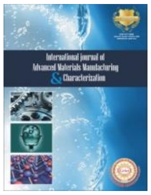


Advanced Materials
Manufacturing & Characterization

journal home page: www.ijammc-griet.com

Defect Location and Sizing by Ultrasonic Phased Array on Aero Grade Material Aluminum He-15

S.V.Ranganayakulu, A.kucheludu, B. Veera Bhadraiah, B. Ramesh Kumar

Centre for Non Destructive Evaluation, Guru Nanak Institutions, Technical Campus, Ibrahimpatnam – 501506, Andhra Pradesh.
Institute for Plasma Research (IPR), Bhat, Gandhinagar-382428, Gujarat

A R T I C L E   I N F O

Article history:
Received: 29-10-2013
Accepted: 18-01-2014

Keywords:
Aluminum HE-15,
Tungsten Inert Gas Welding (TIG),
Ultrasonic Phased Array,
Sectorial Scan

A B S T R A C T

This paper gives the orientation and inspection of aero grade material by using Ultrasonic Phased Array over conventional methods. The dimension of material sample HE15 is 150*120*10. Two defragmented aluminum alloys are joined by welding process known as Tungsten Inert Gas Welding. Inspection of material is carried out by various Non Destructive Testing methods namely ultrasonic method, radiography method, liquid penetrant and Phased array technique. Sensitivity of material is noticed by scanning of ultrasonic phased array and pulse echo technique method alternatively defects are detected by other NDT methods namely X-ray, Ultrasonic phased array technique and LPT. Few surface flaws are noticed at a depth of 2mm by LPT method. Porosity and inclusion defects are better trace-out through phased array and X-ray radiography respectively. Ultrasonic Phased Array sectorial scan technique produces immediate images, allowing straight forward visualization of the internal structure and simplifying data interpretation of weld joint. The defect is identified and located by Ultrasonic Phased array Dynamic depth focusing Technique.

1.Introduction

Non Destructive Evaluation (NDE) comprises various activities includes testing, inspection, and examination, Measuring about an object to determine whether the object contains defects irregularities, discontinuities, or flaws [1].

There are four NDT methods are conducted in the experiment such as Pulse Echo Technique, Ultrasonic Phased Array, Radiography and Penetrant methods are enlarged to evaluate the defects of the material.

2. SAMPLE PREPARATION

Aluminum alloy is selected for welding process by joining two defragmented aluminum alloys. HE-15 is a family of aluminum group (2014). TIG welding is implemented for the sample preparation [6].

2.1. Chemical composition and mechanical properties

The material consist of aluminum alloy HE-15 is a copper based alloy, chemical composition and mechanical properties are given billow

Table 1 Chemical Composition

Elements	Cu	Mg	Si	Fe	Mn	others
Percentage (%)	3.8-5	0.2-0.8	0.5-1.2	0.7	0.3-1.2	1.5

- Corresponding author: S.V.Ranganayakulu
- E-mail address: nayakulu@rediffmail.com
- Doi: http://dx.doi.org/10.11127/ijammc.2014.03.07

Table2 Mechanical properties

Sl.No	Mechanical properties	Values
1	Hardness, Brinell	135
2	Hardness, Knoop	170
3	Hardness, Rockwell A	50.5
4	Hardness, Rockwell B	82
5	Harness , Vickers	155
6	Ultimate tensile strength	483MPa
7	Tensile yield strength	414MPa
8	Modulus of elasticity	72.4GPa

2.2. Lathe machined work shop

HE-15 is procured from S.A. Enterprises, Fathenagar in Hyderabad. It has thickness of about 12mm in the rectangular shape where the welding is carried out to join the two different aluminum alloys and these plates are non- uniform thickness and scales on the surface. The dimension of the sample is 150*120*10 is machined by lathe machine to get desired shape

2.3. Welding

The type of welding implemented for the experiment is Tungsten Inert Gas (TIG). This welding gives the good specification to weld aluminum alloys [7]. The following welding parameters are maintained during the period of experiment.

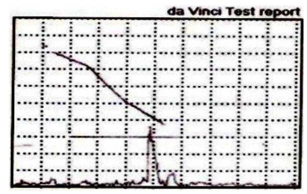
Table 2 Welding Parameters

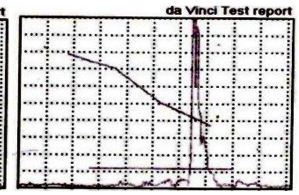
Sl.No	Weld parameter	Parameter Values
1	Current	200-220 Amp
2	Gas flow	10 M/s
3	Electrode	Tungsten (non-consumable)
4	Filler metal	2014
5	Weld speed	10cm/min

3. Experimental setup

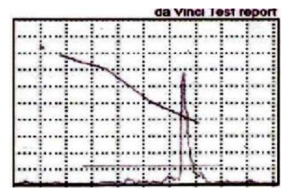
3.1 Ultrasonic testing

Ultrasonic testing is conducted on the aluminum alloys (HE 15) and the defects are detected by scanning the material. Initially calibration is carried out on the V1 block similarly scanning on the material is carried out with reference to DAC curve [8, 9]. Each reflector gives peak amplitude response [Fig1], A-scan is performed on the material for maintain of the quality of material. Three defects are noticed through A-scan pulse echo method.





Defect1. Defect2



Defect3

Fig1: Ultrasonic Defectogram of welded HE15 material Defect1: SD=19mm, BP=25mm, Depth (d) =2mm, Defect2: SD=25mm, BP=22mm, Depth (d) =4mm, Defect3: SD=22mm, BP=23mm, Depth (d) =3.5mm

3.2 Radiography

D4 film was selected and placed between the two foil screens for X-ray Radiography. These are inserted into the film cassette. Cassette was placed in the Equipment arrangement: The X-Ray Voltage and current parameters are selected as 120KV and 3mA. Source to Film Distance and exposing time are calculated by the following formulae.

$$SFD = t\,(1 + (f/Ug)) \qquad (1)$$

The sample is placed between the Penetrameter and the film which is in the direction of X-Ray source. The sample is placed at the distance of 15.1cm from the X-Ray source. When the power is switched on the X-Rays are exposed on the sample with 3sec. after exposing from X-Ray source, the film is brought to the dark room for processing. By proper interpretation defect has been located.

3.2 Ultrasonic phased array

Inspection using Phased array has much common with conventional ultrasonic's, since the physic s of wave propagation, reflection, refraction, mode conversion and diffraction remain the same but the method of generating and receiving the ultrasonic waves that is different. The ability to modify or control the beam profile generated by a Phased array Probe leads to three main Electronic Scanning Techniques that cannot be achieved using conventional ultrasonic Systems. Combination of linear Scanning, Dynamic Depth focusing and Sectorial scanning techniques provides a far more complicated scan and greater coverage is not possible by conventional methods.

Probe is selected according to the required beam focal distance, scan pattern and the time delays for the elements are calculated. Rapidly and repeatedly steering of probe by Sectorial Scanning Method gives the immediate images with straightforward visualization of the internal structure. The defect is located and identified by adjusting the inspection angle and focal spot sizes. Figure 3 shows the image of the weld root [10]

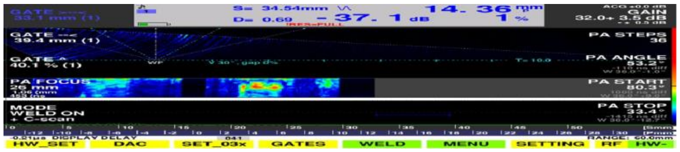


Fig2: Ultrasonic phase array Defectogram of welded HE15 material Defect at 0.69mm depth

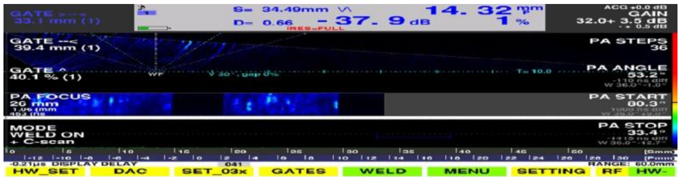


Fig3: Ultrasonic phase array Defectogram of welded HE15 material Defect at 0.66mm depth

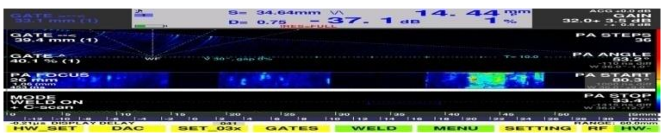


Fig4: Ultrasonic phase array Defectogram of welded HE15 material Defect at 0.75mm depth

3.3 Liquid penetrant testing

3.3.1 Surface cleaning

The surface of the component must be thoroughly cleaned by solvent (chemical) cleaner used by spray cans and completely dried before the inspection. Now the samples are free from oil grease, and other contaminates. The surface cleaning is required for achieving successful indication.

3.3.2 Penetrant application

After the surface preparation water washable penetrant [fig5] was applied by the spray can so a penetrant film is formed on the component surface. The florescent penetrant was applied by the liquid spray.

Fig5 Penetrant application on HE15 welded sample

3.3.3 Dwell time

The liquid film should be remained on the surface for a period of 15 minutes to allow penetrant into surface openings. This is called dwell time Removal of excess penetrant: The excess penetrant is removed from the surface. The excess penetrant is washed off with water and cleaned by lint free cloth.

3.3.4 Developer application

The development stage is to reveal the presence of surface defect. Developer is applied by spraying on the surface with non-aqueous wet developer contains ketene, propane corbinal solvents. A thin uniform layer of developer is deposited on the surface [fig6] of the component. Liquid penetrant present within the defect will be slowly drawn by the capillary action into the pores of the developer. The development stage may omit in the florescent penetrant method.

3.3.5 Interpretation

After optimum developing time as been allowed the component surface is inspected for indications of penetrant bleed back into the developer. Die penetrant inspection is carried out in strong lighting condition.

3.3.6 Florescent method

Florescent particles of 5g were taken in 1 litter of water and mixed well. The florescent applied to the welded plates by spraying method. Then the excess penetrant is removed by lint free cloth and inspected under UV light for defects.

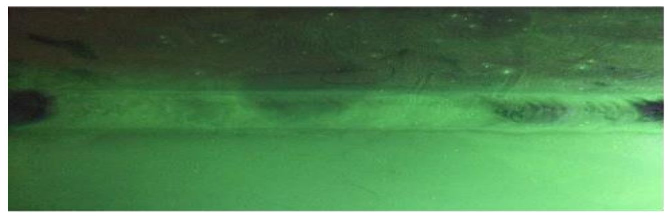


Fig7:- Florescent test on HE15welded material

4. Results and discussion

4.1 Penetrant test

The Welded HE 15 samples were tested by the dye and florescent penetrant methods. A single blow hole was observed [fig6, 7] at the heat affected zone [HAZ]. The dimensions of the blow hole open to surface ±1mm depth and 2to3mm width and the defect can be repairable.

4.2 ultrasonic test

The welded HE 15 samples were tested by ultrasonic testing. There was one inclusion at the weld and some porosity [fig1] was detected at the welded region. The dimensions of the inclusions were 2mm X 10mm.

4.3 radiography test

Five samples of HE 15 materials were tested by using X-Ray radiography. Inclusions, undercut, lack of penetration, blow holes and small porosity were detected from the recorded film

4.4 ultrasonic phased array

Two samples of HE 15 materials were tested. Blow holes, porosity [fig2, 3, 4] were observed at the welded region. In this test the accurate size of blow holes were 2mm to 3mm and porosity less than 1mm

Conclusions

It was concluded that, Ultrasonic method is more sensitive in detection of internal defects. X-ray Radiography gave the images of internal defects. Liquid penetrant testing is less sensitive in detection of defects technique Finally Ultrasonic phased array gave the accurate location and dimensions of porosity which could not be detected by Radiography testing and Ultrasonic testing.

Acknowledgement

Authors are grateful to the authorities of BRFST, Institute for plasma Research to carryout research (Project no: NFP-MAT-F12-01). Gratefully acknowledgements due to "Dr H S Saini, Managing Director and Sardar G S Kohli, Vice Chairman, Guru Nanak Institutions, Ibrahimpatnam for cooperation and encouragement.

References

1. American Society for Metal Hand book Vol.11, ASM Metals Park, Ohio "Non Destructive Inspection and Quality Control".
2. ASTM handbook vol.17, "Non-Destructive Evaluation and Quality Control".
3. Sharpe, R.S., "Sizing Crack like Defects by Ultrasonic means, Research Techniques in Non-Destructive Testing". vol.3, pp. 48-56, Academic Press, London, Silk M.G, 1977.
4. Wooldridge, A.B., Chapman, R.K., Woodcock G S., Munns, I J., and Georgiou, G A., "Reliability of radiography for detection of planar manufacturing defects in thick section welds", vol.39(3), pp.139-147, 1997.
5. Erhard, A., and Ewert, U., "The TOFD Method -Between Radiography and Ultrasonic in Weld Testing", pp.10-12, DGZP Jahrestagung, Celle, 1999.
6. Causes for Weld Defects IIW Doc. XIIB- 046-83, International Institute of Welding, 1983.
7. Little Richard, L., Tata Mc Graw- Hill Publication Company ltd ,Welding and welding Technology,1997.
8. Raj, B., Jayakumar, T., Tavasimuthu, M., "Practical Non Destructive Testing".
9. Drury, S.C., third edition, June "Ultrasonic Flaw Detection for Technicians" 2004.
10. "Non Destructive Examination of Welds –Radiographic Examination of Welded Joints". BS EN 1435:1997.