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Experimental Investigation of Ultrasonic flaw Defects in weld clad materials using NDT Technique

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Abstract: - Automated Ultrasonic testing method will be used in the many industries and is used for location of discontinuities to detect internal defects under test within the material. By knowledge the lowest size of a defect may start from 0.5 mm onwards. Ultrasonic testing is a fast and automated method because the signals are available in electronic form to be tested in plates and pipes. This is mainly used for whether the material will be accepted or rejected easily based on internal cracks. 'MODOSONIC' software package has been extensively using in many Industries to find flaws and cracks.

The objective of the work is to find the flaws in various materials like mild steel (M.S) plate clad with mild steel (M.S) electrode, mild steel plate clad with brass electrode, mild steel plate clad with stainless steel electrode, mild steel pipe clad with mild steel electrode. To detect the flaws at various angles the probes are placed at 45^0, 60^0 and 70^0. When the size of the weld plate is less than 25 mm, then it will be preferable to use and find flaws in materials with 70^0 probe angle. With MODOSONIC software package, it is found that mild steel pipe welded with mild steel electrode highlighted more internal flaws at 70^0 probe angle from experimental analysis.

***Keywords*:** Ultrasonic testing, flaw detector machine, probes, welding materials and MODOSONIC

1. Introduction:

Non Destructive Testing (NDT) is a wide-ranging group of investigation techniques used in science and technology to find the defects of a material like minute cracks and flaws within the system or component. NDT does not change the shape of article after inspection, but it is extremely valuable technique that can be applied on weld-clad materials to save time and money in product assessment. NDT is a kind of a process to investigate various trials on estimating materials, components or assemblies for discontinuities or break-ups and differences in characteristics without altering the serviceability of the part or system. The part can be reused once again after the inspection or test is completed. Apart from NDT, there are other destructive tests can be applied on a limited number of samples rather than materials, parts or assemblies that can actually put into service. The destructive tests are often applied to find the mechanical properties of materials like impact resistance, yield strength, ductility, ultimate tensile strength, fracture toughness and fatigue strength.

Today modern industries are applying many kinds of NDT techniques in fabrication, manufacturing and job related inspections, repaired working parts to ensure the quality of product reliability and integrity, to control the flaws in weld-clad materials, to lower the production costs and to maintain a uniform level in quality. NDT is used to ensure the quality of metal-clad flaws both in fabrication and production phases, and work-related inspections are necessary to ensure their usefulness and the safety to the public. It should be noted that while the medical field uses many of the same processes, the term "Non-Destructive Testing" is generally not used to describe medical applications.

Vural et al., [1] investigated the Ultrasonic testing on the applicability of spot welded different steel. In many of car bodies and transportation fields, the resistance spot welding of different steel sheets are done to evaluate the fatigue life of loads. In this study, they were fabricated two steel sheets claded each other using resistance spot weld. The specimens and nugget diameters were tested in a special ultrasonic test apparatus designed for spot welded sheets of AISI 304 – Galvanized steel sheet combination were subjected to the fatigue test up to 25 % stiffness drop. Any rupture or fatigue in spot welded joints after fatigue test is found. Ammirato et al., [2] carried out the ultrasonic testing of different metal welds in boiling water reactors and pressurized water reactor vessels and highlighted the complications of ultrasonic testing of dissimilar metal welds. They have developed a conventional shear wave transducer for testing the dissimilar metal welds in the nozzle to safe end joints on boiling water reactor recirculation piping. For welds thickness less than 38 mm, transducer frequency of 2.1 MHz have used and were successful in constantly detecting the cracks with depths around 22 % of the wall thickness or greater. Large thickness welds required the use of element 1MHz transducer. With larger angles of refraction the best flaw detection performance was obtained. Bindal et al., [3] has done the work on water centred couplants for general purpose use for ultrasonic NDT applications. Studies show that the newly developed couplants provide 3 decibels better coupling as compared to the other conventional couplants. Engel and Geiger., [4] have done work on Radiographic testing and ultrasonic testing in stainless steel bead in TIG welding. Kemnitz et.al., [6] reported radiographic testing on Lockheed Missiles. Thirugnanam, et al., **[7]** developed a standard practice for production and evaluation of field metallographic replicas. Yusof and Jamaluddin [8] have highlighted the various welding defects and its associated flaws for various applications in welding industries.

1. Experimental Setup of Ultrasonic Testing Equipment:

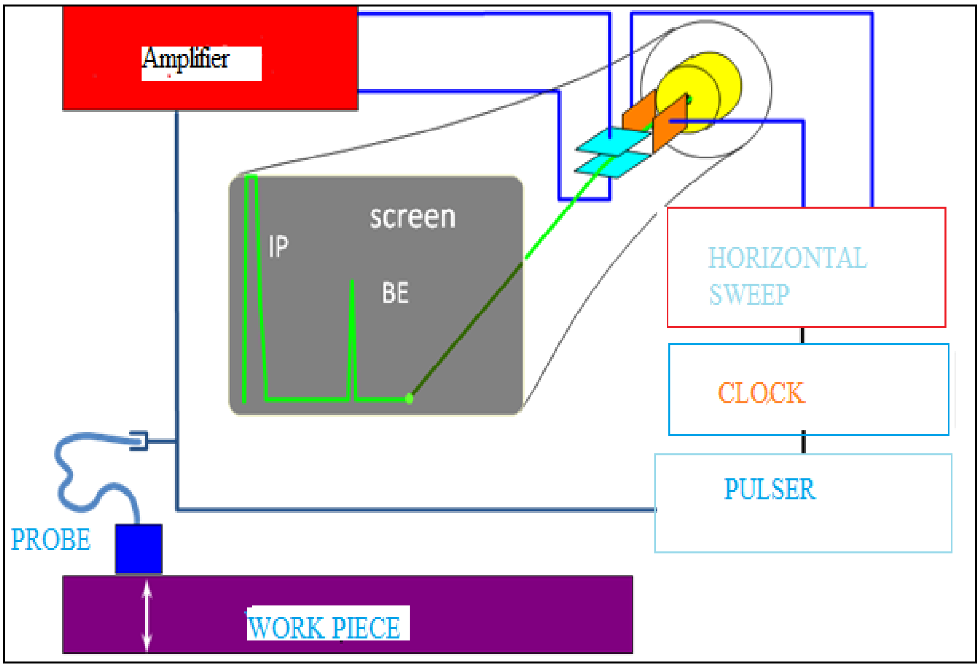

Fig. 1 Experimental set-up of ultrasonic testing equipment

The set-up of ultrasonic testing equipment is shown in figure 1 are used to present a deflected shear wave into the test material with adjustable versions or fixed angle versions of transducers to determine the angles of incident and refraction. The principle of angle beam transducers uses the refraction and mode conversion to produce deflected shear or longitudinal waves in the test. The incident angle necessary to produce a desired deflected wave can be determined from Snell's Law. Angle beam transducers shown in figure 3 are used to locate sizeable flaws which are oriented non-parallel to the test surface.

Ultrasonic instruments basically perform various functions to generate, receive and display the pulses of electrical energy that have been converted to and from the pulses of ultrasonic energy by a transducer unit attached to an instrument. After adjusting the instrument, an operator can estimate the displayed pulse signals amplitude and calculates the time-distance relationships between received and generated signals.

Fig. 2 Ultrasonic Flow Detector Machine

Fig. 3 Angle beam transducer

Exhaustive instructions for operation of individual samples can be obtained from the operation and maintenance guide for the specific instrument being tested. The amount of energy received from ultrasonic machine is a function of time with A-scan presentation shown in figure 4. The amount of energy received is plotted on Y- axis and the elapsed time is displayed on X - axis. A-scan display will allow the signal to be displayed in its natural frequency form as a fully rectified radio frequency signal or as either the positive or negative half of the radio frequency signal.

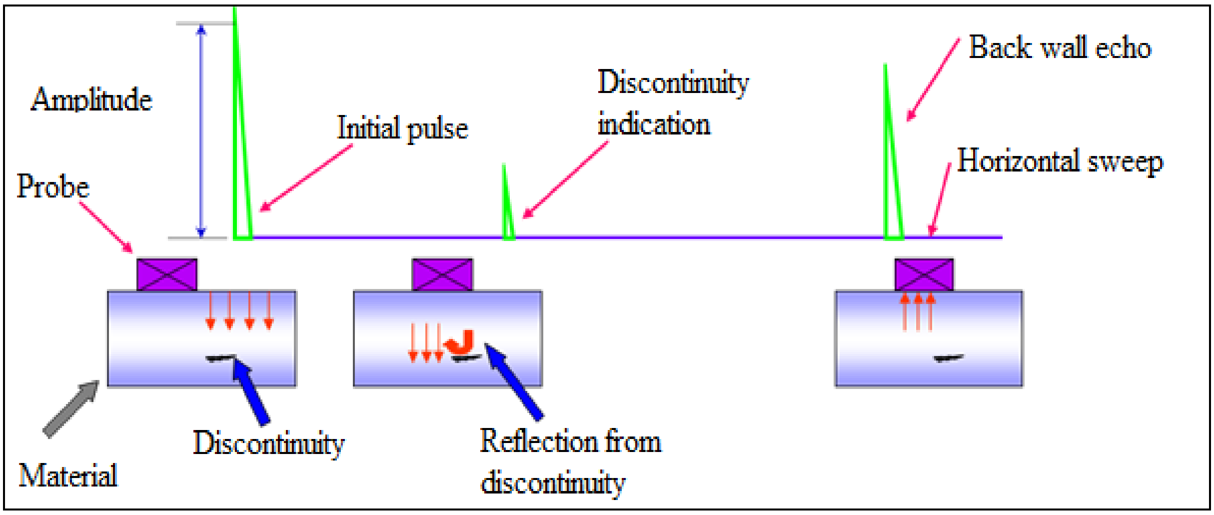

Fig. 4 A-scan presentation

2. Results and Discussions

A – Scan display shows the Distance Amplitude Correction (DAC) offers a means of establishing a graphic “Reference Level Sensitivity” as a function of sweep distance. DAC allows the signals to be reflected from similar break-ups, where the signal attenuation as a function of depth has been correlated. A-scan display also shows the DAC to allow for loss in amplitude over a material depth (time), electronically by certain instruments graphically. The near field length and beam spread may vary according to the transducer size, velocity, frequency and materials attenuation. For each situation, DAC curve must be established. It may be employed in both longitudinal and shear modes of operation as well as either contact or immersion inspection techniques.

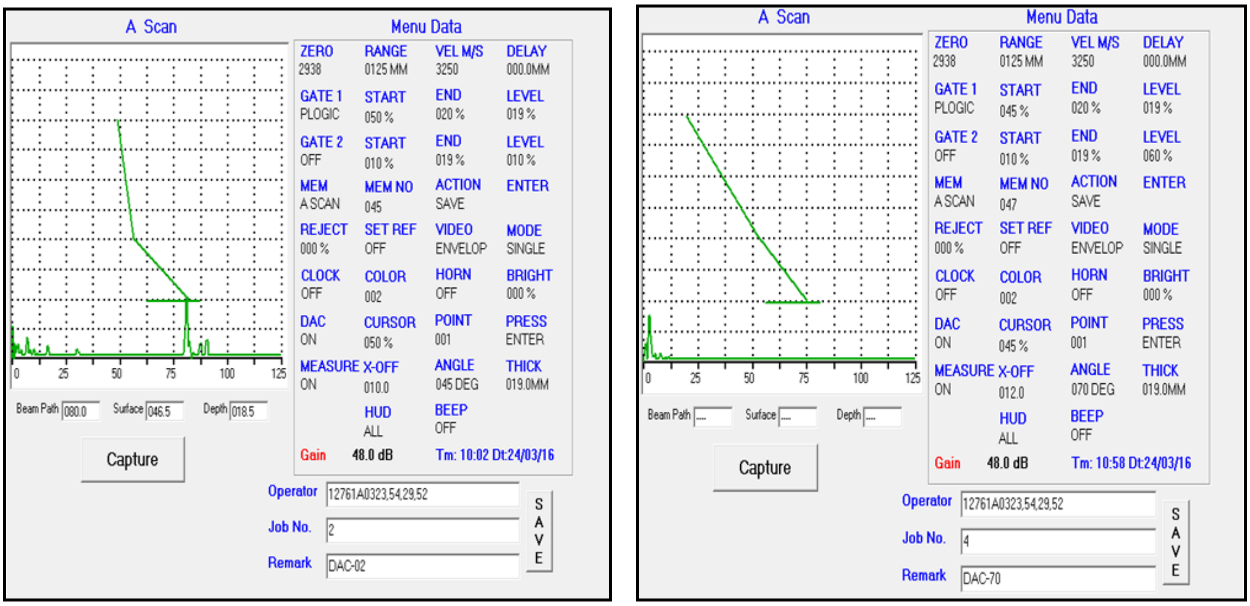

Fig. 5: Distance amplitude correction curves of i) 45^0 Probe ii) 70^0 Probe

Distance Amplitude Correction curves of probes of 45^0 and 70^0 are shown in figure 5. But DAC curve probes are available at various angles. The main aim of the above figures is to find flaws in the curve region, and to draw the curve by using the side drilled hole block. The above figures are mainly used to find the welding defects and flaws above and below 25mm plate or pipe.

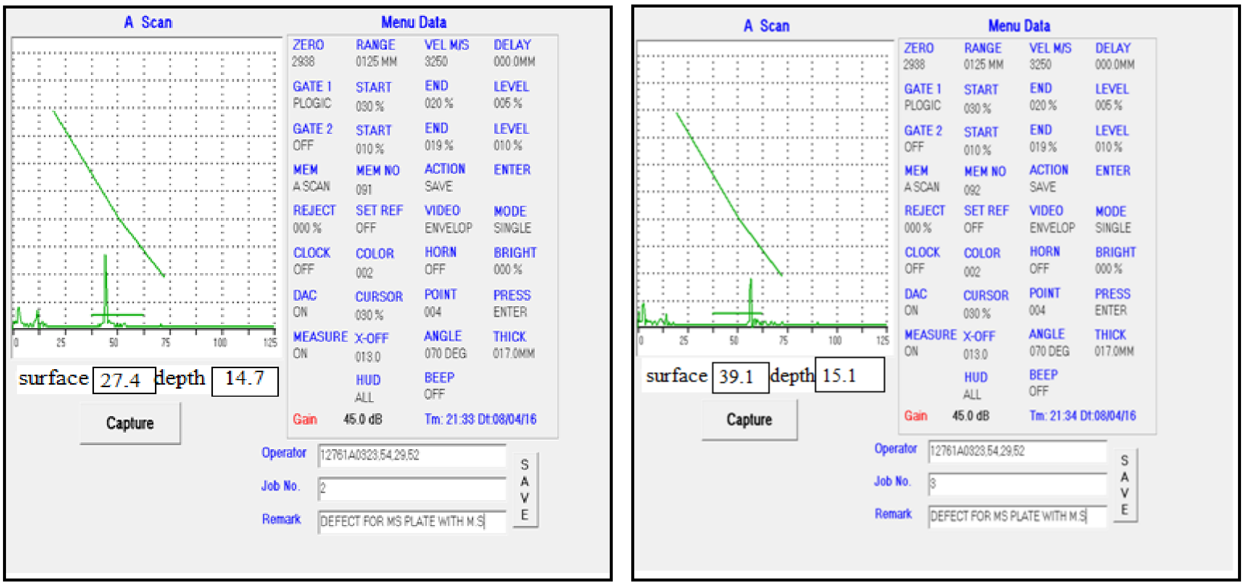

Fig.6 Mild steel plate clad with Mild steel electrode with surface and depths defects

Weld defect present at 14.7 mm depth and surface distance will be 27.4 mm is shown in figure 6 represents the type of defect is due to lack of penetration and the other side of figure 6 presents welding defect at 15.1 mm depth and surface distance will be 39.1mm. The type of defect is lack of penetration and porosity.

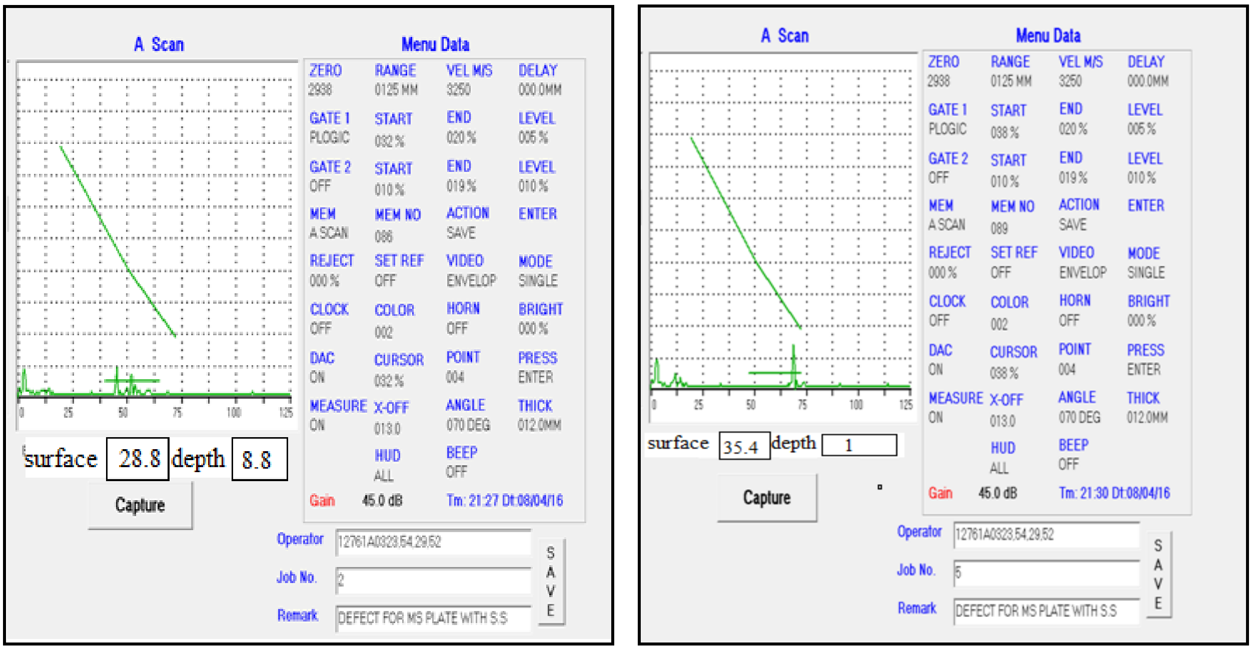

Fig. 7 Mild steel plate clad with stainless steel electrode defects

Welding defect present in M.S plate cladded with S.S. electrode is shown in figure 7 indicates the flaw at 8.8 mm depth and surface distance will be 28.8 mm. The type of defect is porosity. Another side of figure 7 shows welding defect at 1mm depth and surface distance will be 35.4 mm. The type of defect is classified as crack.

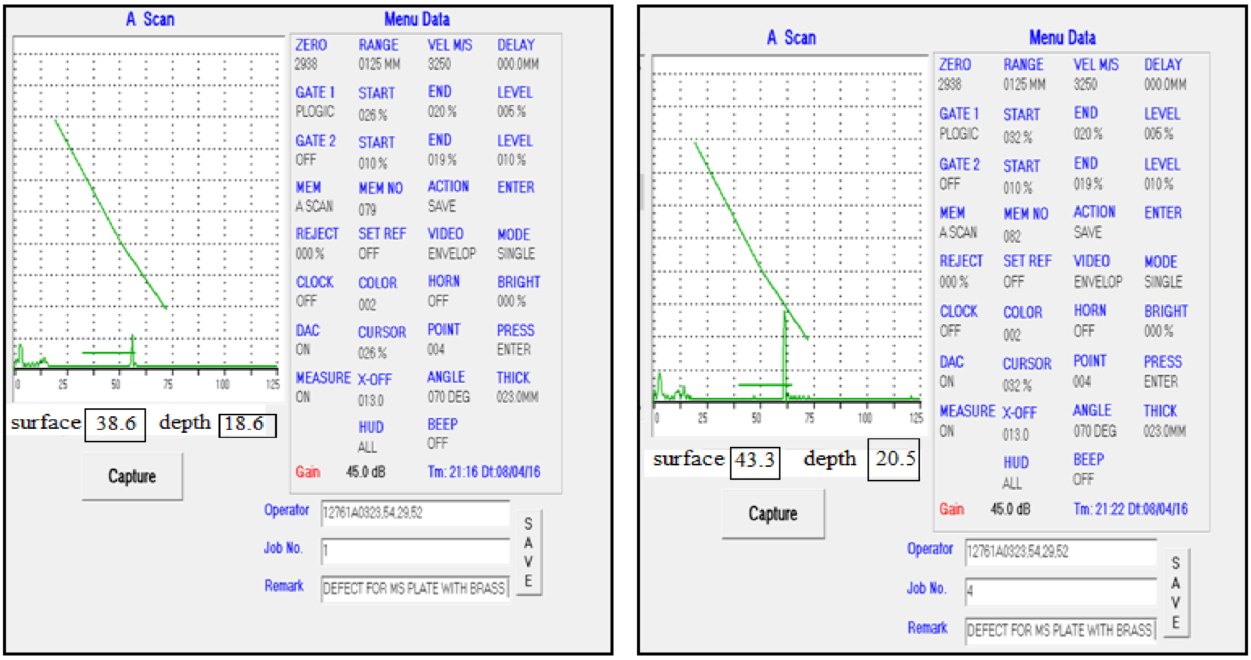

Fig.8 Mild steel plate clad with brass electrode defects

Figure 8 represents a welding defect of M.S. plate cladded with brass electrode shows crack defect in 18.6mm depth and surface distance will be 38.6mm. The side figure also presents the welding defect in 20.5mm depth and surface distance will be 43.3mm. The type of defect is lack of penetration.

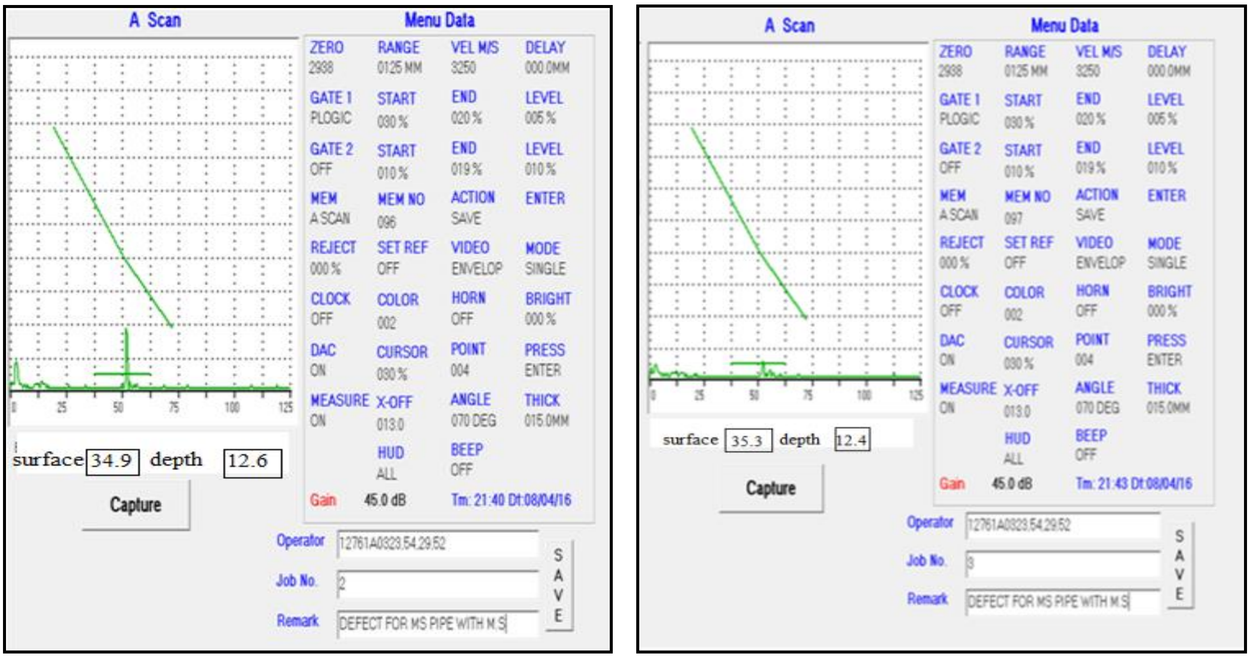

Fig.9 Mild steel pipe clad with mild steel electrode defects

Figure 9 represents a M.S pipe clad with M.S electrode showing welding defect in 12.6mm depth and surface distance will be 34.9 mm. The type of defect is lack of penetration. The side figure shows welding defect in 12.4mm depth and surface distance will be 35.3mm. The type of defect is Porosity. The various flaws present in different welded materials are shown in table 1.

Table 1: Various flaws present in different weld clad materials

S.NO	THICKNESS	DEPTH	TYPE OF FLAW
Mild steel plate welded with mild steel electrode			
1	17	14.3	Lack of penetration
2	17	14.7	Lack of penetration
3	17	15.1	Lack of penetration and porosity.
4	17	15.8	Crack
Mild steel plate welded with Stainless steel electrode			
1	12	6.3	Lack of penetration
2	12	8.8	Porosity
3	12	1	Crack
Mild steel plate welded with Brass electrode			
1	23	18.6	Crack
2	23	19.8	Crack
3	23	20.5	Lack of penetration
4	23	20.2	Lack of penetration
Mild steel pipe welded with Mild steel electrode			
1	15	12.6	Lack of penetration
2	15	12.4	Porosity
3	15	19.4	Crack
4	15	12.4	Lack of penetration
5	15	12.4	Porosity

3. Conclusion

In both the government and private sectors, especially for irrigation pipe lines, welding is extensively used in the fabrication, maintenance and repair of structural parts. To ensure its quality, the welding should be flawless. All the defects shall be detected as early as possible in order to increase the reliability of the part or component of that equipment and it can be corrected before handing it over to the client. It can be concluded that NDT is a very important tool for the fabrication, manufacturing and welding industries. The ultimate goal of any industry is to support the NDT in a great way to operate economically with high reliability and to produce the quality end-products.

Ultrasonic testing is conducted to locate discontinuities within the material under test and often used to detect internal defects by using the "Modesonic software". Ultrasonic testing can easily be automated because it is a fast method and the signals are available in electronic form.

1. By using the different types of probes 45, 60 and 70 degree probe to draw distance amplitude curves. This is mainly used to find the defects in within the curve.

2. Ultrasonic testing is conducted on four different materials. Those are M.S plate welded with M.S. electrode, M.S. plate welded with Stainless Steel electrode, M.S. plate welded with Brass electrode, M.S. pipe welded with M.S. electrode. It can be concluded that M.S pipe welded with M.S. electrode highlighted more internal flaws at 70^0 probe angle from the experimental results.

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