Dye Penetrate Testing To Check Surface Cracks, Blow Holes With Fluorescent And Non Fluorescent Method

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Abstract*- This paper is intended to provide an introduction to the non-destructive method of Liquid Penetrate Testing. Penetrate testing is a non-destructive testing method that builds on the principle of visual inspection. Penetrate testing increases the visibility of small discontinuities that the human eye might not be able to detect. Liquid Penetrate Inspection (LPI) is one of the most widely used non-destructive evaluation (NDE) methods. Its popularity can be attributed to two main factors: Its relative ease of use and its flexibility. Materials that are commonly inspected using LPI include the following: Metals (aluminium, copper, steel, titanium, etc.), Glass, Many ceramic materials, Rubber, Plastics. So our paper points to test various arc welded joints like Plate, K joint and Y Joint with fluorescent and non fluorescent process to check the defects and blow holes within acceptable range or not.*

Keywords- Capillary action, defect, developer, dwell time, emulsification time, emulsifier, fluroscent dye, penetrant.

I. INTRODUCTION

Liquid Penetrate Inspection is a method that is used to reveal surface Breaking flaws by bleed out of a colours or fluorescent dye from the flaw. In penetrate testing; a liquid with high surface wetting characteristics is applied to the surface of a component under test.

Liquid Penetrate Inspection (LPI) is one of the most widely used non-destructive evaluation (NDE) methods. Its popularity can be attributed to two main factors: Its relative ease of use and its flexibility. Materials that are commonly inspected using LPI include the following: Metals (aluminum, copper, steel, titanium, etc.), Glass, Many ceramic materials, Rubber, Plastics.

II. LITERATURE REVIEW

Liquid Penetrant Test (dye penetrant) is the simplest method of NDT but the advantage of speed and accuracy in detecting defects on the surface. This method is used to find defects in the open surface of solid components, both metal and non-metal, such as ceramics and fiber plastic. Through this method, defects in the material will be seen more clearly by looking at the indication on the surface of the test object after sprayed developers who then in skeet to be used as reporting work that will be translated to acceptance criteria. This test can also be used in the aircraft industry for routine maintenance in checking of aircraft components, in which the test procedure, the surface preparation of the components, the component protection during the test and all pertaining to the penetrant test [1].

Ultrasonic Testing (UT) is one of the non-destructive test on the material. Ultrasonic test is that uses the sound frequency to detect defects in solid objects. This is based on the fact that solid objects represent good sound waves. This Testing Principle is performed by reflecting ultrasonic sound waves an object then the reflection of the wave from the object is captured by the probe. The difference in surface depth is an indication of a defect in an object [2].

The metal welding process has been known for a long time, various techniques have been developed till now, and one of the most applied welding techniques in the field is Shield Metal Arc Welding (SMAW). The SMAW welding process is included in the arc welding process group, which includes Tungten Arc Welding Gas and Metal Arc Melding Gas. In some previous studies stated that the welding arc welding technique can be examined the results weld using ultrasonic testing [3].

The assessment process was developed using an ultrasonic method of a transducer conducted on the welded joint area by direct contact technique. The methodology for qualifying and demonstrating ultrasonic test technique to determine the results of welded joints on pressure vessels. The pressure vessel is made of welded steel plate welded joint with customized shape and size. The inspection process is carried out from only one part i.e. the outer part of the welded joint [4] .

Ultrasonic tests by comparing SMAW and GTAW welding results in AISI 316L steel. The austenitic character is divided into grain orientation distribution and anisotropy shows that on GTAW specimen is more isotropic than SMAW for grain orientation. B-scan results show SMAW inspection easier than GTAW process [5] .

Ultrasonic applications for conventional processes include casting and welding. They reported ultrasonic wave on austenitic stainless steel (AISI 316) with an investigation system of 20 kHz ultrasonic wavelength effect on the material microstructure during the welding process [6].

The complex vibration system in which ultrasonic welding is effectively applied to different types of specimens include the same metal specimen as well as to specimen with different metals. The inspection of the thickness of the welded joint using an ultrasonic laser SAFT. Detecting from the defects on the butt connections on the welding is required to reduce the cost and rework time. The specimen were used from steel with thickness 25 mm and 50 mm [7].

Standard American Society of Mechanical Engineers (ASME) Section IX is the most commonly used standard for welder qualification. Committees and subcommittees of volunteer workers are interested in advancing the quality and efficiency of the welding industry by developing this code. ASME is specialized for welder qualification and welding procedures. A "construction standard" such as ASME part VIII Division I must be used in conjunction with Part IX for fabrication [8-10].

III. STEPS INVOLVED IN PERFORMING LPT

Step 1 Surface Preparation:

The surface must be free of oil, grease, water, or other contaminants that may prevent penetrant from entering flaws. The sample may also require etching if mechanical operations such as machining, sanding, or grit blasting have been performed. Surface cleaning can be done in three ways

- Vapor Degreasing
- Buffing
- Solvent Cleaning

Step 2 Penetrant Application:

Once the surface has been thoroughly cleaned and dried, the penetrant material is applied by spraying, brushing, or immersing the part in a penetrant bath.

There are three types of Methods

- Dipping
- Brushing
- Spraying

Step 3 Penetrant Dwell:

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 the penetrant is in contact with the part surface. Generally, there is no harm in using a longer penetrant dwell time as long as the penetrant is not allowed to dry. The ideal dwell time is often determined by experimentation and may be very specific to a particular application.

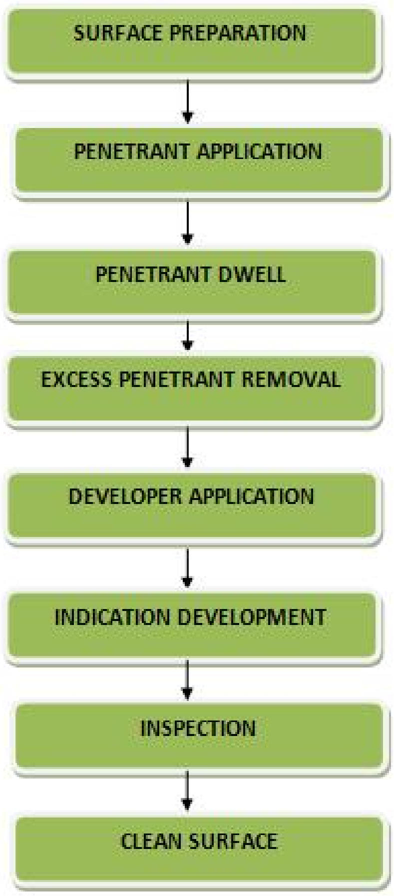

Fig 1 Steps involved in Liquid penetration test

Step 4 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.

The removal technique depends upon the type of penetrant used

- Solvent Removable
- Water Washable
- Post Emulsifiable

Step 5 Developer Application:

A thin layer of developer is then applied to the sample to draw penetrant red in flaws back to the surface where it will be visible. Developers come in a variety of forms that may be applied by dusting (dry powdered), dipping, or spraying (wet developers).

Step 6 Indication Development:

The developer is allowed to stand on the part surface for a period of time sufficient to permit the extraction of the trapped penetrant out of any surface flaws. This development time is usually a minimum of 10 minutes. Significantly longer times may be necessary for tight cracks.

Step 7 Inspection:

Inspection is then performed under appropriate lighting to detect indications from any flaws which may be present. In this step the inspector evaluates the penetrant indications against specified accept/reject criteria and attempts to determine the origin of the indication. The indications are judged to be relevant, non-relevant

Step 8 Clean Surface:

The final step in the process is to thoroughly clean the part surface to remove the developer from the parts that were found to be acceptable. The residual materials could possibly affect the performance of the part or affect its visual appeal.

IV. CHEMICALS USED IN LPT

3.1 Penetrant Testing Materials:

A penetrant must easily spread easily over the surface of the material being inspected to provide complete and even coverage and it can be drawn into surface breaking defects by capillary action. It should remain in the defect but remove easily from the surface of the part. It should remain fluid so it can be drawn back to the surface of the part through the drying and developing steps. Penetrant must be highly visible or fluoresce brightly to produce easy to see indications. It should not be harmful to the material being tested or the inspector.

All penetrant materials do not perform the same and are not designed to perform the same. Penetrant manufactures have developed different formulations to address a variety of inspection applications. Some applications call for the detection of the smallest defects possible and have smooth surfaces where the penetrant is easy to remove.

Penetrant materials come in two basic types. These types are listed below:

Type 1 - Fluorescent Penetrants
Type 2 - Visible Penetrants

Fluorescent penetrants contain a dye or several dyes that fluoresce when exposed to ultraviolet radiation. Visible penetrants contain a red dye that provides high contrast against the white developer background. Fluorescent penetrant systems are more sensitive than visible penetrant systems because the eye is drawn to the glow of the fluorescing indication.

3.2 Developers

The role of the developer is to pull the trapped penetrant material out of defects and spread it out on the surface of the part so it can be seen by an inspector. The fine developer particles both reflect and refract the incident ultraviolet light, allowing more of it to interact with the penetrant, causing more efficient fluorescence. The developer also allows more light to be emitted through the same mechanism. This is why indications are brighter than the penetrant itself under UV light. Another function that some developers perform is to create a white background so there is a greater degree of contrast between the indication and the surrounding background.

The developers are classified into six standard forms. These forms are listed below:

Form a - Dry Powder
Form b - Water Soluble
Form c - Water Suspendable
Form d – Non-aqueous Type 1 Fluorescent (Solvent Based)
Form e – Non-aqueous Type 2 Visible Dye (Solvent Based)
Form f - Special Applications

3.3 Selection of a Penetrant Technique

The selection of a liquid penetrant system is not a straightforward task. There are a variety of penetrant systems and developer types that are available for use, and one set of penetrant materials will not work for all applications. Many factors must be considered when selecting the penetrant materials for a particular application. These factors include the sensitivity required, materials cost, number of parts, size of area requiring inspection, and portability.

When sensitivity is the primary consideration for choosing a penetrant system, the first decision that must be made is whether to use fluorescent penetrant or visible dye penetrant. Fluorescent penetrants are generally more capable of producing a detectable indication from a small defect. Also, the human eye is more sensitive to a light indication on a dark background and the eye is naturally drawn to a fluorescent indication.

3.4 Type of Developer Used and Method of Application

Sensitivity Ranking (highest to lowest) Developer Form Application Technique.

	Developer Form	Method of Application
RANKING	Non-aqueous, Wet Solvent	Spray
	Plastic Film	Spray
	Water-Soluble	Spray
	Water-Suspendable	Spray
	Water-Soluble	Immersion
	Water-Suspendable	Immersion
	Dry	Dust Cloud (Electrostatic)
	Dry	Fluidized Bed
	Dry	Dust Cloud (Air Agitation)
	Dry	Immersion (Dip)

The following table lists the main advantages and disadvantages of the various developer types.

Developer	Advantages	Disadvantages
Dry	Indications tend to remain brighter and more distinct over time and easy to apply	Does not form contrast background so cannot be used with visible systems and difficult to assure entire part surface has been coated.
Soluble	Ease of coating entire part and white coating for good contrast can be produced which work well for both visible and fluorescent systems	Coating is translucent and provides poor contrast (not recommended for visual systems) and indications for water washable systems are dim and blurred
Suspendable	Ease of coating entire part and indications are bright and sharp and White coating for good contrast can be produced which work well for both visible and fluorescent systems	Indications weaken and become diffused after time
Non-aqueous	Very portable and easy to apply to readily accessible surfaces. White coating for good contrast can be produced which work well for both visible and fluorescent systems. Indications show-up rapidly and are well defined and Provides highest sensitivity	Difficult to apply evenly to all surfaces and more difficult to clean part after inspection.

3.5 Quality Control of Lighting

After a component has been properly processed, it is ready for inspection. While automated vision inspection systems are sometimes used, the focus here will be on inspections performed visually by a human inspector, as this is the dominant method. Proper lighting is of great importance when visually inspecting a surface for a penetrant indication. Obviously, the lighting requirements are different for an inspection conducted using a visible dye penetrant than they are for an inspection conducted using a fluorescent dye penetrant. The lighting requirements for each of these techniques, as well as how light measurements are made, are discussed below.

3.6 Types of defects a penetrant test can find most effectively

Small round defects than small linear defects:

Small round defects are generally easier to detect for several reasons. First, they are typically volumetric defects that can trap significant amounts of penetrant. Second, round defects fill with penetrant faster than linear defects. One research effort found that elliptical flaw with length to width ratio of 100, will take the penetrant nearly 10 times longer to fill than a cylindrical flaw with the same volume.

Deeper flaws than shallow flaws:

Deeper flaws will trap more penetrant than shallow flaws, and they are less prone to over washing.

Flaws on smooth surfaces than on rough surfaces:

The surface roughness of the part primarily affects the removability of a penetrant. Rough surfaces tend to trap more penetrant in the various tool marks, scratches, and pits that make up the surface. Removing the penetrant from the surface of the part is more difficult and a higher level of background fluorescence or over washing may occur.

3.7 Health and Safety Precautions in Liquid Penetrant Inspection

Chemical Safety: Whenever chemicals must be handled, certain precautions must be taken as directed by the material safety data sheets (MSDS) for the chemicals. Before working with a chemical of any kind, it is highly recommended that the MSDS be reviewed so that proper chemical safety and hygiene practices can be followed. Some of the penetrant materials are flammable and, therefore, should be used and stored in small quantities. They should only be used in a well ventilated area and ignition sources avoided. Eye protection should always be worn to prevent contact of the chemicals with the eyes.

Ultraviolet Light Safety: Ultraviolet (UV) light or "black light" as it is sometimes called, has wavelengths ranging from 180 to 400 nanometers. These wavelengths place UV light in the invisible part of the electromagnetic spectrum between visible light and X-rays. The most familiar source of UV radiation is the sun and is necessary in small doses for certain chemical processes to occur in the body. However, too much exposure can be harmful to the skin and eyes. Excessive UV light exposure can cause painful sunburn, accelerate wrinkling and increase the risk of skin cancer.

V. RESULTS

Type of metal – Mild steel
Thickness – 12 mm
Types of joint – 'Y' , 'K' and Metal plate
Parameters :

Voltage – 110 watts
Type of Welding – Arc Welding
Metal Rod Length – 12 mm

Table 5.1
Results of LPT conducted in fluroscent process

SL NO	TYPES OF INDICATIONS	ACCEPTANCES (BELOW 4.8)		REJECTENSE (ABOVE 4.8)	RESULT
1	Y – Joint				
	Hole	0.3	0.2	-	YES
	Cracks	0.5	0.7	-	YES
2	K – Joint				
	Hole	0.3	0.4	-	YES
	Cracks	0.4	0.6	-	YES
3	Metal plate				
	Hole	0.2	0.5	-	YES
	Crack	0.7	0.4	-	YES

Table 5.2
Results of LPT conducted in non fluroscent process

SL NO	TYPES OF INDICATIONS	ACCEPTANCES (BELOW 4.8)		REJECTENSE (ABOVE 4.8)	RESULT
1	Y – Joint				
	Hole	0.3	0.4	-	YES
	Cracks	0.5	0.7	-	YES
2	K – Joint				
	Hole	0.3	0.4	-	YES
	Cracks	0.4	0.6	-	YES
3	Metal plate				
	Hole	0.2	0.5	-	YES
	Crack	0.7	0.4	-	YES

VI. CONCLUSION

This paper has provide an introduction to the non-destructive method of Liquid Penetrant Testing. Penetrant testing has increased the visibility of small discontinuities that the human eye might not be able to detect. We have tested the various welded joints like K- Joint, Y- Joint and Welded Plate for blow holes and cracks. The observed blow holes and cracks are in permissible range which displayed in Table 5.1 and 5.2.

PENETRATION TESTING can be a very valuable tool during new constructive and in service inspections. PENETRATION TESTING does have limitations and is not the best method for all applications. It can be concluded that, for quick, low cost examinations in any location, PT is often the best choice of NDT methods.

VII. CONCLUSION

MMCs are the material exhibiting properties that are hard to be obtained from a single material otherwise. These can be tailored and used as per the demands of various industrial applications by suitable fusion of their constituent materials. Aluminum is preferred as matrix component due to its ductility and low density.PM is one of the most promising and versatile routes for the fabrication of composites as compared to other manufacturing methods. This method ensures more homogeneous microstructure of the fabricated MMC as compared to other techniques. However, the existence of a new phase in addition to impurities in the form of carbon could be witnesses in XRD results due to partial reaction between matrix and reinforcement. Al2O3, reinforcement of the brittle nature, reduces the impact strength and increases the hardness of composite while fabrication with melt stirring technique. The interface between matrix and reinforcement in an MMC has an effect on the amount of martensitic transformation. The toughness of composite deteriorates with weak interface, but no effect on the wear resistance and hardness were noticed.

REFERENCES

[1] Callister W 2001 Fundamental of Materials Science and Engineering (John Wiley & Sons Inc).
[2] Anonim 2014 Modul Pelatihan NDT Level I dan II (Balai Besar bahan dan Barang Teknik (B4T)).
[3] Tiago Vieira da Cunha and Carlos Enrique 2014 Ultrasound in arc welding: A review Ultrasonic.
[4] Rafael Martínez et al. 2013 Ultrasonic inspections in the fabrication of the ITER vacuum vessel sectors Fusion Engineering and Design 88 pp 2155– 2159.
[5] Tabatabaeipour, and F Honarvar 2010 A comparative evaluation of ultrasonic testing of AISI 316L welds made by shielded metal arc welding and gas tungsten arc welding processes Journal of Materials Processing Technology 210 pp 1043–1050.
[6] Habib Alavi, Sandip P Harimkar 2015 Melt expulsion during ultrasonic vibration-assisted laser surface processing of austenitic stainless steel Ultrasonics 59 pp 21–30.
[7] Levesque et al. 2016 Inspection of thick welded joints using laser-ultrasonic SAFT Ultrasonics 69 pp 236–242.
[8] ASME Boiler and Pressure Vessel Committee 2013 ASME Boiler and Pressure Vessel Code Section VIII Division I (New York).
[9] Ahmed Khalid Hussain, Abdul Lateef, Mohd Javed and Pramesh.T , Influence of Welding Speed on Tensile Strength of Welded Joint in TIG Welding Process, International Journal of Applied Engineering Research, Vol.1, No.3, 2010, pp.518-527.
[10] N.P P.Migoun, A.B.Gnusin, M.Stadhaus and G.R-Jaenisch,New Potentials of Penetrant Testing, ECNDT,2006.