Study of Defects in AISI 410 Weldmet through Liquid Penetrant and Magnetic Particle Test

N. Nagendra Kumar[1] G. Amith[2] G. Shashikanth[3] G. Rahul[4] D. Surya[5]
[1]Assistant Professor [2,3,4,5]UG Scholar
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]Guru Nanak Institute of Technology, Rangareddy, Telangana, India

Abstract— Non-destructive testing is a different kind of tests which are used to learn about the physical properties of specimens. By the other techniques like tensile testing and hardness testing the specimen is destructed after the experiment but in this testing type the specimen is not destructed. There are eight different NDT methods: Visual Inspection, Microscopy, Radiography, and Dye penetrate, Ultrasonic, Magnetic Particle, Eddy Current and Acoustic Emission. These methods are only separated in application technique. We used two different types of methods for our testing, liquid penetration test and Magnetic particle testing. Non-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.

Keywords: Non-destructive testing

I. INTRODUCTION

A general definition of non-destructive testing (NDT) is an examination, test, or evaluation performed on any type of test object without changing or altering that object in any way, in order to determine the absence or presence of conditions or discontinuities that may have an effect on the usefulness or serviceability of that object. Non-destructive tests may also be conducted to measure other test object characteristics, such as size; dimension; configuration; or structure, including alloy content, hardness, grain size, etc. The simplest of all definitions is basically an examination that is performed on an object of any type, size, shape or material to determine the presence or absence of discontinuities, or to evaluate other material characteristics.

Non-destructive examination (NDE), non-destructive inspection (NDI), and non-destructive evaluation (NDE) are also expressions commonly used to describe this technology. Although this technology has been effectively in use for decades, it is still generally unknown by the average person, who takes it for granted that buildings will not collapse, planes will not crash, and products will not fail.

Although NDT cannot guarantee that failures will not occur, it plays a significant role in minimizing the possibilities of failure. Other variables, such as inadequate design and improper application of the object, may contribute to failure even when NDT is appropriately applied.

NDT, as a technology, has seen significant growth and unique innovation over the past 25 years. It is, in fact, considered today to be one of the fastest growing technologies from the standpoint of uniqueness and innovation. Recent equipment improvements and modifications, as well as a more thorough understanding of materials and the use of various products and systems, have all contributed to a technology that is very significant and one that has found widespread use and acceptance throughout many industries.

II. LITERATURE SURVEY

Ranganayakulu et al. (2015) studied about TIG welded EN-08 steel specimen by the use of Non-Destructive Evaluation. The work describes the correlation of different NDT methods for identifying intensity of flaw, accuracy of orientation and position of flaw in same specimen is carried out. 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 the surface. This testing produce offer low reliability and moderate sensitivity and requiring considerably high degree of operator skill. 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. As the test specimen is mild steel magnetic particle inspection is also possible, fluorescent magnetic particle are chosen for better sensitivity of inspection. According to the studies surface defects are discontinuous that are detected through liquid penetrant test and magnetic particle inspection.

Jitesh Kumar Singh et al. (2015) conducted Non-destructive testing (NDT) on welded metal to enhance the quality of material. Welding is a common joining process used extensively in automobile, aerospace, machinery manufacturing industries and various other fields. For every manufacturing there may be a chance of occurring defects in it. The understanding of various defects , remedies can help to ensure higher quality and longer lasting welds. NDT is a mechanism which helps in finding out of defects of any item like weld before major harm to item without affecting its usefulness. The primary purpose of NDT is to determine the quality of material with a view to acceptance or rejection.

Mohit Bector et al (2014) compared the various NDT techniques by using them on v- butt welded joint on stainless steel cylinder by means of time consumption, flaw detection, crack depth detection, safety and cost. According to the authors point of view in order to check whether there is any defect in the joint there may be use Non-destructive technique to check it. Gas Tungsten Arc welded (GTAW) stainless steel used for comparison of different parameters, it's checked for defects by using different NDT techniques. NDT is used to find defects in various types of metals and non-metals. In case of metals there may be chance of occur defects at joints and joint surroundings. Most of metals are joined by welding process but in welding process if there is any moisture content on electrode it leads to occur defects. Author uses GTAW welding for preparation of sample for comparison this welding process is slag inclusion, spatter free. After Inspection it is concluded that magnetic particle test show defect free for same material ultrasonic test show the defects because magnetic particle test depends on the relative absorption of iron powder near the surface or sub surface. Time consumption for liquid penetrant test is less compared to ultrasonic test and magnetic particle test. Flaw detection and crack depth detection is excellent in ultrasonic test. Magnetic particle test is hazardous compared to ultrasonic test and liquid penetrant test .

Ranganayakulu etal.(2017) studied characterization of weldments defects through Non-destructive Evaluation techniques. NDT testing methods are valuable tools in quality assurance of weldments in engineering and technology. The author took Aluminium, Titanium, D3 tool steel for characterization of these aerospace and industrial application metals. These sample are prepared by using GTAW welding. Defects which are open to the surface and sub-surface defects up to 6 mm depth are detected by Visual inspection, Liquid penetrant test, Magnetic particle inspection and the thickness of the defects are characterized by Ultrasonic test, orientation of weldments were detected by using Gamma rays and Ultrasonic test. The effect of various parameters such as accuracy precision and sensitivity guide line that influence the selection of NDT technique were determined. Liquid penetrant test identifies surface discontinuities in all the weldments. Radiography test shows the orientation and magnitude of defects.

III. METHODOLOGY

A. *Process Involved in Methodology*

1) *Liquid Penetrant Testing*

Liquid Penetrant testing (LPT) is one of the most widely used non-destructive testing methods for the detection of surface discontinuities in non-porous solid materials. It is almost certainly the most commonly used surface NDT method today because it can be applied to virtually any magnetic or nonmagnetic material. LPT provides industry with a wide range of sensitivities and techniques that make it especially adaptable to a broad range of sizes and shapes. It is extremely useful for examinations that are conducted in remote field locations, since it is extremely portable. The method is also very appropriate in a production type environment where many smaller parts can be processed in a relatively short period of time.

B. *Equipment used in Liquid Penetrant Test*

1) *Precleaners*

Precleaning is an essential first step in the penetrant process. The surface must be thoroughly cleaned to assure that all contaminants and other materials that may prohibit or restrict the entry of the penetrant into surface openings are removed. Thorough cleaning is essential if the examination results are to be reliable.

Fig 1: Pre cleaner

2) *Penetrant*

Penetrant Equipment systems range from simple portable kits to large, complex in-line test systems. The kits contain pressurized cans of the penetrant, cleaner/remover, solvent, and developer and, in some cases, brushes, swabs, and cloths. A larger fluorescent penetrant kit will include a black light. These kits are used when examinations are to be conducted in remote areas, in the field, or for a small area of a test surface. In contrast to these portable penetrant kits, there are a number of diverse stationary-type systems. These range from a manually operated penetrant line with a number of tanks, to very expensive automated lines, in which most steps in the process are performed automatically.

Fig. 2: Penetrant

3) *Emulsifiers/Removers*

The purpose of the emulsifiers used in penetrant testing is to emulsify or break down the excess surface penetrant material. In order for these emulsifiers to be effective, they should also possess certain characteristics, including: The reaction of the emulsifier with any entrapped penetrant in a discontinuity should be minimal in order to assure that maximum sensitivity is achieved. The emulsifier must be compatible with the penetrant. The emulsifier must readily mix with and emulsify this excess surface penetrant. The emulsifier mixed with the surface penetrant should be readily removable from the surface with a water spray.

4) *Application of Developer*

After excess penetrant has been removed, a white developer is applied to the sample. Several developer types are available, including: non-aqueous wet developer, dry powder, water-suspendable, and water-soluble. Choice of developer is governed by penetrant compatibility (one can't use water-soluble or suspendable developer with water-washable penetrant), and by inspection conditions. When using non-aqueous wet developer (NAWD) or dry powder, the sample must be dried prior to application, while soluble and suspendable developers are applied with the part still wet from the previous step. NAWD is commercially available in aerosol spray cans, and may employ acetone, isopropyl alcohol, or a propellant that is a combination of the two. Developer should form a semi-transparent, even coating on the surface.

The developer draws penetrant from defects out onto the surface to form a visible indication, commonly known as bleed-out. Any areas that bleed out can indicate the location, orientation and possible types of defects on the surface. Interpreting the results and characterizing defects from the indications found may require some training and/or experience.

Fig. 3: Application of developer

5) *Inspection*

The inspector will use visible light with adequate intensity (100 foot-candles or 1100 lux is typical) for visible dye penetrant. Ultraviolet (UV-A) radiation of adequate intensity (1,000 micro-watts per centimeter squared is common), along with low ambient light levels (less than 2 foot-candles) for fluorescent penetrant examinations. Inspection of the test surface should take place after 10- to 30-minute development time, and is dependent on the penetrant and developer used. This time delay allows the blotting action to occur. The inspector may observe the sample for indication formation when using visible dye. It is also good practice to observe indications as they form because the characteristics of the bleed out are a significant part of interpretation characterization of flaws.

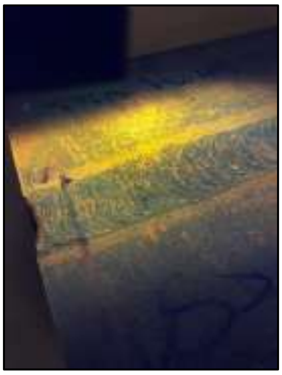

Fig. 4: Inspection

6) *Post Cleaning*

The test surface is often cleaned after inspection and recording of defects, especially if post-inspection coating processes are scheduled.

Fig. 5: Post Cleaning

IV. Magnetic Particle test

In this magnetic particle testing, dry magnetic particles are dusted on to the surface of the test object as item is magnetized. Dry particle magnetization inspection is well suited for inspections conducted on rough surfaces. When an electromagnetic yoke is used the AC current creates a pulsating magnetic field that provides mobility to powder Dry particle inspection is used to detect shallow surface cracks. Dry particles with half wave DC is the best approach when inspecting for lack of root penetration in welds of thin materials.

Steps for calibration

- Select AISI 410 material and prepare it for the calibration.
- For calibrating the metal with help of AC current take a 2 kg material. Because with help of ac current the yoke can lift the material up to 2 kgs by using MPT set up as shown in Figure 6

Fig. 6: Calibration under DC Current

- Check the direction of current and magnetic field with help of pie gauge according to the left-hand rule as shown in Figure 7.

Fig. 7: Identification of Orientation Magnetic Field

- Iron (fluorescent or Non-fluorescent) particles are applied on the porous metal and it is inspected under fluorescent light for fluorescent spray as shown in Figure8.

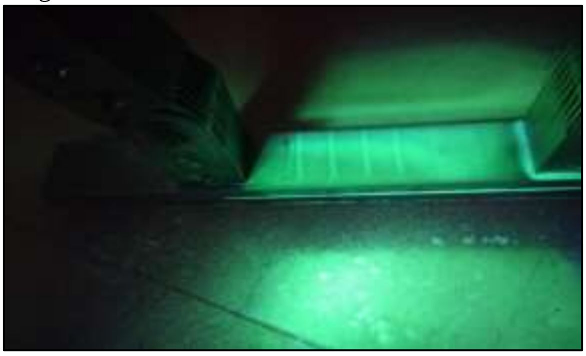

Fig. 8: Inspection under fluorescent light

In magnetic particle testing, various methodologies for inspection are used in which one of them are mentioned below:

A. *Dry Particle Inspection*

In this method, a dry magnetic particle of variable colours may be red, black, grey is used to achieve a high level of contrast between the particle and parts to be inspected. Apart from colour, size of the particle also varies.

For fine particle, size is of 50µm (0.002 inches) with diameter 3 times smaller and 20 times lighter than coarse particle. This enhances the sensitivity of the particles to very small discontinuity. This inspection is well suited for rough surface.

As surface preparation was done in liquid penetrant testing, discussed earlier. Here it is also important but not much critically as done is earlier LPT. The surface must be free from grease, oil moisture, loose dirt, paint, rust or scale as shown in Figure 9. It affects the sensitivity.

Fig. 9: Surface Preparation on Heat Effected Zone

By using direct or indirect magnetizing technique with AC or half wave source necessary magnetic flux established in the component to be inspected. And sheet magnetized by yoke as shown in Figure 10.Apply the magnetic particles by the use of sprayer which contains fined magnetic particles on the component.

Fig. 10: Application of Magnetic Particles

Excess magnetic particle from component must be removed by gentle puffs of dry air. Removal force of air should be enough to remove the excess particles without dislodging any particle held by a magnetic flux leakage field. This is applied when electromagnetic are used as a source of magnetizing. If bar magnets are used then they can be left in place.

By help of normal eyes or with some light source may be ultraviolet light, the clustered particles on the component can be easily located as shown in Figure 11.

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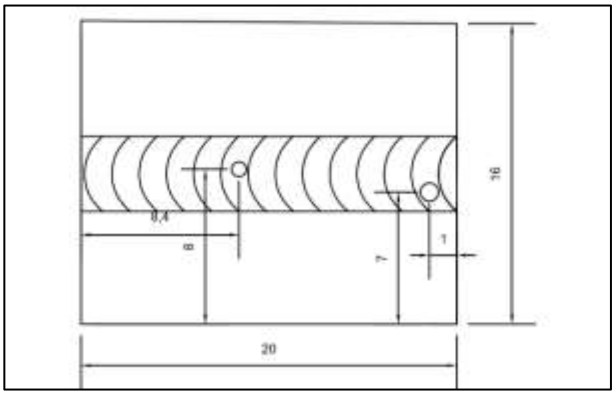
Fig. 11: Visual Inspection

V. RESULTS AND DISCUSSIONS

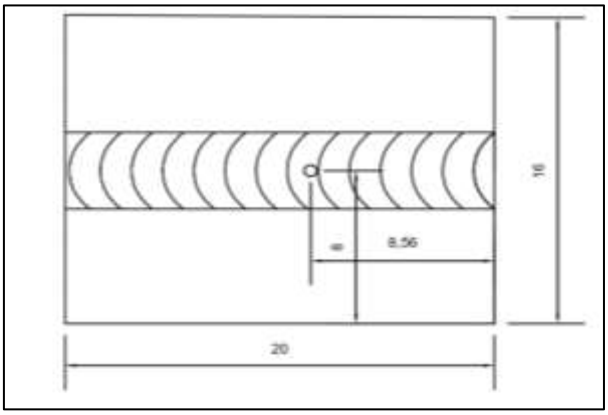
It was concluded that liquid penetrant testing is more sensitive in detection of surface defects and Radiography method is more sensitive in detection of internal defects. We found the defects like porosities and cluster porosities through liquid penetrant test and magnetic particle test.

A. *Defectogram of liquid penetrating test.*



Note: All dimensions are in cm.
Defects
Volumetric defect: 1mm (8.4mm,8mm),
Linear defect : 4mm
Volumetric defect: 1mm (19mm,7mm)

B. Defectogram of Magnetic Particle Testing.



Note: All dimensions are in cm.
Defects
Linear defects: 6mm (12mm, 8.5mm)

References

[1] Rajender Singh "Introduction to Basic Manufacturing Process and workshop Technology" New Age publications, 2006.
[2] P. Kalyanasundaram, C. K. Mukhopadhyay, S. V. Subba Rao "Text book of Practical Acoustics Emission" Oxford publications, UK, 2007.
[3] Alexander Nana Kwesi Agyenim-Boateng, Edward Kumi Diawuo and Psalmeil Nana Nti Agyei "Dye Penetrant Inspection Technique of Turbine Rotating Component" International Journal of Modern Trends in Engineering and Research, Volume 02., Issue 10.,2015, pp. 171-176.
[4] P. N. Rao "Manufacturing Technology" Tata Mc-Graw Hill Education, 2013.
[5] S. V. Ranganayakulu, Samrat Goud Burra and B. Ramesh Kumar "Non-Destructive Evolution Study of Welded EN-08 Mild Steel Specimen" 2015.
[6] Jitesh Kumar Singh and S. K. Bharadwaj "Non-destructive testing of welded metals to enhance the quality of material" International Journal of Technical Research and Applications Volume 3., Issue 3., 2015, pp.47-51.
[7] E. S. Gorkunov, R. A. Savrai, A. V. Makarov, S. M. Zadvorkin, and I. Yu. Malygina "Magnetic Inspection of Fatigue Degradation of a High-Carbon Pearlitic Steel" ISSN 1061-8309, Russian Journal of Non-destructive Testing, Vol.47., Issue 12., 2011, pp.803-809.
[8] V. I. Krainii, O. N. Budadin, and T. E. Ttoitskii-Markov "Increasing the Reliability of the Detection of Flaws in Complex Structures by Integrating the information of Multiparametric Non-destructive Testing" Russian Journal of Non-destructive Testing, Vol. 48., Issue No.2., 2012, pp.115-122.

