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Properties of Materials Laboratory

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Introduction and Objective:

Non-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed, the part can still be used. NDT methods can detect surface flows as well as internal flows.

Many methods of NDT can be applied on testing a specimen, in this experiment we will be inspecting a piece of metal (a steel tube) for defects using three of them: The magnetic particle method (Electro Magnetic Yoke), High frequency eddy current method, and Ultrasonic unit (Ultrasound test).

Materials and Equipment's:

1) Steel tube
2) Black magnetic ink

3) Iron magnetic powder

4) Electro-magnetic yoke

5) Aluminum and steel specimens
6) Locater UH high frequency eddy current unit probes

7) Ten-eleven SG ultrasonic unit and transducer

8) Ferrous and non-ferrous specimens

Experimental Procedure:

Magnetic particle method (electromagnetic Yoke)

Procedure:

1) Clean inspected area of specimen with steel brush and wipe off with cloth.
2) Place yoke on test piece perpendicular to direction of suspected cracks.
3) Energize yoke magnetic field will form in test piece.
4) Apply magnetic ink or powder while yoke is still energized
5) Indications will form immediately.

High frequency eddy current method:

Procedure:

1) Connect probe required and set the frequency switch to match.
2) Set type of alarm condition required.
3) Set the metal selector-switch to match the metal to be tested.

4) Set alarm level required.
5) Switch to “ON”.
6) Place probe on surface of sound part of the metal
7) Press the release “TRAIN” bottom, Lower L.E.D lights up, Raise probe until upper L.E.D lights. Lower probe to surface, raise probe again until upper L.E.D lights, lower probe to surface. “TRAIN” period is ended when both L.E.D’s are extinguished.
8) Movement upwards during “TRAIN” should be only a fraction of a (mm). Downward movement to the surface of the metal should be gentle.
9) Probes with flat ends should be held accurately perpendicular to the metal surface during the train procedure.
10) Ideally the probe should be raised and lowered about twice/sec during the train period but this is not critical. After two or three cycles, the probe may be left resting on the metal until the train period is offer.
11) Ensure that left-off is compensated by raising the probe slightly by inserting a plastic spacer (0.1-0.2) and check that meter deflection is less than 20% when sensitivity is set at 5.

Now that GMH2 flat-end shielded probes will compensate only over very short distances, so lift-off is best checked by rocking the probe by say +/- 15 degrees.

12) The unit is now compensated for lift-off and will indicate surface breaking cracks. Sensitivity may be set by training on the calibration block of similar metal and setting the deflection of a given slot depth e.g. 80% deflection for 0.5 mm slot.
13) Move the probe lightly across the work piece surface, maintaining the probe approximately perpendicular to the surface of the sample.
14) A crack will be deflection by a sharp kick on the meter.
15) The meter deflection is at a maximum when the probe head is over the center of the crack. The magnitude of the deflection indicates the severity of the crack.

Ultrasonic testing

1) Connect transducer as a Tx “transmitter” or Rx “receiver”
2) Set gain required
3) Set range required
4) Turn on the unit
5) Set focus needed
6) Place lubricant “oil, water” on the surface of the workpiece.
7) Place transducer on surface of the metal
8) Move the transducer gently across the workpiece surface.
9) A discontinuity “crack, hole” will be indicated by a pip on the oscilloscope
10) The distance between the blips (pips) is proportional to the depth of the defects.

Discussion:

This experiment was made to detect defects and flaws or cracks on the surface of the specimen. Nondestructive testing (NDT) is used for preventing accidents, monitoring conditions and assure safety and reliability. Nondestructive testing does not destroy the material in any way.

Nondestructive testing can detect surface flows and internal flows.

- Surface flows can be detected using: •Visual inspection
  • Magnetic particle methods
  • Electrical methods

- External flows can be detected using: • Acoustic methods: Sonic and Ultrasonic methods
  • Radiological methods which may be subdivided into x-ray examination and gamma-ray examination.

- Visual inspection: • Fluorescent-penetrant inspection: -It finds invisible surface cracks and defects.
  -This method is widely used for testing and inspection on iron, steel, aluminum, bronze, tungsten carbide and nonmetals such as glass and ceramics.

- Dye penetrant: -This method is called Spot-check, by the Magnaflux Corporation.
  -In this method, soaking time should be sufficient to get the penetrant into fine cracks.
  -a bright colored indication marks the defects.
  -Spot-check is available in sealed pressure spray cans or for brush or spray gun application.
  -Advantages: portability for remote uses or for rapid inspection of small sections in the shop, low cost, and ease of application.

- Magnetic particle method (electromagnetic Yoke) : -a procedure used to determine the presence of defects at or near the surface of ferromagnetic objects.
  -It is based on the principle that if an object is magnetized, irregularities in the material, such as cracks or non-metallic inclusions, cause an abrupt change in the path of a magnetic flux flow through the piece normal to the irregularity, resulting in a local flux leakage field and interference with the magnetic lines of force.
  -This interference is detected by the application of a fine powder of magnetic material. Surface crack is indicated by a line of fine particles following the outline of the crack.

- High Frequency eddy current method: -This method is only suitable for the detection of surface and near surface defects in products of uniform section such as bars, rods, tubes, and wire.

- Ultrasonic Testing: -Ultrasonic testing uses frequencies in the range of 0.5 to 20 MHZ.

  -Ultrasonic vibrations, in contrast to audible vibrations, are not easily transmitted through gases.
  -discontinuities and interfaces particularly with air cause ultrasonic vibrations to bd almost completely reflected.
- Flaw Detection: Ultrasonic waves may be used in two ways for flaw detection: -The pulse-reflection method. -Transmission method

1. The pulse reflection method: -By far it is the most used.

-Advantages of this method are: the distance of the defect from the transmitting-receiving crystal can be accurately measured and also that this measurement can be made for just one side of the component.

2. Transmission method: -A continuous ultrasonic beam is used.
    - In the transmission method the two surfaces of the component on which the probes are used must be parallel because if the ultrasonic beam reaches the opposing face at am angle, there will be refraction in addition to reflection.

- Radiographic Testing: -It utilizes the ability of X-Rays pr gamma rays that are emitted from radioactive materials.
    - The test results are determined from a radiograph, which is a film exposed to radiation that has gone through the test material.
    - Portable X-ray analyzers are used for verifying and sorting metals and alloy content and impurities.
    - These devices are ideal for sorting scrap metals for producing high integrity steel and nonferrous metals.
    - A radiation detector may be used to determine material thickness.

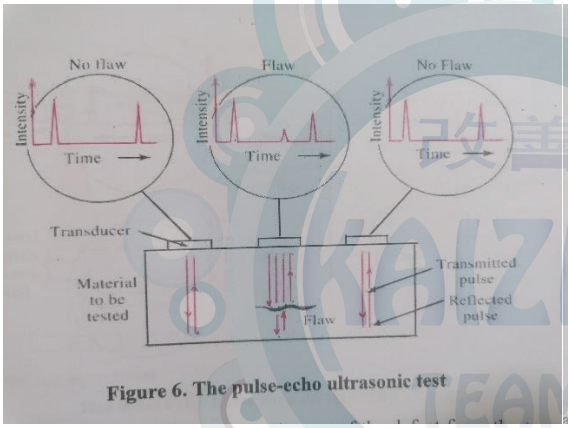

Figure 6. The pulse-echo ultrasonic test

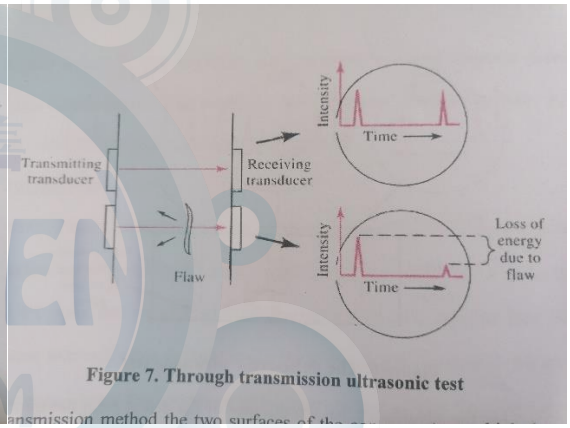

Figure 7. Through transmission ultrasonic test

Conclusion and results:

In this experiment we used three types of tests to detect defects in a piece of metal (steel tube) and ensure that it is free of defects without having to damage it. Therefore these tests are called (non-destructive testing).

This type is classified as follows:

1. The magnetic particle method (electromagnetic yoke).
2. High frequency eddy current method.
3. Ultrasound test.

As a result, we were able to inspect the same steel tube in three different ways without having to destroy it and dispose of or replace it at each test, thus reducing cost.

References:

Experimental Laboratory Manual in Materials Science and Engineering

YouTube videos

Notes from the experiment