SRI VIDYA COLLEGE OF ENGINEERING & TECHNOLOGY
VIRUDHUNAGAR - 626 005
DEPARTMENT OF MECHANICAL ENGINEERING
ME 6019 – NON DESTRUCTIVE TETSING MATERIALS
QUESTION BANK - 2 MARKS & 16 MARKS

UNIT-II

SURFACE NDE METHODS

1. What is Liquid Penetrant Inspection?

Liquid Penetrant Inspection is a non-destructive method of finding discontinuities/openings in the surface of a nonporous solid material.

2. State the principle of LPT?

The principle of Liquid Penetrant Testing is that a liquid applied to the test surface is drawn into the defect by capillary attraction. After subsequent cleaning of surface and application of developer powder, the liquid from the surface cavities are readily absorbed by the developer and rendered visible to the human eye.

3. Explain the procedure for the liquid penetrant testing?

- Cleaning
- Penetrant application
- Removal of excess penetrant
- Application of developer
- Inspection & evaluation

4. What are the penetrant testing materials used in LPT?

a) Penetrant
b) Cleaners and emulsifiers
c) Developers
d) Special requirements
e) Test blocks

5. What are the different types of penetrant testing methods?

- Water washable method
- Post-emulsifiable method
- Solvent removable method

6. What is penetrant?

The penetrant material consists of the indicating dye plus the carrier fluid. The indicating dye may give a colour contrast with respect to the surrounding, as is the case for visible dye penetrant methods, or a brightness contrast for the fluorescent dye penetrant.

7. What are the types of emulsifiers used in LPT?

1) Hydrophilic emulsifiers

2) Lipophilic emulsifiers

8. What are the advantages of LPT?

a) Comparatively simple as no electronic systems are involved.

b) Equipment is cheaper

c) Can be employed to any material except porous materials

d) Suitable for in situ inspection.

9. What are the limitations of LPT?

a) It can detect surface-breaking defects only.

b) Not suitable for rough surfaces and porous materials.

10. What are the applications of LPT?

a) This method is capable of detecting discontinuities open to the surface of the material under test.

b) Penetrant method is very reliable in the detection of fatigue cracks which occur during the service life of a material.

11) What is Magnetic Particle Testing?

Magnetic Particle Testing is used for the testing of materials which can be easily magnetized. This method is capable of detecting flaws open-to-surface and just below the surface.

12) What is magnetism and what is magnet?

The ability of a ferromagnetic material to attract other ferromagnetic materials is called magnetism and the pieces with this ability are called magnets. Magnets are classified as permanent and temporary.

13) What is the principle of MPT?

When a specimen is magnetized, and magnetic lines of forces are predominantly inside the ferromagnetic material. The magnetic field introduced into the specimen is composed of magnetic lines of force. When ever there is a flaw which interrupts the flow of magnetic lines of

force, some of these lines must exit and re-enter the specimen.

14) What is magnetic ink?

The magnetic particles can be applied as powder or more commonly as liquid suspension, usually known as magnetic ink. To be detected linear flaws such as cracks must be favourably oriented in relation to the direction of the magnetic field.

15) What are the magnetizing techniques used in MPT?

1) Magnetization using a magnet
2) Magnetization using an Electromagnet
3) Contact current flow method
4) Using a threading bar
5) The coil
6) Induced current flow

16 MARKS

1. Discuss briefly about LPT And its methods (16)

Penetrants are then classified by the method used to remove the excess penetrant from the part. The four methods are listed below:

- Method A - Water Washable
- Method B - Post-Emulsifiable, Lipophilic
- Method C - Solvent Removable
- Method D - Post-Emulsifiable, Hydrophilic

Water washable (Method A) penetrants can be removed from the part by rinsing with water alone. These penetrants contain an emulsifying agent (detergent) that makes it possible to wash the penetrant from the part surface with water alone. Water washable penetrants are sometimes referred to as self-emulsifying systems. Post-emulsifiable penetrants come in two varieties, lipophilic and hydrophilic. In post-emulsifiers, lipophilic systems (Method B), the penetrant is oil soluble and interacts with the oil-based emulsifier to make removal possible. Post-emulsifiable, hydrophilic systems (Method

D), use an emulsifier that is a water soluble detergent which lifts the excess penetrant from the surface of the part with a water wash. Solvent removable penetrants require the use of a solvent to remove the penetrant from the part.

Penetrants are then classified based on the strength or detectability of the indication that is produced for a number of very small and tight fatigue cracks. The five sensitivity levels are shown below:

- Level ½ - Ultra Low Sensitivity
- Level 1 - Low Sensitivity
- Level 2 - Medium Sensitivity
- Level 3 - High Sensitivity
- Level 4 - Ultra-High Sensitivity

The major US government and industry specifications currently rely on the US Air Force Materials Laboratory at Wright-Patterson Air Force Base to classify penetrants into one of the five sensitivity levels. This procedure uses titanium and Inconel specimens with small surface cracks produced in low cycle fatigue bending to classify penetrant systems. The brightness of the indication produced is measured using a photometer. The sensitivity levels and the test procedure used can be found in Military Specification MIL-I-25135 and Aerospace Material Specification 2644, Penetrant Inspection Materials.

2. How will inspect a material using LPT Explain in detail. (16)

   Dye penetrant inspection (**DPI**), also called **liquid penetrant inspection** (**LPI**) or **penetrant testing** (**PT**), is a widely applied and low-cost inspection method used to locate surface-breaking defects in all non-porous materials (metals, plastics, or ceramics). The penetrant may be applied to all non-ferrous materials and ferrous materials, although for ferrous components magnetic-particle inspection is often used instead for its subsurface detection capability. LPI is used to detect casting, forging and welding surface defects such as hairline cracks, surface porosity, leaks in new products, and fatigue cracks on in-service components

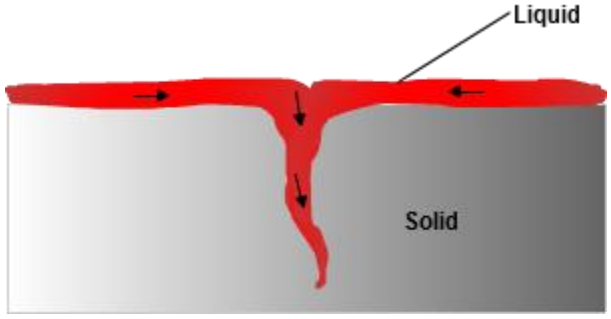
   Principles

DPI is based upon capillary action, where low surface tension fluid penetrates into clean and dry surface-breaking discontinuities. Penetrant may be applied to the test component by dipping, spraying, or brushing. After adequate penetration time has been allowed, the excess penetrant is removed and a developer is applied. The developer helps to draw penetrant out of the flaw so that an invisible indication becomes visible to the inspector. Inspection is performed under ultraviolet or white light, depending on the type of dye used - fluorescent or nonfluorescent (visible).

3. Explain in detail about the step by step procedure of inspection in LPT? (16)

Basic Processing Steps of a Liquid Penetrant Inspection

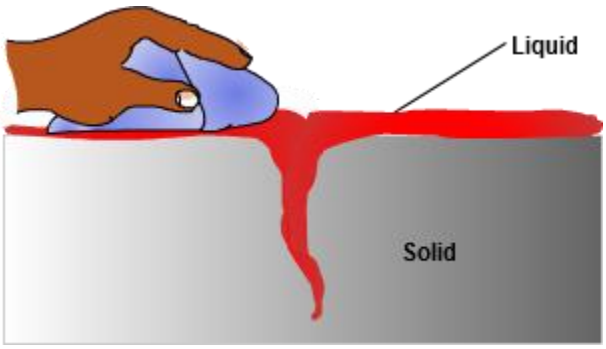
1. **Surface Preparation:** One of the most critical steps of a liquid penetrant inspection is the surface preparation. The surface must be free of oil, grease, water, or other contaminants that may prevent penetrant from entering flaws. The sample may also require etching if mechanical operations such as machining, sanding, or grit blasting have been performed. These and other mechanical operations can smear metal over the flaw opening and prevent the penetrant from entering.



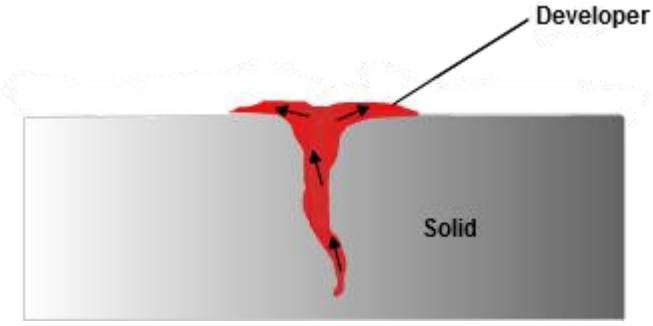
2. **Penetrant Application:** Once the surface has been thoroughly cleaned and dried, the penetrant material is applied by spraying, brushing, or immersing the part in a penetrant bath.

3. **Penetrant Dwell:** The penetrant is left on the surface for a sufficient time to allow as much penetrant as possible to be drawn from or to seep into a defect. Penetrant dwell time is the total time that the penetrant is in contact with the part surface. Dwell times are usually recommended by the penetrant producers or required by the specification being

followed. The times vary depending on the application, penetrant materials used, the material, the form of the material being inspected, and the type of defect being inspected for. Minimum dwell times typically range from five to 60 minutes. Generally, there is no harm in using a longer penetrant dwell time as long as the penetrant is not allowed to dry. The ideal dwell time is often determined by experimentation and may be very specific to a particular application.



4. **Excess Penetrant Removal:** This is the most delicate part of the inspection procedure because the excess penetrant must be removed from the surface of the sample while removing as little penetrant as possible from defects. Depending on the penetrant system used, this step may involve cleaning with a solvent, direct rinsing with water, or first treating the part with an emulsifier and then rinsing with water.



5. **Developer Application:** A thin layer of developer is then applied to the sample to draw penetrant trapped in flaws back to the surface where it will be visible. Developers come in a variety of forms that may be applied by dusting (dry powdered), dipping, or spraying (wet developers).

6. **Indication Development:** The developer is allowed to stand on the part surface for a period of time sufficient to permit the extraction of the trapped penetrant out of any surface flaws. This development time is usually a minimum of 10 minutes. Significantly longer times may be necessary for tight cracks.

7. **Inspection:** Inspection is then performed under appropriate lighting to detect indications from any flaws which may be present.

8. **Clean Surface:** The final step in the process is to thoroughly clean the part surface to remove the developer from the parts that were found to be acceptable.

4. Discuss in detail about the Principle and theory of diamagnetism? (8)

   Diamagnetic materials create an induced magnetic field in a direction opposite to an externally applied magnetic field, and are repelled by the applied magnetic field. In contrast, the opposite behavior is exhibited by paramagnetic materials. **Diamagnetism** is a quantum mechanical effect that occurs in all materials; when it is the only contribution to the magnetism the material is called a *diamagnet*. Unlike aferromagnet, a diamagnet is not a permanent magnet. Its magnetic permeability is less than μ_0, the permeability of vacuum. In most materials diamagnetism is a weak effect, but a superconductor repels the magnetic field entirely, apart from a thin layer at the surface.

Theory[edit]

The electrons in a material generally circulate in orbitals, with effectively zero resistance and act like current loops. Thus it might be imagined that diamagnetism effects in general would be very, very common, since any applied magnetic field would generate currents in these loops that would oppose the change, in a similar way to superconductors, which are essentially perfect diamagnets. However, since the electrons are rigidly held in orbitals by the charge of the protons and are further constrained by the Pauli exclusion principle, many materials exhibit diamagnetism, but typically respond very little to the applied field.

5. Explain in detail about the Methods of MPT briefly (16)

   Magnetic particle Inspection (**MPI**) is a non-destructive testing (NDT) process for detecting surface and slightly subsurface discontinuities in ferromagnetic materials such asiron, nickel, cobalt, and some of their alloys. The process puts a magnetic field into the part. The piece can be magnetized by direct or indirect magnetization. Direct magnetization occurs when the electric current is passed through the test object and a magnetic field is formed in the material. Indirect magnetization occurs when no electric current is passed through the test object, but a magnetic field is applied from an outside source. The magnetic lines of force are perpendicular to the direction of the electric current, which may be either alternating current (AC) or some form of direct current (DC) (rectified AC)

Magnetic Particle Testing (MPT) is a **nondestructive examination (NDE)** technique used to detect surface and slightly subsurface flaws in most ferromagnetic materials such as iron, nickel, and cobalt, and some of their alloys. Because it does not necessitate the degree of surface preparation required by other NDE methods, conducting MPT is relatively fast and easy. This has made it one of the more commonly utilized NDE techniques out there today.

MPT is a fairly simple process with two variations: Wet Magnetic Particle Testing (WMPT) and Dry Magnetic Particle Testing (DMPT). In either one, the process begins by running a magnetic current through the component. Any **cracks or defects** in the material will interrupt the flow of current and will cause magnetism to spread out from them. This will create a “flux leakage field” at the site of the damage.

The second step involves spreading metal particles over the component. If there are any flaws on or near the surface, the flux leakage field will draw the particles to the damage site. This provides a visible indication of the approximate size and shape of the flaw.

There are several benefits of MPT compared to other NDE methods. It is highly portable, generally inexpensive, and does not need a stringent pre-cleaning operation. MPT is also one of the best options for detecting fine, shallow surface cracks. It is fast, easy, and will

work through thin **coatings**. Finally, there are few limitations regarding the size/shape of test specimens.

Despite its strengths, the method is not without its limits. The material must be ferromagnetic. Likewise, the orientation and strength of the magnetic field is critical. The method only detects surface and near-to-surface defects. Those further down require alternative methods. Large currents are sometimes required to perform this method, thus "burning" of test parts is sometimes possible. In addition, once MPT has been completed, the component must be demagnetized, which can sometimes be difficult.

6. Write briefly about the theory of magnetism? How will inspect a work piece by using MPT. (16)

Principle of MPT

This testing method is called MT (Magnetic Testing) or MPT (Magnetic Particle Testing), and suitable for the surface / subsurface flaw inspection of ferromagnetic materials. Principle of MPT is as follows:

1. When the workpiece to be inspected is magnetized, magnetic flux is induced.
2. If there is a flaw on the surface, magnetic flux leaks into the air at the position of the flaw.
3. Then magnetic particles (dyed or fluorescent encapsulated) are applied to the surface.
4. These magnetic particles will migrate to the flaw where the magnetic flux leaks and forms a flaw indication that is several tens of times of actual flaw width.
5. The inspector visually identifies the flaw.

Procedure of MPT

Procedure of MPT is **"Pre-cleaning" - "Magnetization" - "Applying magnetic particle" - "Observation" - "Post-cleaning"**.

(1) Pre-cleaning

Oil, paint, rust and other foreign materials on the surface to be inspected not only prevent

attraction of magnetic particles to the flux leakage, but also lead to form a false indication.Therefore such materials will be cleaned chemically or mechanically before magnetization process.

(2) Magnetization

The workpiece is magnetized as direction of magnetic flux is orthogonal to direction of a flaw. Following method is applied for proper magnetization.

1. Axial current method : To pass electric current longitudinal direction of the workpiece
2. Cross current method : To pass electric current cross direction of axis of the workpiece
3. Prod method : To pass electric current between two prods contacted inspection area of the workpiece
4. Through conductor method : To pass electrical current through the hole of the workpiece
5. Coil method : Put the workpiece in a magnetizing coil
6. Yoke method : Put the workpiece between magnetic poles
7. Through flux method : To pass magnetic flux through the hole of the workpiece

(3) Applying magnetic particle

1. Types of magnetic particle
   Easy magnetization and migration to flux leakage and discriminative flaw indication are required for performance of magnetic particle.
   There are two types of magnetic particle, one is non-fluorescent particle (white, red, black) for observation under visible light, and the other is fluorescent magnetic particle for observation under UV light.
   Dry method, magnetic particle is applied to the surface as it stands, and wet method, magnetic particle is dispersed in oil or water, are applied.
2. Applying timing of magnetic particle
   There are two methods. Magnetic particle is applied during magnetization of the workpiece, or applied after ceasing magnetization. In later case residual magnetism is utilized for forming flaw indication.

(4)Observation

UV light is used for observation of the workpiece under dark environment in case of using fluorescent magnetic particle for inspection.

(5)Post-cleaning

Demagnetization, removing residual magnetic particle and rust proofing of the workpiece are done if required.