EVALUATION OF DEFECTS IN THE SS-304L MATERIAL BY USING NON DESTRUCTIVE EXAMINATION TECHNIQUES

Syed Mobin Baba[1], Shaik Azgerpasha[2], Shaik Fayaz[3]

[1]*Asst Professor, Mechanical engg. dept., SEC, TS, India*
[2]*Research Scholar, Noida International University (NIU), Noida-India.*
[3]*NDT Inspector, MEIL, Hyd-India*

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Abstract - *NDE stands for Non Destructive Examination. It is a wide group of analysis techniques used in science and industry to evaluate the defects of a material, component or system without causing damage. The sample been inspected is SS-304L Nuclear grade material. It is used in the construction and the structure applications of the nuclear reactors. It is the most commonly used stainless steel and it belongs to the family of 'AUSTENITIC STAINLESS STEEL'. It doesn't display magnetism but it is austenitic, corrosion resistant steel with excellent strength, tough, fabrication characteristics and weld ability. The dimensions of the sample are 300x150x10mm.*

The basic NDE methods which are used for inspecting our sample are Liquid Penetrating Test(LPT) and the Ultrasonic testing. Principle of LPT is based on Reverse Capillary action. It is a widely applied and low-cost inspection method is used to locate surface-breaking defects in all non-porous materials. Principle of Ultrasonic testing is based on Ultrasonic pulse echo technique*. It is used to detect the internal flaws or to characterize the materials. The technique used in ultrasonic testing is pulse echo technique. Defects are correlated with radiographic films and detected over defectogram.*

We have inspected the material SS-304L by means of LPT and ultrasonic technique to find the defects like Lack of Fusion, Lack of Penetration, slag inclusion, pin hole and porosity on the surface and internal flaws *of the material.*

***Key Words*: Liquid penetration test, Reverse Capillary action Ultrasonic Test, Ultrasonic pulse echo technique.**

1. INTRODUCTION

Non-Destructive Examination (NDE) is groups of analysis techniques are used in many defense and aerospace industry to evaluate the properties of a material, Non-Destructive Examination techniques (NDE) are important in testing materials for defects without altering their physical properties. It does not permanently alter the article being inspected. Hence, the material that is being tested is preserved. It is highly valuable technique that can save both money and time in product evaluation and it is one of the best suitable methods in analyzing the effects of aging in mechanical and civil structures. Non-destructive Examination is one part of the function of Quality Control and is complementary to other long established methods. By definition non-destructive Examination is the testing of materials, for surface or internal flaws or metallurgical condition, without interfering in any way with the integrity of the material or its suitability for service. The technique can be applied on a sampling basis for individual investigation or may be used for 100% checking of material in a production Quality Control System.

Whilst being a high technology concept, evolution of the equipment has made it robust enough for application in any industrial environment at any stage of manufacture - from steelmaking to site inspection of components already in service. A certain degree of skill is required to apply the techniques properly in order to obtain the maximum amount of information concerning the product, with consequent feed back to the production facility. Non-destructive Testing is not just a method for rejecting substandard material. The technique uses a variety of principles. On-destructive Testing is one part of the function of Quality Control and is complementary to other long established methods. By definition non-destructive testing is the testing of materials, for surface or internal flaws or metallurgical condition, without interfering in any way with the integrity of the material or its suitability for service.

2. SAMPLE USED FOR STUDY

2.1 SS 304L

SS 304L is an austenitic Chromium-Nickel stainless steel offering the optimum combination of corrosion resistance, strength, and ductility. These attributes make it a favorite for many mechanical switch components. The low carbon content reduces susceptibility to carbide precipitation during welding.

- **COMPOSITION**

Chromium	18.2%
Silicon	.5%
Nickel	8.5%
Carbon	.015%
Manganese	1.6%

Iron Balance

- **MECHANICAL PROPERTIES**

Ultimate Tensile Strength:

- ANNEALED - 100,000 PSI
- COLD ROLLED - 210,000 PSI

Yield Strength (.2% Offset):

- ANNEALED - 40,000 PSI
- COLD ROLLED - 190,000 PSI

Elongation in 2" * :

- ANNEALED - 40%
- COLD ROLLED - 2%

Modulus of Elasticity (Tension) :

- ANNEALED - 28 x 106 PSI
- COLD ROLLED - 25 x 106 PSI

Poisson's Ratio

- ANNEALED - 0.29

2.2 TUNGSTEN INERT GAS WELDING

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used, though some welds, known as autogenously welds, do not require it. A constant-current welding power supply produces electrical energy, which is conducted across the arc through a column of highly ionized gas and metal vapors known as plasma.

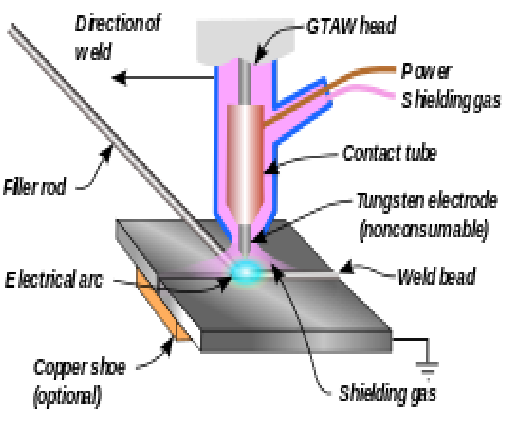

Fig.2.2 TIG welding weld area

GTAW is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as aluminum, magnesium, and copper alloys. The process grants the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds.

Welding Parameters

However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques. For GTAW of carbon and stainless steels, the selection of a filler material is important to prevent excessive porosity. Oxides on the filler material and work pieces must be removed before welding to prevent contamination, and immediately prior to welding, alcohol or acetone should be used to clean the surface. Preheating is generally not necessary for mild steels less than one inch thick, but low alloy steels may require preheating to slow the cooling process and prevent the formation of martensite in the heat-affected zone. Tool steels should also be preheated to prevent cracking in the heat-affected zone. Austenitic stainless steels do not require preheating, but martensitic and ferritic chromium stainless steels do.

2.2.1 GTAW Welding Limitations

- Requires greater welder dexterity than MIG or stick welding
- Lower deposition rates
- Costlier for welding thick sections.

3. SAMPLE PREPARATION

1) Machining:

The SS304L samples are received in the plate form have thickness of about 10mm. The plates are having non-uniform thickness and scales on the surface.

These plates were machined by lathe machine forget accurate thickness throughout the plate with smooth surface for NDT methods.

2) Joint Preparation:

The V butt-joint was prepared by the machine using wedge cutting method.

3) Welding:

The welding was done by tungsten inert gas welding (TIG). The welding parameters were shown in the Table. The welded samples were cleaned by wire brush and chipping was done to remove scales.

Parameters	
Current	200-220 Ams
Gas flow	10 m/s
Electrode	Tungsten
Filler metal	2014
Weld speed	10cm/ min

- For SS304L is 310X150X10 mm

The welded samples were inspected for defects by the following NDT methods. As per ASNT standards.

3.1 LIQUID PENETRANT TESTING

The penetrant testing to detect the surface flaws or defects.

3.1.1 Apparatus Used

Work piece

Lint free cloth

Cleaner

Penetrant

Developer

Fig. LPT spray kit

3.1.2. SS304L material

- **Pre-cleaning**

In the pre-cleaning part, we have to remove the oil and dust particle use cloth for simple wiping. In this water washable visible liquid penetrant inspection should be done. This can be no residue, better penetrant action. And also low odour, user friendly. It has fast action and lower process time.

- **Penetrant application**

This is generally done by spraying penetrant from the aerosol can. The material has high density and good wettability. The penetrant is **red and fluorescent**; this penetrant contains red dye plasticizer, hydro carbon solvents and glycol ethicr, surfactant. Propellant - propane-butane mixture.

Fig. applying penetrant

- **Dwell time**

The penetrant is left on the surface for a sufficient time to allow as much penetrant as possible to be drawn from or to seep into a defect. The times vary depending on the application, penetrant materials used, the material, the form of the material being inspected, and the type of defect being inspected for. We are maintaining the dwell time as 20 mints based on my material.

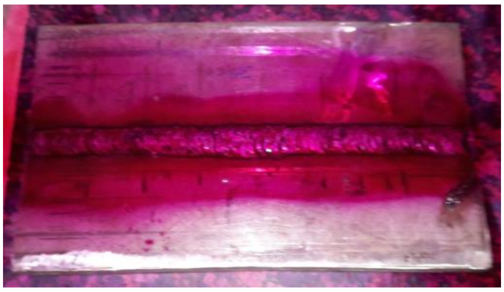

Fig. During the dwell period the SS304L Material

- **Solvent removing**

The excess penetrant is removed from the surface. The excess penetrant is washed off with water and cleaned. Depending on the penetrant system used, this step may involve cleaning with a solvent, direct rinsing with water, or first treating the part with an emulsifier and then rinsing with water. The solvent remover should in the laminar flow to the material.

- **Applying developer**

A thin, light coating of developer should be sprayed on the part being examined. We are using non aqueous developer and it should be made of chlorine, Sulphur within acceptable limits. These developers can be non-toxic and non-corrosive. After applying the developer, a dwell time needs to be observed to allow time for the dye to exit the flaws and create an indication (flaw) in the developer.

The developer should be applied with the distance of 15-30 cms with an angle of 30^0C. Don't apply heavy and bubble form, then the material.

- **Inspection**

It is critical to examine the part within the time frame designated in the written procedure. Length of an indication can grow over time as penetrant bleeds out, causing an acceptable indication to be a reject able defect.

3.2 Ultrasonic Testing

3.2.1 Apparatus Used

- Probe used: Angle (45degrees)
- Couplant: 2t Oil, Grease
- Equipment: Da Vinci Alpha
- Calibration: V2 Blocks

Fig: (a) UT apparatus

(b) Flaw detector

3.2.2 Procedure

The ultrasonic testing is mainly used for detecting the sub-surface defects. The ultrasonic testing mainly two steps are required for testing any material they are

1. Calibration of equipment
2. Construction of DAC

With respect to testing material

Procedure for calibration of equipment:

Angle probe calibration:

The inspection is carried out after the changes done in the flaw detector parameters for angle probe. They are

- ✓ Velocity
- ✓ Angle
- ✓ Surface distance

- The ultrasonic equipment is calibrated by the V_2 block (angle probe). The V_2 block is almost exclusively used because back wall echo sequence is received due to the angular beaming from a plane-parallel calibration block.
- The corresponding echo sequence is produced according to whether the probe beams into the 25 mm radius or the 50 mm radius.
- No echoes appear with sound paths by which the sound pulses from the "wrong" direction meet at the center point because these pulses are absorbed by the front damping element of the probe.
- Now the normal and angle probe calibrations are completed.

Construction of Distance Amplitude Correction (DAC) curve:

Distance Amplitude Correction (DAC) provides a means of establishing a graphic 'reference level sensitivity' as a function of sweep distance on the A-scan display. The use of DAC allows signals reflected from similar discontinuities to be evaluated where signal attenuation as a function of depth may be correlated. In establishing the DAC curve, all A-scan echoes are displayed at their non-electronically compensated height.

The DAC curve constructed with respect to the reference standard which incorporate side drilled holes (SDH), flat bottom holes (FBH) having same composition to the test sample. The DAC option was selected then The probe was moving on the surface of the reference block the side drill hole Gives a echo it consider as first peak for DAC at 80% as 100%, 2nd SDH shows half of the first echo 3rd SDH shows half of the 2nd wall echo these echo are free zed then DAC was plotted.

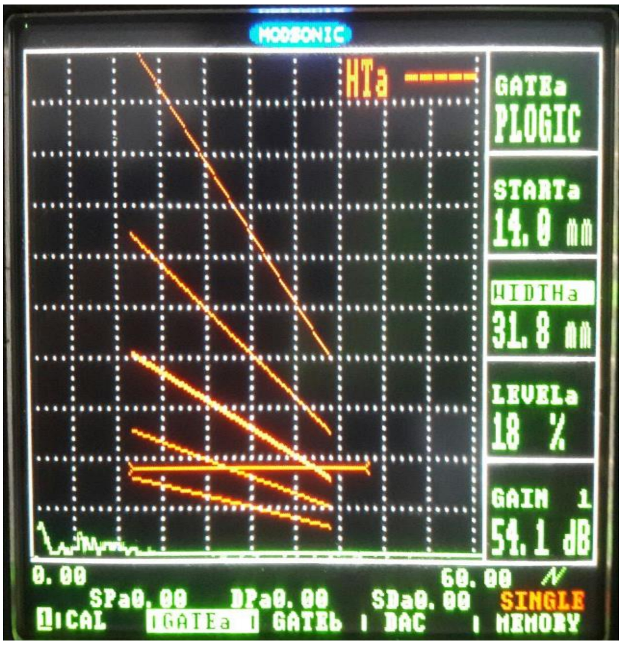

Fig.3.2.2 plotted graph of DAC Curve

3.2.2.1 SS304L material welds inspection:

The inspection is carried over the work piece by applying 2T oil as couplant and welding zone is inspected. The pinhole found in large scale. The pinhole is above the reject line of DAC Curve which is depth of 2.43 mm and amplitude of flaw has 49% from graph.

Fig. No Defect Found.

The defects amplitude peaks are freeze and defects are noted.

4. PENETRANT TESTING

SS304L Sample Testing

The SS304L samples were tested by the dye and florescent penetrant methods. This sample doesn't get any defect because it has good welding. The following sample was recorded as a photo that shown in fig.

Fig. Recorded sample

The SS304L sample defectogram and test report are shown

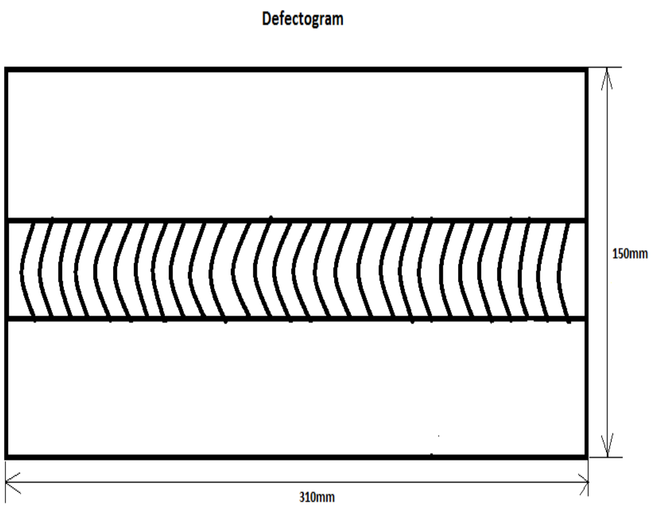

Fig. Defectogram of SS304L sample

4.1 ULTRASONIC TESTING

- **SS304L Material Testing**

The welded SS304L samples were tested by ultrasonic testing. There was one pinhole at the weld was detected at the welded region. The defectogram is shown in fig.

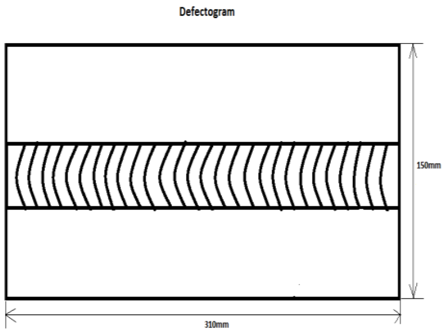

Fig. defect gram SS304L sample

CONCLUSIONS

- LP testing is more sensitive in detection of surface defects and this was an old and less expensive technique. The samples have shown one significant surface defects in TIG welding.

- Ultrasonic method is more sensitive in detection of internal defects. Ultrasonic A-scan tests have shown response of welds defects like pinhole at different depths with both samples. The characterization of weld defect with reference to the known size is carried by establishing a DAC curve with proper calibration. The ultrasonic examination technique has potential superiority to examine the high thick multi pass TIG and establishments of the weld defect study.

- It was concluded that, liquid penetrant testing is more sensitive in detection of surface defects and this was an old and less expensive technique. Ultrasonic method is more sensitive in detection of internal defects.

REFERENCES

1. ASTM handbook volume number 17 "Non-Destructive Evaluation and Quality Control"

2. Ultrasonic Flaw Detection in Metals-banks old field & Revinding-ILIFEE 1962

3. Ultrasonic Flaw Detection for Technician's-third edition, June 2004 by S.C.Drury

4. Hand Book of Non Destructive Evaluation-Charles Heller

5. Kundu, T. (Ed), (2003), Ultrasonic Non-Destructive Evaluation; Engineering and Biological Material Characterisation, CRC Press, USA.

6. Practical Non Destructive Testing by Baldev Raj, T. Jayakumar, M. Thavasimuthu

AUTHORS

First Author: Asst Professor in SEC, Master of Technology in Production Engineering.

Second Author: Research Scholar, Member of ASME, published five (5) technical papers in International Journals and presented one (1) technical paper International Conference.

Third Author: NDT Inspector, Megha Engineering & Infrastructures Ltd (MEIL), Hyderabad, India.