Student report

OVERVIEW OF NON-DESTRUCTIVE TESTING AND EVALUATION METHODS:MAGNETIC PARTICLE TESTING

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Abstract: This present gives a brief overview of Magnetic particle testing as one of very simple methods of non-destructive testing and evaluation of ferromagnetic materials. Magnetic particle testing is a method based on flux leakage. In case of crack or any other anomality in material, magnetic field will leave material and create leakage field. That leakage field will attract magnetic particles that we put on the surface of material. This way, magnetic particles will visually mark place on material where crack or anomality is located.

Keywords: Electromagnetic field, Non-destructive testing, Non-destructive evaluation, Flux leakage, Magnetic particle

NDT INTRODUCTION

Non-destructive testing (NDT) is defined as the testing if there are some irregularities or flaws in material or object, but without destroying the object or affecting future usefulness of material or object. In other words, NDT allows objects or material to be inspected and measured without damaging them. Non-destructive evaluation (NDE) is used very often interchangeably with non-destructive testing, but NDE, besides defining if some irregularity exist, gives some quantitative descripton of irregularity (e.g dimension). In the future text, I am going to use abbrivition NDT&E for Non-destructive testing and evaluation.

Some basic NDT techniques are:

- Acoustic Emission Testing (AE)
- Computed tomography (CT)
- Electromagnetic testing (ET)
- Interferometry
- Infrared and thermal testing (IR)
- Laser testing
- Leak testing (LT)
- Liquid penetrant testing (PT or LPI)
- Magnetic particle testing (MT or MPI)
- Radiographic testing (RT)
- Ultrasonic inspection (UT)
- Visual and optical testing (VT)

MAGNETIC PARTICLE TESTING

Basics of Magnetic particle testing

MPI uses magnetic fields and small magnetic particles, such as iron filings to detect flaws and irregularities in components. It is very easy to apply this kind of testing and it doesn't require any prior surface preparation like other methods may require. The only requirement from an inspectability standpoint is that the component being inspected must be made of a ferromagnetic material. This method is basically combination of magnetic flux leakage method and visual inspection.

If the bar magnetic is broken, as a result we are going to have two bar magnets, but, if the magnet is just cracked, as a result, magnetic poles (south and north) will form at the edges of crack and, as a result of those two magnetic poles, magnetic field will appear in the air around the crack. This is called magnetic leakage (figure 1) and created field is called flux leakage field.

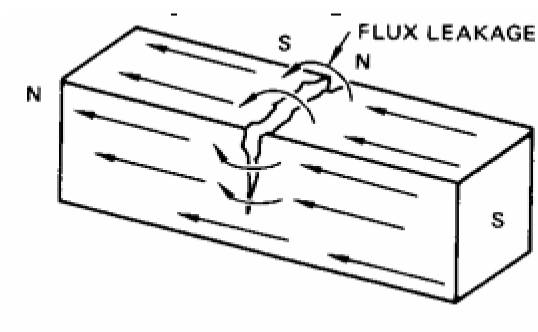

Fig.1 - *Magnetic leakage around crack* [3]

If we put small iron particles on the material, iron particles are going to be attracted by flux leakage field and visually it will be very easy to spot the places of big concentration of particles (figure 2). This is basic principle of magnetic particle testing.

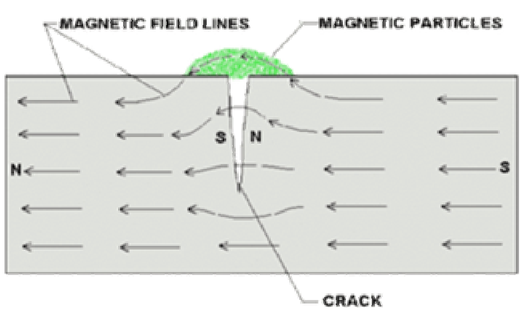

Fig.2 - *Localization of particles around the crack* [3]

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The magnetic particle tesing, as described above, is basically consisted of two phases:

1. The first step of magnetic particle analysis is to magnetize the component that is going to be inspected. If any defect is present on the surface, it will create a leakage field
2. Magnetic particle are applied on the surface. If there is a leagage field, particles will be attracted by the field and clustered around defect.

Magnetic Field Orientation and Flaw Detectability

To be able to make proper inspection, it is very important to understand the result depend on orientation of magnetic field and the crack. There are 2 basic types of magnetic field. A longitudinal magnetic field has magnetic lines of force that run parallel to the long axis of the part (figure 3) and this kind of magtic field can be established using electromagnet (solenoid) or permanent magnet.

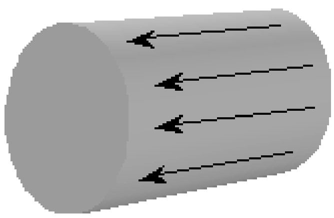

Fig.3 - *Longitudinal magnetic field* [3]

A circular magnetic field has magnetic lines of force that run circumferentially around the perimeter of a part (figure4). A circular magnetic field is induced in an article by either passing current through the component or by passing current through a conductor surrounded by the component.

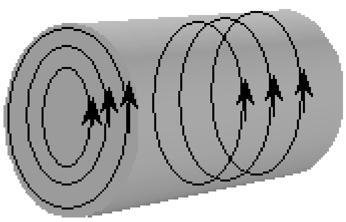

Fig.4 - *Circular magnetic field* [3]

Being able to magnetize an object with the different direction of magnetic field is very important because the best result will be if magnetic field and crack are orthogonal. That is because leakage field will be biggest in the case of orthogonality. That's why proper inspection require that object is magnetized in two direction at right angles to each other (usually under 90 degrees).

Magnetization of Ferromagnetic Materials

There are two basic types of magnetization: magnetization using direct induction (direct magnetization) and magnetization using indirect induction (indeirect magnetizing). Direct magnetization consider passing current throught the object (figure 5). This way, a circular magnetic field will be created.

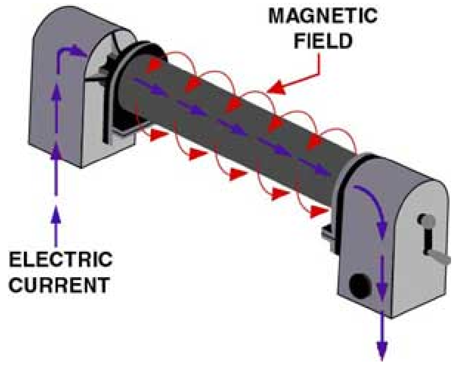

Fig.5 – *Direct magnetization* [3]

When using direct magnetization, it is very important to provide good contact between the test equipment and the test component.

Indirect magnetization is accomplished by using very strong external magnetic field to establish magnetic field within the object (figure 6). External magnetic field can be created using a permanent magnet or using a electromagnet. Permanent magnet is used rearly because it is very difficult to create field that will be stroing enough and it is very difficult to control it.

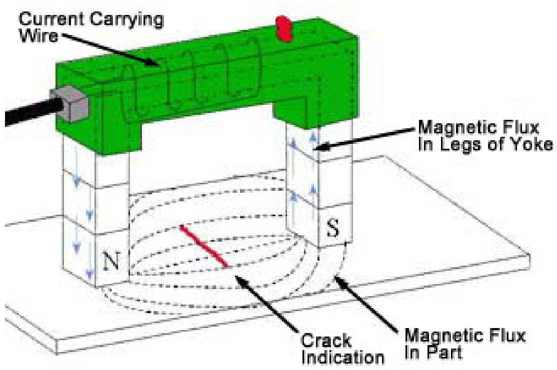

Fig.6 – *Indirect magnetization* [3]

As a electromagnet a solenoid can be used. This way, it is very easy to create a longitudinal magnetic field within the object if the dimentions of the solenoid are bigger then dimensions of the object (figure 7).

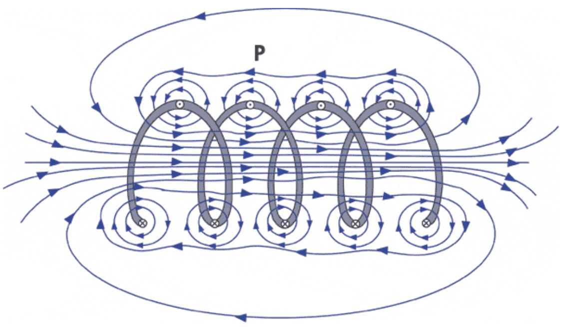

Fig.7 – *Magnetic field of a solenoid* [3]

If the testing object is cylindrical, the magnetic field can be easily producing using a simple central conductor.

Demagnetization

After testing is finished, it is very important to demagnetize the component. There is several ways to perform this task. One is to heat material above Curie temperature (when material looses its magnetic properties).

Another way is to use slowly reducing AC current as shown on figure 8.

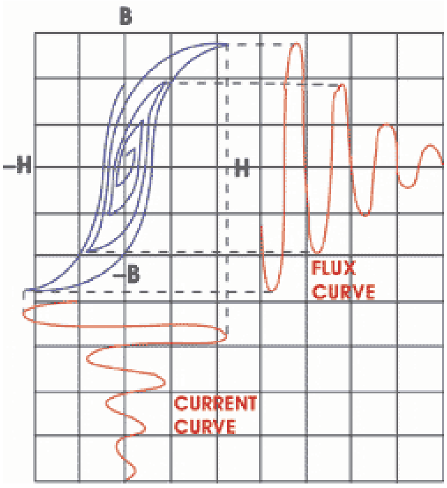

Fig.8 – *slowly reducing AC current used for demagnetization* [3]

CONLUSION

Magnetic particle testing is one of non-destructive methods based on flux leakage principle. This kind of testing don't give many information about a crack, only the position. But, this method don't require a lot of preparation before inspection and, also, test equipment is very simple and easy to implement in portable version.

REFERENCES

[1] American Sociaty for Nondestructive Testing website, http://www.asnt.org

[2] The British Sociaty for Nondestructive Testing website, http://www.bindt.org

[3] The NDT resource center website, http://www.ndt-ed.org

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He received many prestigious world-known awards and certificates for his creative work. Hence, he is included in the work of world groups of creativity, research and new technology in Brussels, Moscow, Pittsburgh and other world cities. He is also involved in research projects from the field of theoretical electrical engineering in Germany, Belgium and Russia.