Non Destructive Testing For Multipass Gas Tungsten Arc Welding Process for Dissimilar Material

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ABSTRACT

Nondestructive testing or non-destructive testing (NDT) is a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing any physical damage. In the present work mainly discussed about the defects occurred during welding process. Materials used in present welding process are SS-316L and Inconel-625. The defects are examined using visual inspection, liquid penetration and radiography processes. The welding process utilized is Gas Tungsten Arc Welding (GTAW).Application of this project is in major fields of Aerospace, Aircrafts, Pipeline industry, Automobile sector, manufacturing units.

Keywords: *NDT, TIG welding, multi-pass welding, Dis-similar materials.*

1. Introduction:

Non-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the service ability of the part or system.

The destructive tests are also often used to determine the physical properties of materials such as impact resistance, ductility, yield and ultimate tensile strength, fracture toughness and fatigue strength, but discontinuities and differences in material characteristics are more effectively found by NDT. Today modern nondestructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. During construction, NDT is used to ensure the quality of materials and joining processes during the fabrication and erection phases, and in-service NDT inspections are used to ensure that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public..

The test on the specimen is carried out in two parts, the first being a search for defects and second the measurement of their position and echo amplitude [1]. The magneto elastic technique is used for characterizing and determining the amount of residual stress in magnetic materials. High speed automatic testing is possible using multiple NDT methods[2].

1.1. Gas Tungsten Arc Welding:

Tungsten inert gas welding process also called as gas tungsten arc welding is named so because it uses electrode primarily made of tungsten and inert gas for shielding the weld pool to prevent its contamination from atmospheric gases especially when joining high strength reactive metals and alloys such as stainless steel, aluminium and magnesium alloys, wherever high quality weld joints need to be developed for critical applications like nuclear reactors, aircraft etc. Invention of this process in middle of twentieth century gave a big boost to fabricators of these reactive metals as none of the processes (SMAW and Gas welding) available at that time were able to weld them successfully primarily due to two limitations a) contamination of weld from atmospheric gases and b) poor control over the heat input required for melting . Moreover, welding of aluminium and its alloys with shielded metal arc welding process can be realized using halide flux coated electrodes by overcoming the problems associated with Al2O3, however, halides are very corrosive and therefore welding of aluminium is preferable carried out using inert shielding environment with the lerp of processes like GTAW and GMAW. Despite of so many developments in the field of welding, TIG process is invariably recommended for joining of thin aluminium sheets of thickness less than 1mm.

There are four basic components of TIG welding system namely a) DC/AC power source to deliver the welding current as per needs, b) welding torch (air/water cooled) with tungsten electrode and gas nozzle, c) inert shielding gas (He, Ar or their mixture) for protecting the molten weld pool contamination from atmospheric gases and d) controls for moving the welding torch as per mode of operation (manual, semi-automatic and automatic). This process uses the heat generated by an electric arc between the non-consumable tungsten electrode and work piece (mostly reactive metals like stainless steel, Al, Mg etc.) for melting of faying surfaces and inert gas is used for shielding the arc zone and weld pool from the atmospheric gases.

Argon and helium are the mostly commonly used shielding gases for developing high quality weld joints of reactive and ferrous metals. Small amount of hydrogen or helium is often added in argon to increase the penetration capability and welding speed. These two inert gases as shielding gas are different in many ways.

The materials used in present welding process are SS-316L and Inconel-625.

2. METHODOLOGY AND TESTING:

2.1. NDT METHODS:

The test method names often refer to the type of penetrating medium or the equipment used to perform the test. Current NDT methods are: Acoustic Emission Testing (AE), Electromagnetic Testing (ET), Guided Wave Testing (GW), Ground Penetrating Radar (GPR), Laser Testing Methods (LM), Leak Testing (LT), Magnetic Flux Leakage (MFL), Microwave Testing, Liquid Penetrant Testing (PT), Magnetic Particle Testing (MT), Neutron Radiographic Testing (NR), Radiographic Testing (RT), Thermal/Infrared Testing (IR), Ultrasonic Testing (UT), Vibration Analysis (VA) and Visual Testing (VT). The tests were performed on Stainless Steel.

The six most frequently used test methods are MT, PT, RT, UT, ET and VT. Each of these test methods will be described below, followed by the other, less often used test methods.

Visual Testing (VT):

Visual testing is the most commonly used test method in industry. Because most test methods require that the operator look at the surface of the part being inspected, visual inspection is inherent in most of the other test methods. As the name implies, VT involves the visual observation of the surface of a test object to evaluate the presence of surface discontinuities. VT inspections may be by Direct Viewing, using line-of sight vision, or may be enhanced with the use of optical instruments such as magnifying glasses, mirrors, boroscopes, charge-coupled devices (CCDs) and computer-assisted viewing systems (Remote Viewing). Corrosion, misalignment of parts, physical damage and cracks are just some of the discontinuities that may be detected by visual examinations.

Magnetic Particle Testing (MPT):

Magnetic Particle Testing uses one or more magnetic fields to locate surface and near-surface discontinuities in ferromagnetic materials. The magnetic field can be applied with a permanent magnet or an electromagnet. When using an electromagnet, the field is present only when the current is being applied. When the magnetic field encounters a discontinuity transverse to the direction of the magnetic field, the flux lines produce a magnetic flux leakage field of their own as shown in Figure 1.

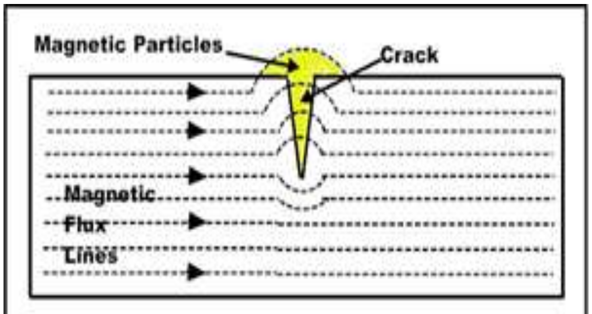


Figure 1

Because magnetic flux lines don't travel well in air, when very fine colored ferromagnetic particles ("magnetic particles") are applied to the surface of the part the particles will be drawn into the discontinuity, reducing the air gap and producing a visible indication on the surface of the part. The magnetic particles may be a dry powder or suspended in a liquid solution, and they may be colored with a visible dye or a fluorescent dye that fluoresces under an ultraviolet ("black") light.

MT Techniques:

MT Techniques are used in the application of Yokes, Prods, Coils, Heads and Central Conductor.

Liquid Penetrate Testing(LPT):

The basic principle of liquid penetrant testing is that when a very low viscosity (highly fluid) liquid (the penetrant) is applied to the surface of a part, it will penetrate into fissures and voids open to the surface. Once the excess penetrant is removed, the penetrant trapped in those voids will flow back out, creating an indication. Penetrant testing can be performed on magnetic and non-magnetic materials, but does not work well on porous materials. Penetrants may be "visible", meaning they can be seen in ambient light, or fluorescent, requiring the use of a "black" light. The visible dye penetrant process is shown in Figure 7.

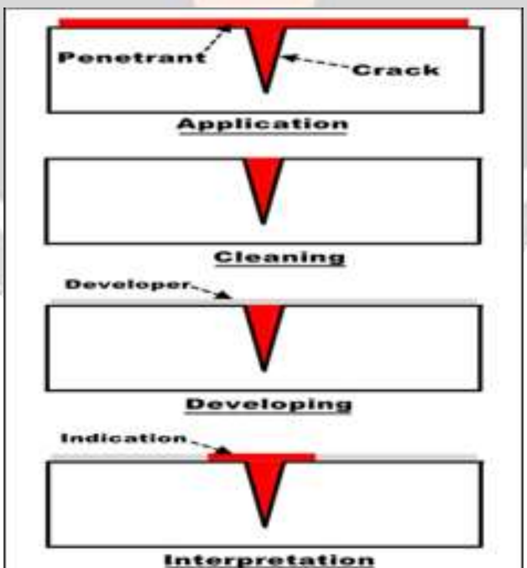


Figure 7

When performing a PT inspection, it is imperative that the surface being tested is clean and free of any foreign materials or liquids that might block the penetrant from entering voids or fissures open to the surface of the part. After applying the penetrant, it is permitted to sit on the surface for a specified period of time (the "penetrant dwell time"), then the part is carefully cleaned to remove excess penetrant from the surface. When removing the penetrant, the operator must be careful not to remove any penetrant that has flowed into voids. A light coating of developer is then be applied to the surface and given time ("developer dwell time") to allow the penetrant from any voids or fissures to seep up into the developer, creating a visible indication. Following the prescribed developer dwell time, the part is inspected visually, with the aid of a black light for fluorescent penetrants. Most developers are fine-grained, white talcum-like powders that provide a color contrast to the penetrant being used.

PT Techniques:

PT Techniques are used for the Solvent Removable, Water-washable, Post-emulsifiable.

Radiographic Testing(RT):

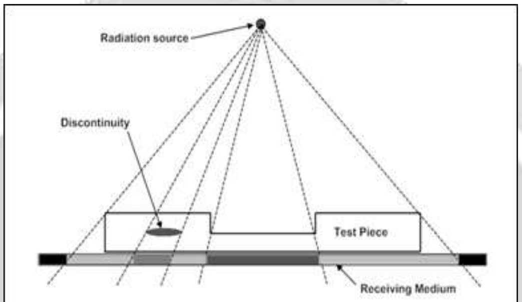


Figure 8

Industrial radiography involves exposing a test object to penetrating radiation so that the radiation passes through the object being inspected and a recording medium placed against the opposite side of that object. For thinner or less dense materials such as aluminum, electrically generated x-radiation (X-rays) are commonly used, and for thicker or denser materials, gamma radiation is generally used.

Gamma radiation is given off by decaying radioactive materials, with the two most commonly used sources of gamma radiation being Iridium-192 (Ir-192) and Cobalt-60 (Co-60). IR-192 is generally used for steel up to 2-1/2 - 3 inches, depending on the Curie strength of the source, and Co-60 is usually used for thicker materials due to its greater penetrating ability.

The recording media can be industrial x-ray film or one of several types of digital radiation detectors. With both, the radiation passing through the test object exposes the media, causing an end effect of having darker areas where more radiation has passed through the part and lighter areas where less radiation has penetrated. If there is a void or defect in the part, more radiation passes through, causing a darker image on the film or detector, as shown in Figure 8.

RT Techniques:

By using RT techniques we can demonstrate through Film Radiography, Computed Radiography, Computed Tomography, Digital Radiography

Ultrasonic testing:

Ultrasonic testing uses the same principle as is used in naval SONAR and fish finders. Ultra-high frequency sound is introduced into the part being inspected and if the sound hits a material with a different acoustic impedance (density and acoustic velocity), some of the sound will reflect back to the sending unit and can be presented on a visual display. By knowing the speed of the sound through the part (the acoustic velocity) and the time required for the sound to return to the sending unit, the distance to the reflector (the indication with the different acoustic impedance) can be determined. The most common sound frequencies used in UT are between 1.0

and 10.0 MHz, which are too high to be heard and do not travel through air. The lower frequencies have greater penetrating power but less sensitivity (the ability to "see" small indications), while the higher frequencies don't penetrate as deeply but can detect smaller indications.

The two most commonly used types of sound waves used in industrial inspections are the compression (longitudinal) wave and the shear (transverse) wave, as shown in Figure 10.

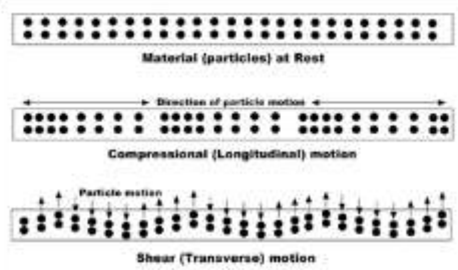


Figure 10

Compression waves cause the atoms in a part to vibrate back and forth parallel to the sound direction and shear waves cause the atoms to vibrate perpendicularly (from side to side) to the direction of the sound. Shear waves travel at approximately half the speed of longitudinal waves.

Sound is introduced into the part using an ultrasonic transducer ("probe") that converts electrical impulses from the UT machine into sound waves, then converts returning sound back into electric impulses that can be displayed as a visual representation on a digital or LCD screen (on older machines, a CRT screen). If the machine is properly calibrated, the operator can determine the distance from the transducer to the reflector, and in many cases, an experienced operator can determine the type of discontinuity (like slag, porosity or cracks in a weld) that caused the reflector. Because ultrasound will not travel through air (the atoms in air molecules are too far apart to transmit ultrasound), a liquid or gel called "couplant" is used between the face of the transducer and the surface of the part to allow the sound to be transmitted into the part.

UT Techniques:

Using UT techniques we can inspect the Straight Beam, Angle Beam, Immersion Testing, Through Transmission, Phased Array, Time of Flight Diffraction.

3. RESULTS:

Visual Inspection Test:

The clear surface with minute excess material deposition and slight pores were observed in the visual inspection test

Penetration Test:

In the penetration test ,using FLOROCENT, small cracks and pores are focusedly appeared during the inspection and using NON-FLOROCENT, it was seen clearly the cracks and material indeposition spots. From the test done, for SS 316L TIG welded plates with minimum thickness of 5mm after welding at room temperature in weld and HAZ areas, no indications were found. Hence the sample is acceptable applicable standards.

Liquid penetrant test:

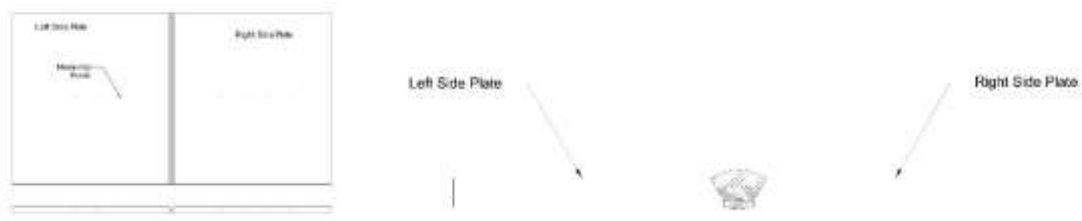
In the liquid penetrant test , the test is done for SS 316L TIG welded plates with minimum thickness of 5mm after welding at room temperature weld and HAZ areas, defect indications were found in the jobs. Hence the jobs are not acceptable according to the applicable standards.

Ultrasonic Test: In the ultrasonic test , the test is done for SS 316L TIG welded plates with minimum thickness of 5mm after welding at room temperature weld and HAZ areas, lack of penetration was found in the first two jobs and for other two jobs , there is no lack of penetration. Hence the jobs are not acceptable according to the applicable standards.

Radiography Test:

From the radiography test, the volumetric approach had proved two types of defects which were found to be crack in second pass of weld and an improper material deposition after second pass when inspected.

The sample size:



SS-316L : 100X60X5 (mm) GROVE ANGLE : 30˚ from Verticle.

INCONEL-625 : 100X60X5 (mm) GROVE ANGLE : 30˚ from verticle.

Weld Distance : 2 (mm) MAX.

Fillet Rod Diameter: 1.6 (mm).

Number Of Pass : 3.

4. CONCLUSION:

From Non-Destructive Test(NDT), the observed defects cannot be rectified within the same samples. Hence in practical application welding parameters such as voltage, current, filler rod feeding and weld speed should be optimized to achieve the perfect NDT defect free and strong welds. So analysis over NDT would support any applicant in field of TIG welding.

5. REFERENCES:

1. Herbert Krautkramer **,"**ULTRASONIC TESTING OF MATERIALS", ISBN: 978-3-662-02359-4
2. "Introduction to Nondestructive testing:A training guide" by paul E.Mix.
3. "Non-destructive testing softcover reprint of the original" by B.Hull.
4. "Mechanics of Nondestructive testings " by Stinchcomb.
5. "Emerging Technologies in Nondestructive Testing V" by Alkiviadis S.Paipetis.
6. "Ultrasonic Methods of Nondestructive Testing" by Blitz Simpsom**.**