ENGINEERING APPLICATION OF NON DESTUCTIVE TESTING: A REVIEW

Ayushi Ganorkar[1], Gunjan Waghmare[2], Isha Bind[3], Arnav Londhe[4], Vaniket Madavi[5]

Department of Civil Engineering,
K.D.K. College of Engineering, Nagpur, Maharashtra

Abstract— The applications of non-destructive testing are widespread and are used in a variety of industries such as aerospace, automotive, construction, manufacturing, power generation, and more. NDT methods can be used to detect defects in welding, corrosion, fatigue, and stress, among other things. NDT can also be used to inspect composite materials, metals, and non-metals, as well as welds, castings, and forgings. Some common non-destructive testing methods include ultrasonic testing, magnetic particle inspection, liquid penetrant testing, radiographic testing, and visual inspection. Each method has its own strengths and limitations, and the choice of technique depends on the specific requirements of the application. NDT plays an important role in ensuring the safety and reliability of structures and components, as it can detect defects that may not be visible to the naked eye. By identifying and addressing defects early on, NDT helps to prevent costly failures, reduce downtime, and ensure of longevity of materials and structures.

Keywords— NDT Techniques, Compressive strength, Structural Defects

I. INTRODUCTION

Faults or defects on the exterior and inside of materials are recognised and characterised in the field of non-destructive evaluation (NDE) or non-destructive testing (NDT) without the material being torn apart or otherwise damaged. Non-destructive testing (NDT) is the process of assessing, evaluating, and inspecting materials or components for characterization. NDT techniques provide or provide a cost-effective method for testing a sample for individual investigation and examination. They can also be used to check the complete material in a quality control system during production. success in fixing the current problem. Finding a fault typically demands the use of multiple NDT test techniques. It may necessitate a combination of procedures as well as intrusive, probing apertures. a better understanding.

NDT is a method of analysing and testing materials or components without causing damage or affecting their physical properties. The goal of NDT is to find flaws, imperfections, and abnormalities inside a material or component. This method is extensively used to verify the quality and dependability of products and buildings in the manufacturing, construction, and maintenance industries.Visual testing, ultrasonic testing, radiographic testing, magnetic particle testing, dye penetrant testing, eddy current testing, and acoustic emission testing are all examples of NDT procedures. Each of these procedures has advantages and disadvantages, and the proper technique is determined by the type of material or component being tested, the type of flaw being found, and the application.

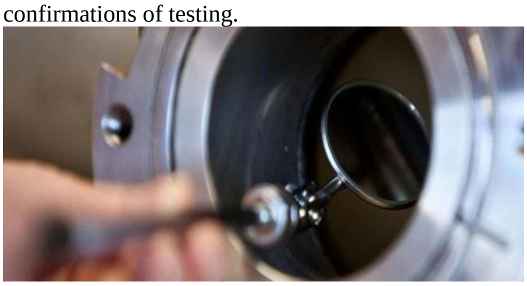
II.NON DESCTRUCTIVE TESTING METHODS

1. Visual and optical Testing
2. Ultrasonic Testing
3. Electromagnetic Testing
4. Radiographic Testing
5. Liquid Penetrant Testing
6. Magnetic particle Testing
7. Acoustic Emission Testing
8. Magnetic Resonance Imaging Testing
9. Near-Infrared Spectroscopy
10. Optical Microscope Testing

III.METHODS

3.1 VISUAL AND OPTICAL TESTING

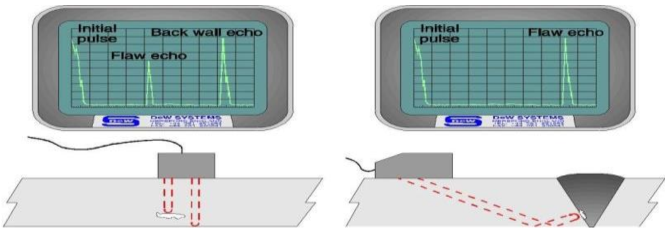
Visual inspection is especially efficient at finding macroscopic faults like bad welds. Many welding flaws are macroscopic, such as crater cracking, undercutting, slag inclusion, and incomplete penetration welds. Similarly, VI may discover defects in composite buildings and pipelines of various types. Bad welds or joints, missing fasteners or components, bad fittings, inappropriate dimensions, improper surface polish, huge cracks, cavities, dents, inadequate size, wrong parts, lack of code approval stamps and similar confirmations of testing.



3.2 ULTRASONIC TESTING

This method is used to discover internal and surface (especially remote surface) flaws in sound conducting materials. The principle is comparable to echo sounding in several ways. A short pulse of ultrasound is produced by applying an electric charge to a piezoelectric crystal, which vibrates for a very short period at a frequency proportional to the crystal's thickness. This frequency is typically in the 1 MHz to 6 MHz range in fault detection. Vibrations or sound waves at this frequency can travel a long distance with little attenuation in homogenous elastic materials such as many metals. For example, the velocity in steel is 5900 The information in ultrasonic testing is provided by a cathode ray tube, in which horizontal movement of the spot from left to right represents time elapsed, giving the appearance of a horizontal line on the screen. The system is electronically synchronised so that the spot begins to traverse the screen as soon as the probe receives its electrical pulse.

3.3 ELECTROMAGNETIC TESTING

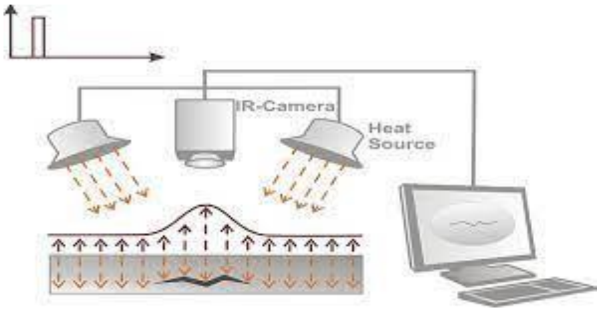


As a type of NDT, electromagnetic testing (ET) is the act of producing electric currents or magnetic fields, or both, inside a test object and monitoring the electromagnetic response. If the test is properly set up, a flaw within the test object produces a measurable response. The main uses of the eddy current technique are the detection of surface or subsurface faults, the measuring of conductivity, and the assessment of coating thickness. Eddy currents can be generated in any electrically conducting material that is subjected to an alternating magnetic field (usually at frequencies ranging from 10Hz to 10MHz). Normally, an alternating magnetic field is created by feeding an alternating current through a coil. The coil can be of various shapes and have between 10 and 500 turns of wire. The magnitude of the eddy currents created in the product is determined by conductivity, permeability, and the geometry of the setup. Any change in material or geometry can be detected as a change in coil impedance by the excitation coil. The most basic coil is a ferrite rod with many turns of wire twisted at one end that is placed near the surface of the product to be tested. When a crack forms in the product surface, for example, the eddy current must travel further around the crack, which is recognised by the impedance change example, the eddy current must travel further around the crack, which is recognised by the impedance change.

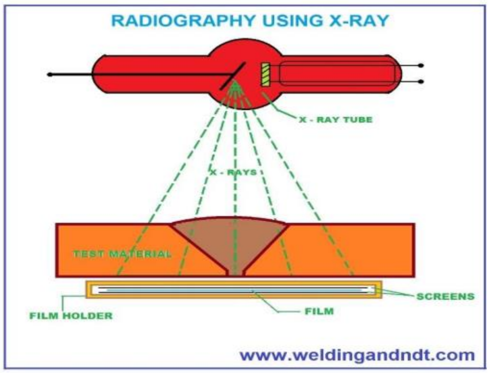
3.4 THERMOGRAPHY TESTING

The science of measuring and mapping surface temperatures is known as infrared thermography. The use of thermal measurements of a test object as it responds to a stimulus distinguishes infrared and thermal testing procedures. The most frequent sensing method is thermal imaging cameras. Passive imaging of machinery or electronics can detect hot areas that indicate a problem. After-energy imaging of test objects can be used to monitor the flow of heat in the object, which is a function of material qualities as well as limits. In imaging disbonds and delaminations in composite materials, flash thermography techniques have proven to be quite effective.

Another notable recent breakthrough is the utilisation of mechanical energy to promote localised heating at subsurface discontinuities such as metal fissures, which opens up a new field of application for the IR approach. Infrared thermography, a nondestructive remote sensing technique, has proven to be a reliable, practical, and cost-effective means of testing concrete. Internal voids, delaminations and cracks in concrete constructions including bridge decks, highway pavements, garage floors, parking lot pavements and building walls can be detected. Temperature differences as small as a few hundredths of a degree Celsius can be measured and viewed by an infrared thermographic scanning device. Depending on the ambient conditions and the intended results, infrared thermographic testing can be performed during the day or at night.



3.5 RADIOGRAPHY TESTING



Radiography has an advantage over other techniques in that it gives a permanent reference for the interior soundness of the radiographed object. The capacity of an x-ray released from a source to pierce metals depends on the accelerating voltage in the x-ray producing tube. If there is a void in the object being radiographed, more x-rays will flow through that area, giving the film under the part more exposure than in non-void locations. X-ray sensitivity is nominally 2% of material thickness. Thus, for a piece of steel with a thickness of 25mm, the smallest void detectable would be 0.5mm in dimension.As a result, items are frequently radiographed in multiple planes. A thin crack will not be visible until the x-rays are parallel to the plane of the crack. In terms of function, gamma radiography is identical to x-ray radiography. The source of the penetrating electromagnetic radiation, which is a radioactive material such as m Co 60, is the difference. However, because of the risks associated with handling radioactive materials, this method is less popular. This approach is appropriate for detecting internal faults in ferrous and nonferrous metals, as well as other materials. Electrically generated X-rays and radioactive isotope-emitted Gamma rays are penetrating radiation that is differentially absorbed by the substance through which it passes; the greater the thickness, the higher the absorption.

IV.ENGINEERING APPLICATIONS

4.1 Visual and Optical Evaluation:

Visual and optical testing is a non-destructive testing approach that involves inspecting the surface of an object for visible faults or irregularities using visual aids such as borescopes and magnifying glasses. This technology is widely used in the manufacturing and maintenance industries to detect surface cracks, corrosion, and other problems that could jeopardise the material's integrity.

Engineering applications of visual and optical testing include: Inspection of welds, castings, and forgings for surface cracks, porosity, and other defects. Detection of corrosion, erosion, and wear on machinery parts.Inspection of electrical components for defects such as broken wires or damaged insulation.

4.2 Ultrasonic Testing:

Ultrasonic technique use high-frequency sound waves to analyse an object's internal structure. This approach is used to discover interior faults in metals, polymers, and other materials, such as cracks, voids, and inclusions. Ultrasonic testing has engineering uses such as inspecting pipes, pressure vessels, and other equipment for internal corrosion, erosion, and other problems. Crack detection in aircraft components like turbine blades and engine parts. Material thickness measurement in pipes, tanks, and other structures.

4.2 Electromagnetic Testing:

This testing detects in materials by using electromagnetic waves. Cracks, voids, and other faults in metals and other conductive materials are detected with this technology.Detection of surface and subsurface cracks in metals, including aircraft components, pressure vessels, and pipelines, is one of the engineering uses of electromagnetic testing.Material thickness measurement in non-conductive materials such as fibreglass and plastic.Weld inspection in pipelines, pressure vessels, and other machinery

.4.3 Thermographic Testing:

This method employs that thermal imaging to detect temperature fluctuations on an object's surface. This technique is used to detect faults in materials such as fractures, delamination, and voids. The following are some engineering applications of thermographic testing: Defect detection in composite materials used in aerospace and automotive. Examine electrical components such as circuit boards and transformers for hot areas that could indicate a failure. Identifying insulation flaws in buildings and other structures.

4.4 Radiography Testing:

Radiography procedure uses X-rays or gamma rays to examine an object's internal structure. This approach is used to discover interior faults in metals, polymers, and other materials, such as cracks, voids, and inclusions. Inspection of welds, castings, and forgings for internal faults is one of the engineering uses of radiography testing. Corrosion and erosion detection in pipelines and other structures. Material thickness measurement in structures such as bridges and buildings.

V. SUMMARY OF LITERATURE REVIEW

Sr. no.	Author Name	Investigated Problem Type
1	Bates, D. and Smith, G et al(2000)	Rapid non-destructive thermal testing of aircraft components
2	D.J. Titman et al. (2001)	The use of thermography in non-destructive structural testing
3	P Cawley (2001)	The use of thermography in non-destructive structural testing
4	Jacek Jarmulak et al (2001)	Case-based reasoning for interpretation of data from NDT.
5	Li Zhijun (2001)	Testing of advanced composites without causing damage.
6	G. S. Park et al. (2001)	Optimum Design of a NDT System to Maximize Magnetic Flux Leakage.
7	P. Tschelisnig (2001)	Acoustic emission testing (AET) – an integral NDT method
8	H. A. Crostack, W. Reimers(2001)	Evaluation of component integrity by non-destructivetesting
9	Zahran, 0. S., Shihab, S. etal (2002)	Ultrasonic Techniques for Rail-track Inspection: Recent Advances.
10	K Mori, A Spagnoli et al(2002)	A non contacting NDT method for defect detection in concrete

VI. CONCLUSION

In conclusion, non-destructive testing (NDT) plays a crucial role in ensuring the safety, reliability, and efficiency of various structures, components, and materials. NDT techniques allow for the detection of flaws, defects, and inconsistencies without causing damage or altering the properties of the tested material or product. The application of NDT is diverse, spanning multiple industries such as aerospace, automotive, construction, manufacturing, and more. Some common NDT techniques include ultrasonic testing, radiography, magnetic particle inspection, eddy current testing, and visual inspection. By implementing NDT, companies can save time and money by identifying issues early and avoiding costly repairs or replacements. NDT can also improve product quality and reduce the risk of catastrophic failures, ensuring that products meet or exceed industry standards and regulations.

Overall, NDT is an essential tool in modern engineering and manufacturing, providing a non-invasive and reliable means of inspecting materials and products for defects and ensuring their safety and reliability.

REFERENCES

[1]. D. Bates, G Smith, D Lu, J Hewitt; Rapid thermal non-destructive testing of aircraft components; Composites Part B: Engineering; Volume 31, Issue 3, 1 April 2000, Pages 175–185

[2]. D.J. Titman; Applications of thermography in non-destructive testing of structures; NDT & E International; Volume 34, Issue 2, March 2001.

[3]. P Cawley; Non-destructive testing—current capabilities and future directions; Journal of Materials: Design and Applications; October 1, 2001 vol. 215 (213-223).

[4]. Jacek Jarmulak, Eugene J.H. Kerckhoffs, Peter Paul van't Veen; Case-based reasoning for interpretation of data from non-destructive testing; Engineering Applications of Artificial Intelligence; Volume 14, Issue 4, August 2001.

[5]. Li Zhijun; Non-Destructive Testing of Advanced Composites; Aerospace Materials & Technology, 2001.

[6]. G. S. Park, P. W. Jang, Y. W. Rho; Optimum Design of a Non-Destructive Testing System to Maximize Magnetic Flux Leakage; Journal of Magnetics Vol.6 No.1, 2001, (31-35).

[7]. P. Tschelisnig; Acoustic emission testing (AET) an integral non-destructive testing method; International Journal of Materials and Product Technology 2001 - Vol. 3, No.3/4 pp. 267 – 275.

[8]. H. A. Crostack, W. Reimers; Evaluation of component integrity by non-destructive testing; International Journal of Materials and Product Technology 2001 - Vol. 3, No.2 pp. 147 – 162.

[9]. Zahran, 0. S., Shihab, S. and AI-Nuaimy, W. (2002). Recent Developments in Ultrasonic Techniques for Rail track Inspection. NDT 2002, Southport, The British Institute of NDT.

[10]. K Mori, A Spagnoli, Y Murakami, G Kondo, I Torigoe; A new non-contacting non-destructive testing method for defect detection in concrete, NDT & E International; Volume 35, Issue 6, September 2002, Pages 399–406.