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Experimental Validation on ASTM A516 Grade 70 Carbon Steel by Non-Destructive Testing

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ABSTRACT

Welding is one type of erection process. It is process of joining by applying heat energy and molten metal used extensively in automobile industries, aircraft machine frames structural work ship building and various other fields. Physical properties of welds are affected by several factors. To produce satisfactory welds which fulfil the requirement of quality the integrity of quality control is important. To understand the various defects, their causes and remedies can help to improve higher quality and longer lasting welds. This report contains major information of surface irregularities and weld discontinuities.

Non-destructive testing is the process conducting examination on any component (welds, casting bars, automobile etc.) without affecting its usefulness of component to detect discontinuities in component and physical properties of component. There are more than sixteen methods of NDT in metals, in this the most important onesVisual, Ultrasonic, radiography, magnetic particle testing and penetrant testing are discussed in detail. The experimental outputs are discussed and comparisons are made based on the cost, accuracy, safety, time consumption, etc. Based on these considerations conclusions and recommendations are made.

KEYWORDS: *Butt welding,Mild Steel,Radiography,Ultrasonic testing*

I. INTRODUCTION

The primary purpose of a non-destructive inspection is to determine the existing state or quality of a material, with a view to acceptance or rejection. [1]. It presents a method for the automatic detection and classification of defects in radiographic images of welded joints obtained by exposure technique of double wall double image (DWDI). As a continuation of our radiography R&D, we recently established a high-energy x-ray inspection system for industrial NDT. [2,3]. It was considered that liquid penetrant testing is more sensitive in detection of surface defect and magnetic inspection is sensitive in sub surface defects. Finally, ultrasonic method is more sensitive in detection of internal defects. [4]. Ultrasonic testing (UT) is a non-destructive test method that uses sound waves to detect cracks and defects in parts and materials. [5]It can also be used to examine materials thickness.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. [6]. 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 ofthe flaw. [7,8].

II. METHODS & MATERIALS USED

ASTM A516 grade 70 is a medium carbon steel designed for used in pressure vessels and boilers. It consists manganese, phosphorous, sulphur and silicon. It is strongest carbon steel plates specified by ASTM. It is high strength metal, easy to fabricate and securely welded. It has a high corrosion resistance. It is also available in grade 55, 60 and 65.

We are taken ASTM A516 grade 70 with 200X200X12mm size plates.

P number of ASTM A516 grade 70 materials is 1

Group number of ASTM A516 grade 70 materials is 1

Composition:

Carbon – 0.1 to 0.2%
Silicon – 0.6%
Manganese – 1 to 1.7%
Phosphorous – 0.03%
Sulphur – 0.03%
Chromium – 0.3%

Mechanical properties:

Tensile strength – 510 to 650N/mm^2
Yield stress – 335N/mm^2

Type of weld: Butt weld by using shielded metal arc welding.

Butt welds are mostly used welds in industries. Butt welds are welds where two pieces of metal are to be joined in the same plane.

III. LIQUID PENETRANT TESTING

3.1.Pre cleaning of test piece:

The surface must be free from oil, grease, water, rust, scale, acids, even water or other contaminants that may prevent penetrant from entering flaw

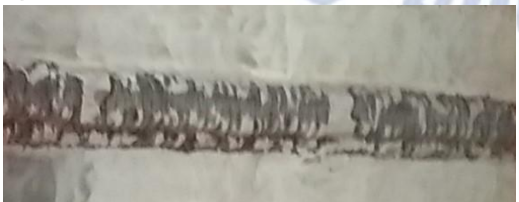

FIG 1: Pre cleaning image of the test piece

3.2.Application of penetrant:

The application of penetrant material is done by spraying. The penetrant is left undisturbed on the surface for enough time allowing 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 excess penetrant is removed on the surface.

Fig 2: After the application of the penetrant

3.3.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.

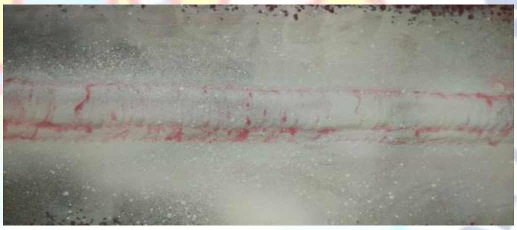

Fig 3: finding the flaws of the surface after the application of developer

3.4.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. There is NO surface defects are observed in the test piece.

3.5.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.

IV. MAGNETIC PARTICLE TESTING (MPT)

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

4.1 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.

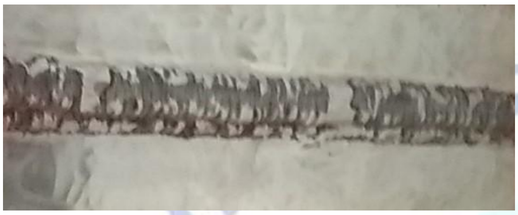

Fig4: pre cleaning image of the test piece

Fig5: magnetic particle inspection

Fig6: Both the figs indicate the magnetic particle application and detecting the flaws of sub-surface

V. ULTRASONIC TESTING

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.

Table of data to draw DAC Curve

S.NO	THICKNESS T=40	ACTUAL SURFACE DISTANCE	ACTUAL BEAM PATH	Ref Db
1	1/4t=10	9.84	13.9	58.8
2	1/2t=20	19.96	57.9	57.9
3	3/4t=30	24.53	65.6	65.6

Fig 7: DAC Curve

5.1 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 and slag is found. Cluster Porosity is above acceptance line of DAC Curve which is up to depth of 2mm. Other pin holes and minor defects under repair line need to be repair which are at 4 mm depth and the amplitude of flaw is 50 % from graph (with the help of curve). We can predict this as inclusion.

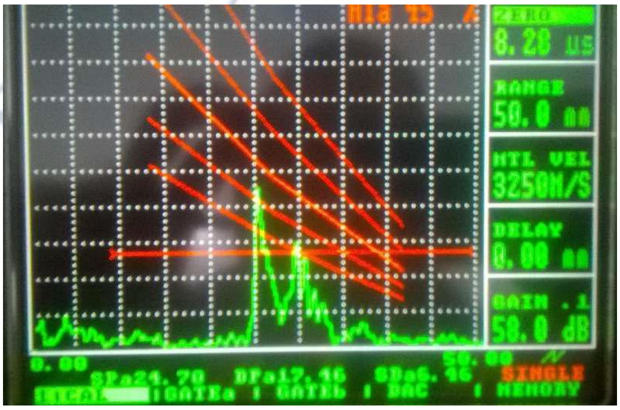

Fig 8: Inclusion

VI. RADIOIGRAPHYTESTING

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.The part is placed between the radiation source and apiece 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.

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

Fig 9: Cluster Porosity and Inclusion

VII. RESULTS

- Small discontinuities are observed on the surface of the test piece through liquid penetrant test. Subsurface slag,lack of fusion and cluster porosity 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. The cluster porosity slag flaw leaves insufficient clues.
- Two internal discontinuities (slag, porosity)were detected through ultrasonic testing. 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.
- From all the above results that are attained from ultrasonic and radiography are high sensitive than other two.

VIII. CONCLUSION

We are finding at the time of inspection SMAW gives the moderate quality of the weld on the mild steel. But TIG gives the best method to get the best quality of welding than SMAW. But SMAW requires less cost and less time than the TIG welding. If we plan properly by using SMAW also we have a chance to get same strength as TIG.

We are conducting tests on the welds by using NDT to reduce the production cost and reduce the damage of the component and improve the life time of the welds.

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