing the arc to rotate clockwise or anticlockwise depending upon the direction of the magnetic field and polarity used[8].

2.2 FABRICATION AND ASSEMBLY

This phase deals with the fabrication and assembly of the individual components. The mild steel pieces of the dimension 150 mm X 50 mm X 6 mm are used as a work-piece for the welding. Each metal piece first cleaned for dust and rust. Before the actual welding process the space between the specimens is fixed with a support. The space between the specimens for the butt welding is depends upon the thickness of the work-piece. For a 6 mm thickness there is no requirement of making groove, so a 3 mm gap is maintained during the whole process of welding. The quality and geometry of weld is much depends on correct and same gap throughout length of the specimen.

The magnetic field is applied as per the set-up and then the arc welding machine and electrodes are fixed at their respective places. Multi-meter, clamp-meter and gauss-meter are placed and connected to take the readings. As per the semi-automation to the process feed rod is connected with the work-piece motion.

The weld-pieces obtained after the process is shown in Fig. 2.

Fig 2: Welding specimens after process in presence of magnetic field

The similar setting as with magnetic welding is used in without magnetic field process of welding. Only change is that the magnetic field arrangement is removed. The range of current and voltage are remained similar to the magnetic field welding. The weld-pieces obtained in this process are shown below:

Fig 3: Welding specimens after process without magnetic field

2.3 TESTING THE WELD PIECES

A hardness test is used to determine the hardness of weld metal. In the Rockwell hardness test, the specimen is mounted on the anvil of the machine and a load is applied against a hardened steel ball which is in contact with the surface of the specimen being tested.

The load is allowed to remain 1/2 minute and is then released, and the depth of the depression made by the ball on the specimen is measured. The resultant Rockwell hardness number is obtained from the dial.

Fig 4: Tensile testing apparatus

For the tensile test we use universal testing machine (UTM) The gripping and rupture points are located in the figure. This test is used to measure the strength of a welded joint. A portion of the welded plate locates the weld midway between the jaws of the testing machine. The width thickness of the test specimen are measured before testing, and the area in square inches is calculated by multiplying these before testing , and the area in square inches is calculated by multiplying these two figures.

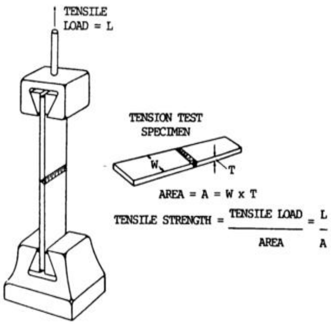

Fig 5: Schematic of impact testing

For testing the impact strength, we use the Charpy test The Charpy piece is supported horizontally between two anvils and the pendulum strikes opposite the notch. A Charpy test measures the welds ability to withstand an Impact force. Low Charpy test readings indicate brittle weld metal Higher Charpy readings indicate the samples toughness.

Weld-pieces are placed at the impact testing machine as simply supported. The hammer of the heavy weight is then released and corresponding values of weight provides the toughness values for weld-pieces.

The energy required to fracture the notch specimens is measured by the impact test. Impact testing was done on Charpy testing machine.

The standard samples were made of dimensions 10×10×55 mm with single notch at the centre having size of 45° and 2mm depth.

Fig 6: Welding specimens for impact test

III. OBSERVATIONS

TABLE 1 : WELD-PIECES WITH MAGNETIC FIELD

WORK-PIECE NO.	CURRENT (A)	VOLTAGE (V)	MAGNETIC-FIELD INTENSITY (GAUSS)	WELDING SPEED (mm/min)
M1.	120	24.5	70	60
M2.	110	23.7	70	60
M3.	115	23	70	60
M4.	135	18.5	70	60
M5.	125	21.5	70	60
M6.	130	19	70	60
M7.	90	27.5	70	60
M8.	95	27.7	70	60
M9.	100	28.5	70	60

TABLE 2 : WELD-PIECES WITHOUT MAGNETIC FIELD

WORK-PIECE NO.	CURRENT (A)	VOLTAGE (V)	MAGNETIC-FIELD INTENSITY (GAUSS)	WELDING SPEED (mm/min)
M1.	120	24.5	70	60
M2.	110	23.7	70	60
M3.	115	23	70	60
M4.	135	18.5	70	60
M5.	125	21.5	70	60
M6.	130	19	70	60
M7.	90	27.5	70	60
M8.	95	27.7	70	60
M9.	100	28.5	70	60

IV. RESULTS

On the basis of different experiments, automation of welding process and effect of magnetic field the following conclusions are derived:

1. The welding set-up on lathe provides automatic motion to the work-piece and welder has to provide only the feed to electrode. This provides the smoothness in welding process.

2. Effect of magnetic field applied transverse to welding direction affects the bead width of joint and increases it.

3. Undercuts, spatter etc. welding defects are reduced.

4. The tensile strength of the weld joint is on improvement side due the refinement of grains.

5. Hardness of the weld decreases as compared with the weld-pieces which are welded without magnetic field.

6. Reinforcement height of weld reduces as the weld bead width is increasing.

7. Toughness of the weld metal increases.

V. FUTURE SCOPE

In this project we have constrained our work by testing the effect of magnetic field in longitudinal direction only. Further this extended for:

- Magnetic field in transverse direction of weld bead
- Magnetic field applied axial to the electrode

Further the study can be extended by conducting the following mechanical properties test

- Bend test
- Non destructive tests

In this project work the weld geometry tests are not conducted only the visual inspection is done and the results based on that are considered. Further the study can be extended by performing the macro structure study of the weld metal. This can be done on polishing and grinding machines. This could be result in perfect testing of weld bead width and penetration depth.

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