Effect of Magnetic Field on Weld Quality and Weld Geometry

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ABSTRACT

With the advancement of welding techniques, Arc-welding is one of 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. This research paper is intended to investigate the effect of magnetic field on the weld quality and geometry of weld in shielded metal arc welding. The objective is to study the effect of welding parameters and to use magnetic field advantageously to improve the weld qualities and weld geometry. 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. In this paper, the effect of a longitudinal magnetic field generated by bar magnets on the weld was experimentally investigated.

Further, various mechanical properties tests as tensile strength, hardness, toughness etc. are conducted to see the effect of external magnetic field on it. A set of weld pieces (with magnetic field and without magnetic field) are tested for various mechanical properties and comparable study is done to know the change in these properties.

Keywords: welding, magnetic field, weld quality, weld geometry

1. INTRODUCTION

Welding is defined as the process in which two similar or dissimilar materials are joined with each other with the help of temperature with or without applying pressure and with or without use of filler materials. Welding is a process of joining different materials. Welding is one of the essential joining processes in manufacturing industries. Welding technology needs constant upgrading with the increasing demand of welding because of these reasons there is the need to properly select welding parameters for a given task to provide a good weld quality and correct bead geometry size.

Most of the welding is carried out by one or the other arc welding process; therefore it is vitally important to discuss the effects of magnetic field on the weld quality and weld geometry. Various types of welding processes like Shielded Metal Arc Welding (SMAW), Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), and Flux Cored Arc Welding (FCAW) are being practiced in industrial environment. Welding technology has obtained access virtually to every branch of manufacturing; to name a few, ships, rail road equipments, building construction, boilers, launch vehicles, pipelines, nuclear power plants, aircrafts, automobiles, pipelines[1]. Among all these welding processes, SMAW is having great significance as it is the simplest of the all arc welding processes. SMAW is a metal joining technique in which the joint is produced by heating the work piece with an electric arc set up between a flux coated electrode and the work piece. The advantages of this method are that it is the simplest of the all arc welding processes. The equipment is often small in size and can be easily shifted from one place to the other [2]. SMAW input process parameters like welding current, welding speed; open circuit voltage and external magnetic field are highly influencing the quality of weld joints. The applications of magnetic field in welding processes have drawn much attention of researchers [3]. However, the effect of external magnetic field on quality of weld is still lack of understanding. Mild steel was selected for work-pieces to be welded because it is the most common form of steel as its price is relatively low while it provides material properties which are acceptable for many applications [1]. Since the weld quality depends generally on the input parameters, it is essential to study the effects of input process parameters on weld quality and weld geometry. This paper presents the study of the effect of external magnetic field on weld quality and geometry taking mild steel as a work piece. 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. A transverse magnetic field deflects the arc in the welding direction, whereas a longitudinal magnetic field deflects the arc perpendicular to the bead [4]. Magnetic field may be applied or induced but interact with arc current to produce a force that causes the arc to deflect. This phenomenon is known as arc blow when it becomes severe. Arc blow arises from two basic conditions, (i) the change in direction of current flow as it leaves the arc and enters the work-piece to seek the ground and (ii) the asymmetrical arrangement of magnetic material around the arc as it is easier for magnetic flux to pass through certain materials (especially ferromagnetic materials) than through air [5]. In the case of SMAW if magnetic field is up to 20 Gauss, it has very little effect and normal welding can be done. For a field in between 20 to 40 Gauss the arc becomes instable and a magnetic field of more than 40 Gauss produces arc blow [6].

For a better understanding of the quality of joint, weld-pieces will be checked by conducting tests on UTM for measuring the tensile strength. The weld geometries will be checked through the visual inspection and penetration depth and weld bead width will be considered.

2. EXPERIMENTAL WORK

A bar magnet was used for the production of magnetic field. A Gauss-meter was used for measuring the magnetic field. To investigate the welding characteristics weld beads were obtained by welding two mild steel flat plates. A lathe machine was used to provide the semi-automation to the welding process. A wooden block was fixed on the carriage and the bar magnet was attached with the tailstock. The welding electrode with holder is to be operated manually while the weld-piece is moved through the lead screw of lathe automatically with a fixed speed. A metallic rod is also used to provide the electric connection within the work-piece.

Fig.1- Measurement of magnetic field by Gauss-meter

3. WELDING UNDER MAGNETIC FIELD

The magnetic field was applied as per the set-up and the arc welding machine and electrodes were placed at their respective positions. Measuring devices are connected to take the readings. The work-pieces obtained after the completing the welding operations are shown in fig.

Fig.2 welds joints obtained under magnetic field.

Table 1: Observation table under varying current and voltage with magnetic field.

WORK-PIECE NO.	CURRENT[A]	VOLTAGE [V]	MAGNETIC-FIELD INTENSITY [GAUSS]	WELDING SPEED [mm/min]
M1.	120	24.5	70	50
M2.	110	23.7	70	50
M3.	115	23	70	50
M4.	135	18.5	70	50
M5.	125	21.5	70	50

4. WELDING WITHOUT MAGNETIC FIELD:

The welding process was done with the same setup by removing the magnetic field arrangement. The current and voltage range remained unchanged during the process. The work-pieces obtained after the completing the welding operations are shown below and the readings are tabulated.

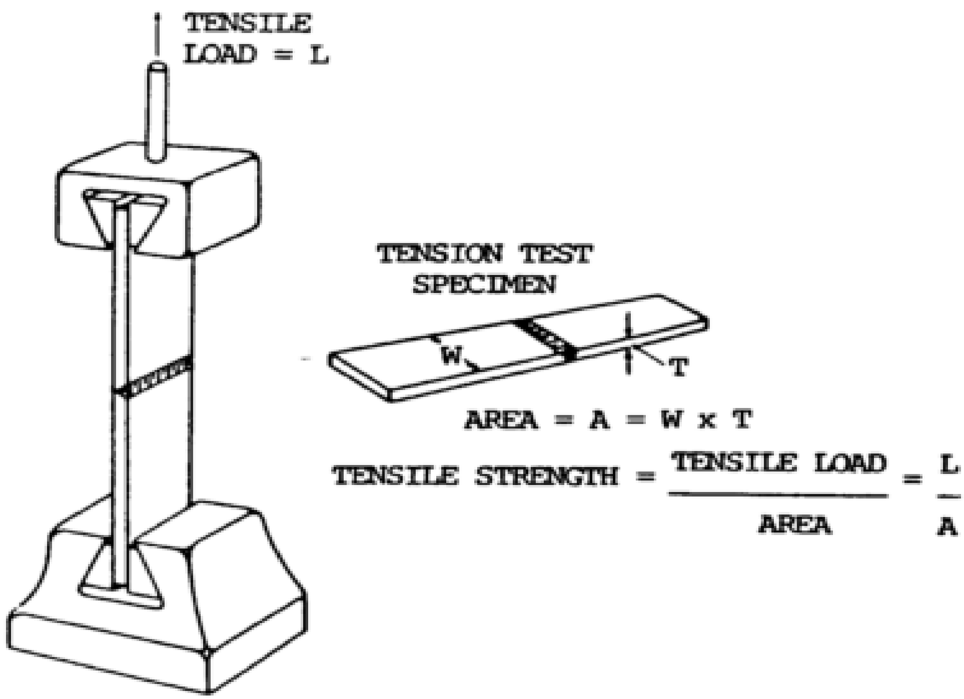
Fig 3 weld joints without magnetic field

Table 2: Observation table under varying current and voltage without magnetic field

WORK-PIECE NO.	CURRENT[A]	VOLTAGE [V]	WELDING SPEED [mm/min]
WM1.	115	23	50
WM2.	120	24.7	50
WM3.	110	23	50
WM4.	135	18.6	50
WM5.	125	21.3	50

5. TEST OF TENSILE STRENGTH

This test was carried out to measure the tensile strength of welded joints. The Tensile strength measures the force required to pull something such as rope, wire, or a structural beam to the point where it breaks. The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The test is conducted on universal testing machine (UTM). A portion of the welded plate is placed 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.



The welded plate is then mounted in UTM that will exert pull on the piece to break the specimen. The maximum load at which the failure of the weld joint takes place is measured which is used to determine the tensile strength of the welded joints. With the help of this test we can define effect of magnetic field on weld quality.

6. EFFECT ON WELD GEOMETRY

The effect of magnetic field can deflect the arc perpendicular to welding direction. An alternating current changes its direction, direction of electrons changes and this changes the direction of force on them. Hence arc is deflected from the line of weld. As a result of this movement bead width can increase.

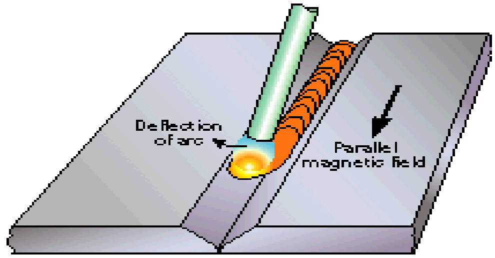


Fig 5- Deflection of arc under magnetic field

Reinforcement height is the distance between the levels of the base metal and the top point of the deposited metal. As the magnetic field is introduced in the welding process a considerable amount of decrease in reinforcement height is observed.

7. CONCLUSION

The primary aim of the research was to define the effectiveness of magnetic field on weld joint. The different experimental results revealed that the welding process performed under the influence of magnetic field; affect the quality and geometry of welded joints. On the basis of experimental work performed during the study weld pieces the following conclusions are drawn:

1. The magnetic field applied transverse to welding direction increases the bead width of joint.
2. The tensile strength of the weld joint is improved.
3. Increasing the magnetic field can increase the weld width but depth of penetration of the weld is decreased.
4. Decrease in reinforcement height is observed under the influence of magnetic field.

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