Welding Strength Measurement in ARC Welding By Changing Its Process Parameters

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Abstract— In this project we discussed the effect of high voltage and low voltage on mild steel weld metals. In this two different voltage welding parameters are investigated. After that the Liquid penetration test is conducted for knowing the defects due to change of voltage, again the welded specimens were cut and machined to standard configurations for Tensile test and Bending test. The results showed that by varying voltage had a remarkable effect on the mechanical properties such as the ultimate tensile strength, elongation percentage, and yield strength of the welded specimens. We have observed that the increment in the voltage increases strength of the weld and have less defects compared to low voltage weld metal.

Keywords: Welding, Parameters, Penetration test, Tensile test, bending test, Mechanical properties

I. INTRODUCTION

Welding is a process of making a permanent joint by establishing interatomic bonds between two parts of metal by using heat or heat and pressure. In welding, the interface of the two parts to be joined are melted and allowed to solidify or are heated to plastic state and then the pressure is applied so that a permanent joint is formed. It is usually performed on parts made of the same metal, but some welding methods can be used for dissimilar metals. The principle of welding is based upon the formation of an electric arc between consumable electrode (bare or coated) or non-consumable electrode and the base metal. The heat of the arc is concentrated at the point of welding, and as a result, it melts the electrode (consumable electrode) and base metal. When the weld metal solidifies, a sound joint is formed. When the metal solidifies, the slag gets deposited on its surface as it is lighter than metal, and the weld metal is allowed to cool gradually and slowly. The slag deposited over the weld is removed by chipping. The electric arc is produced when current flows across the air gap between the end of metal electrode and the work surface. This arc is strong stable electric discharge occurring in the airgap between an electrode and the work. The temperature of this arc is about 36000 C which can melt and fuse the metal very quickly produce joint. The temperature of the arc at the centre is around 6500^0C. Only 60 to 70 percent of the heat is utilized in arc welding to heat up and melt the metal. The remaining 40 to 30 percent is dissipated into surroundings.

II. EXPERIMENTAL SETUP.

A. Material:

The material IS2062 Grade B Mild Steel of the required dimension was purchased from the local market and the test specimen was prepared from it. The chemical composition of IS2062 Grade B mild steel by weight (wt.%) is given as follow C- 0.22, Mnl-50, Si-0.40, CE-0.41, P-0.045, S-0.045 and Fe.

1) *Composition of mild steel:*

A small amount of carbon makes mild steel to change it properties. Different amount carbon produces different types of steels. There are small spaces between the iron lattice. Carbon atoms get attached to these spaces and makes it stronger and harder. The harder the steel the lesser the ductility. The modulus of elasticity calculated for the industry grade mild steel is 210,000 MPa. has an average density of about 7860 kg /m3.Mild steel is a great conductor of electricity. So, it can be used easily in the welding process. Because of its malleability, mild steel can be used for constructing pipelines and other construction materials. Even domestic cook wares are made of mild steel It is ductile and not brittle but hard. Mild steel can be easily magnetized because of its ferromagnetic properties. So electrical devices can be made of mild steel. Mild steel is very much suitable as structural steel. Different automobile manufacturers also use mild steel for making the body and parts of the vehicle. Mild steel can be easily machined in the lathe, shaper, drilling or milling machine its hardness can be increased by the application of carbon. Mild steel is very much prone to rust because it has high amount of carbon. When rust free products are needed people prefer stainless steel over mild steel.

B. Material and Method:

Material IS 2062 Grade B Mild Steel of the required dimension was purchased he local market and the test specimen was prepared from it. The chemical composition of IS2062 Grade B mild steel by weight (wt.%) Is given as follow C- 022, Mn-50, Si-0.40, CE-0.41, P-0.045, S-0.045 and Fe.

C. Steps involved in welding process:

1) *Preparation of the specimen:*

The test specimen for analysis of mechanical properties of hardness and tensile strength were prepared as per ASTM standard and its: Specimen for tensile test and bending test: An impact specimen as per ASTM A370 is prepared with the following dimensions.

- Length-150mm
- Width 100mm
- Thickness 6mm

2) *Groove preparation:*

Initially the given specimen has unequal dimensions so for achieving the smooth specimen we have done the grinding around the specimen. At the top of the both specimens we removed some excess metal i.e, 3mm and within angle of 45deg i.e. 90 deg for two specimens. The main purpose of making angle is for achieving the V "with help of V 'shape we have to maintain the cap during welding.

3) Welding Process:

The IS2062 GRADE B Mild Steel has been join together using arc welding at different range which is at 50, 100, 45, 90. The electrode that is used for welding is E6013. The figure 3.7 shows the preparation of the work piece. The welded plate and the geometry of the 6 mm plates butt welded with a weld gap of 3 mm. Specimens of dimensions 150 mm x 100 mm x 6 mm were prepared as suggested. Work piece faces and edges were suitably prepared using wire brush prior to the welding processes. The plates were welded together by the arc welding process employing basic coated electrodes. E6013& E7013 low hydrogen electrodes rod was used for the welding operation. A high voltage DC generator with rectifiers, capable of supplying current up to 110A, air and water-cooled electrode holder was used for the welding operation Pair of prepared metal plates were butted leaving a gap of about 3 mm in between, while the gap is filled completely, putting into consideration the root, hot and bead. The welding was done under controlled and varying welding fill, cap pass, variables. The welded samples were allowed to cool and tapped with chipping hammer to remove the slag in other to ensure the gap was perfect.

Fig. 2.2: Welding process

D. Welding tests:

1) Non- destructive test
2) Destructive test

1) Non- destructive testing:

NDT is a testing and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or welding defects and discontinuities without causing damage to the original part.[12]

- liquid penetrant
- radiography
- magnetic particle
- eddy current
- ultrasonic testing

a) Liquid Penetrant Test:

This also called as DYE PENETRATION TEST (DPT). It is a type of Non-Destructive Test, Bywe find the weld defects at the weld joint. It is a low-cost inspection method. In dye penetration test we have applied some chemical agents in the sequential order as follows for both face layer and root layer.

- Pre-cleaning
- Application of penetrant
- Dwell time
- Excess removal of penetrant
- Application of developer
- Inspection
- Post cleaning

1) Pre-cleaning: It is the initial stage of the dye penetration test. In this the test surface is cleaned to remove dirt particles. Pre cleaning is necessary for all testing materials, because presence of dirt particles shows the false indications on the material. To avoid the false indications, it is required to all testing materials. For pre cleaning the alkaline solutions are generallyus.
2) Application of penetrant: The penetrant is then applied to the surface of the item being tested. The penetrant is usually brilliant coloured mobile fluid with high wetting capability. Usually following chemicals ssed as penetrates
3) Dwell time: Penetrant dwell time is the total time that the penetrant is in contact with the part surface. The dwell time is important because it allows the penetrant the time necessary to seep or be drawn into a defect.
4) Removal of excess penetrant: The excess penetrant is then removed from the surface, Emulsifiers represent the highest utility level, and chemically interact with the oily penetrant to make it removable with a et spray. When using solvent remover and lint-free cloth it is important to not spray the yent on the test surface directly, because this can remove the penetrant from the flaws. If excess penetrant is not properly removed, once the developer is applied, it may leave a background in the developed area that can mask indications or defects. In addition, this may abo produce false indications severely hindering the ability to do a proper inspection. Also, the removal of excessive penetrant is done towards one direction either vertically or horizontally as the case may be.
5) Application of developer: After excess penetrant has been removed, a white developer is applied to the sample. The AMS 2644 classify developers into six standard forms. The developer draws penetrant from defects out onto the surface to form a visible indication, commonly known as bleed-out. Any areas that bleed out can indicate the locate orientation and possible types of defects on the surface

2) Destructive testing:

Destructive weld testing, as the name suggests, involves the physical destruction of the completed weld in order to evaluate its characteristics. Typically they involve sectioning and/or breaking the welded component and evaluating various mechanical and/or physical characteristics.

- tension tests
- bend tests
- Charpy impact tests
- Hardness test

a) Tensile Test:

Tensile properties of the weld joints can be obtained either in ambient condition or in special environment (low temperature, high temperature, corrosion etc.) Depending

upon the requirement on the application using tensile test which is usually conducted at constant strain rate 1. The Tensile test can be conducted on the specimen which was welded at high voltage was broken at weld joint as shown in figure 3.18. The load bearing capacity of high voltage specimen is 50KN with deflection of 20mm. And low voltage specimen was broken at weld joint, the load bearing capacity of low voltage specimen is 42KN with deflection of 14mm.

b) BEND TEST:

Bend test is one of the most important and commonly used destructive tests to determine the ductility and soundness (for the presence porosity, inclusion, penetration and other internal weld discontinuities) of the weld joint produced using onder one set of welding condition bending of the weld joint can be done from face or noch side depending upon the purpose. Whether face or root side of the weld is to be assessed. The root side bending show the lack or penetration and fusion if any at the root. For bend test, the loud increased until cracks start to appear on face or root of the well for face and root bend test respectively and angle of bend this stage is used as a measured of ductility of weld joints. Higher is bend angle (needed for crack initiation) greater is ductility of the weld. Fracture surface of the joint from the face / root side due to bending reveals the presence of internal weld discontinuities if any in bending text, the plate thickness need no to be less than 45mm)

III. RESULT AND DISCUSSIONS

A. Results for liquid penetration test:

Both high voltage and low voltage on the weld metals. We conducted LPT on specimens LPT is used to determine the surface defects. By using LPT we have observed the following surface defetcts on high voltage specimen as shown in figure3.1 &3.2

Fig. 3.1: Defects on face of weld

Fig. 3.2: Defects on root of weld

On face weld we have observed that No significance defects (NSD), On root weld we have observed that porosity and lack of penetration(LOP). We have observed the following surface defects on low voltage weld metal. The defects as shown in fig 3.3 &3.4

Fig. 3.3: defects on face weld

Fig. 3.4: defects on root weld

On root weld we have observe spatter and on face weld lack of penetration.

B. Result for tensile test:

We conducted the tensile test on both high voltage and low voltage weld metals and we got the following results.In tensile test high voltage weld metal broken at load of 55KN and with deflection of 23mm .Low voltage weld metal broken at a load of 48KN with deflection of 20mm.By observing the tensile test results we concluded that high voltage weld metal has more tensile strength than low voltage weld metal.

Load(KN)	Elongation (mm)
0	0
20	5
40	10
55	23

Table 3.4: Load and Elongation (High voltage)

Load(KN)	Elongation(mm)
0	0
15	10
30	16
48	20

Table 3.5: Load and Elongation(Low voltage)

C. Results for bending test:

We conducted the bending test on both high voltage and low voltage weld metals at both root and face of the weld metals. We got the following results in bending test.

Bending test results for high voltage weld metal

1) *For face*

Maximum load: 3 KN

Deflection: 87mm

2) *For root*

Maximum load: 3.5 KN

Deflection: 89 mm

Bending test results for low voltage weld metal

1) *For face*

Maximum load: 4 KN

Deflection: 22 mm

2) *For root*

Maximum load: 3.5 KN

Deflection: 90 mm

In this for both low voltage and high voltage metal crack occurs at weld joint.

We concluded that high voltage weld metal has maximum load bearing capacity than low voltage metal.

Load(KN)	Depth(mm)
2	3
2.3	6
2.6	12
2.8	25

Table 4.6: on face of weld (High voltage)

Load(KN)	Elongation(mm)
0	0
15	10
30	16
48	20

Table 4.8: on root of weld (Low voltage)

IV. CONCLUSION

After considering the parameters, arc welding is a simple process which does not require excessive amount of equipment. LPT, The tensile test, bending test, are studied over two different voltages on similar metals joined by arc welding. Two similar metals are welded with different voltages i.e. High and low are examined. The present study can be looked into in the following steps:

1) The value of tensile strength and bending of the welded metal is higher when high voltage is used as compared to the case of low voltage.
2) When low voltage is used the weld metal has more defects compared to high voltage.

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