Engineering Materials

Module 3: Destructive and Non-Destructive Testing

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IAT Curriculum Unit

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Module 3: Destructive and Non-Destructive Testing

Module Objectives

After the completion of this module, the student will be able to:

- differentiate between destructive and non-destructive testing.
- Explain the importance of using destructive and non-destructive testing to find the material properties and to locate defects.
- distinguish between tensile, compression, hardness, and toughness tests.
- differentiate between visual, die penetrant, magnetic particles, ultrasonic, and radiographic tests.
- evaluate the use of certain tests to examine materials based on their properties.

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Introduction

Once it is recognized that material properties are important to the suitability of the material for a certain application, it becomes necessary to determine the actual values to effectively design a structure using materials having the desired characteristics.

There are many tests used to determine the various mechanical properties of metals. While some of these tests provide values for more than one property (eg. tensile test), most are designed to determine the value for a specific characteristic of the metal. Therefore it may be necessary to perform several different tests to determine all the desired information.

Test methods are usually grouped into two classes, destructive or non-destructive. Destructive tests make the material or the part useless for service once the test has been performed. Nondestructive testing (NDT) does not affect the component regarding its further usage. NDT is used to examine the properties of an object or material without causing damage.

1. Destructive testing

Destructive tests determine how materials behave when loaded to failure. Tensile, compression, hardness and impact tests are examples of destructive tests that are used to measure the mechanical properties of the material and provide actual values to effectively design a structure using the proper thoroughly materials.

1.1 Tensile test

Tensile tests are simple, relatively inexpensive, and fully standardized. By pulling on a test piece (see Fig. 3.1), you will very quickly determine how the material will react to forces being applied in tension. As the material is being pulled, you will find its strength along with how much it will elongate.

As you continue to pull on the material until it breaks, you will obtain a good, complete tensile profile.

Details of the tensile test will be discussed in the next module.

1.2 Compression test

A compression test determines the behavior of materials under compression forces as shown in Fig. 3.2. The specimen is compressed and deformation at various loads is recorded. Compressive stress and strain are calculated and plotted as a stress-strain diagram. The compression test will be discussed in module 5.

1.3 Hardness test

Hardness as discussed in module 2 is the ability of the metal to resist indentation. Hardness tests are performed using some type of penetrator which is forced against the surface of the test object. Depending upon the type of hardness test being used, either the diameter or depth of the resulting indentation is measured as shown in Fig. 3.3.

The hardness test procedure, evaluation and types will be discussed thoroughly in module 6.

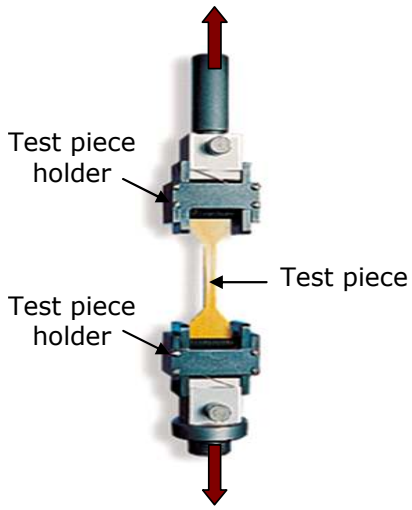


Fig. 3.1: Tensile test.

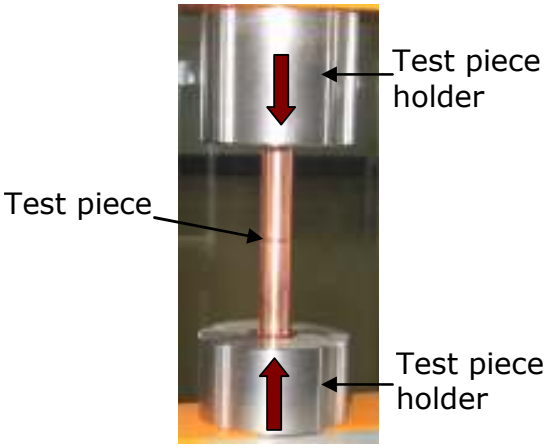


Fig. 3.2: Compression test.

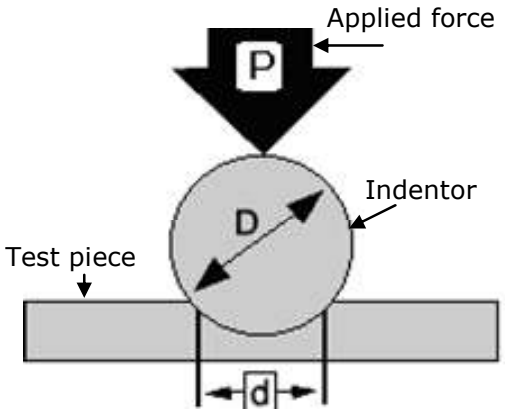


Fig. 3.3: Hardness test.

1.4 Impact test

Impact testing is testing the object's ability to resist sudden shock. As explained in module 2, toughness is the ability of the material to withstand sudden shock or load. The impact test is used to determine the energy absorbed in fracturing a test piece at high velocity as shown in Fig. 3.4. The impact resistance of a part is a critical measure of its service life.

Further details on how to conduct the test and evaluate its results will be discussed in module 7.

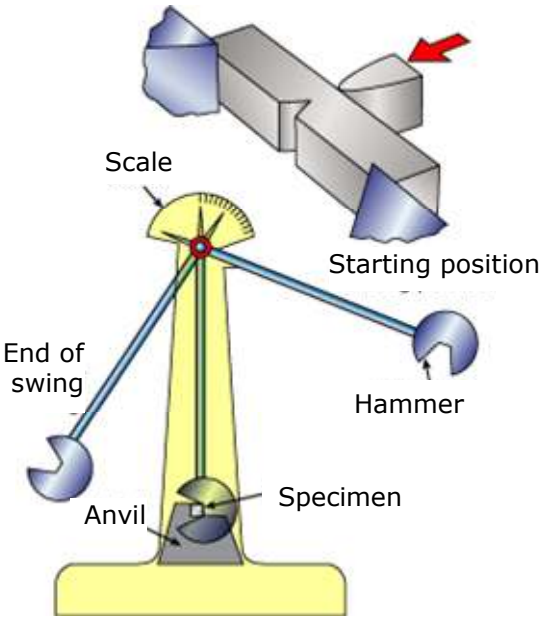


Fig. 3.4: Impact test.

2. Non-Destructive Tests

The major disadvantage of destructive tests, as the name implies, is that the test object is destroyed in the process. Therefore, a number of tests have been developed to provide an indication of the acceptability of the test object without destroying it. These various tests are referred to as 'non-destructive tests'. Non-destructive tests, by definition, leave the test object unchanged and ready to be placed in service if acceptable.

There are numerous non-destructive tests used to evaluate the material, the most commonly used ones are:

1. Visual Test (VT)
2. Die Penetrant Test (PT)
3. Magnetic Particles Test (MT)
4. Ultrasonic Test (UT)
5. Radiographic Test (RT)

2.1 Visual Test (VT)

Visual test is considered the most important non- destructive test, it will result in the discovery of the vast majority of defects which could be found later using some other more expensive NDT methods.

Visual inspection will examine only surface defects, however internal and subsurface defects could be identified using other NDT methods.

During the test it is important to have a good lighting source and a magnifier, which will help in the visual interpretation of defects. See Fig. 3.5.

Fig. 3.5: A technician conducting a visual test.

2.2 Die Penetrant Test (PT)

Die penetrant test is used to locate discontinuities which are opened to surface (surface discontinuities). This is done by applying a penetrant to the cleaned surface of the test piece. Once this penetrant is allowed to remain on the surface for a certain time (dwell time), it will be drawn into any surface opening as shown in Fig. 3.6(a). After that excess penetrant is removed (Fig. 3.6(b)) and the developer is applied (Fig. 3.6(c)). The developer draws the remaining penetrant from discontinuities. The resultant indications are shown in high contrast and magnify the presence of the discontinuity so that it can be visually interpreted as shown in Fig. 3.6(d). The die penetrant test procedures, limitations, and details will be discussed in module 8.

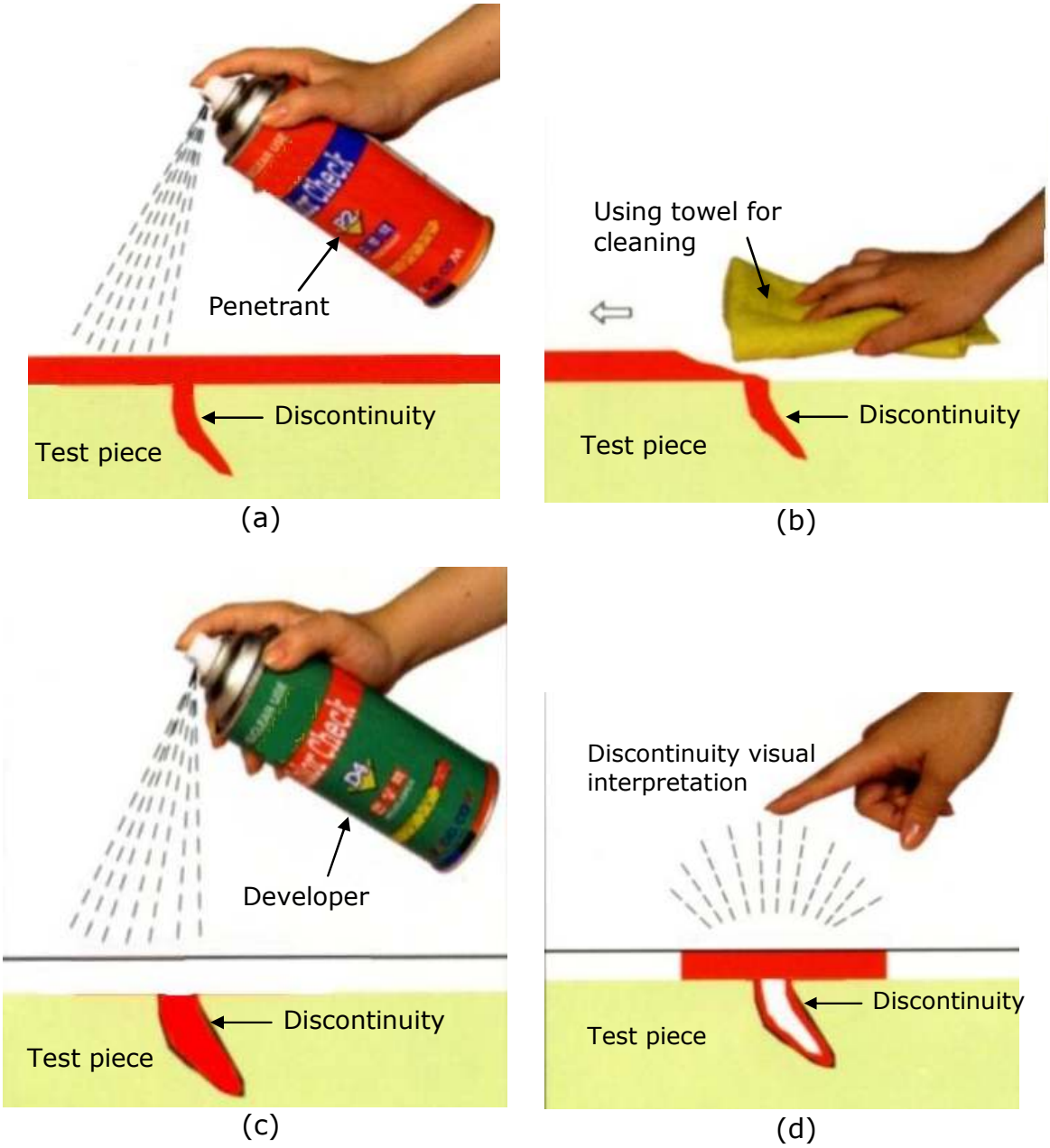


Fig. 3.6: (a) Appling penetrant. (b) Cleaning. (c) Applying developer. (d) Interpreting discontinuities.

2.3 Magnetic Particles Test (MT)

Magnetic particles test method is used primarily to discover surface discontinuities in ferromagnetic materials, however indications can be observed as well from subsurface discontinuities which are very close to the surface. Discontinuities present in a magnetized part will cause the applied magnetic field to create poles of opposite sign on either side of the discontinuity, creating a very attractive force for iron particles. If iron particles are sprinkled on this surface, they will be held by this attractive field to produce an accumulation of iron particles and a visual indication as shown in Fig. 3.7. Magnetic particles inspection will be discussed thoroughly in module 9.

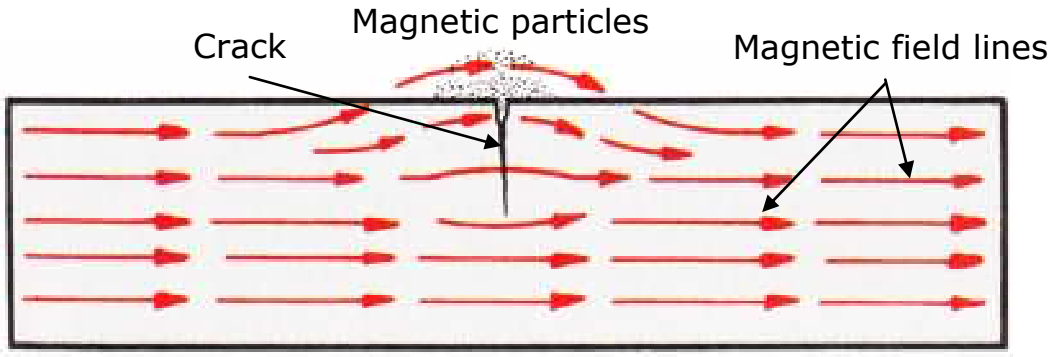


Fig. 3.7: Magnetic particles test.

2.4 Ultrasonic Test (UT)

Ultrasonic testing (UT) is an inspection method which uses sound waves, well above the range of human hearing, to measure geometric and physical properties in materials. Sound waves travel at different speeds in different materials. However, the speed of sound propagation in a given material is a constant value for that material. Sound waves can be used to detect cracks and internal discontinuities for almost any kind of material. By observing the echoes that are reflected from the material, it is possible to judge distances by the length of time required to receive an echo from any discontinuity as shown in Fig. 3.8, however highly skilled technicians are required to interpret these results and locate discontinuities if any.

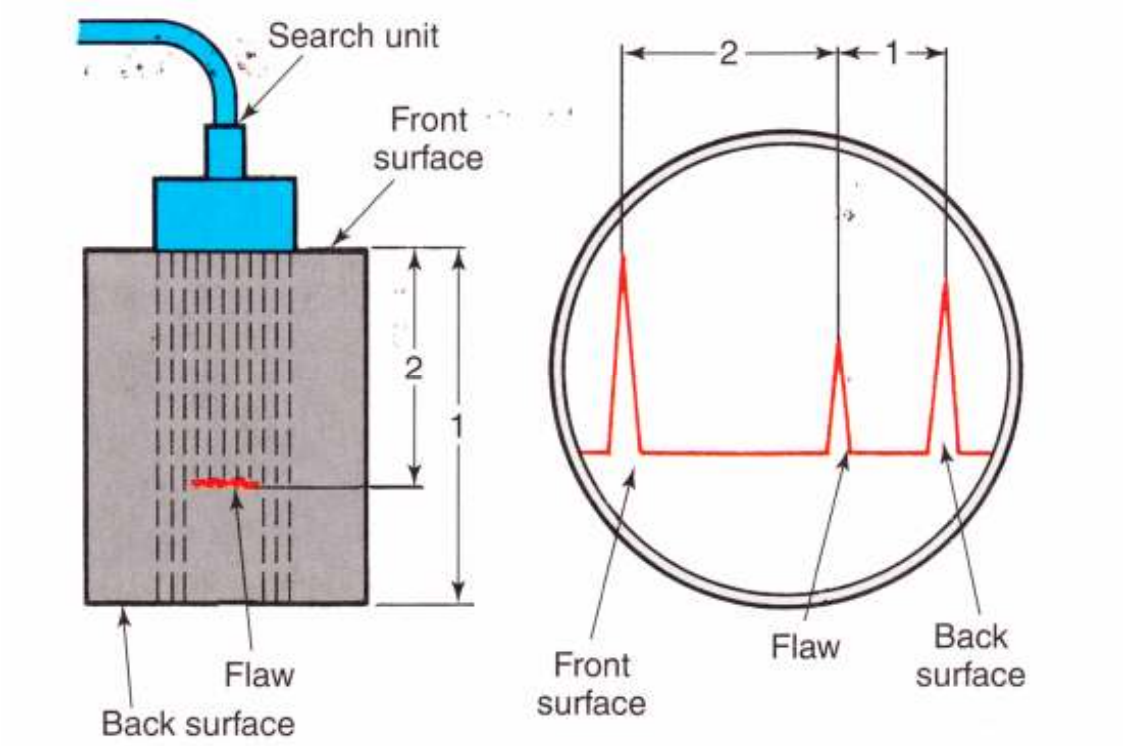
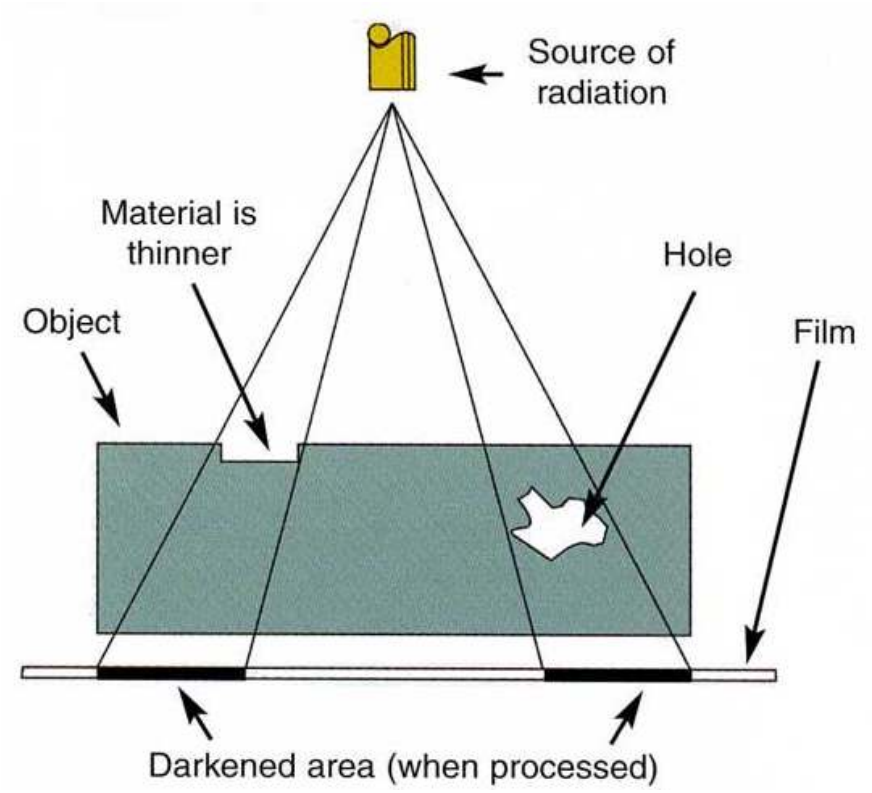


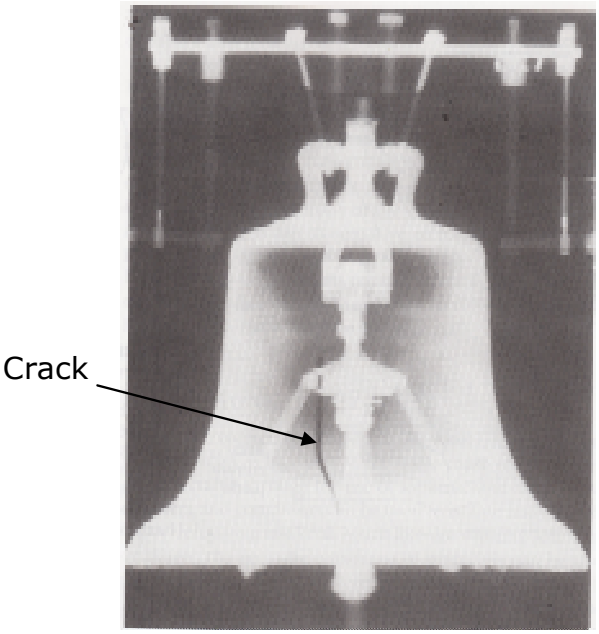
Fig. 3.8: Ultrasonic test.

2.5 Radiographic Test (RT)

The radiographic test involves passing gamma rays through a part and onto light sensitive film to detect internal flaws (cracks, pores, etc.). It is widely used in the inspection of critical parts and material. The technique involves the use of radiation projected through the object under inspection and onto a section of photographic film as shown in Fig. 3.9(a). The developed film has an image of the internal structure of the part or assembly as illustrated in Fig. 3.9(b).



(a)



(b)

Fig. 3.9: (a) Radiographic test technique. (b) Radiograph of a bell showing a crack.

Activity 1

For each of the non-destructive testing methods shown below list one major limitation to its use:

a. Visual test.
b. Die Penetrant test.
c. Magnetic test
d. Ultrasonic test
e. Radiographic test.

Use the engineering materials class's blog created by your instructor to post your answers.

3. Supplementary recourses:

1. Mechanical and Non-destructive testing video.

4. References:

1. Machining Fundamentals by John R. Walker
2. Materials and Processes in Manufacturing, tenth edition by J T. Black and Ronald A. kosher.
3. Different internet sites.

Student's notes