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Study of the Effect of Penetrant Temperature Variations on Corrosion Sensitivity of 7075 Alumnium material using the Liquid Penetrant Test Method at PT. Dirgantara Indonesia (IAe)

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Abstract

Non Destructive Test is a testing and analysis method carried out to evaluate and detect differences in characteristics or defects that arise in materials, components, structures or systems without causing damage to the part being tested. Liquid Penetrant Test is a Non-Destructive Test method using Liquid Penetrant containing Fluorescent by utilizing power capillarity which is the ability of the penetrant liquid to enter the gap discontinuity and developer work to lift the liquid back up which penetrates into cracks so that defects and corrosion can be detected. The purpose of this test is to determine discontinuities in the fabricated material by using 3 variations of penetrant temperature 5°C, 10°C - 38°C, and 75°C using 2 pieces of 7075 Aluminum material. Experiments carried out at normal temperatures (10°C-38°C) show clear indications of the material. while experiments using temperatures of 5°C and 75°C will make the indication on the material unclear (false indication) due to various factors such as viscosity, dwell time, penetration, developing.

Keywords: Liquid Penetrant Test, Fluorescent, Discontinuity

Introduction

Airplanes are a means of transportation that is widely used by the public, both for business, tourism and defense purposes. Airplanes have various components and structures that must always be in top condition in order to operate safely and efficiently. Aircraft structure is the parts that form the frame and fuselage, such as wings, tail, fuselage, landing gear, etc (Rahmatullah et al., 2023). The aircraft structure must be able to withstand various stresses and loads due to forces that occur when the aircraft flies, such as aerodynamic forces, inertial forces, centrifugal forces, and gravitational forces. The result of this force continuing to work can cause fatigue. Fatigue, one of which can cause cracks in the aircraft structure (Yiğit et al., 2021)

One of the inspection methods used in the aviation industry is Non Destructive Test (NDT). NDT stands for non-destructive testing. In other words it is a way of testing without destroying. This means that the component- the casting, weld or forging, can continue to be used and that the non -destructive testing method has done no harm (Ashok Reddy, 2017). Non Destructive Test is a testing and analysis method carried out to

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evaluate and detect differences in characteristics or defects that arise in materials, components, structures or systems without causing damage to the part being tested (Popescu et al., 2013). Non-Destructive Tests have various advantages, such as cost-effective, time-saving, easy to carry out, and do not affect the function or performance of the object being tested (Yunianto et al., 2023). In the aircraft industry, non-destructive aircraft maintenance can be used to inspect aircraft components, such as corrosion, material failure and crack detection in parts or structures such as wings, landing gear and etc (Guirong et al., 2015). One of the Non-Destructive Test methods that is often used is the Liquid Penetrant Test method, which is the simplest Non-Destructive Test method but has the advantage of speed and accuracy in detecting defects on the surface of the test object (Abdo et al., 2021). In principle, the test method with liquid penetrant utilizes capillarity (Zaenal Abidin et al., 2023). In this method, liquid penetrant is applied to the surface of the specimen at a certain time that has been determined, after a while the penetrant on the surface is cleaned before developer is applied to reveal the liquid penetrant remaining in the crack, so that the developer will draw the liquid penetrant to the surface and the defects will be visible (Tugrul, 1997). Penetrants may contain a blend of aromatic and ali-phatic hydrocarbon solvent(s), refined mineral oil(s), dye, surface active agent(s), alcohol(s), and hydrocarbon propellant(s) (Irek & Sania, 2016). The ingredients of the developer may include 2-propanol, 2-propanone, isobutane, and talc. (Jiménez-Becerril et al., 2013). In liquid penetrant inspection; liquids with low surface tensions, which wet the solids well and have the ability to penetrate the discontinuities on the surface of the part, are used (Uludağ, 2017) . Penetrant liquids can be applied to the material to be examined by brushing, washing, spraying, and sometimes dipping (Manikandan et al., 2020). Liquid penetrant inspection, which is convenient, fast and easy to apply on the part, is based on the principle of capillarity (Pereira et al., 2019). Penetrant liquid containing dye penetrating the surface discontinuities with capillary effect creates a visual contrast between the discontinuity and the surrounding surface. This increasing the visibility of the discontinuity (NavAir, 2007)

Penetrant fluids used in NDT are categorized into types. The coloring substances added are as follows:

a) Visible Penetrant contains a visible red dye clear under normal lighting conditions

b) Fluorescent Penetrant contains fluorescent dyes (yellow green) which will emit visible light when viewed with an ultraviolet lamp

c) Dual Sensitivity Penetrant, this penetrant contains a combination both visible and fluorescent dyes (Mix, 2004)

Penetrants are further grouped based on method cleaning residual penetrant from the surface of the material specimen, namely as follows :

a) Water-Washable Penetrant, contains an emulsifying agent or can rinsed with water.

b) Post-Emulsifable Penetrant, emulsifier is required separately so that the penetrant can be rinsed using water.

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c) Emulsible Lipophilic is by diffusion. Molecule the emulsifier enters the penetrant layer, while at the same time Simultaneously the penetrant molecules enter the emulsifier layer.
d) Emulsible Hydrophilic is by peeling off the layer penetrant, hydrophilic emulsifier is a solution between water and substances chemicals called surfactants.
e) Solvent Removeable Penetrant, must be cleaned with use a special solvent if using a visible penetrant in a pressurized can (Bina et al., 2018)

Surface cleaning is very important before and after it is done liquid penetrant testing for 2 reasons, if the specimen is not clean physics and chemistry, penetrant testing becomes ineffective, and if all used penetrant material is not cleaned after testing, it will can cause damage to the specimen after the part is installed on the body aircraft (chlorine and sulfur can damage some types of alloys for example corrosion will occur later) (Capabilities et al., 1930). The cleaning process is generally specified by several factors such as the type of dirt being cleaned, metal composition the parent, the level of cleanliness required according to requirements, cost factors and time (Larson, 2002). Surface cleaning can be done in several ways, including: cleaning with detergent, cleaning with solvent vapor, cleaning with water vapor, cleaning with solvents, cleaning with acid solutions (pickling), cleaning with paint remover, cleaning with etching, ultrasonic cleaning, and mechanical cleaning (Szalai et al., 2023).

Research Methods

This test was carried out using the liquid penetrant test method using fluorescent liquid. The purpose of this test is to determine discontinuities in the fabricated material by using 3 variations of penetrant temperature 5°C, 10°C - 38°C, and 75°C using 2 pieces of 7075 aluminum material. The stages in the research are as follows:

Cleaning Surface Treatment

1. Manual Cleaning
   The first stage is an initial cleaning stage with the aim of removing dirt on the surface such as dust, marker marks, paint and fingerprints left behind.
2. Racking
   After initial cleaning, the workpiece specimen is fastened or racked to the wire which will then be dipped in the next stage.
3. Alkaline Cleaning
   The next stage is cleaning using an alkaline solution. This is done with the aim of removing dirt that is still on the surface which was missed or cannot be removed with MEK.
4. Rinsing
   The next stage of rinsing is used to clean the workpiece using fresh water to remove adhering alkaline liquid.

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5. Deoxidizing
   Next, the oxidizing stage is the process of removing oxide content and fine particles attached to the workpiece by scraping the surface of the specimen.

Penetrant Test

1. Preparation of test specimens
   The first stage is to prepare the workpiece, make sure it is clean, dry and free from contamination or coatings that can interfere with the efficiency of the surface.
2. Penetrant Application
   At this stage, the test specimen is dipped in fluorescent liquid with temperatures of 5°C, 10°C - 38°C, and 75°C, ensuring that the test specimen is dipped evenly. The contact time required ranges from 20 to 60 minutes.
3. Penetrant Cleaning
   In this case, the method used is water washable penetrant, cleaning which is done by spraying water on the workpiece to which the penetrant is applied. This manual rinsing must always be carried out under UV-A light. Do not use water-air combinations.
4. Drying
   Drying is carried out to remove surface water content after rinsing with fresh water. This drying process is carried out using an oven with a temperature of no more than 70°C under any circumstances.
5. Developer
   This developer is carried out during the drying process, the developer used is a dry powder produced by agitation with dry air. Developer must be used as a thin layer evenly over the entire surface being inspected and then wait 15 minutes to 2 hours before inspection.

Result and Discussion

Result of Research

From the tests that have been carried out, the results of the Penetrant Test were obtained. It can be seen in the following table.

Discussion

From the results of the inspection that was carried out, it was found that there were only one type of corrosion is pitting corrosion. Pitting corrosion occurs when an area little is affected by corrosive environments and becomes anodic This can then cause small holes to form in the metal. Pitting corrosion is usually found in passive metals and alloys such as alloys aluminum, stainless steel and stainless alloys when the oxide film is damaged chemically or mechanically.

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Table 1. normal temperature test results (10°C - 38°C) on material 1

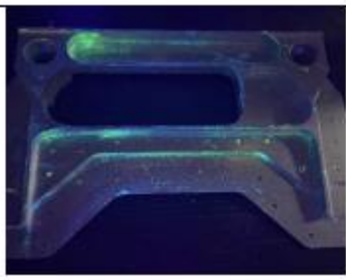
No	Suhu	Material	
		Tampak Depan	Tampak Belakang
1	10°C-38°C		

Table 2. normal temperature test results (10°C - 38°C) on material 2

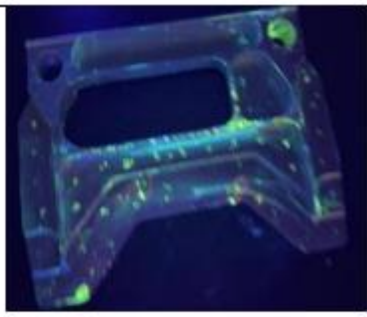
No	Suhu	Material	
		Tampak Depan	Tampak Belakang
1	10°C-38°C		

Table 3. 75 °C Temperature Test Results on Material 1

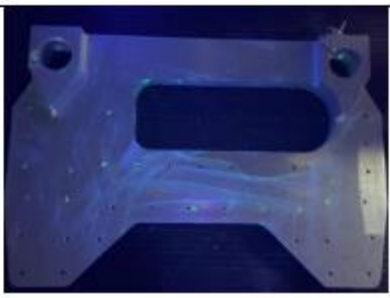
No	Suhu	Material	
		Tampak Depan	Tampak Belakang
1	75°C		

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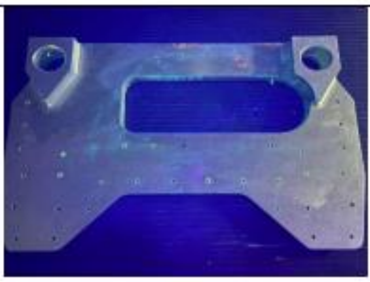
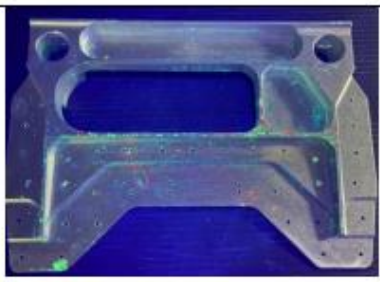
Table 4. 5°C Temperature Test Results on Material 2

No	Suhu	Material	
		Tampak Depan	Tampak Belakang
1	5°C		

Based on the tests carried out, there are variations in temperature used to see the sensitivity of corrosion on the surface of the material. On the first experiment using normal temperature (10°C-38°C) was clearly visible there are many indications on the surface of material 1 and material 2. This result looks clearly different when experiments are carried out with temperature penetrant liquid 5°C and 75°C. In the second experiment with liquid temperature penetrant 5°C can be seen that the indications are on the surface the material becomes darker and unclear compared to the experiment with normal penetrant liquid temperature (10°C-38°C). This is because of the fluid penetrant with a temperature of 5°C has a higher viscosity in comparison with a penetrant liquid at a normal temperature (10°C-38) which will occur delays during the penetration process due to the penetrant liquid It is moist which makes it difficult for the penetrant liquid to enter the gaps discontinuity in the material because it has high viscosity. The temperature low will occur separation of dye from the solution, this can reduce the brilliance of the penetrant due to the loss of coloring content in the liquid penetrant. In the third experiment with a penetrant liquid temperature of 75°C it can be seen that the indications on the surface of the material become darker and unclear compared to experiments with normal penetrant liquid temperatures (10°C-38°C) is the same as the experiment with a penetrant liquid temperature of 5°C. This matter because higher temperatures can evaporate some of the liquid then increases the dye concentration and improves visibility indications that make the penetrant liquid dry more quickly when applied penetration so that it is difficult for the penetrant liquid to enter the gaps discontinuity in the material. High temperatures can also reduce the viscosity of the penetrating fluid so that it can speed up penetration. Penetrant component swhich are volatile will evaporate quickly when applied with liquid penetrant the penetrant layer is very thin, the loss of components evaporating will change the composition of the penetrant so drastically that it is non-existent any remaining fluid can enter the discontinuity. Increased temperature also reduces the color of fluorescent liquid dyes (fading due to heat) thus making the indication less visible.

After inspection, the material will be left for 5 days the aim is to see whether new indications appear on the surface of the material. Material is stored in a homogeneous

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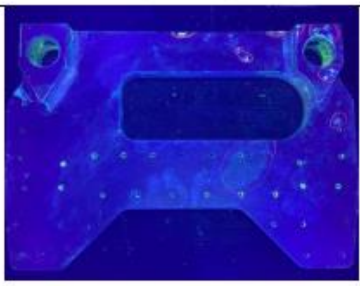
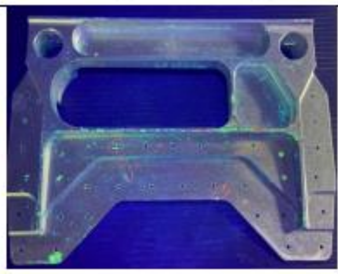
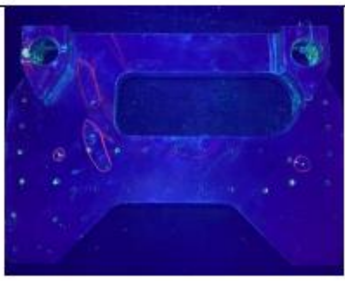
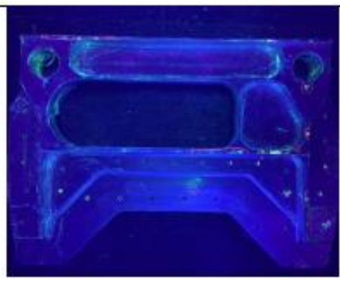
place and closed so that it does not contaminated by fine particles. The following results were obtained

Table 5 Visual Material After Leaving for 5 Days

No	Suhu	Material	
		Tampak Depan	Tampak Belakang
1	5°C		
2	75°C		

Based on the table above, these are the results obtained during the material left for 5 days, the results obtained new indications that no found in previous experiments, but in fact this is not an indication new, these indications were already on the surface of the material before it was carried out test. In previous experiments this indication was not seen because penetrant fluid is still in the discontinuity so it requires time for the developer to lift the penetrant liquid out of the discontinuity so that these indications can be seen. therefore at the time The material was left for 5 days, this indication was only visible because of the developer's work which is optimal in lifting the penetrant out of the discontinuity.

Conclusion

The use of temperature in the liquid penetrant test greatly influences the results of the inspection of the material. Experiments carried out at normal temperatures (10°C-38°C) showed clear indications of the material. while experiments using temperatures of 5°C and 75°C will make the indications on the material unclear (false indications) due to various factors. the liquid temperature is too lower than the normal temperature will have higher viscosity where there will be a delay in during the penetration process because the penetrant liquid will act moisture which makes it difficult for the penetrant liquid to enter discontinuity gap, while using a temperature higher than normal will evaporate some of the liquid which makes the penetrant liquid dry more quickly when done penetration so that it is difficult for the penetrant liquid to enter the gaps discontinuity. The use of

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developer plays an important role so that the process can be optimized, the longer the developer's contact time with the penetrant liquid, the easier it will be for the developer to pull the penetrant liquid out of the discontinuity gap.

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