



Effects of External Magnetic Field on Welding Arc of Shielded Metal Arc Welding.

KEYWORDS

Yunis Ahmad Dar

Shivpora-A Srinagar,
J&K, 190004

Charanjeet Singh

HJ-472, Housing Board Colony, B. R.
S. Nagar, Ludhiana, Punjab, 141012

Younis Farooq

Chanamohalla Hyderpora Srinagar,
J&K, 190014

ABSTRACT *The main aim of this study is to show the characteristic changes obtained by the deflection of welding arc in the presence of external magnetic field. The magnetic field has been applied from various orientations upon the weld bead and its effects have been discussed accordingly. The welding process which has been considered under study is shielded metal arc welding. The material taken is mild steel and bar magnets of 10T intensity has been used. It has been seen that when magnets are placed in the longitudinal position of the weld bead, there is a tremendous deflection in welding arc while in transverse position of magnets, very less deflection is observed. This deflection in welding arc changes the weld bead properties. It is observed that weld pool penetration reduces while the weld bead width increases thereby affecting the parameters of the process. The results and conclusions are discussed as per the observations while the microstructures and hardness of parent materials are observed as well.*

Summary

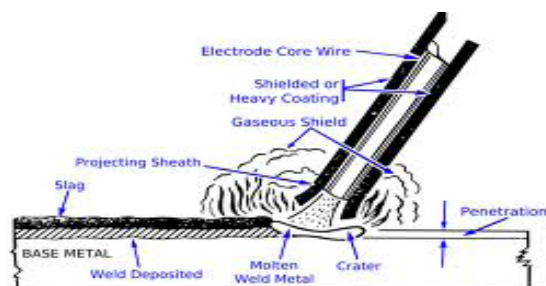
This paper has presented the applications of welding technology to determine the optimal process parameters for Shielded Metal Arc Welding. The proposed model is used to predict process parameters for a given welding material.

Introduction

This work is undertaken by the aim of deflecting the welding arc of shielded metal arc welding (SMAW), also known as manual metal arc welding (MMA) welding or informally as stick welding is a manual arc welding that uses a consumable electrode coated in flux to lay the weld. An electric current in the form of either alternating current or direct current from a welding power supply, is used to an electric arc between the electrode and the metals to be joined. As the weld is laid, the flux coating of the electrode disintegrates, giving off the vapours that serve as a shielding gas and providing the layer slag, both of which protect the weld area from atmospheric contamination. This process is used primarily to weld iron and steels (including stainless steel) but aluminium, nickel and copper alloys can be with this method. Short circuit metal transfer is normally used in SMAW process.

Operation

To strike the electric arc the electrode is brought into contact with the workpiece in the short sweeping motion and then pulled away slightly with a movement like lighting a match. This initiates the arc and thus the welding of workpiece and the consumable electrode and causes droplet of the electrode to be passed from the electrode to the weld pool. The flux provides the molten slag which covers the filler metal as it travels from the electrode to the weld pool. Once part of the weld pool, the slag floats to the surface and protects the weld from contamination as it solidifies. Once hardened it must be chipped away to reveal the finished weld.



DIRECTION OF FORCE

The direction of force on a positive charge or a current is determined by the right hand rule. Using the right hand and pointing the thumb in the direction of the moving positive charge or positive current and fingers in direction of magnetic field the resulting force on the charge will point outwards from the palm. The force on a negative charged particle is in the opposite direction. If both the speed and charge are reversed then the direction of force remains the same. For that reason a magnetic field measurement (by itself) cannot distinguish whether there is a positive charge moving to the right or a negative charge moving to the left. On the other hand, a magnetic field combined with an electric field can distinguish between the Seehall effects below. An alternative, similar trick to the right hand rule is Fleming's left hand rule.

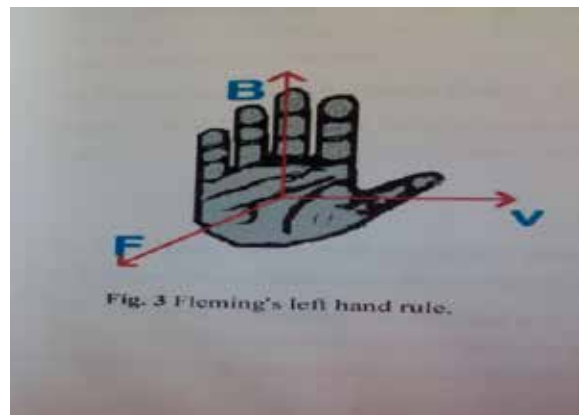


Fig. 3 Fleming's left hand rule.

Force Exerted By Magnetic Field:

When none of the magnetic field bypasses any sections of the core (no flux leakage), the force exerted by an electromagnetic on the core material is:

$$F = B^2A/2\mu_0$$

Effects Of Magnetism On Welding Arc:

A magnetic field externally applied to the welding arc deflects the arc by electromagnetic force (Lorentz Force) in the plane normal to the field lines. The magnetic force 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 external magnetic field. A transverse magnetic field deflects the arc in the welding direction, whereas a longitudinal magnetic field deflects the arc perpendicular to the bead. Magnetic arc oscillation leads to a change of arc length, which in turn periodically changes the welding current and voltage. An alternating parallel magnetic field causes the arc to oscillate in a position normal to the direction of welding, which has an effect like mechanical weaving. The magnetic field is applied to the welding arc in parallel to the welding direction and the arc is deflected sideways with respect to the welding direction. If an alternating field is applied to the arc, it can be oscillated over the weld pool in a position normal to the direction of welding. The width of an arc oscillation is dependent upon the flux density of the applied magnetic field, the arc current and the arc length.



Experimentation

Preparation of weld beads under different conditions of magnetic field:

Firstly, the experiment is initiated by preparing work pieces. The dimensions for the metal plates are 4" x 2" x 1/4". The material used for the metal plates is Mild Steel. The Specimens are cut with the help of metal cutting equipment (by holding the Work Pieces in the bench vice and cutting with help of moveable slitting saw grinder).

The Shielded Metal Arc Welding Set (SMAWS) is used to lay (form) the welding bead on the prepared specimens.

The Welding Parameters used are as follows:

- The current is set at 100A.
- The Open Circuit Voltage is 85 volts.
- The Dimensions for specimens are 4" x 2" x 1/4".
- The Electrode used as per AWS (American Welding Society) is "E6013".
- Polarity of Welding Set: Straight polarity

The welding process is then initiated. A welding bead is laid on the mild steel specimen plate manually. This is repeated by using different conditions of magnetic field.

Four different conditions are as follows:

- Without any magnetic field interference.
- Magnetic field on one side of the workpiece.
- Magnetic field on the head of work piece or along the longitudinal direction that is along the welding axis.
- Magnetic field of equal strength on both sides of work piece.

Preparation of Weld Beads for the study of their Microstructures.

The welding specimens are cut with the help of metal cutter so as to get the cross section of welding beads. Polishing and super finishing process is then conducted in two steps:-

- Polishing with the help of emery papers of appropriate specifications.
- Super finishing with the help of lapping machine.

Polishing with the help of emery paper set is done by rubbing the specimen surface on the emery paper only in one direction so as to have surface flow lines only in one direction and to have minimum crust and trough distance. The different emery papers used are given in the specified order as used in polishing process:

- P220
- P400
- P600
- P1200
- P2000

The final product from the above polishing process is then super finished with the help of lapping machine.

Polishing with the help of lapping machine:

- The Diamond Lapping Compound is applied to the surface to be polished.
- Super finishing lapping cloth is used for the polishing purpose. The super fine cloth is then fixed on a circular rotating disc.
- The specimen surface coated with diamond lapping compound is then further coated with aerosol oil spray.
- The circular disc with superfine polishing cloth is then rotated at a high speed.
- The surface coated with diamond lapping compound is then pressed to the surface of the rotating disc all the while applying liberal amounts of aerosol oil spray.
- The specimen is polished in order to obtain mirror like view. The mirror view is required to obtain good microstructure.

Study of Microstructure of the Polished Surface

The polished specimens are then studied under the microscope. Now before viewing the grain structure of the polished specimens, acetone is applied to the polished surface for cleaning purposes. The polished surface is then washed with water and then the nitric acid is applied to the polished surface for etching process. This nitric acid is called etchant in the above process. Specimen is placed on the lens of the microscope which is connected to a computer system to study the grain structure of the specimen. There are many different computer softwares which can be used to obtain & study images of grain structures obtained from the microscope. Some of these softwares are AVERCAP, MIAS 2.0 (metallurgical imaging and analysis software) etc. The images of the grain structure are then saved with the help of computer software. Also the depth of penetration of bead is measured with the help of computer software for all the four specimens.

Hardness Test

- Rockwell hardness tester was used to determine the hardness of different welded workpieces. Before commencing the test all the weld beads were prepared by keeping weld bead top surface flat with help of surface gr

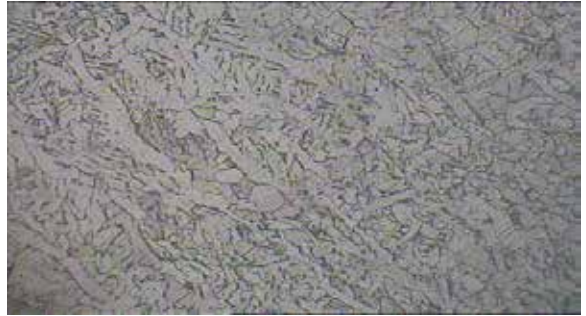


- The scale used is HRB.
- The indentation was made with the help of 1/16" inch diameter steel sphere.
- The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, where A is the scale letter.
- When testing metals, indentation hardness correlates linearly with tensile strength. This important relation permits economically important nondestructive testing of bulk metal deliveries with lightweight, even portable equipment, such as hand-held Rockwell hardness testers.
- The determination of the Rockwell hardness of a material involves the application of a minor load followed by a major load, and then noting the depth of penetration from a dial, on which a harder material gives a higher number. The chief advantage of Rockwell hardness is its ability to display hardness values directly, thus obviating tedious calculations involved in other hardness measurement techniques.
- It is typically used in engineering and metallurgy. Its commercial popularity arises from its speed, reliability, robustness, resolution and small area of indentation.
- In order to get a reliable reading the thickness of the test-piece should be at least 10 times the depth of the indentation. Also, readings should be taken from a flat perpendicular surface, because convex surfaces give lower readings. A correction factor can be used if the hardness of a convex surface is to be measured.
- The readings taken in different directions are given below:

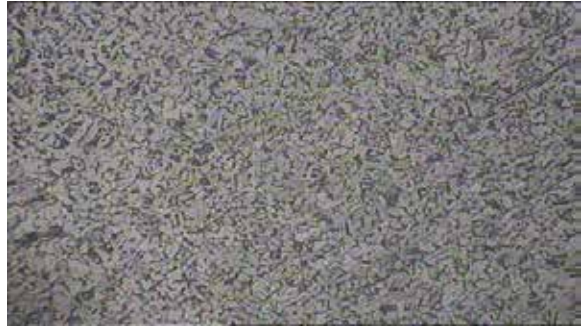
S. No.	Various Conditions used	Hardness value range
1.	Welding without magnets	B87, B89
2.	Welding with magnets on both sides of transverse direction	B88, B91
3.	Welding with magnet on one side of transverse direction	B89, B92
4.	Welding with magnet in longitudinal direction	B85, B86

Results and Discussions

- When welding was done in transverse direction by keeping magnets both sides and one side, there was no considerable effect on the weld bead.
- But when welding was done along the welding direction with magnet kept at the starting position there was considerable effect on the weld bead.
- In longitudinal direction, the weld bead width increased and depth of penetration reduced.
- Also arc blow was more in the longitudinal direction but in all other conditions there was increased spatter.
- Also the grain structure obtained in longitudinal direction was different. There was considerable effect on the grain structure as shown below:

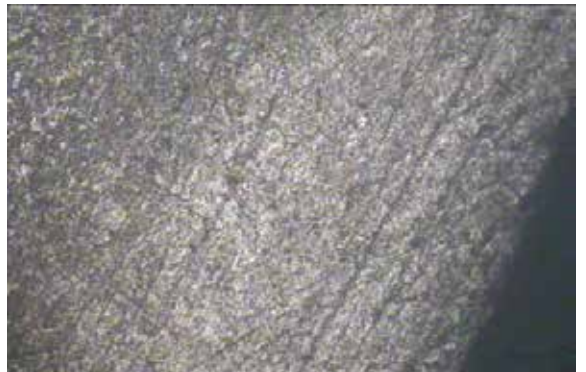


Weld bead grain structure

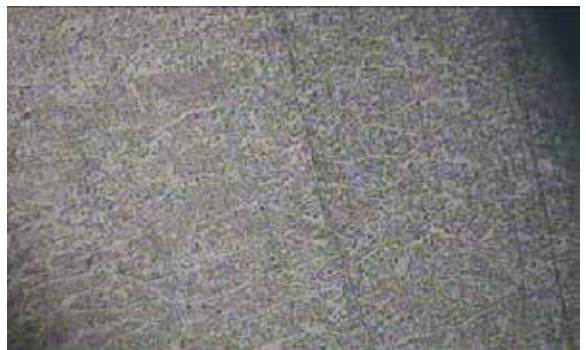


Base metal grain structure

- Other grain structure which were obtained in different directions were shown below :



Welding without magnet



Welding with magnets both sides in transverse direction

- The weld beads which were obtained in different directions were shown below:



All the workpieces being surface grinded



Depth of penetration reduced in Longitudinal direction

Conclusions

From our experiments, we conclude that when the arc is brought in magnetic field it deflects and due to this many developments can be made in the field of welding engineering and technology.

- There was increased spatter in transverse direction whether we keep magnet on one side or both sides.
- In longitudinal direction when magnet was kept near the starting point there was considerable deflection near the starting point which resulted in increased weld bead and reduced depth of penetration.
- In longitudinal direction, the metal deposited per unit time was increased and less material was being consumed in surfacing as compared to conventional welding processes.
- The hardness of the weld was reduced in longitudinal direction slightly but there is increase in hardness values in transverse direction.
- The reinforcement increased in transverse direction whether we keep magnet on one side or both sides.

Future Prospects of Magnetic Steering of Welding Arc

Magnetic steering of welding arc helps in improving cladding economically. In cladding a thick layer of some superior metals like stainless steels is laid on to a carbon or low alloy steel plate to make it corrosion resistant. The main use of cladding is in the production of vessels for chemical, Papermill, Petroleum, refining and nuclear power plants. Cladding resist localized corrosion such as pitting, crevice corrosion, intergranular corrosion and stress corrosion cracking. By uniformly steering the welding arc, we can deflect the arc thereby reducing the penetration and can obtain a wide weld bead. As the bead is wide we can achieve metal surfacing or cladding over the metal surface in less number of runs. Shallow penetration with low dilution and adequate joint strength is the desired aim of our work.

Benefits of arc steering

- As the bead is wide, electrode consumption reduces.
- Adequate metallurgical compatibility is obtained.
- Less no. of runs required.
- Saves time to complete operation and reduced costs.

Acknowledgement

It is giving us immense pleasure and satisfaction to convey our gratitude to our H.O.D. Prof. J.S.Grewal, (GNDEC, Punjab) for guiding our team with all his worthy suggestions and ideas during the entire research that helped us a lot to finish our study successfully. Again we can't forget to thank Dawn Motors Pvt. Ltd, Punjab, for issuing us with all the necessary requirements to carry out our study with ease.

REFERENCE

- Parmar R.S, Welding processes and Technology. M.S Khanna Publishers. | • Howard Cary B, Modern Welding Technology, (Prentice Hall Inc, Englewood Cliffs, NJ), 1979. | • Nandkarni S V, Modern Welding Technology, (Oxford and IBH Publishing CO. Pvt. Ltd, New Delhi), 1988. | • Mc Pherson N A, Baker T N & Miller D W, Metal Mater Trans, 129A (1997) 823-832. | • Cottrell A.H, Theoretical Structural Metallurgy, New York, St. Martin's Press, 1955. |