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Crack Detection of Ferromagnetic Materials through Non Destructive Testing Methodology

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Abstract: *The real components have so many defects in the material, which acts as a crack. In fact, manufacturing of a component is not ideal. In manufacturing several kinds of defects are generated like voids and inclusions. Thus, it must be check all the critical components through non-destructive techniques (NDT) to detect the potential dangerous cracks. In Certain crucial components such as Airplanes, Space Vehicles, Nuclear Plants, Heavy Machinery, Dams, Concrete etc., online monitoring of defects is necessary. Concrete is different from other construction materials. Concrete can be made from combination of different materials. Its final properties depend on its treatment at construction site. To achieve this, sophisticated technologies are used. Ferromagnetic Composite Iron (FCI) is used in power generating devices and DC brushless Motors. Laminations can be substituted by Ferromagnetic Composite Iron (FCI) materials which offer a great manufacturing advantage. Non Destructive testing (NDT) is a major part of quality control. In Non-Destructive testing (NDT) different materials are tested for surface, volumetric and internal defects present in it. Non Destructive testing (NDT) is also an assurance that the proposed product is good and reliable. To apply these techniques, a certain level of skills is very necessary so that maximum amount of information is fetched related to the proposed product during testing. This paper deals with the Non Destructive Testing Methodology Used for crack detection in ferromagnetic materials.*

Keywords: *Crack, Ferromagnetic Materials, Non Destructive Testing, CAI, CAT, CAQC.*

I. Introduction

In industries it is impossible to synthesize product which is totally immune to crack(s). Crack may occur during manufacturing, testing or use. The products so developed are usually subjected to fatigue loading. During fatigue loading, the component may develop crack due to cyclic loading. Crack is simply defined as to fail or to give up. Crack may also be defined as break/rapture without complete separation of parts. Crack generally occurs with a sharp or a sudden sound. In industries the structures are generally subjected to fatigue or cyclic loading. Manufacturing Failure is indicated by cracks which occur in different kind of materials such as metals, composite, plastics and minerals. During production, time to time checking of product is necessary to avoid any kind of damage to the product by cracks during its manufacturing. Inadequate crack detection may result in various hazards which may cost human life at top. The crack when propagated to a high level develops into fracture which ultimately causes the whole structure to collapse.

The materials which exhibit a much high level of saturation magnetization are generally referred to as ferromagnetic materials. Ferromagnetic materials have a enamors applications in industry and in other places.

The ferromagnetic materials have vast applications in industries and power plants. In some places ferromagnetic materials are also used for creating and distributing electricity.

The ferromagnetic materials are based on the property of Bohr Magneton. Bohr Magneton is defined as the moment which is associated with the electronic property of spin.

$$m = \pm \frac{e}{m} \frac{1}{2} h$$

Here, $\frac{e}{m}$ is the Ratio of electronic charge to mass
h is the Planck's constant whose value is $1.05*10^{-34}$ joule-sec

II. Literature Review

L. Boni, et. al. [1], has mentioned in his paper that metal pads which have thin bonds are more effective to achieve damage tolerance in case of cracks present in structures**.** Four different tests are performed based on four different configurations to know about the residual strength and the growth of crack. It is observed that a minor role is played in case of thin bonded metals by pads debonding.

A.chudnovsky [2], has discussed in his paper about the empirical equations. Under the conditions of creep and fatigue, these equations are used to calculate the slow growth of the crack. Energy release rate or stress intensity factor are the basic functions in terms of which the propagation rate of crack is generally expressed. Under varying load conditions, the crack behavior is determined using crack stability analysis. Also the crack growth resistance technique is used to determine the crack behavior. A constant crack resistance is assumed for stable crack propagation.

J.C.Newman, et. al. [3], has mentioned in his paper about various ways to determine the growth of crack. The most used, easy and reliable method used is the FASTRAN life-prediction code. On testing, cracks were developed on open ends and the thus the test data was obtained.

Lei Ma, et. al [4], has mentioned in her paper about the crack propagation through cyclic loading. Using molecular dynamic simulation, the test specimen was put under cyclic loading and was observed. The cracks propagated and brittleness was observed in crack propagation.

Haiying Zhang, et. al [5], has mentioned in his paper about the crack-layer concept for the slow growth of crack. The estimation of lifetime and fracture growth is done by modeling of crack-layer model. This method has been applied to a numerous engineering materials in past few decades for the brittle fracture. Finite Element Methods are used to calculate the driving forces of crack-layer.

III. Crack

Crack is nothing but simply a failure of material. Crack can also be understood as breakdown of component without complete separation of its adjoining parts. Areas in low shear and where bending plays a major role usually have flexural cracks. Bending stresses and shear stresses are the key features for a crack to propagate and finally resulting in fracture. For a safe structure, detection of crack is must otherwise the structure may collapse as a result of propagation of crack. Crack could be symmetrical or asymmetrical. When determination of crack is done in a rotor, then a spare rotor is used for the substitution of cracked rotor otherwise the consequences may be hazardous. Cracks are classified as deep cracks or semi-deep cracks. Semi deep cracks are the results of varying pressure and humidity conditions followed by the type of material used. Due to sudden movement of structures as a result of earthquakes, semi-deep cracks are developed into deep cracks. Complex Variable Approach is used to derive the general equation of crack in anisotropic bodies. Stress functions are used to determine the value of stress-intensity factor which represents the conditions of crack and its extension.
Microscopic techniques are used to determine and locate cracks and to study their nature. Ultrasound, X-Ray etc. is used to identify the cracks and structural damage. Then microscopic techniques are used to analyze the damage done to the structure. A high level of precision is achieved using high powerful tools such as inverted microscopes. The Worn out part is removed and analyzed under high resolution magnification to get more information about that part.

IV. Non Destructive Testing (NDT) Methodology

The known Full Form of NDT to a person is Non Destructive Testing. As the name suggests, it is a testing without destroying the elements or components used in testing. In modern world, structures are subjected to high pressure and high load conditions. The main purpose of Non Destructive Testing (NDT) is to make sure that the structure, component, material or element doesn't fail within the pre-determined time.

Non Destructive Testing (NDT) is also used to check the quality of raw material before processing the part and is used until the final inspection of product.

Apart from all the above mentioned uses, Non Destructive Testing (NDT) for condition monitoring, energy level monitoring, residual life assessment.

There are four main criteria for Non Destructive Testing (NDT) techniques

- Type of Material
- Type of Defect
- Size of Defect
- Location of Defect

V. Common Non Destructive Testing (NDT) Methods

5.1 Volumetric Examination Method

- **Ultrasonic Testing-UT**

In this method sound waves of high frequency are used to detect the changes in the properties of materials. It is used to determine the thickness of metallic and non-metallic materials whose only one side is accessible.

- **Radiography Testing-RT**

In this method the source of radiation is an X-Ray device or Radioactive Isotope. X-rays are passed through the material and are captured on film just like in a simple X-ray. Digital Devices are also used to capture X-Rays. After the film is processed an image is obtained which shows Variation in density. The density change depicts the imperfections.

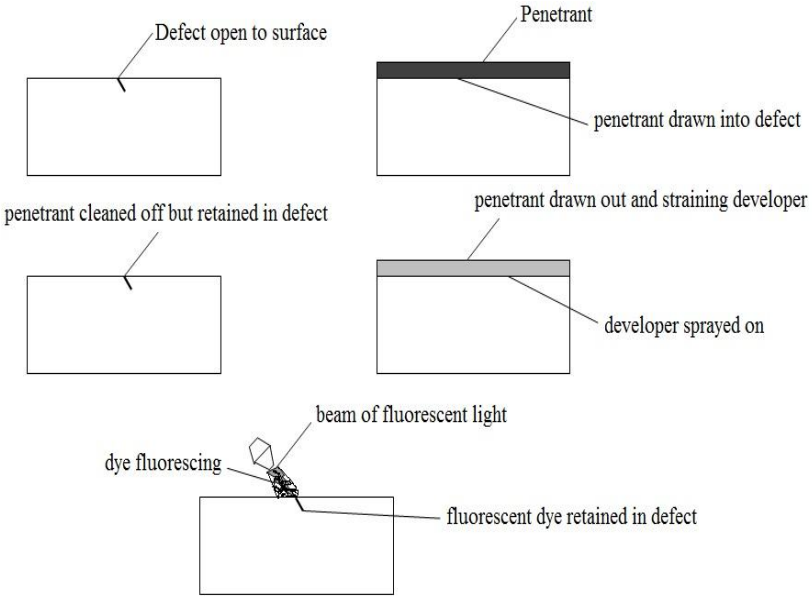

Fig. 1: Non Destructive Evaluation (NDE) Principles

5.2 Surface Examination Method

- **Visual Inspection-VT**

It is the oldest method. A component is scanned using high power lens or Cameras to determine the Surface condition of that component.

- **Liquid Penetrant-LP**

In this method visible or fluorescent dye solutions are used to coat the test object. The dye in excess is removed. Penetrant is made to flow out of the imperfections. With the naked eyes, the change in color between the penetrant and developer is used. In case the imperfection is not visible with the naked eyes, ultraviolet lamp is used to see the imperfections.

- **Magnetic Particle-MP**

Magnetic particle is a fast and easy method used in iron and steel materials for the detection of surface irregularities. Magnetic flux lines and magnetic particles are used to detect the defects in components. Wherever the magnetic flux lines changes, discontinuity is located.

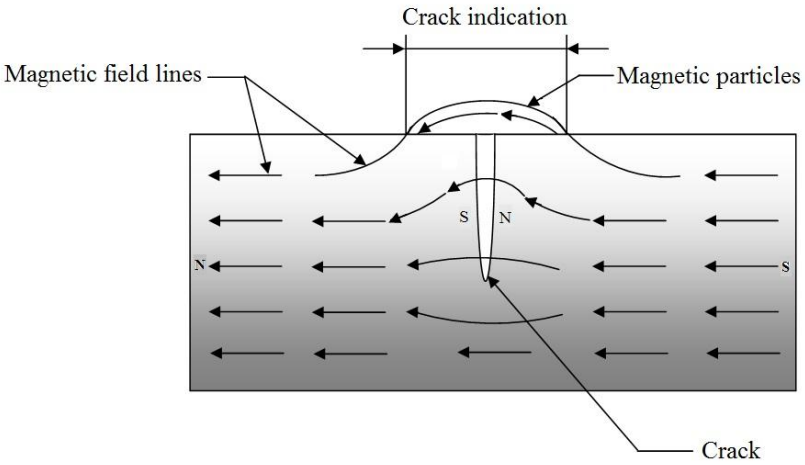

Fig. 2: Magnetic Particle Inspection Method

- **Eddy Current-EC**

It is a non-contact method. In eddy current testing, induced magnetic flux is responsible for the generation of electric current in conductive materials. Imperfections cause the change in properties of material and change the induced magnetic field. When detected, these changes indicate the imperfections in test material.

5.3 Integrity Examination Method

- **Leak Testing-LT**

Pressure gauges, Soap bubble test, electronic listening devices, Liquid and gas penetrant are used to detect the leak. In pressure Vessels, pipelines and other pressure retaining components, several other technologies are used to detect the leak.

- **Acoustic Emission Testing-AET**

Emission is defined as during stressing a solid material the imperfections grows and if short bursts of acoustic energy are emitted by material, these are known as "Emissions". Special Receivers are used in ultrasonic testing to detect the acoustic emissions. The source of emission is evaluated by studying the intensity, rate and other characteristics of emitted ray. Triangular technique is used to locate the defect.

5.4 Condition Monitoring Method

- **Thermography-Infrared Testing-IR**

The thermal profile of any item, building or machine is generated using thermography in graphic form so that a working temperature assessment is derived. The difference in the component temperature is identified by doing this.

- **Vibration Analysis-VA**

Vibration noise is produced by the rotary machines. The condition of the machine is estimate by monitoring the frequency, amplitude etc. of the vibrations. The vibrations cause some parts of machine to crack or rapture.

VI. Conclusion

Non Destructive testing (NDT) techniques have these common features:

- Some degree of disassembly is used in many cases of machines or structures.
- Thickness measurement would be an exception.
- Real Time monitoring is not offered by any of the techniques.
- Operator skill is required for the interpretation of results.
- Operator must have access to equipment to perform tests.

REFERENCES

[1]. Crack propagation in flat panels stiffened by bonded pads, International Journal of Fatigue, Volume 68, November 2014, Pages 1-9
[2]. Slow crack growth, its modeling and crack-layer approach: A review, International Journal of Engineering Science, Volume 83, October 2014, Pages 6-41
[3]. Predicting crack growth in specimens with overloads and cold-worked holes with residual stresses, Engineering Fracture Mechanics, Volume 127, September 2014, Pages 252-266
[4]. Molecular dynamic simulation of fatigue crack propagation in bcc iron under cyclic loading, International Journal of Fatigue, Volume 68, November 2014, Pages 253-259
[5]. Applying the crack-layer concept to modeling of slow crack growth in polythene, International Journal of Engineering Science, Volume 83, October 2014, Pages 42-56