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NDE ANALYSIS AND EXPERIMENTAL INVESTIGATIONS OF EN 19 WITH AND WITHOUT PWHT PROCESS

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ABSTRACT

GMAW is simply an art of joining metals by heating and then pressing together which simply requires a heat source to produce a high temperature zone to melt the material its application includes: used in ships building, bridges, pressure vessels, industrial machinery, automobile, rolling stock and many other fields. Welding operation is to be carried out on the medium carbon steel followed by heat treating (annealing), the specimen has to be heat treated at the weld zone to a temperature of 850°C using heat treatment furnace. For effective study of the effect of annealing on the welded joint, mechanical test hardness and tensile to be carried out of the heat treated (annealed) of the EN 19.

Keyword : *NDT , Welding joint , PWHT , Mechanical & Hardness Test, IMAGEJ.*

1. INTRODUCTION TO NDTE

Non-destructive Test and Evaluation is aimed at extracting information on the physical, chemical, mechanical or metallurgical state of materials or structures. This information is obtained through a process of interaction between the information generating device and the object under test. The information can be generated using X-rays, gamma rays, neutrons, ultrasonic methods, magnetic and electromagnetic methods, or any other established physical phenomenon.

The process of interaction does not damage the test object or impair its intended utility value. The process is influenced by the physical, chemical and mechanical.

NDT Methods range from the simple to the intricate. Visual inspection is the simplest of all. Surface imperfections invisible to they may be revealed by penetrate or magnetic methods. If serious surface defects are found, there is often little point in proceeding further to the more complicated examination of the interior by other methods like ultrasonic or radiography.

The principal NDT methods are Visual or optical inspection, Dye penetrant testing, Magnetic article testing, Radiography testing and Ultrasonic testing.

ASNT - American Society for Nondestructive Testing

ISNT - International Society for Non destructive Testing

CWI - Certified Welding Inspector

NDT - Non Destructive testing

NDE - Non Destructive Evaluation

NDI - Non Destructive Inspection

2. APPLICATION OF NDT

1. Nuclear, space, aircraft, defense, automobile, chemical and fertilizer industries.
2. Heat exchanger, Pressure vessels, electronic products and computer parts.
3. High reliable structures and thickness measurement.

TYPES OF NDT

1. Visual Testing- Ultraviolet. Infrared and visible light
2. Penetrate testing
3. Electromagnetic testing
4. Magnetic particle Testing
5. Acoustic Emissions
6. Ultrasonic testing
7. Radiography (RT) – X rays , Gamma rays & Beta particles
8. Penetrant Test Report

3. INRODUCION TO GMAW

Gas Metal Arc Welding (GMAW) is a semi-automatic or automatic process that uses a consumable electrode and a shielding gas**.** GMAW equipment includes a power source, wire electrode, wire feeder, shielding gas, and welding gun. GMAW typically uses a constant voltage power source and direct current electrode positive (DCEP) polarity.

Mechanised pulsed gas metal arc welding (GMAW) has been used successfully in field welding of large diameter pipelines, such as oil and gas transmission lines. Notwithstanding this, GMAW still has a reputation for lack of fusion and its use is precluded for critical applications by most engineering companies and operators. GMAW uses the same wire as GTAW, but does not seem to be as prone to nitrogen loss and frequently gives better corrosion properties.

There is some indication that pulsed GMAW is not as easily applied to positional welding of duplex stainless steels, as it is to austenitic stainless steels. Good weld profiles have been obtained with a proprietary gas mix of 11%He, 0.4%CO_2, balance Ar. In addition, He-containing gases have been developed which have also shown good results.

In 1948, GMAW was developed by the Battelle Memorial Institute. It used a smaller diameter electrode and a constant voltage power source developed by H. E. Kennedy. It offered a high deposition rate, but the high cost of inert gases limited its use to non-ferrous materials and prevented cost savings. In 1953, the use of carbon dioxide as a welding atmosphere was developed, and it quickly gained popularity in GMAW, since it made welding steel more economical. In 1958 and 1959, the short-arc variation of GMAW was released, which increased welding versatility and made the welding of thin materials possible while relying on smaller electrode wires and more advanced power supplies. It quickly became the most popular GMAW variation.

The spray-arc transfer variation was developed in the early 1960s, when experimenters added small amounts of oxygen to inert gases. More recently, pulsed current has been applied, giving rise to a new method called the pulsed spray-arc variation.

The typical GMAW welding gun has a number of key parts—a control switch, a contact tip, a power cable, a gas nozzle, an electrode conduit and liner, and a gas hose. The control switch, or trigger, when pressed by the operator, initiates the wire feed, electric power, and the shielding gas flow, causing an electric arc to be struck. The contact tip, normally made of copper and sometimes chemically treated to reduce spatter, is connected to the welding power source through the power cable and transmits the electrical energy to the electrode while directing it to the weld area. It must be firmly secured and properly sized, since it must allow the passage of the electrode while maintaining an electrical contact. Before arriving at the contact tip, the wire is protected and guided by the electrode conduit and liner, which help prevent buckling and maintain an uninterrupted wire feed. The gas nozzle is used to evenly direct the shielding gas into the welding zone—if the flow is inconsistent, it may not provide adequate protection of the weld area. Larger nozzles provide greater shielding gas flow, which is useful for high current welding operations, in which the size of the molten weld pool is increased. The gas is supplied to the nozzle through a gas hose, which is connected to the tanks of shielding gas. Sometimes, a water hose is also built into the welding gun, cooling the gun in high heat operations.

INRODUCTION TO EN19

EN19 steel is a high quality engineering alloy steel containing chromium and molybdenum. It falls in a class of low alloy steel. It has high fatigue strength, abrasion and impact resistance, toughness, and torsion strength. It can be heat treated in a number of ways to give it a combination of properties. EN19 Steel is one steel grade in BS 970-1955 standard, which is specification for wrought steels for mechanical and allied engineering purpose. Although there is new version of BS 970-1996 latest edition. And EN19 steel grade is similar to 709M40 grade in new version. EN19 Alloy Forging Steel.

CHEMICAL COMPOSITION OF EN19

Element	C	Si	Mn	P	Cr	Mo	Fe
Content (%)	0.35-0.45	0.15-0.30	0.50 – 0.80	0.035	0.90-1.50	0.20-0.40	96.78-97.77

COMPOSITION OF EN19

SL.NO	ELEMENT	COMPOSITION IN WEIGHT % MIN	MAX
1	Carbon, C	0.37	0.43
2	Manganese, Mn	-	0.70
3	Silicon, Si	-	0.23
4	Molybdenum, Mo	0.2	0.3
5	Chromium,Cr	0.7	0.9
6	Sulphur	-	0.04

PROCESS PARAMETERS AND THEIR LEVELS

TEST PLATE NO	STATUS	AMPS	VOLT	BEVEL θ
1	WOPWHT	140	18	60
2	WOPWHT	160	20	65
3	WOPWHT	180	22	70
4	PWHT	140	18	60
5	PWHT	160	20	65
6	PWHT	180	22	70

EXPERIMENTAL PROEDURE

Post Weld Heat Treatment or PWHT must be performed after every welding in order to ensure the material strength of the part is retained. PWHT ensures the reduction of residual stresses, controlling material hardness, and enhancement of mechanical strength.

If PWHT is neglected or performed incorrectly, the residual stresses can combine with service load stresses. The value may exceed a material’s design limitations leading to weld failures, higher cracking potential, and increased susceptibility to brittle fracture.

THREE PHASE GAS METAL ARC WELDING MACHINE

PWHT METHOD

1. Normalizing is a heat treatment technique in which the specimen is heated up to its re-crystallization temperature and is kept at that temperature for the required soaking time. It is then cooled in air. [2-4] In the case of EN19 Steel alloy, it was heated up to a temperature of 900^{0}C and is soaked at that temperature for about 60 minutes. It is then removed from the furnace and is allowed to cool in air.

2. Annealed In the annealing process, the specimen is heated up to its recrystallization temperature, and soaked for the required amount of time. It is then allowed to cool inside the furnace itself. In the case of EN19 Steel alloy [2]-[4], it is heated up to 900^{0}C and soaked for about 60 minutes. It is then allowed to cool inside the furnace itself.

3. Quenching is a heat treatment process in which the specimen is heated up to its recrystallization temperature, and soaked for the given period of time. The specimen is then taken and immersed in a quenchant immediately. The quenchants used were water, brine, and oil (SAE 40). In the case of EN19 Steel alloy [2]-[4], 3 specimens are taken. They are heated up to 900^{0}C and soaked for 60 minutes. After the soaking time, one specimen is immersed in water, another in brine and the third specimen is immersed in quenchant oil. Brine solution has the fastest cooling rate. Whereas, water and oil quenchants are slower, with oil being the slowest.

CONCLUSION

Based on the review, the following conclusions are drawn:

1. Reheat cracks in the welding joint, and the grain growth did not appear obviously in the HAZ, depending on the weld heat input.
2. Slight reduction the hardness variation.
3. PWHT don’t deteriorate property of HIC-Resistance of vessel plates severely.
4. This work is effectively used to improve the properties of weldment by using optimal PWHT processes.
5. Significant improvement in ductility, toughness and grain refinement accompanied with decrease in hardness and brittleness.
6. Low PWHT temperature and time effect on temper martensite with a coarse Grain.
7. The ductility of the metal is increased because of the mechanical property change in the microstructure.
8. Stress relief heat treatment analysis indicates that a sustainable in the amount of pearlite results in better hardness and tensile strength.

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