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# Investigation of Arc Welding and Inspection using Ultrasonic Testing

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***Abstract. Welding has the vast application in ship construction, automobile industries, bridge construction, aircraftmachine frames, structural design etc. 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 research is done to ensure the impression of current and voltage on porosity found inside the welding joint and other defects. This is done to improve the quality of material. This research is carried out for single V-groove electric arc welding and inspected by Phased Array Ultrasonic Testing (PAUT) method. The investigation of this work is to make a comparison based on defects and porosity among the welding samples for different voltage and current.***

## I.INTRODUCTION

Because of the need to optimize the weld quality, traditional inspecting takes a long time which causes an increase in the cost of products and sometimes makes inspecting impossible. The solution to this is real-time inspection which can detect the quality of the weld immediately after or at the time of production. Non-destructive testing (NDT) methods identify cracking, porosity, incomplete penetration, inclusions, as well as a lack of sidewall fusions and similar defects [1].

This technique is used for the detection of internal surface (particularly distant surface) defects in sound conducting materials. In this method high frequency sound waves are introduced into a material and they are reflected back from surface and flaws. Reflected sound energy is displayed versus time, and inspector can visualize a cross section of the specimen showing the depth of features. A typical UT system consists of several functional units, such as the receiver, piezoelectric transducer, and display devices. A receiver is an electronic device that can produce high voltage electrical pulses. Driven by the receiver, the transducer generates high frequency ultrasonic energy [2]. The sound energy is introduced and propagates through the materials in the form of waves. When there is a discontinuity (such as a crack) in the wave path, part of the energy will be reflected back from the flaw surface. The reflected wave signal is transformed into an electrical signal by the piezoelectric transducer and is displayed on a screen. These reflected echo patterns can be analyzed to locate and determine the size of cracks and other flaws, including incomplete penetration or incomplete fusion as well as porosity or slag inclusions [3,4].

Phased array instruments utilize more complex hardware and software to provide a higher level of both test and interpretive capability. Instead of a single element transducer, phased arrays use a multitude of elements, all individually pulsed and time -delayed. Ultrasonic beams are formed by constructive and destructive interference from these multiple sources. The latest phased array instruments are now portable and functionally convenient as well. Phased arrays are sufficiently developed that costs can be competitive overall with conventional ultrasonic and software is sufficiently user-friendly that everyday operators can use it [5,6].

In conventional ultrasonic method, inspection is done at a fixed angle. So much times are 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 [7-10].

## II.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. The samples are of mild steel. The thickness of each sample is 10mm and length is 177mm. Bolarc 10 electrode is used for welding. The samples for single V Groove electric arc welding are shown in Figure 1 [7]. The voltage and current setting for different samples are shown in Table 1.

(a) Before welding

(b) After welding

**FIGURE 1.** Preparation of samples

**TABLE 1.** Voltage and current setting in MIG welding [7]

| Samples | Current (A) | Voltage(V) |
|---|---|---|
| Sample 1 | 210 | 40 |
| Sample 2 | 220 | 50 |
| Sample 3 | 230 | 60 |
| Sample 4 | 240 | 70 |
| Sample 5 | 250 | 80 |

## III.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 3 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 [4,8].

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 [10,11**].**

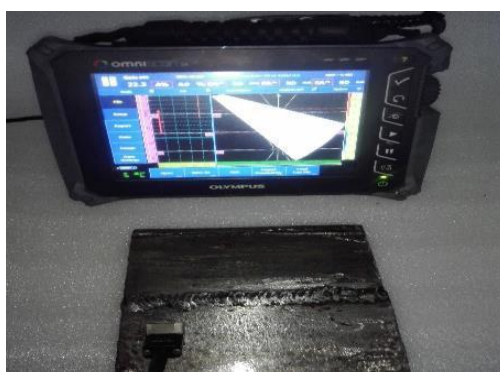
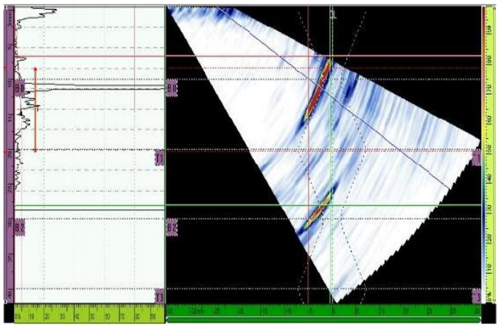


**FIGURE 2.** Experimental set up

## IV.EXPERIMENTAL RESULTS

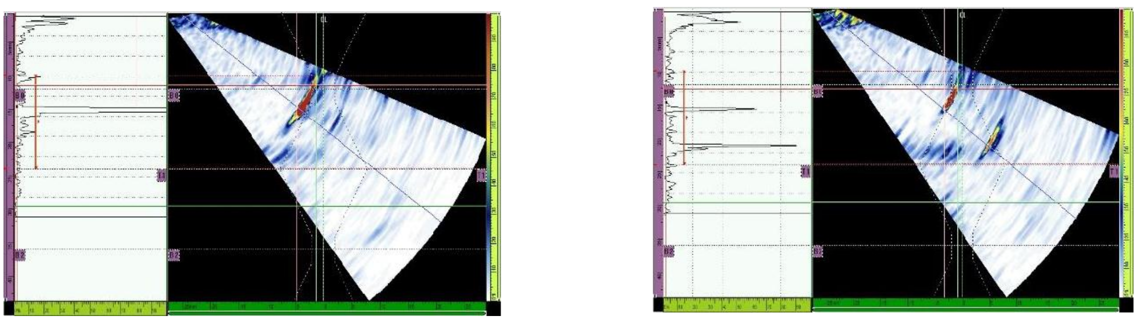
Very low current and voltage is used to weld for sample 1. For this sample many defects are found which size and types are different. The sectorial views of start and end from our investigation of sample 1 are shown in Figure 3. In Figure 3, the defect is present at a depth of 7.8 mm and 7.59 mm and corresponding defect size is 10.3 mm and 8.5mm. 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 [8].



(a) (b)

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

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

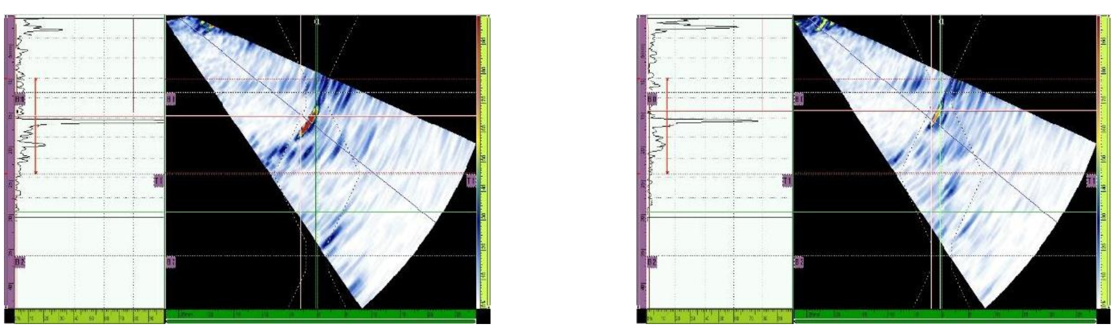


(a) (b)

**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 6.8mm and 7.13mm and corresponding defect size is 6.63mm and 6.74mm. 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.[8]

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

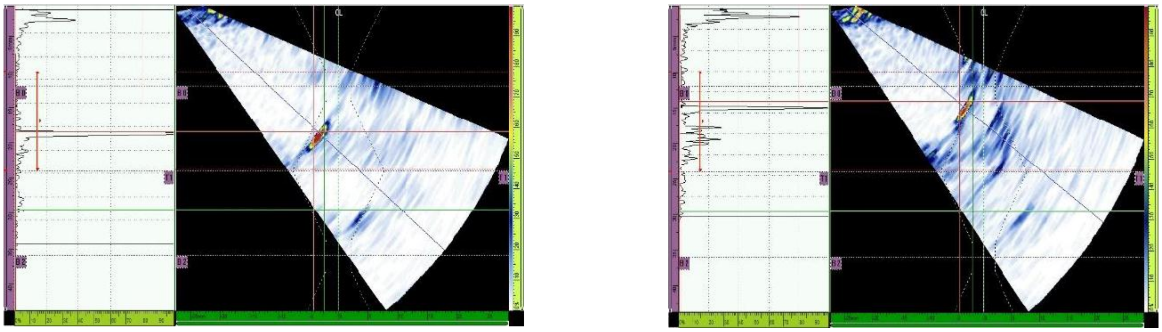


(a) (b)

**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 6.32mm and 6.23mm and corresponding defect size is 3.43mm and 2.24mm. 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.[8]

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.

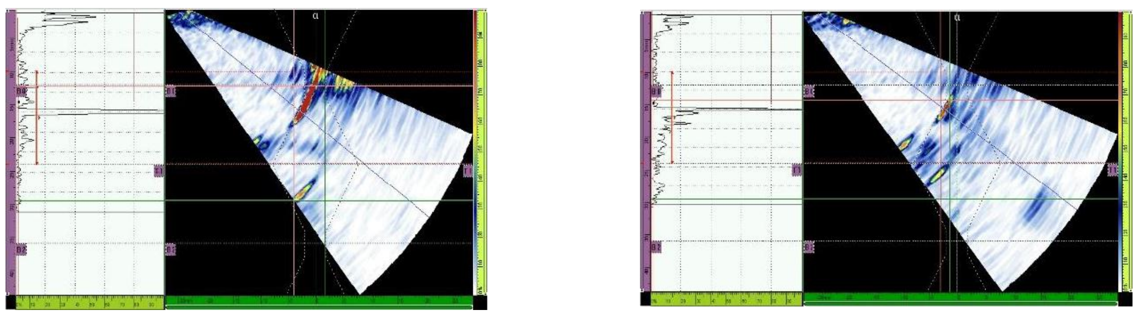


(a) (b)

**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 6.73 mm and 6.96 mm and corresponding defect size is 3.7 mm and 3. 58 mm. 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 [8].

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

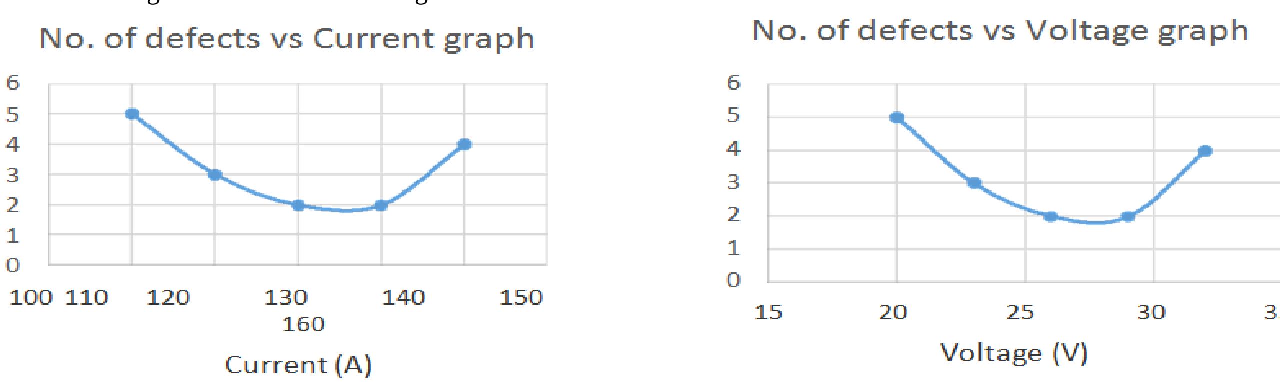


(a) (b)

**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 5.59mm and 6.17mm and corresponding defect size is 9.61mm and 5mm. Due to excessive penetration the defects are observed in this sample. The defects are known as undercut and crack. Slow travel speed and wide root gap are also responsible for this [8].

From the above figures, it can be seen that the 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 below in Figure 8.:




(a) (b)

**FIGURE 8.** (a) Number of defects vs Current, (b) Number of defects vs Voltage

## V.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 to reduce the number of defects at the time of welding.

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