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Engineering Materials

Module 8: Die Penetrant Test

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August 2010

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Module 8: Die Penetrant Test

Module Objectives

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

- Explain the basic principles of the Die Penetrant test.
- Describe the main parts of the Die Penetrant Kit used to perform the Die Penetrant test.
- Identify the different types of penetrant used in the test.
- Recommend the Die penetrant test for a specific material.
- Describe the most common flaws expected to be located after the test.
- Explain the Die penetrant test procedure.
- Carry out a Die Penetrant test for different specimen using a certain procedure.
- Use the product data sheet to identify relevant information.
- Record and report the defects using standard report form.

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Introduction

Liquid penetrant is one of the most widely used NDT methods. It offers a fast, cheap and relatively simple means of surface inspection, making it attractive to a large number of industries. It is used to detect surface flaws in almost all non-porous materials, and this includes magnetic and non-magnetic materials. The aerosol spray cans used in the test made the test portable and easy to apply. The portable spray cans test kit consists of 3 main bottles cleaner, penetrant, and developer.

The cleaner is used for cleaning the test piece before and after the test, the penetrant is the dye used during the test, and the developer is used to show the indications and make them visible.

1. Principle of the test

The test is used to locate surface breaking flaws by bleed out of a colored or fluorescent dye from the flaw. The technique is based on the ability of a liquid to be drawn into a "clean" surface breaking flaw by **capillary action**. "The capillary action, or capillarity, is a phenomenon where a liquid spontaneously rises in a narrow space such as a thin tube. This effect can cause liquids to flow against the force of gravity". (Fig. 8.1).

After a period of time called the "dwell," excess surface penetrant is removed and a developer applied. The developer draws the penetrant from the flaw to show its presence.

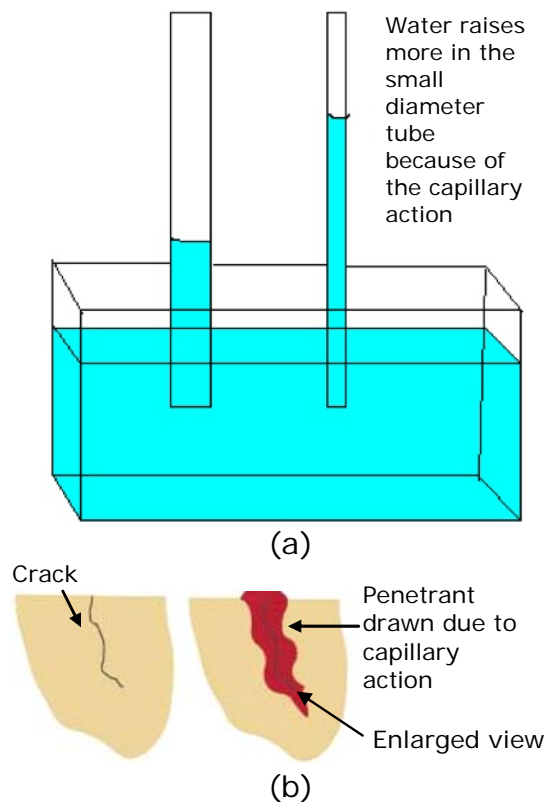


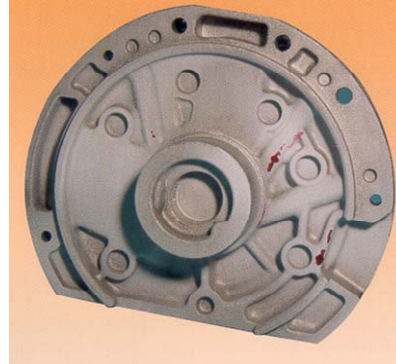
Fig. 8.1: (a) Capillary action in tubes with different diameters. (b) Capillary action causes the penetrant to be drawn into the crack.

2. Types of penetrant

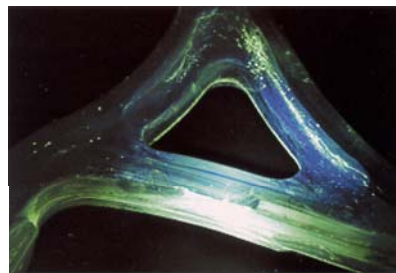
The type and the color of the penetrant material are very important in providing good contrast against the developer or the part being inspected

There are mainly two types of penetrant used:

1. Visible penetrant: the dye color used is usually red but other colors can be purchased for special applications. The flows detected could be seen under normal lighting conditions as shown in Fig. 8.2a.
2. Fluorescent penetrant: the dye used has a Fluorescent material to show the defects more clearly. Special lighting is required to see the revealed flaws as shown in Fig. 8.2b.



(a)



(b)

Fig. 8.1: (a) Visible penetrant (b) Fluorescent penetrant.

3. Uses and limitations of the test.

Penetrant test (PT) is used to detect welding, casting and forging flaws such as cracks, porosity, and other defects that break the surface. The material should have relatively smooth and non-porous surface to provide true test results.

3.1 What Can NOT be inspected using PT?

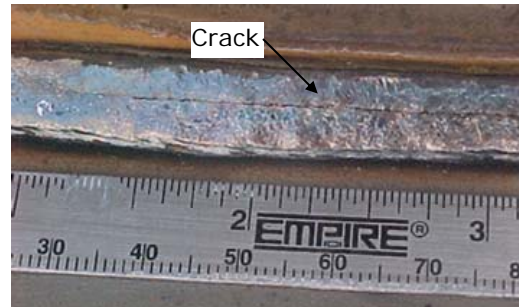
- Components with rough surfaces, such as sand castings, that traps and holds the penetrant.
- Porous ceramics.
- Wood and other fibrous materials.
- Plastic parts that absorb or react with the penetrant materials.
- Components with coatings (paints) that prevent the penetrant from being drawn into the defects.

3.2 Examples of surface flaws located using the penetrant test

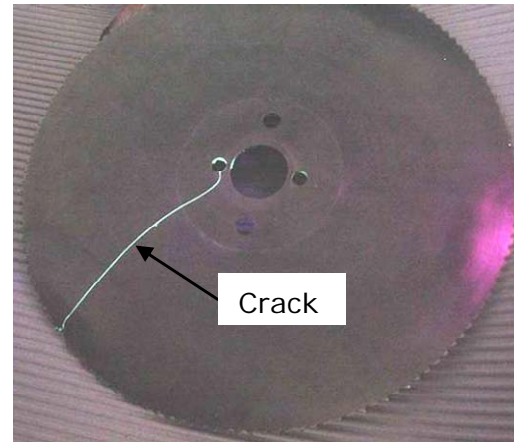
1 Cracks: they are considered the most critical discontinuity as they propagate very fast. Cracks are most commonly initiated when the load or stress applied to a member exceeds its tensile strength. Cracks could be found in many parts that are manufactured using operations such as welding, casting and forging. (Fig. 8.3 (a-b)).

2. Incomplete Fusion: It is a welding flaw in which fusion doesn't occur between the base metal and the weld metal. It is also called incomplete fusion as the weld metal is less than required. (Fig. 8.3c).

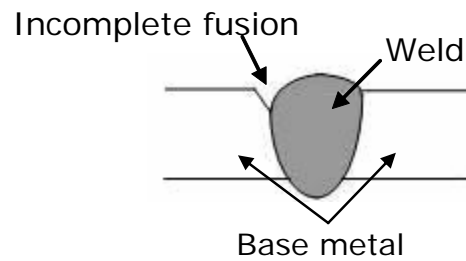
3. Porosity: It is a cavity type flaw formed by the gas entrapment during solidification. Porosity could be found in casting, and welding products. (Fig. 8.3d).



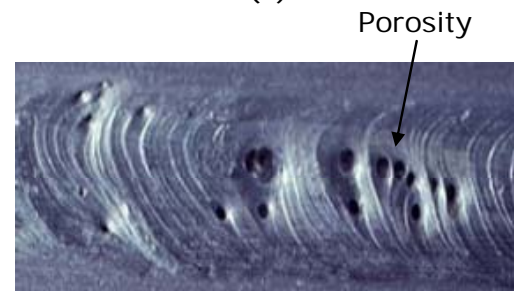
(a)



(b)



(c)



(d)

Fig. 8.3: (a) Welding crack. (b) In service crack. (c) Incomplete fusion. (d) Welding porosity.

4. Die penetrant test procedure

1. Surface preparation

One of the most critical steps of a liquid penetrant test is the surface preparation. The surface must be free of dirt, scale, oil, grease, water, and all the other contaminants that may prevent the penetrant from entering flaws. Fig. 8.4 shows a technician using the cleaner to prepare the part for the test.



Fig. 8.4: Surface cleaning before the test.

2. Penetrant application

Once the surface has been thoroughly cleaned and dried, the penetrant material is applied by brushing, spraying or immersing the part in a penetrant bath as shown in Fig. 8.5 (a-c).



(a)



(b)



(c)

Fig. 8.5: Applying the penetrant by (a) Brushing (b) Spraying. (c) Immersing in a 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 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. It is advised to read the product data sheet carefully to find the penetrant dwell time recommended by the manufacturer. Minimum dwell times typically range from 5 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.

4. Excess Penetrant Removal

The penetrant removal procedure must effectively remove the penetrant from the surface of the part without removing the penetrant from the defect. If the removal process extracts the penetrant from the flaw, the flaw indication will be reduced.

The most commonly used methods for excess penetrant removal are:

1. **Water wash method:** the test piece is sprayed with water to remove the excess penetrant as shown in Fig. 8.6a.
2. **Solvent wipe method:** the test piece is wiped with a rag dampened with the solvent cleaner as shown in Fig. 8.6b.

NOTE: Don't spray the solvent remover on the test piece surface directly to avoid removing the penetrant inside the flaws.



(a)



(b)

Fig. 8.6: Excess penetrant removal
(a) Water wash method (b) Solvent wipe method.

5. Application of developer

A thin layer of developer is then applied to the sample. The role of the developer is to draw the penetrant trapped in flaws back to the surface to be visible. Developers come in a variety of forms that may be applied by dusting (dry powdered), dipping, or spraying (wet developers). (Fig 8.7).



Fig. 8.7: Spraying the developer

6. Indication development

The developer is allowed to stay 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 around 10 minutes unless stated by the developer manufacturers. 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.

The crack if any will be indicated with the red dye absorbed by the white absorbent as shown in Fig. 8.8.

A very important step of evaluation is to document findings on an inspection report form.

The inspection report may be supported with drawings or photos of indications.



Fig. 8.8: A crack indication that appears after the test.

8. Clean the 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. See Fig. 8.9.



Fig. 8.9: Cleaning the acceptable parts.

5. Practical Task:

Use the specimen provided by your teacher and the penetrant kit (cleaner, penetrant, and developer) shown in Fig. 8.10 to perform the penetrant test as per the following procedure.

Note: Use a plastic or a paper sheet on the table to protect it from the sprayed paint.



Fig. 8.10: The penetrant kit and the specimen.

1. Surface preparation

Clean the surface from dust and dirt by using the cleaner can and a piece of cloth as shown in Fig. 8.11.

The oil may fill the surface breaking cracks; therefore cleaning the specimen is very important for the test validity.



Fig. 8.11: Cleaning the surface.

2. Penetrant application

Once the surface has been thoroughly cleaned and dried, the penetrant material is applied by the spraying method as shown in Fig. 8.12.

Ensure that the surface to be inspected is completely covered with the penetrant.



Fig. 8.12: Applying the penetrant.

3. Penetrant dwell

The penetrant is left on the surface for a sufficient time. Use the penetrant “product data sheet” provided to find the recommended penetrant dwell time.

4. Excess penetrant removal

Wipe off the excess penetrant on the surface with a rag that has been sprayed with the cleaner.

Don't spray the specimen directly to avoid removing the penetrant inside the flaws. (Fig. 8.13).



Fig. 8.13: Removing the excess penetrant.

5. Application of the developer

A thin layer of the developer is then applied to the sample (after ensuring that the cleaning medium has been dried) to draw the penetrant trapped in flaws back to the surface where it will be visible. (Fig. 8.14).



Fig. 8.14: Applying the developer.

6. Indication Development

The developer is allowed to stay on the part surface for a period of time that is sufficient to permit the extraction of the trapped penetrant out of any surface flaws. This development time is usually around 10 minutes.

7. Inspection

Inspection is then performed under appropriate lighting. Use a lens to detect indications from any flaws which may be present as shown in Fig. 8.15.

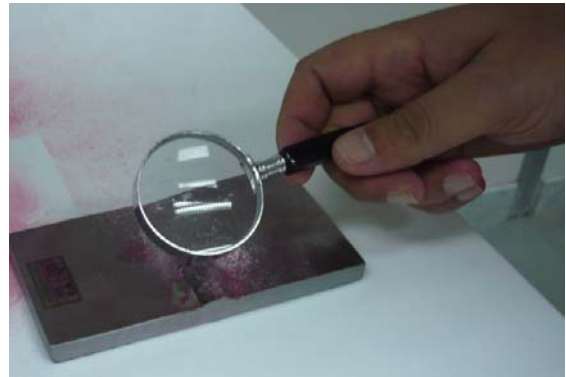


Fig. 8.15: Using a magnifier to locate flaws.

A very important step of evaluation is to document findings on an inspection report form.

This may be supported with photos taken for flaws and indications to be attached with the report.

8. 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.

9. Clean the surface

The final step in the process is to thoroughly clean the part surface to remove all paints and ensure that all the indications are not seen for further tests.

For further reading, you can use the following links:

1. http://en.wikipedia.org/wiki/Dye_penetrant_inspection
2. <http://www.ndt-ed.org/EducationResources/CommunityCollege/PenetrantTest/Introduction/history.htm>

6. Supplementary recourses

1. Mechanical and Non-destructive testing video.
2. Die penetrant test video.

7. References

1. Modern engineering materials edition 1.
2. Engineering materials 1. "An introduction to Properties, Applications, and Design".
3. Modern Materials and Manufacturing Processes, R. G. Bruce, M. M. Tomovic, J. E. Neeley, and R. R. Kibbe, Prentice Hall, 2nd Ed., 1987, pp 55-60.
4. Different internet sites.

