Magnetic Flux Leakage for Tank Inspection 2F-4905

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Abstract

In the world of metal and non-metal industries, materials are a common thing. However, to get a quality material, a test needs to be done. One of them is the Magnetic Flux Leakage (MFL) method which is widely used for Non-Destructive Test (NDT). NDT is one of the activities to test the properties of metals which is often known as physical metallurgy. In this study, it was carried out to detect defects or corrosion in the bottom of storage tank 2F-4905 at PT Mitsubishi Chemical Indonesia by applying API 650 Standard. This is done as a form of occupational health and safety program to ensure there is no potential damage that can cause leaks in the future. The results obtained from the inspection found no irregularities or defects in the test results that did not meet the acceptance criteria set by PT MCCI based on the standard for storage tanks, namely API 650.

Keywords: Non-Destructive Test; Magnetic Flux Leakage; Discontinuities; Physical Metallurgy

Introduction

Testing is essential as a quality controller of a component (Irwansyah, 2019). The application of component testing is also increasingly widespread, starting in machinery, building, and other fields. One of the well-known component testing techniques is Non-Destructive Test (NDT). NDT is a test carried out to determine damage or defects in the component being tested with the aim of maintenance without damaging the component (Jim et al., 2016). So, using NDT is the right choice because this test does not damage the tested component and has the aim of knowing whether the component is still in a safe period (according to quality standards) or has exceeded the tolerance limit for damage to the component (Alexandri & Sugandika, 2017).

From the NDT inspection project on the welding area of Tank 2F-4905 at PT Mitsubishi Chemical Indonesia carried out by PT Double Waves Indonesia in accordance with the recommended test method referring to the API 650 storage tank inspection standard on welded steel tanks for oil storage. The main inspection method used was Magnetic Flux Leakage (MFL). MFL is a non-destructive testing method to detect corrosion and pitting in steel structures, generally in storage tank sections and pipelines (Feng et al., 2022).

PT MCCI applies company standards to maintain product grade and quality. One of the standard applications of the NDT testing process for components or materials is storage tank floor inspection (Sharif et al., 2019). The purpose of writing this paper is to find out the NDT methodused in the 2F-4905 Tank inspection, especially the MFL method and to find out the condition of the 2F-4905 tank andensure that there are no leaks or potential defects that can cause leaks in the future. The result of this test is to obtain a review of object deficiencies, the level of defects and object failures.

Research Methods

The research method is carried out by inspection on Tank 2F-4905 using MFL testing with reference to API 650 storage tank inspection standards. Tank 2F-4905 is a tank used to hold paraxylene-type oilat PT MCCI, which will be used to produce PTA (Polyethylene Terephthalate Acid). The equipment used for scanning is Eddyfi Silverwings Floormap3DIM-R to detect defects orcorrosion in the bottom of the tank. After scanning using the equipment, a top and bottom discontinuity scheme analysis was performed to determine whether the corrosion was on the top side or the bottom side.

The NDT testing procedure using the MFL method is the same as other NDT methods, requiring calibration and other preparations to ensure accurate measurement results (Irfan, 2018). The MFL method test was carried out as follows:

Material

MFL was performed using the MFL system tool - (Eddyfi Silverwings Floormap3DiM-R and/or Hand Scan) as shown in Figure 1, then Appropriate MFL, Appropriate coating simulation plate, and A-scan Ultrasonic flaw detector and probe for confirmation checks were used as supporting testing tools. The component used is PX Tank 2F-4905. The diameter of the outer tank is 27500 mm.

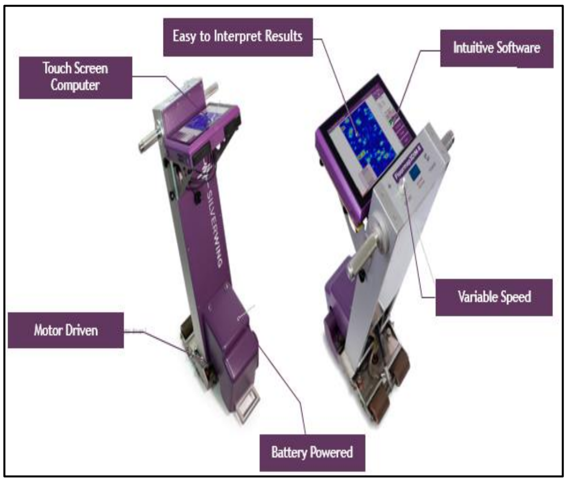

Figure 1 Eddyfi Silverwings Floormap3DiM-R Testing Tool

Preparation

Before testing, the tank floor should be clean and free of product residue. Thepresence of standing water should be avoided as it may cause damage to the sensors. The plate to be tested is numbered according to the agreed numbering system and set up lighting toperform the scan.

Calibration

The sensitivity setting of the MFL equipment should be performed on a suitable reference plate made of a material with magnetic properties and thickness similar to that of the floor section to be inspected (Prémel et al., 2012). A standard reference plate design is illustrated inFigure 2.

The dotted circles represent plate-shaped holes drilled with 10 mm diameter spherical drill tips that penetrate the plate thickness by 20%, 40%, 60%, and 80% through the plate wall. After that, lower thresholds (minimum requirement values) are set starting from 20%.

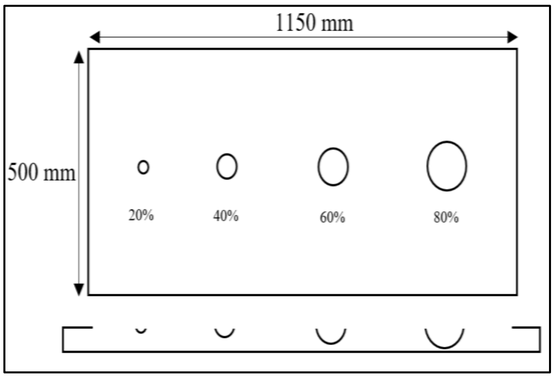

Figure 2 Plate Size Illustration

Scanning

The tank floor should be scanned plate-by-plate following the numbering system specified for the floor. At the end of the scan, the motor wheel shall be raised and the scanner hand moved so that the motor wheel can pass over the welds without imparting shock loads to the magnetic system. The effective scan width is 250 mm for the plate thickness and adjacent scans should overlap by 25% to ensure complete coverage (Pearson et al., 2012).

Detection and Confirmation

When a pit signal above the threshold value is found, the autostop function operates and the scanner stops signaled by the relevant sensor channel LED being illuminated (Azaman et al., 2015). The operator should note the illuminated channel number and locate the corresponding channel number marked on the back of the magnetic bridge. The scanner should be returned to the position where it stopped, pulled back 100 mm and scanning resumed.

Service Report

The report should include floor plans showing the tank datum, plate and annular numbering systems and the positions of the manways, sumps, pipework and obstructions. In mapping mode, this information is automatically generated and displayed in color-coded pixels (Shao et al., 2020).

Results of Research and Discussion

Inspections and tests that have been carried out in the welding area of Tank 2F-4905 as a whole are in accordance with those recommended by PT MCCI, namely referring to the API 650 storage tank inspection standard concerning welded steel tanks for oil storage (Nurdin, 2021). Standard that specifies minimum requirements for the material, design, manufacture, installation and testing of oil storage tanks, which are manufactured in various sizes and capacities as vertical ceiling, cylindrical, welded, closed and open and which store petroleum products such as diesel (Shi et al., 2015). Using the API 650 standard on the grounds that it matches the type of object being tested, namely oil storage tanks.

Can be seen in Figure 3, the data shows the results of scanning on the ground floor of Tank 2F-4905 at PT MCCI and is differentiated based on the layout of the identified data to make it easier to analyze.

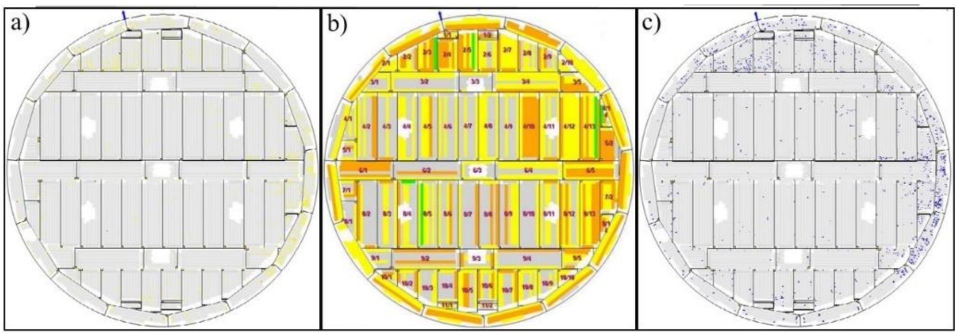

Figure 3 MFL Inspection on PX Tank 2F-4905. a) Layout data top and bottom discontinuities, b) Maximum discontinuities per track, and c) Identification results of top and bottom discontinuities

Figure 3a shows the tank floor layout resulting from the discontinuities scanning of the top and bottom of the tank floor. The total diameter of the scanned tank floor is 27,500 mm, with a total of 15 annular (ring plate) and 71 tank plates according to the numbering system agreed upon during preparation. For each length and width and thickness of the plate varies. Figure 3b shows the maximum value of discontinuities from scanning each track. Discontinuity values are distinguished based on a predetermined color scheme. Then in Figure 3c displays the results of identifying the location of discontinuities on the top or bottom tank floor which are also distinguished based on the color scheme.

From the scanning data layout, it can be seen that the discontinuities on each part of the tank floor have been seen quite a lot with varying degrees of severity. Based on the color scheme in Figure 3b, the minimum value of discontinuity severity starts from 20% marked in yellow and the maximum value is set at 100% marked in red. After obtaining the test data results that discontinuities with a severity level starting from 40% must be further verified using the UT (Ultrasonic Thickness) method to measure the thickness of the plate in order to ensure that there are no discontinuities that do not comply with the acceptance criteria (Pearson et al., 2016). The data is presented in Table 1.

Tabel 1 UT Verification Result Data

Row / Plate	X, Y (mm)	Length, Width (mm)	Comment (verified by UT)
2/3	1616, 1578	60, 60	6,54 mm
2/5	1425, 3381	70, 80	6,12 mm
4/13	427, 244	70, 90	7,00 mm
4/14	146, 528	50, 80	6,90 mm
8/4	1257, 5914	60, 50	9,00 mm
8/5	518, 1543	50, 50	9,10 mm

Of all the tank sections tested, defects were found at a severity level of 40% - 49% marked with a green color scheme which is the most severe discontinuity as shown in Figure 4.

Based on the data in Figure 4, it can be seen that there are 6 discontinuities found with values above 40%. Therefore, these 6 discontinuities must be further verified so that the UT verification test results are obtained as shown in Table 1. The measured discontinuity area and thickness are still <100 mm and <10 mm. This is still said to be safe because the severity of the discontinuities found in the tank is still low and PT MCCI still does not want to patch the tank.

Figure 4 Defects with the highest severity found during scanning

Referring to the experimental data, statistical data was also obtained which displayed a diagram of the number of discontinuities in Tank 2F-4905 with a total of 86 and divided by the percentage group of the damage level. So from there, we get a discontinuity percentage diagram that has been calculated based on the number and percentage group of the damage level. It can be seen that the highest severity of damage is in the range of 40% - 49% and the average severity of damage is in the range of 30% - 39% which states that the tank is still in a safe condition. This is an agreement from PT MCCI in this test. For more details can be seen in Figure 5 and Figure 6.

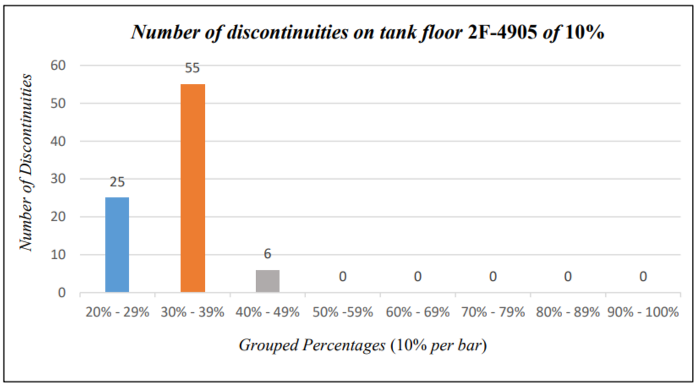

Figure 5 Number of Discontinuities in Tank 2F-4905

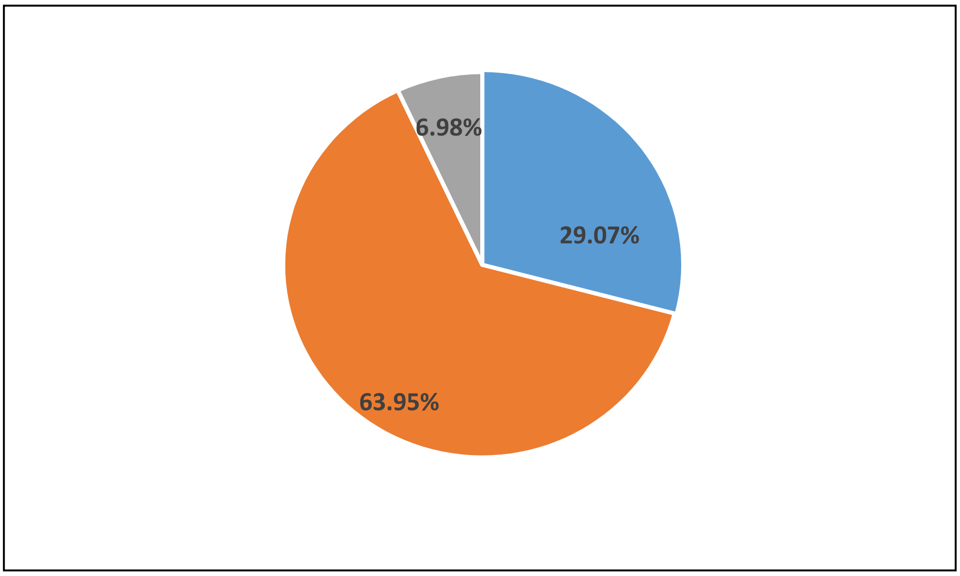

Figure 6 Percentage of discontinuity in 2F-4905 tank

Based on further specifications in the experimental data, it is also shown that the test is more focused on the bottom plate. This is because the bottom of the tank which will later hold more loads - heavy loads so that testing is more tightened (Wu et al., 2021). It is proven by the test results obtained that more discontinuities are detected at the bottom plate. As seen in Figure 7. It can be seen that there are only 2 top discontinuities from all parts of the tank. This indicates that the heavy load accommodated also affects the discontinuities to be more. However, the water collected by the tank does not have such strong corrosive elements as living organisms so there are not many discontinuities that appear at the top of the tank. Discontinuities that arise at the top and bottom plate are very dangerous because they can cause the tank to be unable to be used further because the discontinuity holes can penetrate the plate and occur suddenly. So that routine testing is needed so that the condition of the tank can be controlled and does not cause danger to the surrounding (Kang et al., 2021).

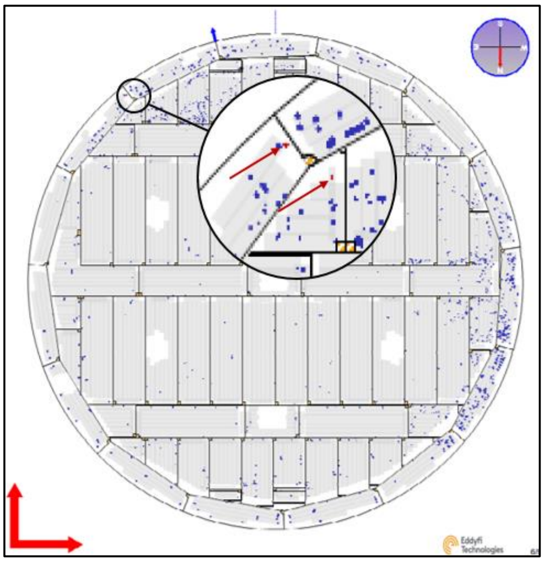

Figure 7 Top Discontinuities

Conclusion

NDT inspection on Tank 2F-4905 using the MFL method refers to standards set for storage tanks, namely API 650. Based on the data and discussion, it can be concluded that:

1. The ability of the MFL method to carry out scanning tests on tanks with precise and accurate test results when carried out based on the right procedures.
2. No defects were found in the test results which did not meet the acceptance criteria set by PT MCCI based on the standard for storage tanks, namely API 650.
3. The condition of the storage tank is that there are no leaks or potential damage.

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