Non Destructive Evolution Study of Welded EN-08 Mild Steel Specimen

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Abstract

This paper describes Non destructive methods on TIG welded EN-08 mild steel taken for studies. Specimen is fabricated with Tungsten Inert Gas Welding (TIG), Heat Effect Zone and Weld Region is inspected for study. The correlation of different NDT methods for identifying intensity of flaw, accuracy of orientation and position of flaw in same specimen is carried out. For each method data is recorded and comparative analysis of NDT methods and potential features of ultrasonic are highlighted. Ultrasonic and radiography method will trace out internal defects. Liquid penetration and magnetic particle inspection implies surface and sub surface defects in mild steel material. According to quality assistance tests are preferred and a detailed explanation regarding intensity of flaw on different NDT techniques is addressed.

Keywords: Penetrant, Developer, U.V Light, Magnetic Field, Magnetic Partials, Acoustic Impedance, DAC, Calibration Blocks, Isotope, Gamma Rays, Film Interpretation.

Introduction:

Liquid penetration process is relatively simple, low capital cost, the arrangement of discontinuities is not a limitation but it has its own limitations as it can inspect depth up to 2 mm. The defects need to open to surface and the testing procedure offers low reliability & moderate sensitivity and requiring considerably high degree of operator skill.[1]

Test objects are coated with visible or fluorescent dye solution. Excess dye is removed from the surface, and a developer is applied. The developer acts as blotter drawing trapped penetrant out of imperfections open to surface. With visible dyes, vivid color contrasts between the penetrant and developer makes "bleed out" easily visible. With fluorescent dyes, ultraviolet light is used to make the bleed out fluorescence bright alloy imperfections readily seen. The principle of penetration testing is capillary action. This paper gives a vivid view on liquid penetration inspection over mild steel EN-08 material weld and HEZ region. We preferred type 3 penetrant, level 4, method A, form d for high sensitivity inspection.

The principle of magnetic particle testing is flux leakage. As the specimen is mild steel it can undergo magnetic particle inspection which is accomplished by inducing a magnetic field in a ferromagnetic material and then dusting the surface with iron particle (either dry or suspended liquid).Surface and near-surface imperfections distort the magnetic field and concentrated iron particle near imperfections, previewing a visual indication of the flaw.[2]

Acoustic impedance mismatch is the working principle of ultrasonic inspection. The Ultrasonic use transmits high-frequency sound waves into the material to detect imperfections to locate changes in the material properties. The most commonly used ultrasonic testing technique is pulse echo, where sound is introduced into a test object and reflections (echoes) are received from internal imperfection or form a part of geometrical surface.[3,4]

Passing highly penetration electromagnetic radiation through an object and recording its image on film will develop a radiography film to study.

A correlation is made with NDT methods like Liquid penetration, Magnetic Particle, Ultrasonic, Radiography Inspection by knowing the weld defect signatures. According to ASTM standards and codes, this correlation saves time in real operation condition.[6]

Material and Method

Mild steel is most widely used material in manufacturing. **EN-08** is usually supplied untreated material which can also be supplied in the normalized or finally heat treated, quenched and tempered which is adequate for a wide range of applications. EN-08 is a very popular grade through-hardening medium carbon steel which is readily machinable in any condition. EN-08 is suitable for the manufacture of varies parts such as general-purpose axles and shafts, gears, bolts and studs. It can be further hardened typically producing components with enhanced wear resistance. For such applications the use of **EN8D** is advisable. It is also available in a free-machining version. **EN8M** in its heat treated forms possess good [7] homogenous metallurgical structures giving consistent machining properties [5].

Composition

Carbon	Mg	Si	S	P	Fe
0.35-0.45 %	0.70-0.90%	0.10-0.35%	0.05	0.05	Rest

Table 1: Mechanical Properties of EN8 Steel

Condition	Yield Stress 106 Pa	Tensile Stress MPa	Elongation %
Normalized	280	550	16
Cold drawn (thin)	530	660	7

Weld sample is fabricated with suitable dimension along with introducing cluster porosity, inclusion in weld region during tungsten inert gas welding to join the materials deliberately. After welding the length of the plates are 150 mm and 300 mm.[8]

Procedure followed to make defective samples during TIG welding

Plate material	-Mild steel EN-08
Plate Thickness	- 10 mm
Plate Width (Before weld)	-75 mm
Plate length	-300 mm
Main weld method	-TIG welding (welding current 110 to 130 amperes).

To opt Appropriate Penetrant, Developer, and Solvent Remover Based on Requirement

Selection of apt penetrant for appropriate material is essential. Physical properties of penetrant like viscosity, surface tension, wetting ability specific gravity, volatility, flammability play a crucial role in selection of penetrant. Even chemical activity of penetrant should be non-corrosive towards the material being inspected. The test has to be conducted according to ASNT and ASTM standards and codes[6].

By coming to know the test piece conditions as a mild steel (EN-08) and TIG welded, type III penetrant that is both fluorescent and visible which is of sensitive level IV and water washable, Form d – non aqueous type 1 fluorescent developer has been chosen.

Experimental Details

1. Pre Cleaning of Specimen (surface preparation). The surface must be free from oil, grease, water, rust, scale, acids, even water or other contaminants that may prevent penetrant from entering flaw. The cleaning solvent used is volatile which does not leave any moisture.

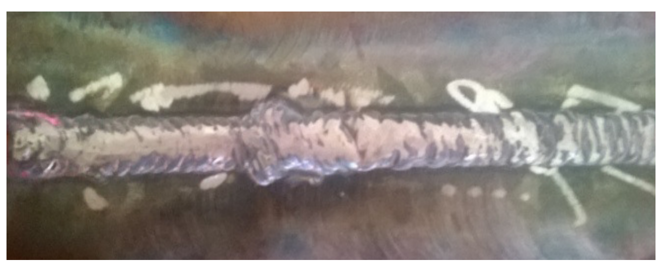

Fig 2: Pre cleaned spacemen.

2. Penetrant Application and Dwell Time

The penetrant material is applied by spraying. 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. Penetrant dwell time is the total time that a penetrant is in contact with the surface part. The time varies depending on the application penetrant material used, form of the material used and the type of defect being inspected. The penetrant used is duel which work both as fluorescent and visible red and dwell time is 20 min.

FIG 3: After Penetrant Application.

3. Excess penetrant Removal

This is the most delicate part of the inspection procedure because the excess penetrant must be removed from the surface of the sample while removing as little penetrant as possible from defects. As our penetrant is emulsified previously it is water washable as the specimen is rinsed with water and gently wiped in one direction with lint free cloth.

4. Developer Application

A thin layer of developer is then applied to the sample to draw penetrant trapped in flaw back to the surface where it will be visible. The developers attain variety of forms that may be applied by dusting, dipping, or by spraying. We applied through spray at a distance of 15 cm away from specimen to apply developer in atomized form even layer.

FIG 4: After Developer Application

5. Inspection

Inspection is then performed under appropriate lighting to detect indication from any flaw which may be present. As it is duel penetrant it can be viewed under black light (U.V light) and visible light. The absorbed porosity in the specimen is shown below.

FIG 5: Cluster Porosity Observed on the Specimen

6. Post Cleaning of Surface

The final step in the process is to thoroughly clean the parts of surface, to remove the developer from the parts that were found to be acceptable.

MAGNETIC PARTICLE INSPECTION:

As the text specimen is mind steel magnetic particle inspection is also possible. We chose fluorescent magnetic particles for better sensitivity of inspection.[2]

Introducing Magnetic Field:

Longitudinal Magnetic field is induced in the specimen with the help of Yoke. These longitudinal magnetic lines will pass through the material and if any gap or interruption

Fig 6: Magnetic Particle Inspection

occurred the magnetic flux leak will take place in that area. At this point, magnetic flux is highly comparative to other areas.

Magnetic Particle Application

Wet Fluorescent magnetic particles are dispersed over the inspection area. It is due to the magnetic flux leak, the magnetic particle will accumulate over the defects.

Inspection:

It is due to Florescent Magnetic Particles inspection that is carried out with the help of U.V (black light) light defect are viewed easily and cluster porosity is observed on the specimen.

Fig 7: Cluster Porosity

ULTRASONIC INSPECTION

Probing is done according to surface condition of inspection. As the inspection area is weld region we cannot directly place probe over weld region. An angle probe of 45 deg is chosen to develop sheer wave for inspection.

1. Calibration of the machine is done by using V1 and V2 blocks. Adjustments are carried out using zero key, range, thickness and other parameters given to device.
2. Specimen reference block is prepared with grade material having same dimensions of test samples. By considering the thickness of the sample sound path, surface distance is calculated. Tolerances are considered as + 1 or -1 on SP and SD values while plotting distance amplitude curve (DAC).
3. Near field effects play a main role if the testing material thickness is less. A-Scan echo is displayed at their non-electronically compensated height and the peak. Amplitude of first each is set to 80% and second echo is less than the 1st and the third echo is less than 2nd echo. By using specific path values, the practical values are noted.[Fig 8,9]

Table 2: Table of data to draw DAC Curve

S.No	Thickness T=40	Actual surface distance	Actual Beam path	Ref Db
1	¼ t = 10	9.84	13.9	58.8
2	½ t = 20	19.96	57.9	57.9
3	¾ t = 30	24.53	65.6	65.6

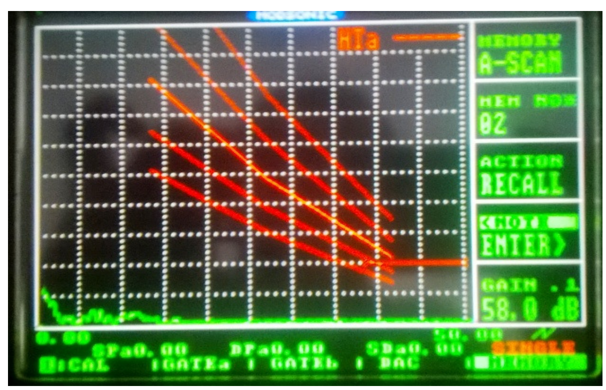

Fig 8: DAC Curve

Inspection:

Inspection is carried over the work piece by applying 2T oil as couplant and HEZ (Heat Effect Zone) is thoroughly inspected. The cluster porosity found in large scale [12].

Cluster Porosity is above acceptance line of DAC Curve which is up to depth of 4.3 mm. Other pin holes and minor defects under repair line need to be repair which are at 3.54 mm depth and the amplitude of flaw is 45 % from graph (with the help of curve). We can predict this as inclusion.

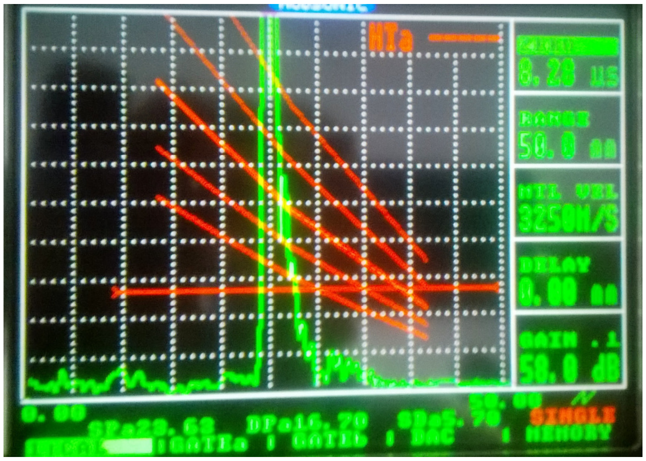

Fig 9: Cluster Porosity

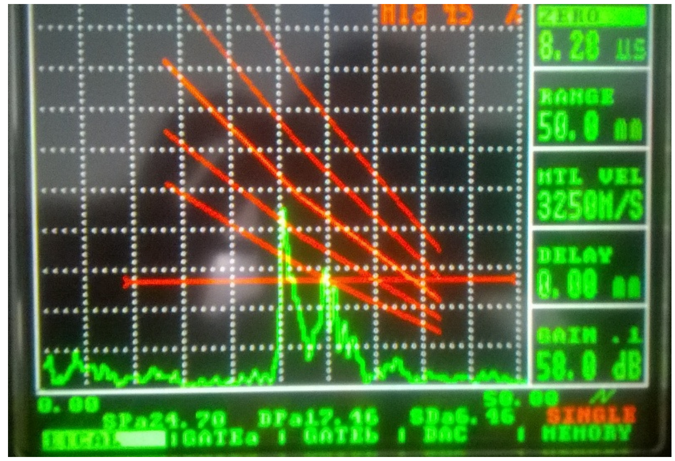

Fig 10: Inclusion

RADIOGRAPHY TESTING

It involves exposing a test objective to penetrating radiation so that the radiation passes through the object being inspected and the are cording medium placed against the opposite side of that object [9, 10].

The part is placed between the radiation source and a piece of film will stop some of the radiation. Thicker and denser areas will stop more radiation. The film darkness will vary with the amount of radiation that reaches the film through the test object. The minimum recommended thickness limitation may be reduced when the radiography techniques are used to demonstrate that the required radiography testing sensitivity has been obtained.

Fig 11: Cluster Porosity and Inclusion.

Radiography test is conducted on the sample consisting of slag and cluster porosity. Wire type and hole type pentameters are taken for test accuracy [11]. The sensitivity achieved is good and the defects in the film are observed easily.

Results and Discussions

- Surface defects are discontinuities that are detected through Liquid Penetration test and illustrated in fig 5. Subsurface slag inclusion cannot be identified. In this inspection we can fix flaws which are open to surface.
- Surface and sub-surface discontinuities are detected through magnetic particle inspection and illustrated in fig 7. The cluster porosity is detected but slag flaw leaves insufficient clues.
- Two internal discontinuities were detected through ultrasonic testing and are shown in fig 9, 10. It is due to near dead zone surface that the defects are hard to identify as accurately as liquid penetration and magnetic particle test.
- Radiography film gives us a clean and solid copy of film to interpret the flaw location, orientation and storage capacity of films.
- Over all the results that are attained from ultrasonic and radiography are high sensitive than other two.

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