Saya / Kami akui bahawa telah membaca
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Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)

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THE INVESTIGATION OF EFFECT OF THE CAPILLARYTY ON THE PENETRANT TESTING

AHMAD GHAZALI BIN ZULCEFLI MUHAMMAD

Laporan ini dikemukakan sebagai memenuhi syarat sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)

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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumbernya"

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ABSTRACT

This project is conducted to investigate the effect of capillarity in Penetrant Test and differentiate the effect of capillary action of different size of discontinuities. Penetrant Test is part of Nondestructive Testing and used widely to detect crack on the surface without destroying the specimen. The test sample is design using CATIAV5R16 and is fabricated using Advance CNC Wire Cut EDM Machine. For the experiment using Penetrant Test, the result will presented in terms of different size of crack and depth. The results are gained by recording the time frame of the experiment every 20 second and the picture are captured as record of the observation. The result then will be compared between cracks. The final result of this project is the completion of fabrication of test sample and applied the sample using PT to gain the final result that relates to the objective targets. The final result shows that the crack with lower depth and greater size of crack will revealed faster and this is because of the effect of capillarity in PT. The objectives for PSM are achieved.

ABSTRAK

Kajian yang dibuat adalah berdasarkan kajian mengenai kesan kapilari di dalam *Penetrant Test* dan membezakan kesan daripada fenomena kapilari terhadap perbezaan saiz bagi setiap retakan pada permukaan sampel ujian. Merujuk kepada kajian ilmiah, kajian mengenai kesan kapilari masih tidak lengkap sepenuhnya. *Penetrant Test* adalah sebahagian daripada ujian yang terkandung di dalam Makmal Ujian Tanpa Musnah dan digunakan secara meluas untuk mengesan retakan pada permukaan sampel tanpa memusnahkannya. Sampel ujian di reka dengan menggunakan perisian CATIAV5R16 dan akan dihasilkan dengan menggunakan mesin *Advance CNC Wire Cut EDM Machine.* Berkaitan dengan eksperimen menggunakan Pengujian Ketembusan, keputusan eksperimen tersebut akan direkod dalam kategori perbezaan saiz retakan dan kedalamannya. Kemudian, keputusan tersebut akan dibandingkan antara satu sama lain. Keputusan akhir bagi hasil kajian mengenai projek PSM adalah rekaan tetap bagi sampel ujian untuk Pengujian Ketembusan dan keputusan exkperimen direkod berdasarkan objektif projek.

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CHAPTER I

INTRODUCTION

1.1 Project Background

This project is about the investigation of the capillarity effect on the penetrant test in terms of different size of crack on the test sample. The test is also carries out the differences in depth of the crack. Penetrant Test (PT) is the test that most widely used in the nondestructive method to find the detection of surface discontinuities in nonporous solid materials because of its capability and was the cheapest one among all the Nondestructive testing (NDT). NDT is a testing that does not destroy the test object. The destructive testing usually provides a more reliable assessment of the state of the test object, destruction of the test object usually makes this type of test more costly to the test object's owner than nondestructive testing and all these will not about to happened if user are using the nondestructive testing. Moreover, the user of this testing does not need to worry about the object tested been destroyed because no matter how many times the NDT test are been repeated on the test subject, it will not broken.

NDT is divided into various methods of nondestructive testing, each testing are different in terms of particular scientific principle. These methods may be further subdivided into various techniques. The various methods and techniques, due to their particular natures, may lend themselves especially well to certain applications and be of little or no value at all in other applications. For example, the ultrasonic testing are only can be used in findings a crack at the test subject within 25% of the thickness of test subject. Therefore choosing the right method and technique is an important part of the performance of NDT. Some of the techniques are Penetrant Test , Radiographic Testing (RT), Impulse Excitation Technique (IET), Ultrasonic Testing (UT), Electromagnetic Testing (ET), Acoustic Emission Testing (AE), Positive Material Identification (PMI), Hardness Testing (Brinell) (HT), Infrared and thermal testing (IR).

The various method and techniques of NDT cost lots of money. However, the easiest and cheapest NDT method available is PT. PT is used because of its low cost, simple, easy to get and widely used in industry. Moreover, the equipment needed for this PT just a simple kind of chemical stored in a spray can and makes the PT are easy to be used.

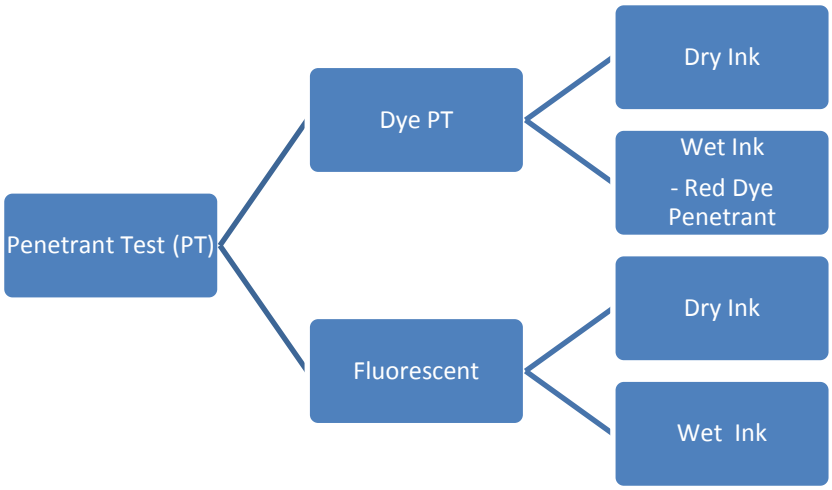

Figure 1.1: Types of Penetrant Test

There are two types of Penetrant Test which are dye penetrant testing and fluorescent penetrant testing as shows at Figure 1.1 above. Dye penetrant testing which

is very simple to use, supplied in aerosol and particularly suitable for field work as no UV lighting is needed as shown in Figure 1.2 below. According to these *Projek Sarjana Muda* (PSM) project objectives, the PT that will be use is red dye penetrant testing. Furthermore, this test is the testing that can easily get the result of the project objectives target which is to find out and to investigate the effect of capillary in PT and differentiate the effect of capillary action of different discontinuities in terms of crack size and depth.

Figure 1.2: Red Dye Penetrant Testing Material

The effect of capillary in PT can be seen in the sensitivity of the penetrant material used. For more sensitivities materials (Fluorescent), the flow conditions are greater to small defects. Also for the liquid penetrant testing, it still applied the capillary action principal to locate surface-breaking defects. For the other views, capillary action happens when there are some result of adhesion and surface tension.

In the capillary principals used in the PT, by referring to Wikipedia, the free encyclopedia “Capillary action, capillarity, capillary motion, or wicking is the ability of a substance to draw another substance into it. The standard reference is to a tube in plants but can be seen readily with porous paper. It occurs when the adhesive intermolecular forces between the liquid and a substance are stronger than the cohesive intermolecular forces inside the liquid” [1].

In the other words, capillary action is the tendency of a liquid to rise in a narrow tubes or small opening such as those between two plywood layers and glued together.

The capillary action, are also known as capillarity, can be referred to the force of intermolecular attraction within the liquid and solid material. The easiest example for this phenomenon is the tendency of a dry tissue paper to absorb a liquid by drawing into the narrow openings between the fibers in the tissue.

1.2 Problem Statement

Capillary action is the phenomenon of a liquid rising or climbing when confined to small openings due to surface wetting properties of the liquid. Every step in the PT utilizes capillary action to promote visual indication of any discontinuities present in an application. However, the size and character of the discontinuities are varying and very different from one another. Hence, there is a need to study the effect of capillary in different size of discontinuities using PT. In daily applications, there will be various kinds of crack size and depth would appear in the surface of metal. However, some of them cannot be trace by just by looking at; some testing must to be done to solve this type of problem. PT is one of the easier and cheapest of all NDT testing method and widely used.

1.3 Project Objectives

The objective of this project is to investigate the effect of capillarity in PT and differentiate the effect of capillary action of different size of discontinuities. In terms of different size of crack, there will be two kind of outcome needed which crack with the difference size but same depth and the crack with the different depth but with same size.

1.4 Project Scope

The scopes of this project involved design and fabrication the Penetrant Testing test sample, development of experimental procedure to investigate the effect of capillary action different size of machined defect and conduct the experiment based on the procedure. The new design must have just one PT sample with several of discontinuities and use several type of machine to complete the test sample fabrication.

1.5 Project Flow

Figure 1.3 below shows that the project flows of PSM 1 and PSM 2. In the PSM 1 project, it's covered from topic selection and project proposal to test sample design. Starting the PSM 2 project, it will continue from fabricate of the test sample until final presentation and the submission of the hard cover report.

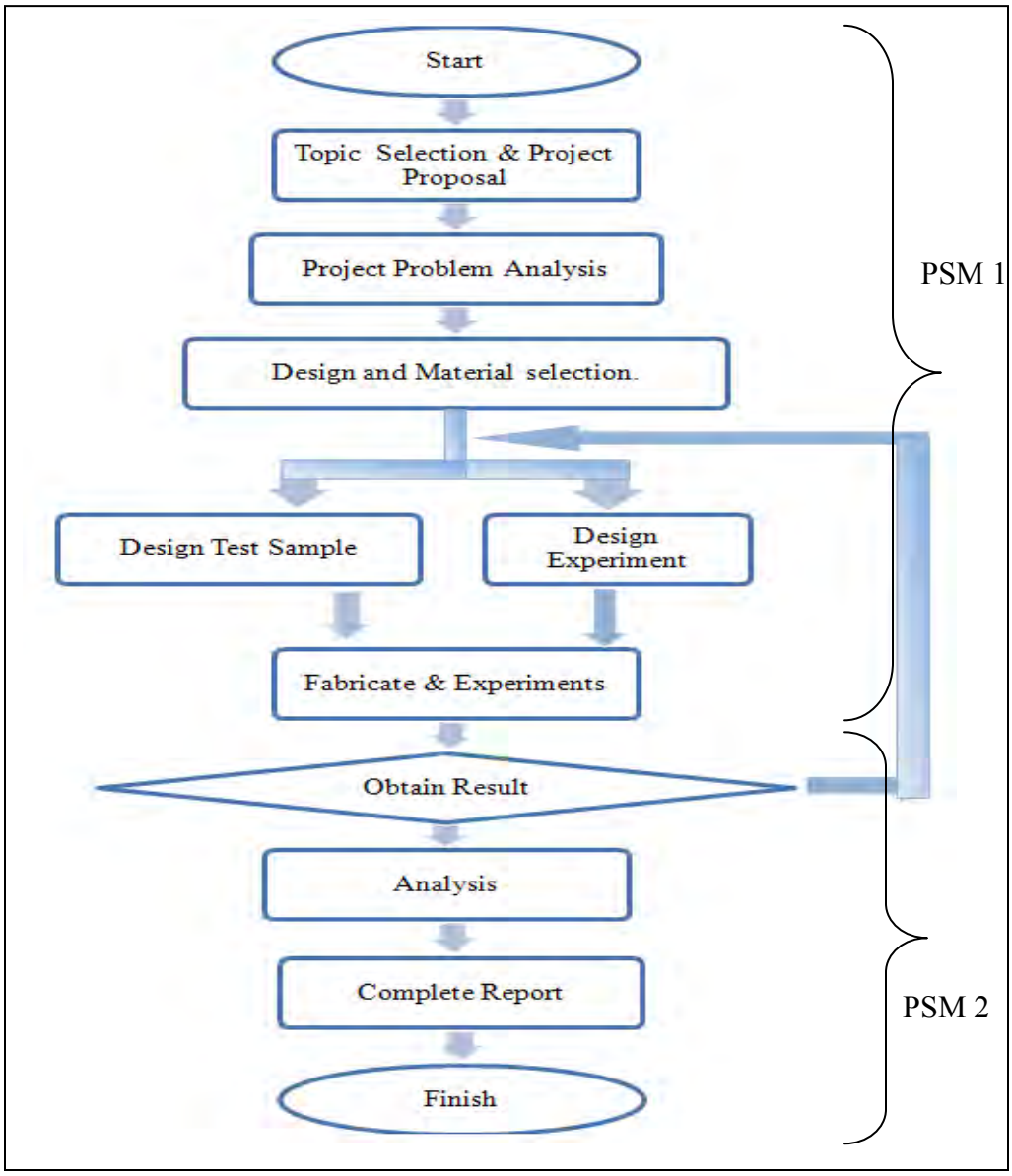

Figure 1.3: Flow Chart of PSM 1 & PSM 2

CHAPTER II

LITERATURE REVIEW

2.1 An overview of Penetrant Test

Penetrant Test generally knows as the NDT most method popular because of the low cost and most effective. From the journal "A practical introduction to penetrants" written by A. de Sterke, penetrant examination is generally considered to be one of the easiest methods of surface inspection. Directions for use are often simply mentioned in a few square inches on the spray can or container of the materials required, and consequently there is a tendency to underestimate the need for accurate application and competent personnel [1]. This is because the PT is very well known in NDT testing and widely used in industry, plus the PT is the easiest method in the NDT testing. Indeed, the principle of penetrant examination is less implementation that invites simplification. These phenomena happened because of the material used in the spray can which is what we called penetrant.

From the other article by Wikipedia [1], penetrant test represent “Dye penetrant inspection (DPI), also called liquid penetrant inspection (LPI), is a widely applied and low-cost inspection method used to locate surface-breaking defects in all non-porous materials (metals, plastics, or ceramics). Penetrant may be applied to all non-ferrous materials, but for inspection of ferrous components magnetic-particle inspection is preferred for its subsurface detection capability[1], these can be explain by the material with rough surface are less effective than the smooth one because it will affect the PT material flows when it‟s been applied on the surface of test sample. For an example, the flow of one drop of rain through the smooth mirror and through the concrete wall will make the rain drop faster on the smooth mirror compared to the rough surface of concrete wall. These phenomena are also related to the surface tension between the rain drop and smooth mirror also for the concrete wall because of the surface tension force between rain drop and mirror are greater than the surface tension force between rain drop and the concrete wall. LPI is used to detect casting and forging defects, cracks, and leaks in new products, and fatigue cracks on in-service components [1]. Figure 2.1 below shows the way on how the penetrant being sprayed on the sample and Figure 2.2 below shows the example of consumables used to perform the PT.

Figure 2.1: Penetrant Test Material is sprayed on Test Sample [3]

Figure 2.2: Example of Dye Penetrant Testing Chemicals [4]

2.2 Penetrant Test Principles

Penetrant Test principles are mainly refers to the operations common for most of the defect-detecting procedures in liquid penetrant testing are the following. Application of the indicator liquid to the test surface, removal from the surface where it only remains thereafter in defect hollows and application of the penetrant-adsorbing developer to the defect mouths, and finally proper detecting of the defects and estimation of their harm. The penetrant is a luminescent usually under ultraviolet light or brightly colored liquid, and the final operation is ordinarily visualization of luminescent or colored “traces” of the defects which are much wider than the sizes of the crack mouth divergences [5]. This shows that the PT principal is that the indicator liquid are applied on the surface of the sample before remove it and clean the sample so that the cracks can easily be determine.