asdf

SURFACE NON - DESTRUCTIVE TESTS (NDT)

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 Here there is the Italian version of this article.

Introduction

In the industrial sector, during the production cycle of a component, it is often necessary to perform some **non-destructive tests**.
They serve to check and verify the integrity of a product, **without altering** its material, and to detect its defects.
These tests don't cause damage to the material and are not invasive. So they emit an opinion of approval or disapproval of a certain product or component.
One of their benefits is that it is possible to allow a more durable life of components analyzed, because the defect is revealed before the end of the working and so it is also possible to have an economic saving.
Moreover NDT range is so vast: in fact they can analyze various types of material: metallic ones and non metallic ones and they also allow to analyze the products with various shapes and thicknesses.

All these benefits have given them, in the last years, a more central role in the field of industrial processes.

An important distinction

It is necessary to make an important distinction within the NDT, which distinguishes them into two categories:

- **surface non-destructive tests**, which give the opportunity to analyze the material only at a superficial level or at least not in depth;
- **volumetric non-destructive tests**, which allow to ceck in depht the material in order to measure defect's depht and then material integrity.

However the first type of test and second one have both some limits so is often used to perform a superficial non-destructive method together with a volumetric one.

In this article I want to give a limited overwiev for each of the types of superficial non-destructive methods, which are:

- **visual inspection** or **visual test** ;
- **dye/fluorescent penetrants** ;
- **magnetic particles test** ;
- **thermography** .

Visual inspection

It is directly executed by the operator and is mostly used in order to detect specific surface characteristics such as alignment, size and shape of machine components.
There are two modes of visual inspection:

- **direct mode**: it is widely used, is very cheap and it is also complementary to other non-destructive test;
- **indirect mode**: it is used when it is difficult to acces area to be analyzed and requires the use of sophisticated equipment.

Dye/fluorescent penetrants

It consists in depositing a liquid substance with low surface tension on the surface of the material to be examinated so the defects in the component absorb the liquid by capillarity principle.
After a thin layer of another substance named **detector** is deposited on material surface in order to evidence the capillary.
This method will create some indications at the difect, which are visible to naked eye.
So in summary this non-destructive test is based on three physical principles:

- **wettability** ;
- **capillarity** ;
- **surface tension** .

Wettability indicates the attitude of a liquid to expand on a surface. An important parameter determining if a surface is wet is the **contact angle**. If it is less than

90°, then the surface is really wet, but if it is more than 90° the forces of cohesion between the molecules of the liquid prevail over the forces of adhesion between the liquid molecules and the surface.

Surface tension can be defined as the energy necessary to increase by a unit quantity the surface of a liquid. It is similar to the forces of cohesion between the surface molecules of a liquid. So a liquid with an high surface tension has a low wettability and vice versa.

Capillarity is based on the interactions between the molecules of a liquid and the walls of a very thin tube and so allows a liquid to rise to the very thin tubes. This phenomenon is explained by the fact that a bond between the molecules of the liquid and the walls of the tube is established and so it brings the liquid to assume a concave shape up.

The phases of this test are the following ones:

- the surface must be prepared carefully;
- depositing the penetrant;
- removing the excess penetrant and desiccation;
- depositing detector and observing the indications.

After preparing the surface and depositing penetrant, the latter must act for a sufficient time to ensure that it is absorbed by the surface defects. This time depends form the type of penetrant used and also by the type of defect to be detected.
The excess penetrant must be removed with caution in order to avoid even the penetrant trapped in defects and, after dessication, the detector must be applied. The detector provides an indication which is larger than the real one, then working as a magnifying glass. Detector time does not exceed 5 minutes.

In the figure below (drawn from: http://www.pentatest.it/servizi/controlli-non-distruttivi/liquidi-penetranti) is shown a piece of a component analyzed by using dye/ fluorescent penetrant:

Magnetic particles test

This type of test is based on the variation of the magnetic field due to the presence of surface defects and it is only used for ferromagnetic materials (e.g. as cobalt, iron, nickel and its alloys). It is widely used in various industrial sectors such as automotive, aerospace, petrochemical one or energetic production one.
As mentioned before the *magnetic particles test* is based on the physical principle of **magnetism** which can be intuitively defined as the property of material to win over other matters.
From the point of wiev of magnetism, the materials can be distinguished in the following ones:

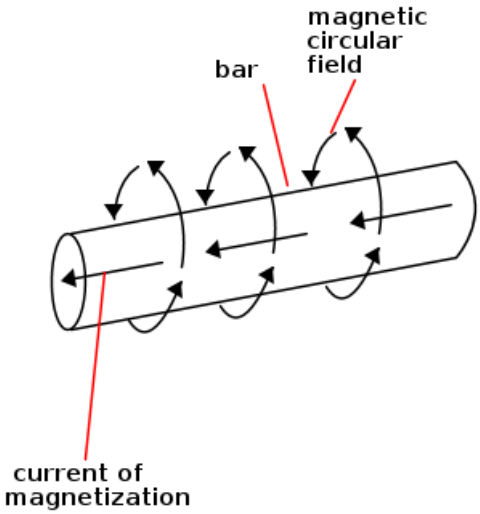
- *diamagnetic materials* that can not be magnetized (e.g. mercury, silver);
- *paramagnetic materials* that can be magnetized and they also are attracted by the magnetic fields (e.g. molybdenum, aluminum);
- *ferromagnetic materials* that are strongly attracted by magnetic fields.

The phases of this test are the following ones:

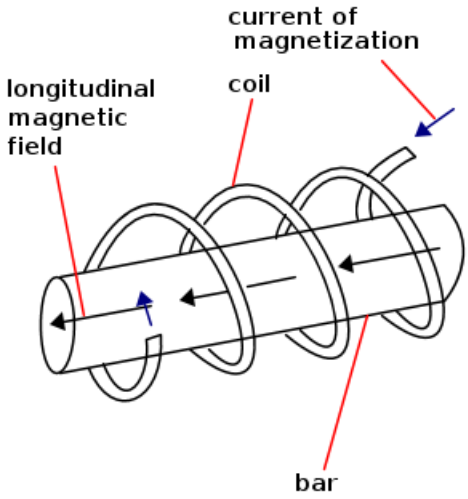
- preparing the surface;
- magnetize the piece;
- depositing coloured or fluorescent ferromagnetic powder;
- illuminating the surface and inspecting the same one;
- possibly demagnetizing the piece.

As always the surface must be carefully prepared by removing all traces of oil, dust and grease because they may act as contaminants making difficult the display of the indications or altering them.
After this phase, the piece must be magnetized. There are two magnetizing modes:

- **circular magnetization**: thanks to the passing of an electrical current it is possible to obtain a circular magnetic field on the piece;



- **longitudinal magnetization**: the piece is magnetized by a magnetic field pre-existing, produced by a coil traversed by an electric current and then all that creates a longitudinal magnetic field to the piece



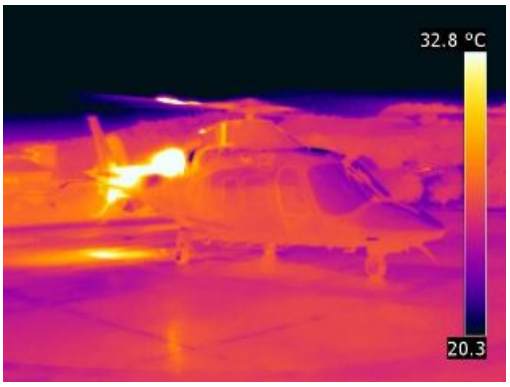
An important condition that can detect the defect is that its orientation with respect to the lines of magnetic flux density is between 45° and 90°.
After the ferromagnetic powder is applied; there are two modes of powder depositing:

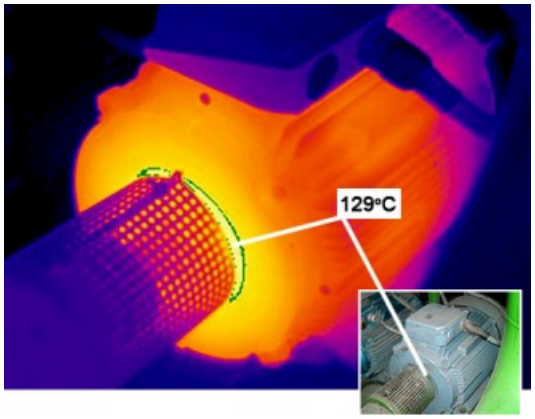
- *continuous method* in which depositing powder and magnetization occur simultaneously;
- *residual method* in which the powder is deposited by using the residual magnetization, after the phase of magnetization has finished.

Finally the surface must be illuminated in order to point out the defects. The demagnetization is optional and it is necessary to be executed when the magnetic field could interfer with the following mechanical workings.

Thermography

Thermography requires heating the component to be tested and measuring the temperature T which comes as a result of infrared radiation emitted from the surface and detected by certain sensors. This type of test is based on the principle of **emissivity** that is the ability of material surface to emit energy by radiation.
The image is captured through a camera, "connected" to a software that allows to scan the picture, drawing a map with different levels of thermal colors, which distinguish the various levels of radiation.From observations of the indications are identified, then the defects.
Thermography is mostly used in construction, energy sector and automotive.





termography (the image is drawn from: http://www.pagineguida.com/termografiacnd/)

an example of mechanical-thermography (the image is drawn from: http://www.monition.com/mechanical-thermography.html)

Estratto da "http://www.electroyou.it/mediawiki/index.php?title=UsersPages:Asdf:the-superficial-non-destructive-methods"