Engineering Materials

Module 9: Magnetic Particles Test

PREPARED BY

IAT Curriculum Unit

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Module 9: Magnetic Particles Test

Module Objectives

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

- Explain the basic principles of the magnetic particles test.
- Describe the main parts of the magnetic particles Kit used to perform the magnetic particles test.
- Differentiate between wet magnetic and dry magnetic particles.
- Carry out a magnetic test for different speciemen using a certain procedure.
- Record and report the defects using standard NDT report.

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Introduction

Magnetic Test (MT) or Magnetic Particle Inspection (MPI) is a nondestructive testing method used for defect detection on ferromagnetic materials.

MT uses magnetic fields and small magnetic particles (i.e. iron filings) to detect surface and subsurface (1-2mm below the surface) flaws in components which must be made of a ferromagnetic material such as iron, nickel, cobalt, or some of their alloys. The MT method is used to inspect a variety of product forms including (Fig. 9.1):

- castings,
- forgings, and
- weldments

Many different industries use magnetic particle inspection for determining the components fitness-for-use such as the structural steel, automotive, and aerospace industries. It can also be used in underwater inspection as shown in Fig. 9.2 to test items such as offshore structures and underwater pipelines.

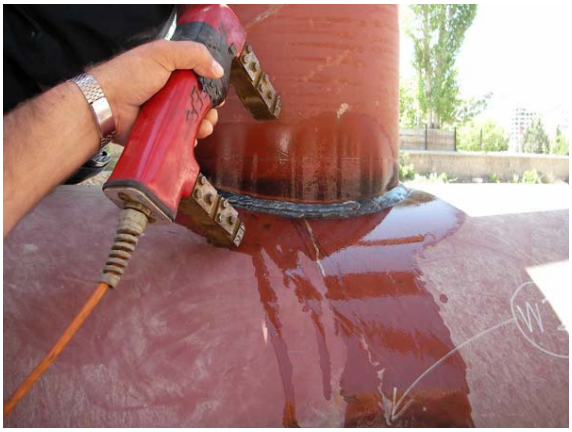

Fig. 9.1: Magnetic particles test of a weldment joining two pipes.

Fig 9.2: A Diver performing underwater magnetic particles test.

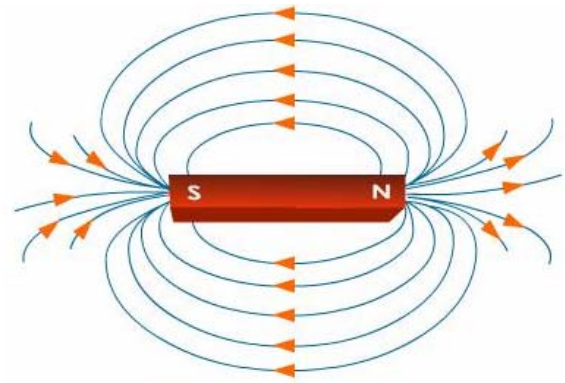

Fig. 9.3: Magnetic flux lines.

1. Basic principles of the magnetic test.

In a bar magnet, the magnetic line of force around the magnet starts from the north pole to the south pole as shown in Fig. 9.3.

If the magnet bar is cracked, a north and south pole will form at each edge of the crack as shown in Fig. 9.4. The magnetic field will still exit the north pole and re-enter the south pole but it will spread out when it faces the small air gap created by the crack (see Fig. 9 4). When this happens, it appears to leak out of the material and, thus is called a flux leakage field.

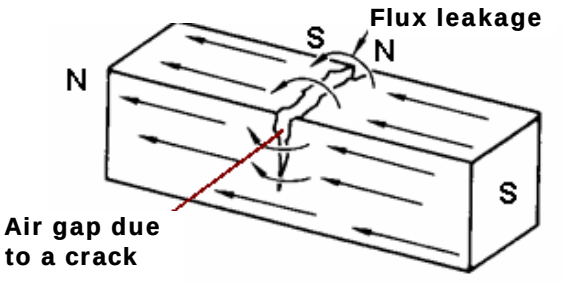

Fig 9.4: Magnetic flux leakage due to a crack.

If iron particles are applied on the cracked magnet, the particles will be attracted to and cluster at the poles that are at the edges of the crack as shown in Fig. 9.5. This cluster of particles is much easier to be seen than the actual crack and these are the basis for magnetic test.

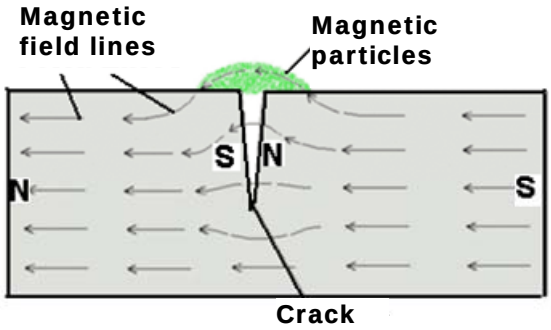

Fig. 9.5: cluster of iron particles

The first step in a magnetic test is to magnetize the component that is to be tested. If any defects on or near the surface are present, the defects will create a leakage field.

The second step is to apply iron particles either in a dry or wet suspended form to the surface of the magnetized part. The particles will be attracted and cluster at the flux leakage fields, thus forming a visible indication that could be detected as shown in Fig. 9.6.

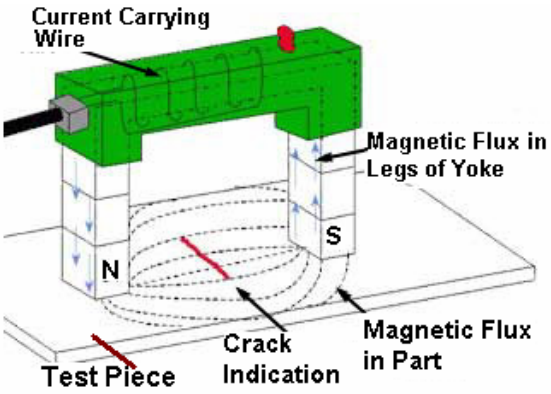

Fig. 9.6: Magnetizing the part to detect a flaw.

2. Magnetic field orientation and flaw detect ability

To properly test a component for cracks or other defects, it is important to understand that the orientation between the magnetic lines of force and the flaw. The best detection of defects occurs when the lines of magnetic force are established at right angles to the longest dimension of the defect (the perpendicular flaw shown in Fig. 9.7).

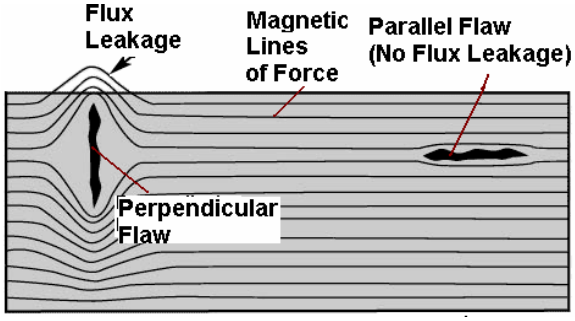

Fig. 9.7: Perpendicular and parallel flaws.

This orientation creates the largest disruption of the magnetic field within the part and the greatest flux leakage at its surface (watch the magnetic field orientation video).

An orientation of 45 to 90 degrees between the magnetic field and the defect is necessary to form an indication. Each part is normally magnetized in two directions at right angles to each other to ensure that the part is completely covered. (Fig. 9.8).

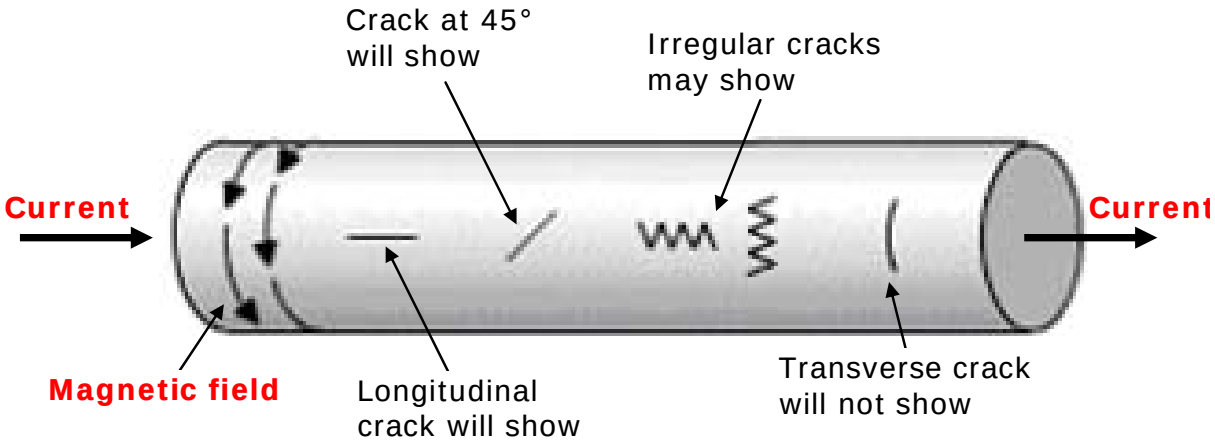

Fig. 9.8: Flaws oriented at different angles.

3. The magnetic test kit

The kit used for the magnetic particles test consists of the following items (Fig. 9.9):

1. Adjustable leg electro-magnetic yoke
2. DC power supply.
3. MPI ink spray can.
4. Kit case
5. White contrast.
6. Grey magnetic dusting powder.
7. Powder spray bulb.
8. Magnetic field indicator
9. Red magnetic dusting powder.
10. Manual air blower.

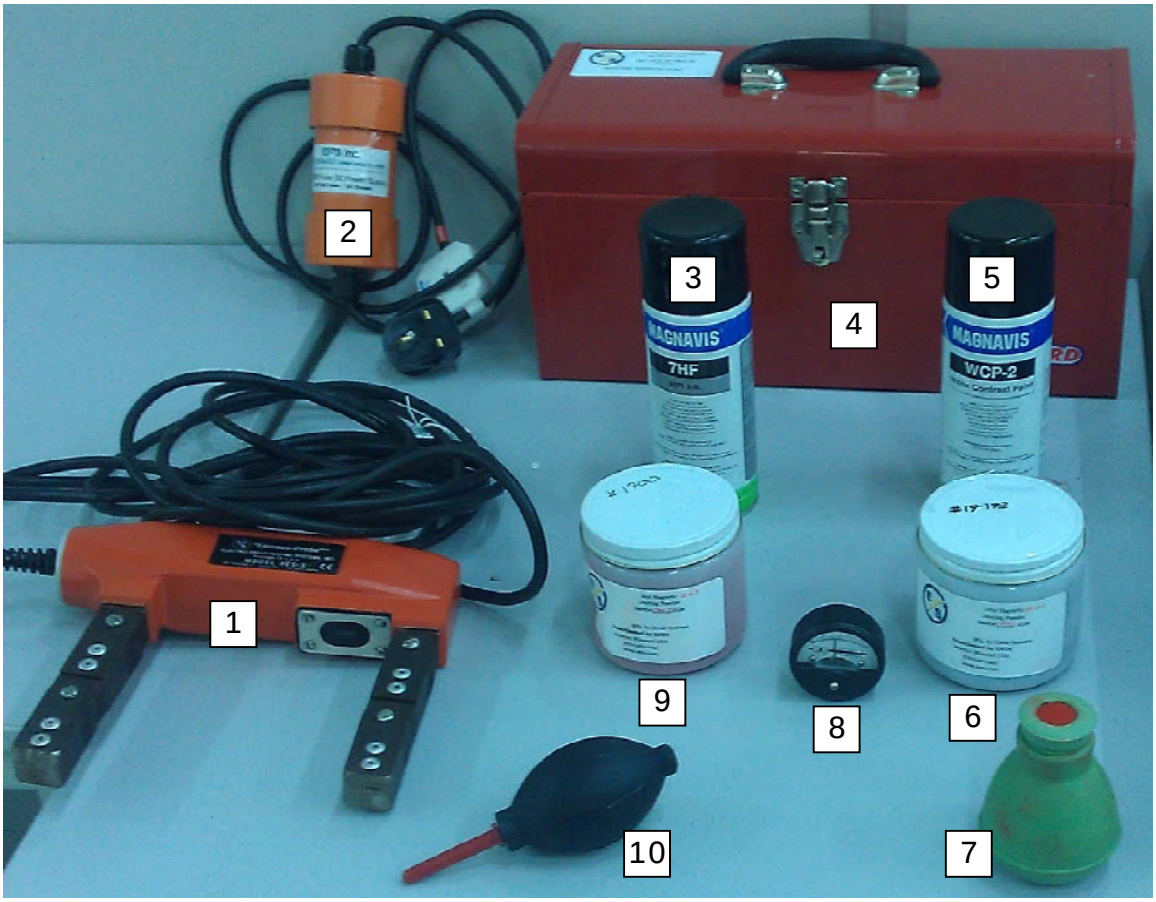

Fig. 9.9: Magnetic particles test kit.

3.1 The electro-magnetic yoke

It is an Electro-magnet that can be used to find defects by producing a strong magnetic field. By placing the two pole pieces of the yoke (yoke legs) on the ferrous material, a path is provided for the intense magnetic field to pass from one pole to another. The electro-magnetic yoke is shown in Fig. 9.10.

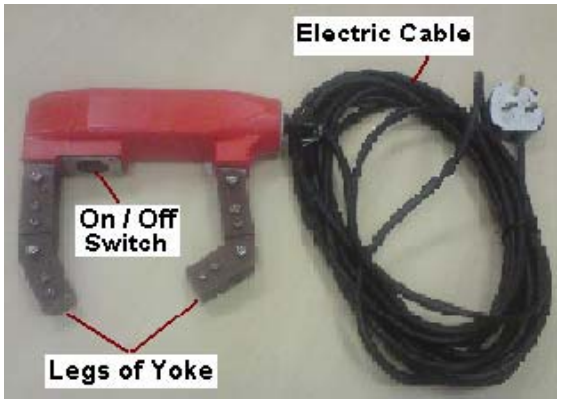

Fig. 9.10: Adjustable leg electro-magnetic yoke.

The ferrous material that is being tested completes the flux path and becomes highly magnetized in unidirectional manner.

A switch (On/Off) is included in the magnetic yoke so that the current and, therefore, the magnetic field can be turned on and off.

3.2 Dry and wet particles

Dry particles are dusted onto the surface of the test object as the item is magnetized as shown in Fig. 9.11. Dry particle inspection is well suited for the inspections conducted on rough surfaces such as ungrounded welds and cast surfaces. (Fig. 9.12).

The wet magnetic particle inspection involves applying the particles while they are suspended in a liquid carrier. (See Fig. 9.13).

A wet inspection has several advantages over a dry inspection.

1. All of the surfaces of the component can be quickly and easily covered with a relatively uniform layer of particles.

Fig. 9.11: Dry magnetic particles inspection.

2. The liquid carrier provides mobility to the particles for an extended period of time, which allows enough particles to float to small leakage fields to form a visible indication.

Therefore, wet inspection is considered best for detecting very small discontinuities on smooth surfaces.

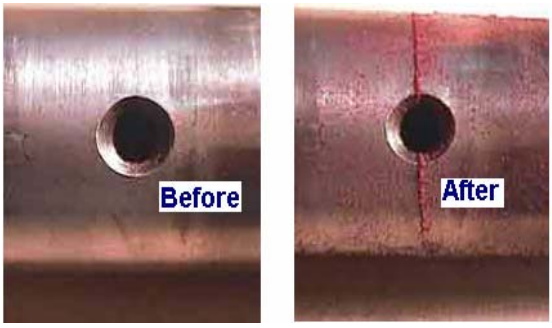

Fig. 9.12: A crack detected after conducting the test.

3.3 Magnetic field indicator

When performing a magnetic test, it is very important to be able to determine the direction and intensity of the magnetic field. The field intensity must be high enough to cause an indication to form. To cause an indication to form, the field strength in the object must produce a flux leakage field that is strong enough to hold the magnetic particles in place over a discontinuity. Flux measurement devices (**Magnetic Field Indicators**) can provide important information about the field strength. (Fig. 9.14).

Fig. 9.13: Wet magnetic particles inspection.

Fig. 9.14: Using a magnetic field indicator to measure the magnetic field.

4. The magnetic particles test procedure:

Use the specimen provided by your teacher and the Magnetic test kit shown in Fig. 9.9 to perform the magnetic test as per the following procedure.

***Note*:** Use plastic or paper sheet on the table to protect it from the (wet/dry) magnetic particles.

1. Surface preparation

The surface should be relatively clean, free of grease, oil or other moisture that could keep particles from moving freely.(Fig.9.15)

2. Apply the magnetizing force

Use the electromagnetic yoke to establish the necessary magnetic flux as shown in Fig. 9.16.

3. Dry or wet particles application

Apply the dry or wet magnetic particles while the magnetizing force is still applied.

a. *Wet particles*: Spray the ink gently over the surface of the part. (Fig.9.17)

b. *Dry particles*: Dust on a light layer and gently blow off the excess powder. (Fig.9.18)

4. *Terminate the magnetizing force.*

Fig. 9.15: Cleaning the test piece.

Fig. 9.16: Magnetizing the test piece.

Fig. 9.17: Applying the wet magnetic particles.

Fig. 9.18: Applying the dry magnetic particles.

5. Inspection

Inspection is then performed under appropriate lighting. Look for areas where the magnetic particles are clustered. Surface discontinuities will produce a sharp indication. The indications from subsurface flaws will be less defined and lose definition as depth increases. (Fig.9.19)

Fig. 9.19: A crack indication detected after inspection.

6. *Turn the yoke 90°* from the original position and repeat steps 2-6.

7. Inspection report

Use the NDT report template provided by your teacher (based on the shape of your specimen) to report your findings. It is required to include all the defects and flaws with their dimensions and location on the test piece.

8. Clean the surface

The final step is to thoroughly clean the surface of the part to make it ready for further tests.

5. Magnetic particles test versus dye penetrant test

Inspection Factor	Magnetic particles	Dye Penetrant
Material	Only materials with a magnetic property.	All metals and ceramics.
Defect location	Surface and subsurface flaws.	Only surface flaws.
Pre cleaning	Important.	Extremely important.
Processing time	Immediate results.	15-30 minutes.
Equipment	Yoke.	None.

6. Supplementary recourses

1. Mechanical and non-destructive testing video.
2. Magnetic field orientation video.
3. Magnetic test_1 video.
4. Magnetic test_2 video.

7. References

1. The magnetic particles test Kit instruction manual.
2. http://www.ndt-ed.org/EducationResources/CommunityCollege/MagParticle/cc_mpi_index.htm
3. Other internet websites

Student's notes