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Welding joint evaluation of mild steel samples for varying current and voltage to reduce the defect using non destructive testing

Md. Emdadul Hoque[1], Md. Jabid Hasan[2], Md. Kamrul Hasan[3]

[1,2,3]Department of Mechanical engineering, Rajshahi university of Engineering & Technology
Email: [1]emdadulhoque@gmail.com, [2]jabid.ruetme12@gmail.com, [3]kamrul0406@gmail.com

Abstract

Safety and durability of every construction mostly depends on the accuracy of welding joint. Therefore, it is very important to join metals without any defect. This paper emphasizes on finding an appropriate methodology among the conventional welding technique to ensure better constructability. Welding is done for varying current and voltage. Experimental work is carried out for single V-groove MIG welding and inspected and analyzed by Phased Array Ultrasonic Testing method. It is done to find out the number of defects for varying current and voltage. This research reveals the best way for conventional welding for maximizing structural safety.

Keywords: Safety and durability, NDT, MIG welding, Phased Array Ultrasonic Testing.

1. Introduction

Different types of method are used to join metal. Welding is one of them. However, all the joint is not acceptable because of defects found inside it. A successful welding joint must depend on some parameter. Voltage and current are the main factor of them. So it is essential to determine the appropriate voltage and current for proper welding [1].

In conventional ultrasonic method, inspection is done at a fixed angle. So many times is required to inspect the whole metal. Otherwise a phased array ultrasonic testing (PAUT) can maintain a range of angles and can scan large area in a very short time. In this respect PAUT is the best way for welding inspection [2].

Ultrasonic testing is a non-destructive testing in which high frequency sound wave is used to inspect internal discontinuities of material. The term 'phase' refers the timing and the term 'array' implies to the multiple elements present in the prob. It consists of multiple transducers. Transducers are used that send electrical pulse to a crystal that then vibrates and sends out ultrasonic sound waves. Since these UT sound waves can't travel through air, a medium is needed that allows the sound waves to pass through into the part material. These transducers are used to send and receive signals within the part material. In order to detect a flaw, sound signals are send out. If it is returned then the signal is analyzed to determine its location and intensity and make a vertical echo pattern in the display. We then look into the weld and interpret what we see. Phased array ultrasonic testing can cover a large area of the work piece material from a single probe location [3].

The elements that are commo*n* used in every NDT Test are: (a) Probing energy or probing medium is used.(b) Probing medium is changed when there causes any discontinuity.(c)Piezoelectric transducer that can convert one form of energy to another form.[4]

Ultrasonic testing is based on the testing for solid materials and they are good conductors of sound wave. The sound not only reflected from the surface but also flaws inside the materials. When the wavelength of sound is smaller, the interaction of sound is so much stronger with the material. Generation and detection of ultrasonic wave for inspection is accomplished by means of a piezoelectric transducer element acting through couplant. The conversion of electrical pulses to mechanical vibrations and the conversion of returned mechanical vibrations back into electrical energy is the basis for ultrasonic testing. Ultrasonic transducer converts electrical energy into sound energy and vice versa by utilizing a phenomena is known as the piezoelectric effect [5], [6].

2. Material

Commercially available mild steel were used in this research. It contains approximately 0.05-0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing. The thickness of each sample is 10mm and length is 177mm [7].

3. Preparation of welded samples

Five samples are prepared of equal dimensions tested for ultrasonic testing method. But different current and voltage are used for different samples. Bolarc 10 electrode is used for welding. The samples for single V Groove electric arc welding are shown in figure 1 [8].

(a) (b)

FIGURE 1. Preparation of samples

Table 1. Voltage and current setting in MIG welding

Samples	Current (A)	Voltage(V)
Sample 1	110	20
Sample 2	120	25
Sample 3	130	30
Sample 4	140	35
Sample 5	150	40

4. Experimental set up

In this research the phased array equipment is Omniscan SX and a contact probe C430-SB produced by Olympus Company was used for weld inspection. Figure 2 shows the experimental set-up for inspection. The OmniScan SX is an advanced, multi-technology flaw detector. It is available with PA and conventional UT modules. Contact probes are specially designed to be used directly in contact with the material to be inspected. Their resistant wear face is acoustically adapted to steel. They are longitudinal-wave probes and contain composite ceramic that produces high-efficiency signals [5].

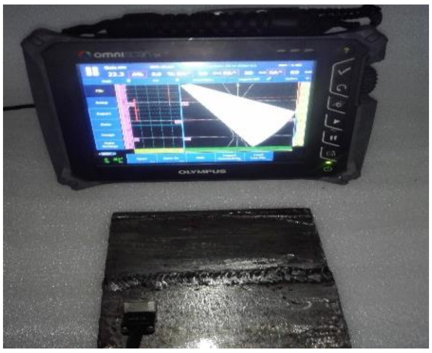
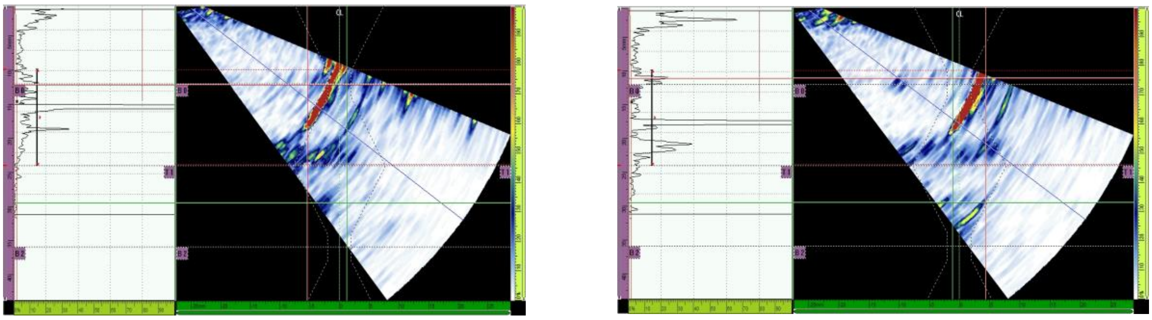


Figure 2. Experimental set-up

5. Experimental Results

For this research the samples were prepared in RUET lab and welded by a professional welder maintaining all other welding factors constant but only change in current and voltage. The welding samples were inspected in RUET lab and varified by a professional Phased Array Ultrasonic tester.

Very low current and voltage is used to weld for sample 1. For this sample many defects are found which size and types are different. The sectorial views of start and end from our investigation of sample 1 are shown in figure 3 [9], [10].

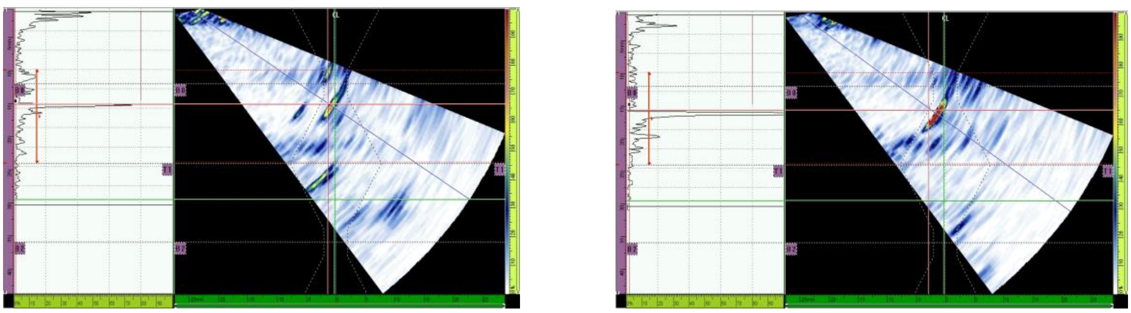


(a) (b)

Figure 3. Sectorial scan of weld in sample 1 (a) at the starting of weld and (b) at the end of weld

In Figure 3, the defect is present at a depth of 7.7mm and 7.6mm and corresponding defect size is 11.2mm and 10.5mm. The defects observed in this sample are larger in size. It is found due to insufficient current and voltage which results poor penetration. If electrodes coated with improper flux ingredients or damp electrodes are used then incomplete penetration may occur.

Low current and low voltage is used to weld for sample 2. In here many defects are found which size and types are also different. The sectorial views of start and end from our investigation of sample 2 are shown in figure 4 [10].

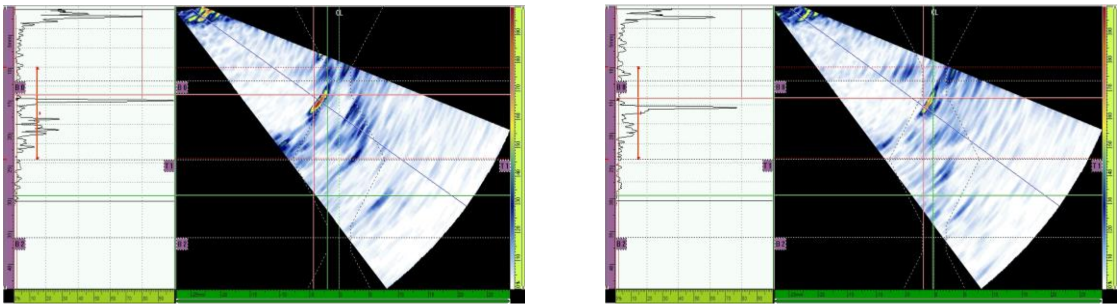


(a) (b)

Figure 4. Sectorial scan of weld in sample 2 (a) at the starting of weld and (b) at the end of weld

In Figure 4, the defect is present at a depth of 6.4mm and 7.1mm and corresponding defect size is 4.8mm and 5.7mm. The defects observed in the sample are due to incomplete penetration. High welding speed and low heat input from the machine are responsible for this. This results can be found because of too large electrode diameter.

Normal current and normal voltage is used to weld for sample 3. The sectorial views of start and end from our investigation of sample 3 are shown in figure 5 [10].

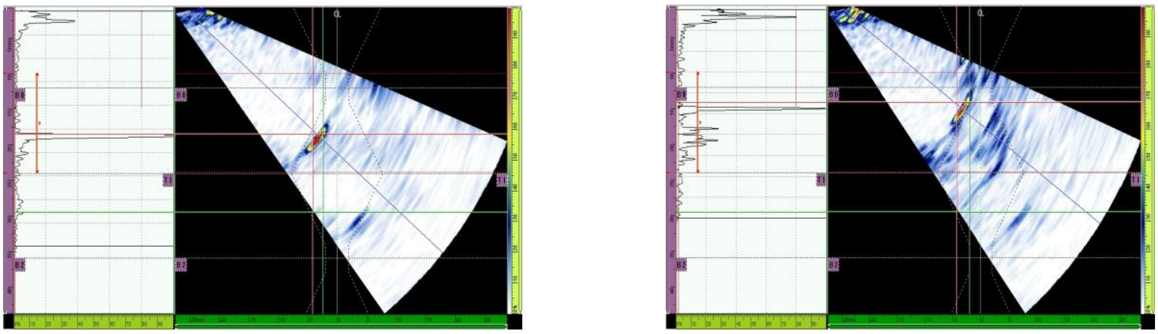


(a) (b)

Figure 5. Sectorial scan of weld in sample 3 (a) at the starting of weld and (b) at the end of weld

In Figure 5, the defect is present at a depth of 6.2mm and 5.3mm and corresponding defect size is 3.3mm and 2.4mm. The defects size is comparatively smaller than others. This results is found due to proper current and voltage. The defects are known as lack of fusion. It is caused due to long arc, fast solidification rate.

Normal current and normal voltage is also used to weld for sample 4. The sectorial views of start and end from our investigation of sample 4 are shown in figure 6 [10].

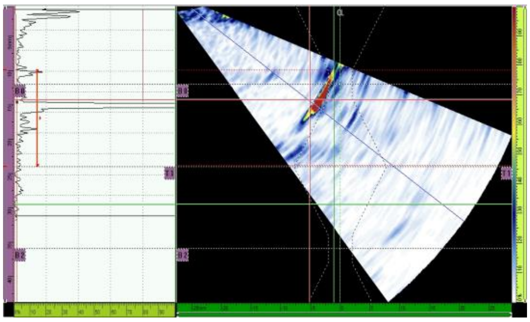


(a) (b)

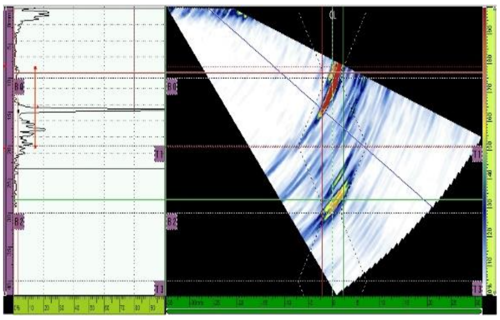
Figure 6. Sectorial scan of weld in sample 4 (a) at the starting of weld and (b) at the end of weld

In Figure 6, the defect is present at a depth of 6.3mm and 6.6mm and corresponding defect size is 3.5mm and 3.6mm. The defects are known as lack of fusion. It is causes due to long arc, fast solidification rate. The defects size is comparatively smaller than others. So proper welding is done for sample 4.

High current and high voltage is used to weld for sample 5. The sectorial views of start and end from our investigation of sample 5 are shown in figure 7 [10].



(a)

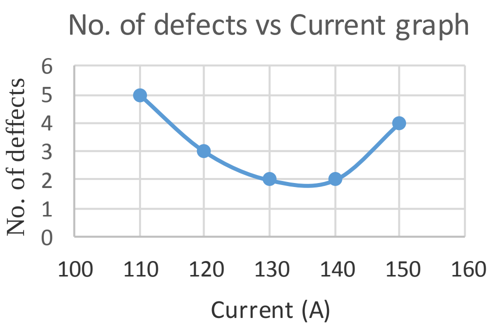


(b)

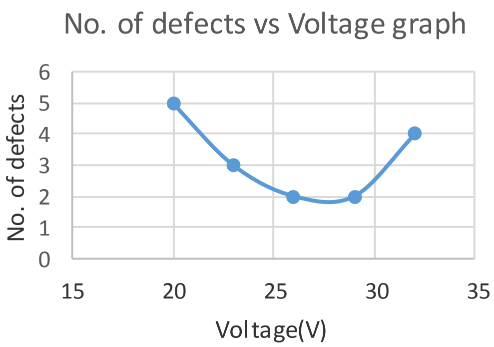
Figure 7. Sectorial scan of weld in sample 5 (a) at the starting of weld and (b) at the end of weld

In Figure 7, the defect is present at a depth of 5.9mm and 6.7mm and corresponding defect size is 9.61mm and 8.8mm. Due to excessive penetration the defects are observed in this sample. The defects are known as under cut and crack. Slow travel speed and wide root gap are also responsible for this.

From the above figures, we can see that number of defects decreases at the increasing of current and voltage but after a definite current and voltage, number of defects starts to increase. Graphs of number of defects vs current and number of defects vs voltage are shown in figure 8.



(a)



(b)

Figure 8 (a) Number of defects vs Current graph, (b) Number of defects vs Voltage graph

6. Conclusions

The investigation is done on welding for varying current and voltage and in this investigation the maximum defects are found on high current and voltage. Lack of penetration is observed for low current and low voltage and excess of penetration is observed for high current and high voltage. Besides, occurrence of defects also depends on welding speed and skill of worker. Every material has different current-voltage characteristics. Therefore, it is important to know the current voltage characteristics and use this to reduce number of defects at the time of welding.

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