Comparing Various NDT Techniques by Using Them on V-Butt Welded Joint on Stainless Steel Cylinder by Means of Time Consumption, Flaw Detection, Crack Depth Detection, Safety and Cost

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Abstract—*Pipes, Pressure vessels and Heat exchangers are the main applications of GTAW welding, but due to high working pressure the working hazards are also high in case the welding joint leaks or breaks down. So in order to check whether there is any defect in the joint we use Non-Destructive Techniques to check the welded joint. Mostly this welding is slag and spatter free, but sometimes due to moisture some blow holes are made in the welding bead and also due to unskilled worker the weld bead may become defective. So in this paper a GTAW welded stainless steel cylinder is checked using different NDT techniques and then compared to know the best method to check the defects in GTAW.*

Keywords: - GTAW, welding, stainless steel, non-destructive testing, comparison, blow holes, defects in GTAW, UT, MT and PT.

I. Introduction

NDT is most widely used technique in finding out the defects in various types of metals and non-metals. In metals most of the defects arise at the joints and their near-by area. Metals can be joined using various techniques like welding, riveting etc. In welding there are various types like SAW, Arc Welding and GTAW etc. GTAW is one of the most used and efficient form of welding because it is slag and spatter free but if the worker is unskilled or there is some moisture content on the electrode then there are high chances of defects in the weld bead and small fractures in the near-zones. GTAW finds its application in welding Pressure vessels, pipes and heat exchangers and if any defect is induced in them while doing welding then it might be hazardous for the safety of workers. NDT is used to check the possible defects which can be caused in GTAW welding.

There are many methods and techniques in NDT and this study aims at comparing various techniques to check GTAW welding defects at different parameters like Time Consumption, Flaw Detection, Crack Depth Detection, and Cost. The techniques compared in this study are Liquid Penetrant Test, Ultrasonic Testing and Magnetic Particle Testing.

Main aim of this paper is to check V-Butt weld bead on Stainless Steel cylinder and look for defects like blow holes, internal cracks, porosity, inclusions and undercutting etc.

II. Experimental Set-up

Experimental set up consists of:

1. Liquid Penetrants
2. Magnetic Particle Setup
3. Ultrasonic Setup

Fig.1:Liquid Penetrants And Developer

Fig. 2: Magnetic Particle Setup

Fig. 3: Ultrasonic Testing Setup

In present work, V-Butt joint Stainless steel cylinder is Gas Tungsten Arc Welded and then it is checked whether the weld bead is strong and defect free. The cylinder is checked on the following basis:

1. Visual Inspection
2. Liquid Penetrant Testing
3. Magnetic Particle Testing
4. Ultrasonic Testing

III. EXPERIMENTAL WORK:

A. Visual Inspection: In visual inspection the cylinder is kept under white light and the light is allowed to fall on the surface of cylinder. Then the cylinder is checked with the help of magnifying glass or microscope at all possible angles and is looked for any surface defects like cracks, surface roughness, small dents etc.

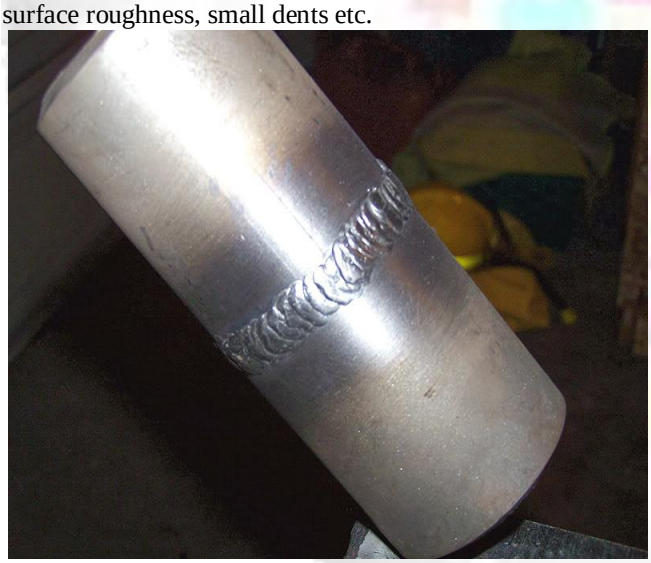

Fig 4: Cylinder kept under white light

B. Liquid Penetrant Testing: After visual inspection, the cylinder is tested with the help of Liquid Penetrant. Firstly the pink/red coloured paint is sprayed on the weld bead of cylinder and then it is allowed to soak inside the surface cracks or defects. After about 10minutes the cylinder is cleaned with the help of dry cloth and then a white developer is sprayed on the weld bead. As soon as the white developer is sprayed on the weld bead, the pink/red paint which was earlier absorbed by the cracks gets pulled out due to capillary effect and we are able to see the surface defects on the cylinder.

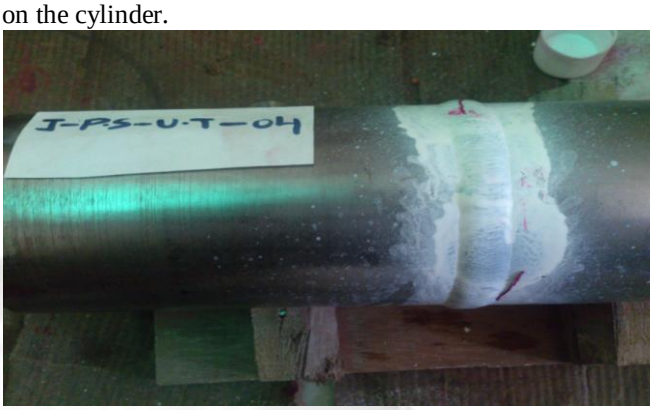

Fig. 5: Visual surface defects on weld bead after Liquid Penetrant Testing

C. Magnetic Particle Testing: In this the sub-surface defects can be easily found out which were not detected in LPT. In the firstly the work piece to be tested in magnetized with the help of electromagnetic. When the work-piece is fully magnetized then the dry iron particles in powdered form are sprinkled near the weld bead. If the iron flakes make particular pattern of magnetic lines of force then there is no error. But if the powder gets accumulated going against the magnetic line of force then at that point there is some magnetic flux leakage which shows that there is sub-surface defect near that portion which must be machined.

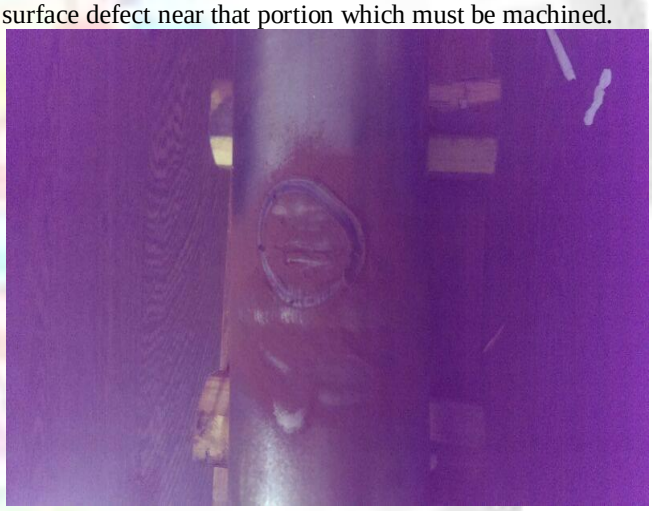

Fig. 6: Defect highlighted by Iron flakes gathered at point of Defect

D. Ultrasonic Testing: In Ultrasonic testing, sound waves of very high intensity are made to travel into the work-piece with the help of a transducer. These waves go through the work-piece and after reaching the other end of the work-piece deflects back to the transducer and is received by its other end. The transmitting transducer may serve as the receiving transducer, or a separate transducer may be used. A discontinuity or flaw in the specimen will also send back an echo. The time intervals that elapse between the initial pulse and the arrival of the echoes are measured with a cathode ray tube (CRT). In the echo pattern a flaw can be recognized by the relative position and amplitude of its echo.

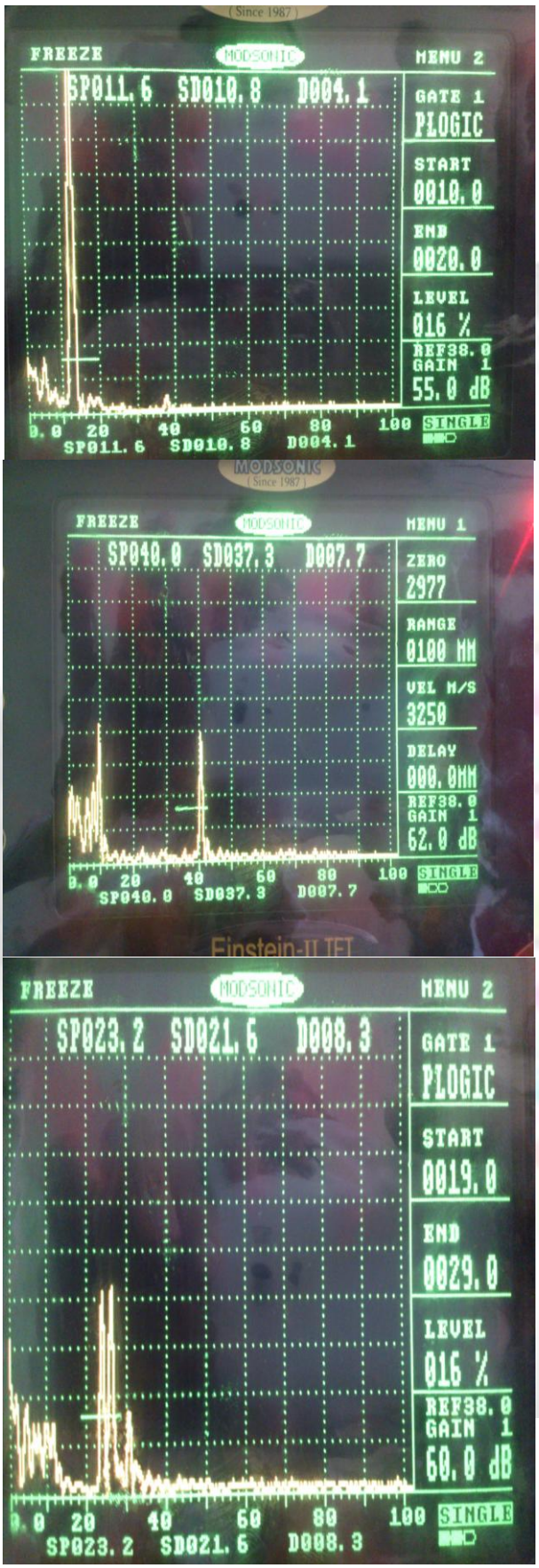

Fig 7: A flaw found at a distance of 4.1, 7.7 & 8.3mm from the test surface

IV. Results and Conclusion:

In the inspection of the V-Butt welded cylinder usingMPT, the result of MPT shows weld zones which are reported defective in ultrasonic are found to be free of defect, this is because MPT test depends on the relative absorption of the iron powder near the surface and sub-surface defects in the material to be tested and consequently when the even if there is a cavity in the weld zone and where there is a thicker weld bead which compensates this cavity, the MPT reports defect free. Hence MPT has limitation in reporting welded defects in cylinders. The penetrant test also could detect only the surface pores of weld zone. Hence ultrasonic test gives better result.

Besides the above qualitative comparison quantitative comparison is made on the time consumption of test conduction, relative flaw detection, crack depth penetration power, safety, cost and portability of the test methods (Table 1 to 6).

Table 1 Comparison of time consumption for conducting and interpreting tests

No.	Specimen	Liquid Penetrant	Magnetic Particle	Ultrasonic
1	GTAW Cylinder	35 Minutes	1H & 20 Minutes	Approx. 2Hours

Table 1 show the time needed for conducting penetrant test is the smallest of the three tests followed by Magnetic Particle test. The reason for the shortest time of penetrant is that it reveals only surface defects.

Table 2 Comparison of relative flaw detection

No.	Specimen	Liquid Penetrant	Magnetic Particle	Ultrasonic
1	GTAW Cylinder	Good	Good	Excellent

In comparing the relative flaw detection of the methods, methods which resulted in the indication of better crack length are marked as “Excellent” and others marked “Good”, “Fair” and “Poor” are set relatively to the excellent method.

Table 3 Comparison of crack depth detection

No.	Specimen	Liquid Penetrant	Magnetic Particle	Ultrasonic
1	GTAW Cylinder	Poor	V. Good	Excellent

In comparing the crack depth detection of the methods, methods which resulted in the indication of better crack depth are marked as “Excellent” and others marked “V. Good”, “Fair” and “Poor” are set relatively to the excellent method. As Table 3 shows only ultrasonic test can detect the depth of a defect.

Table 4 Comparison of safety hazard

Liquid Penetrant	Magnetic Particle	Ultrasonic
LESS	HIGH	NO

As far as safety is concerned none of these methods needs a serious safety care and attention. Relative to Magnetic Particle testing, the penetrant test is less hazardous as far as the necessary masks for nose, mouth and eyes are used.

Each method is also compared based on costs spent to implement the tests. The cost elements are material,

labour and machine costs. The labour rate is Rs.100/hour. Summary of the cost brake down is indicated in table 5.

Table 5 Comparison of cost for testing

No.	Specimen	Liquid Penetrant	Magnetic Particle	Ultrasonic
1	GTAW Cylinder	600	1000	700

Table 5 shows Magnetic Particle is the most expensive method. Cost of Magnetic Flakes is the main reason material cost.

Table 6 Comparison of equipment portability

Liquid Penetrant	Magnetic Particle	Ultrasonic
YES	NO	YES

When portability of test equipment is considered ultrasonic and penetrant tests avail portable type equipments and hence on site test is possible, whereas due to spreading of magnetic flakes MPT cannot be conducted anywhere except for using liquid magnetic particles.

V. Future Scope:

In future work we can test and compare other work-pieces based on their size, shape, use and material type.

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