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Non-destructive testing by liquid penetrant testing and ultrasonic testing – A review

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ABSTRACT

Non-destructive testing (NDT) is commonly thought of a broad field. However, at its core, it refers to a good cluster of tested review ways to analyze the soundness of a cloth, part or structure while not with chemicals or physically neutering it. When it involves correct results, non-destructive testing is reliable due to the variability of obtainable and complementary choices. Any given piece of kit or machinery may be subject to a variety of NDT that eliminates the danger of oversight or quality. This paper consists of a detailed review about the latest researches carried out for finding out the defects using LPT and Ultrasonic method and how it improves the quality of the products by reducing the time taken for testing. NDT is one of the finest and accurate quality tool used in reducing the costs of testing. The Liquid Penetrant Testing (LPT) technique is usually used for the scrutiny of non-ferrous materials and non-magnetic materials like Al, chrome steel in addition as alternative materials which may not be inspected by the Magnetic Particle technique. Ultrasonic testing is mostly used for finding minute deflections and flaws in the materials using transducers.

Keywords— Non-Destructive Testing (NDT), Liquid Penetrant Testing (LPT), Ultrasonic Testing (UT), Transducers, Non-ferrous, Non-magnetic, Magnetic particle technique

1. INTRODUCTION

1.1 Importance of non-destructive testing

Testing comprises all the techniques of materials or products under different types of loadings. This way, the reliability of product to the user is assured and the process of material selection is done with a lot of ease. Testing should not affect the property of the material and the person who is going to conduct the procedure. That is why Non-Destructive Testing methods were introduced and using this even the minute flaws on various materials can be found out. This also improves the customer reliability and quality of the product. Many manufacturing industries are trying to implement these methods to reduce the cost of testing and time by improving the quality at the same time.

1.2 Liquid penetrant testing

In this methodology, the defects or cracks are studied employing a penetrant or a dye. Capillarity or capillary action is the principle behind this testing methodology. Low physical phenomenon fluid penetrates into clean and dry surface-breaking discontinuities. Penetrant is also applied to the check element by dipping, spraying or brushing. When the adequate penetrant time has been allowed, the surplus penetrant is removed and a developer is applied. The developer helps to draw penetrant out of the flaw in order that associate invisible indication becomes visible to the inspector. Testing is often performed under ultraviolet or white light. The operating condition should be between 4°C to 52°C.

1.3 Ultrasonic testing

Ultrasonic testing one of the NDT methods used for finding the flaws and defects arising while manufacturing a product. It consists of several functional units such as pulse (or) receiver, piezoelectric transducer and display devices. Pulser is an electronic device used for producing high voltage electrical pulses. Using the pulse, the transducer generates high-frequency ultrasonic

energy. The sound energy is introduced which in turn propagates through the materials in waveforms. When there is discontinuity such as a crack in the wave path, part of the energy will get reflected back from the flat surface. The reflected wave signal is transformed into electrical signals using the piezoelectric transducer and the output gets displayed on the screen.

2. LATEST RESEARCH TRENDS

Syed Mobin Baba et.al [1]; Evaluation of Defects in the SS-304L Material by Using Non-destructive Examination Techniques; SS-304L is a type of stainless steel made up of a mixture of chromium-nickel offering good corrosion resistance, strength and ductility. The test carried out using this sample they welded using tungsten inert gas welding. The liquid test was carried out on the welded joints to find out the defects. It was found out that LPT is more sensitive in the detection of surface defects and was able to find out one significant surface defect in TIG welding. Length of the indication grows over time as the penetrant bleeds out causing an acceptable indication to reject it.

Xu Guirong et.al [2]; Analysis and Innovation for Penetrant Testing for Airplane Parts; various practical testing are conducted for local inspection, which results in testing of temperature and oil infiltration jams. Before penetration, the parts which can't be dismantled from the plane, it needs to protect from adjacent areas and a combination of surfaces are included to protect and penetrate is applied by using the brush. In this paper, the author analyzed all the problems and the innovative points are summarized which helps in NDT testing in the industry.

Sandeep Kumar Dwivedi et.al [3]; Advances and Researches on Non-Destructive Testing: A Review; The recent advancements and researches about NDT methods for defect characterization in engineering materials are discussed. Also covers the review of various NDT methods that are being used for finding defects and flaws. After various surveys and reviews, the paper concluded by expressing the various methods which can also be used for defect investigation and Ultrasonic testing is widely used for complex part examination.

Belinga Mvola et.al [4]; Real Time Non-Destructive Testing Methods of Welding; the author presents a review about the three most efficient NDT methods of welding. The methods are Radiography, Ultrasonic and Eddy Current. These methods were chosen because they are able to cover most of the industrial needs to detect welding cracks. After reviewing these three NDT methods the author concluded by saying that Eddy Current method is highly sensitive to small cracks and discontinuities. However, it has been found that the Ultrasonic method can detect deeper defects compared to Eddy Current method.

Michele Cevenini [5]; Safety and Productivity Innovations in Liquid Penetrants and Magnetic Particles Testing; the Automotive industry has greatly benefited from safety and productivity improvements in the last few years. Introducing robots in automated LPT systems helps reduction of consumption of liquid penetrant and increases productivity. It helps reduce or lower inspection variable costs. The author concludes by saying it provides safety for the operator from the liquid penetrant application area making it even more reliable and safer working conditions.

Shyamji et.al [6]; Non-Destructive Method by Penetrant Testing; the author discusses the results obtained from a literature review. Aims at introducing inspection and various testing methods to understand the purpose of NDT and its importance in the fabrication industry. The author states that this method enables to find the flaw in a limited period of time increasing the reliability of the equipment. It also helps in identifying dimensional faults and helps improve the structural integrity of the equipment by welding it to perfection.

T. Endramawan [7]; Non-Destructive Test Dye Penetrant and Ultrasonic on Welding SMAW Butt joint with acceptance criteria ASME standard; the author discusses the reason for doing this research. To find the defect and know what type of discontinuity of SMAW welding is occurring. Two methods were used for carrying out the tests and analyze the type of discontinuity. The results show that the defects were scattered throughout the weld. The shortest and longest defect distance was found out and using those as a reference they were re-worked. The author concludes by saying that the material composition had a major role in causing the defect.

Mohit Bector et.al [8]; Comparing 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; The author uses various NDT methods to find the best suitable method. The material was subjected to three different tests such as Liquid Penetrant Test, Magnetic Particle Test and Ultrasonic Test. Based on the researches carried out on each method the author found out that LPT, UT are less hazardous when compared to MT. The MPT has limitations in reporting welded defects, whereas ultrasonic test gives better results and penetrant test detects only the surface pores of the weld zone. The depth of ultrasonic is much better and it is the best methods that can be used for cylinder testing. Based on cost the LPT method is cheaper and based on effectiveness UT method is excellent.

G. Lalitha et.al [9]; Experimental Study on Non-Destructive Testing Techniques (NDTT); this paper describes the developments of NDT technology. Using currently available technology most of the traditional limitations can be overcome. In order to improve the quality of the product, a quality check is important in the industry. Defects which occur as discontinuities will be indicated by the bleeding out of the penetrant. The author concludes by saying indications such as linear indications can be found out using the penetrant method. Indications which are 3 times rounded than the regular indications which are circular or elliptical with lesser length than 3 times the width can be found out accurately.

Andrea Tonti et.al [10]; Experimental Analysis to Validate the Non-Destructive Method of "Liquid Penetrants on Hot Surfaces"; Analysis conducted to support the development of the specific UNI45000540 standard. It helps in characterizing the products

used in LPT on hot surfaces. The analysis was conducted on non-porous materials whose temperature is more than 50°C at the surface level. The tests that are carried in the analysis are those that are required by the draft standard. The author has come to the conclusion that the standard is applicable to all cases where LPT is required at a temperature higher than 50°C and can be used for defining product standards.

K. Manjula et.al [11]; Weld Flow Detection Using Various Ultrasonic Techniques: A Review; among various NDT methods, Ultrasonic testing is a well-known NDT to detect the size and location of defects in a test material. Ultrasonic testing is used more nowadays during production than that of radiography. The study aims at giving a review of various Ultrasonic testing techniques and has come to a conclusion that every technique has its own advantages and disadvantages and has also given examples supporting his statement about the advantages and disadvantages.

Wissam M. Alobaidiet.al [12]; Application of Ultrasonic Techniques in Oil and Gas Pipeline Industries: A Review; The author considers only two main techniques used in pipe plants. One is straight beam evaluation and the other is angle beam evaluation. Six different methods are used to calculate the depth of defect. The author believes in clarifying and discussing the options used in solving engineering problems with a comprehensive historical summary of the information available. It has been found that a straight probe works up to a limited thickness and is capable of detecting defects on the subsurface. Angle beam probe has also been found having limitations that the skd can't be increased unless the sp angle is increased. The author recommends that a second, powerful NDE technique capable of remote detection would be useful alongside Ultrasonic testing.

Paval Mares [13]; Simulation as a Support for Ultrasonic testing; Numerical simulations are becoming an integral part of Non-Destructive Testing. Simulations help to determine on what parameter Ultrasonic examinations are done, especially parameters of the probe. Simulations are very useful for verifying the propagation of the ultrasonic signal in a given area. Implementing new non-destructive methods and other supporting activities can increase the examination quality. So, computer modelling is becoming an integral part of non-destructive testing. The author has concluded by giving other examples on the benefits of using computer modelling in NDT.

PouyanKhalili et.al [14]; the choice of an ultrasonic inspection method for the detection of corrosion at inaccessible locations; Low frequency guided wave inspection is employed as it gives large area coverage from a single transducer position. However, using low frequency guided wave inspection makes it problematic to detect defects at inaccessible areas of the product. A combination of two or more methods is suggested for corrosion inspection at inaccessible regions. The performance of A1, S0, SH0, SH1 inspection methods were established. The author has concluded the paper by recommending a combination of two or more methods when inspecting corrosion at inaccessible locations.

Chaoyong Peng et.al [15]; The sizing of small surface-breaking fatigue cracks using ultrasonic arrays; The author states that Ultrasonic testing provides early warning of failure and useful information about the component. The performance of both the ultrasonic image based sensing and S-matrix correlation method was demonstrated on the sample having real fatigue cracks. The method used is shown to work well for defects in the range of 0.78 – 1.84 wavelengths. The author concludes by saying that within these ranges of applicability, both the methods prove to be very effective and excellent in spotting the cracks with less than 19% errors in all cases.

3. CONCLUSION

- In this present study, it is found that Liquid Penetrant Testing (LPT) is effective in detecting surface cracks and discontinuities. Ultrasonic Testing is effective in detecting internal cracks and discontinuities in the material.
- LPT works even on complex geometric shapes.
- Ultrasonic testing has high sensitivity allowing it to detect extremely small flaws.
- LPT and UT are less hazardous to the inspector as well as the material that is to be inspected.
- LPT can be used even at a temperature of 50°C reducing dwell time of penetrant.
- It helps in reducing costs and time taken in the testing area in various industries.
- Materials required for testing are easily portable and it is cheaper.
- Ultrasonic Testing using automation is the future of NDT in the industry. This helps in reducing man-made errors with high precision and accurate testing of materials within a limited period of time.
- The quality of the product increases automatically due to high precision and accuracy in finding the type of errors and preventing defective products handed over to the customers.

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