Comparison of Magnetic Particle Inspection of Dry and Wet Method to the Inspection on Aircraft Bolts

Mohammad Iqmal Mohd Ali, Muhammad Zarief Daniel Besri, Md Khairul Amiza Md Hairudin

Abstract: ***Most inspection companies or any companies that involve in doing this inspection were usually do not have a clear view of which method was best to use in MPI. It is sometimes unclear whether the magnetic field was sufficiently strong to give good indications. So theoretically, both can be used as an inspection tool and company will choose the best method and resolving the inspection. Dry particle inspection was best used when looking for shallow cracks near rough surface. Components with paint or rust on them can reduce the sensitivity of the test yet still allow for the desired result. Wet suspension Particles are when particles are applied while they are held within a liquid carrier, allowing for even coverage, and to highlight leakage. It provides optimum contrast with the tested surface, allowing for greater detail than dry particles. They are particularly useful for smooth surfaces as these particles will settle in rough surfaces. The objective was to perform Magnetic testing analysis on selected bolt using dry method. To perform magnetic testing analysis on selected bolt using wet method. To determine the sensitivity comparison between wet and dry method on selected bolts. To conclude wet method magnetic testing has been proven to be more sensitive to defect compare to dry method magnetic testing as evidence by Table 3 at 70% and 50% respectively.***

Keywords: ***Magnetic Particle Inspection (MPI), Dry Method, Wet Method***

I. INTRODUCTION

General Introduction

One of the utmost important aspect in aviation industry is inspection, which may be conducted in many forms and methods. Through inspections have duly proven that they not only promote continuous development in many aspects such as maintaining live aircrafts' parts [1-3], discovering new measurements and updates of the current equipment [4-8] and materials [9-10] used in the aviation industry, promoting educational research at higher learning educations [11], and generating profits for different stakeholders at many levels [12-14]; but also prevent from the losses of human lives [15-19]. One of those inspections involve magnetic testing.

Magnetic Testing uses one or more magnetic fields to locate surface and near-surface discontinuities in ferromagnetic materials.

Magnetic testing can be conducted by using two methods which is the dry and wet method [20]. The wet method is commonly known as the Fluorescent Magnetic Particle Inspection (FMPI). On the other hand, the dry methods are dusted onto the surface of the test object as the item is magnetized. Dry particle inspection is well suited for the inspections conducted on rough surfaces [21].

Problem Statement

Most inspection companies or any companies that involve in doing this inspection are usually does not have a clear view of which method is best to use in MPI. It is sometimes unclear whether the magnetic field is sufficiently strong to give good indications. So theoretically, both can be used as an inspection tool and company will choose the best method and resolving the inspection. Dry particle inspection is best used when looking for shallow cracks near rough surface. Components with paint or rust on them can reduce the sensitivity of the test yet still allow for the desired result [22]. Wet suspension Particles are when particles are applied while they are held within a liquid carrier, allowing for even coverage, and to highlight leakage. It provides optimum contrast with the testing surface, allowing for greater detail than dry particles. They are particularly useful for smooth surfaces as these particles will settle in rough surfaces.

Research Objective

- To perform Magnetic testing analysis on selected bolt using dry method
- To perform magnetic testing analysis on selected bolt using wet method
- To determine the sensitivity comparison between wet and dry method on selected bolts

Research Goals

Main goal for intended final year project is to determine the efficiency of the wet method compare to dry method regarding flaw detection and the subsequent time consume and cost.

Scope and Limitation

The final year project scope only limited to selected aircraft standard steel bolt using Bouw and Widen equipment. Other application on other bolt might not yield the result intended.

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Summary

Magnetic Particle Inspection are usually to evaluate ferrous metal on modern or current aircraft but for this research is focusing more on age aircraft. This is by inspecting aircraft bolts for any defect. The inspection using Magnetic Particle Inspection use two methods which is the Dry Method and Wet Method.

II. LITERATURE REVIEW

Non-Destructive Technique

Dwivedi et. al. (2018) described nondestructive testing are methods to evaluate material integrity for surface or internal flaws or metallurgical condition without interfering in any way with the destruction of the material or its suitability for service [23].

Magnetic Particle Inspection

Singh & Singh (2016) described that Magnetic Particle inspection is a nondestructive method that detects discontinuities that are either buried slightly below or open to the material or weld surface. Its advantage over visual inspection is that it can detect defects that are buried below the surface as well as surface opening defects that are too small to be visible by the naked eye [24].

Summary

Magnetic particle inspection is still on the efficient method that is being use in the NDT industry as it gives a good result and precise result. This must be practice in any other industry because it could save life and might be cost. Catastrophic event could be prevented if conducting Magnetic Particle Inspection on components that are ferrous. MPI can enhance and control the manufacturing processes and support in product development of material. Hence, researchers utilized all the necessary equipment and documentations that are readily available for training purposes at UniKL MIAT to conduct the experiments [25].

III. METHODOLOGY

Lighting

The magnetic particle inspection can be performed utilizing particles that are profoundly noticeable under white lighting conditions or particles that are exceptionally unmistakable ultraviolet conditions.

Visible light

According to the Standard Practice for Magnetic Particle Inspection (ASTM), visible light intensity measurement needs to be conducted upon initial light installation or when changes occur that cause the light intensity to change and at the intervals specified in Table 1 (Figure 1). Visible light shall be used when examining with non-fluorescent magnetic particles.

Table. 1 Table Required of Verification Intervals on Lighting (ASTM Table)

Item	Maximum Time Between Verification[A]
Lighting:[B]	
Visible light intensity (5.7.1.1)	weekly
Ambient light intensity (5.7.1.2)	weekly
Black light intensity (5.7.2, 7.3.5)	daily
System Performance:[B] (7.1, 7.1.1, 7.1.2)	daily
Wet particle concentration (7.2.1.1)	8 hours, or every shift change
Wet particle contamination:[B] (7.2.1.2)	1 week
Water break test (7.2.2)	daily
Equipment calibration check:[B]	
Ammeter accuracy (7.3.1)	6 months
Timer control (7.3.2)	6 months
Quick break (7.3.3)	6 months
Yoke dead weight check (7.3.4)	6 months
Black and white light meters	6 months
Gaussmeter accuracy	6 months

[A] When the inspection system is in operation.
[B] The maximum time between verifications may be reduced or extended when substantiated by actual technical/reliability data.

Black Lights

Inspection black lights might meet the necessities. The base satisfactory force is 1000µW/cmˆ2 (10W/mˆ2) at the surface being inspected. Black lights shall be checked periodically for cleanliness and integrity and shall be cleaned, repaired or replaced as appropriate.

Fig. 1 Black Lights

Restricted Area Examination

Where lamps are physically too large to directly illuminate the examination surface, special lighting, such as UV pencil lights or UV light guides or borescopes shall be used. The picture saw must have adequate determination to successfully inspect the required discontinuities.

Fig. 2 UV Light

IV. ANALYSIS

Introduction

Research and series of experimental has been conducted to determine the sensitivity of the magnetic testing wet method and dry method. Result were compared to determine the sensitivity yield by both method and to determine the best method respectively.

The objective of the research was to perform Magnetic testing analysis on selected bolt using dry method to perform magnetic testing analysis on selected bolt using wet method and to determine the efficiency comparison between wet and dry method on selected bolts

Bolt Sampling

Ten AN4-6 3/8-24 TPI aircraft standard bolt were selected for the wet method and dry method sensitivity comparison. The bolts selected share the same dimension for the purpose of controlling the accuracy of the research as showed by Figure 3. The bolt with a crack or corrosion in the shank, radius or thread is rejected. Table 2 shows 10 identical bolts. The crack that has been found was 3 inches below the bolt head

Fig. 3 AN4-6 3/8-24 TPI

Table. 2 Ten Identical Bolts

Sample Bolt	Ten Identical AN4-6 3/8-24 TPI Bolt
A	
B	
C	
D	
E	
F	
G	
H	

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Wet Method

Wet method magnetizing has been conducted on series of 10 AN4-6 3/8-24 TPI. The test was conducted in a control environment. The result was tabulated as evidence by Table 3. The results that showed below was between the comparison of wet method and dry method in term of which method has a more sensitivity. This method has been conducted as per ASTM E1444. Table 3 showed a tremendous result on wet method in terms of sensitivity.

Fig. 4 Bolt Using Wet Method

Dry Method

Ten identical AN4-6 3/8-24 TPI bolt was tested using the dry method. Most crack on the bolt cannot be identified visually by using the dry method. The result is shown in Table 3. From the table, dry method showed just a few signs of crack detection on some of the bolts. This method has been conducted as per ASTM E1444. Table 3 showed that the dry method is less sensitive than wet method although dry method has a portability advantage.

Fig. 5 Bolt Using Dry Method

Results of Wet and Dry Method

Table. 3 The comparison of sensitivity of dry and wet method

#	Sample Bolt	Wet Method	Dry Method	Remarks
1	A	1	1	Crack was found on the bolt thread. Bolt must be discarded
2	B	1	0	Hair line crack was found on bolt shank. Bolt is still usable
3	C	1	1	Fatigue crack was found below the bolt head. Bolt must be discarded
4	D	1	1	Fatigue crack found below the bolt head. Bolt must be discarded
5	E	1	0	Hair line crack was found on bolt shank. Bolt is still usable
6	F	0	0	No crack found
7	G	1	1	Hair line crack was found on bolt shank. Bolt is still usable
8	H	0	0	No crack found
9	I	1	1	Fatigue crack was found below the bolt head. Bolt must be discarded
10	J	0	0	No crack found

Analysis based on charts

From the chart below, 7 sample bolts of AN4-6 3/8-24 TPI has literally showed a high percentage of sensitivity for detecting the cracks. The 80% and above was the amount of sensitiveness that detected the cracks. A huge amount percentage was showed in Figure 6 below compared to dry method. Wet method can be considered as a better detection method rather than dry method. As evidence by Table 4 and further visualize by Figure 6.

The 80% and above was the amount of sensitiveness that detected the fatigue crack, crack and hair line crack on 3 different locations which is on the shank, below the bolt head and the bolt thread.

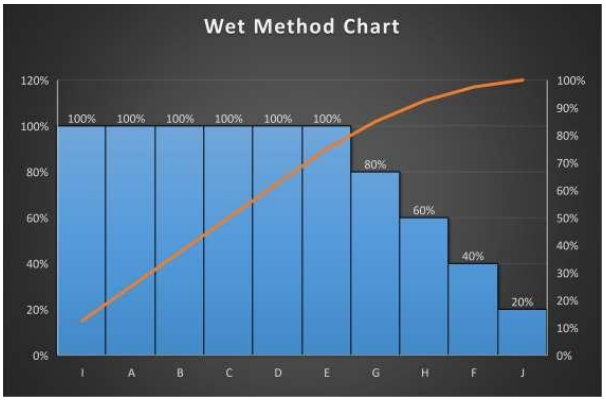

Fig. 6 Wet Method Chart

From the chart below, 5 sample bolts of AN4-6 3/8-24 TPI has literally showed a lower percentage of sensitivity for detection of cracks compared to the previous chart. The 80% and above of sensitiveness detected the cracks. A small amount of percentage was showed in Figure 7 below compared to wet method. The dry method can be considered a less preferable method to be use as the sensitivity to detect cracks are lower than wet method, as most of the bolt has small cracks and can mostly detected by wet method. As evidence by Table 4 and further visualize by Figure 7. The 80% and above was the amount of sensitiveness that detected the fatigue crack, crack and hair line crack on 3 different location which is on the shank, below the bolt head and the bolt thread.

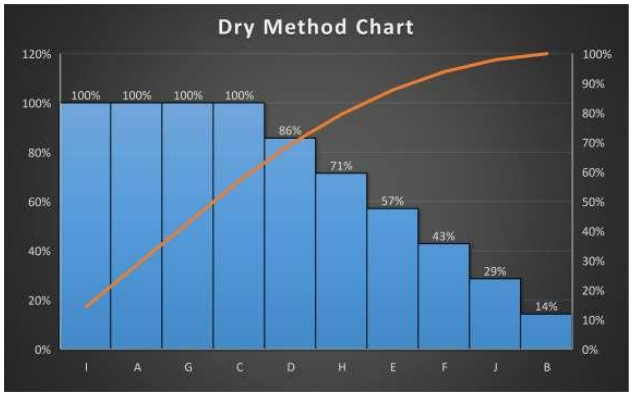

Fig. 7 Dry Method Chart

V. CONCLUSION

From the evaluation that has been taken, the best method should be used is the wet method as it could give a better sensitivity rather than the wet method as evidence by Table 3.

The objective was to perform Magnetic testing analysis on selected bolt using dry method. To perform magnetic testing analysis on selected bolt using wet method. To determine the sensitivity comparison between wet and dry method on selected bolts.

The investigation of magnetic testing via dry method on selected bolt has been completed as evidence by database on Table 4. The investigation of magnetic testing via wet method on selected bolt has been completed as evidence by database on Table 4.

To conclude wet method magnetic testing has been proving to be more sensitive to defect compare to dry method magnetic testing as evidence by Table 3 at 70% and 50% respectively.

Recommendation

A good recommendation to the company that use Magnetic Testing as a part of their inspection techniques, wet method will most preferable to use as it gives the best detection rather than the dry method. Besides that, to keep our environment from being harm by any harmful and hazardous material the wet method fluid must be in a form of a water base rather than a petroleum base. This is because the petroleum base could emit harmful gaseous that are dangerous to the environment. Furthermore, water base has a short preparation time rather than the petroleum base because water base only needs a half hour while the petroleum base needs an hour.

Future work

For a better progress in the future in conducting an inspection on aircraft bolts it is recommended if you would use other types of Non-Destructive Testing method which are more advance and more accurate in term of sensitivity such as radiography, eddy current and ultrasonic.

REFERENCES

1. Zainal Ariffin, M., Johari, M., & Ibrahim, H. (2018). The needs of aircraft avionics' radio line replaceable unit repair center at UniKL MIAT. *International Journal of Engineering and Technology*, 86-88.
2. Johari, M., Jalil, M., & Mohd Shariff, M. (2018). Comparison of horizontal axis wind turbine (HAWT) and vertical axis wind turbine (VAWT). *International Journal of Engineering and Technology*, 74-80.
3. Omar, S., Johari, M., & Abdul Samad, A. (2018). Assessment on risk management of helicopter services for offshore installations. *International Journal of Engineering & Technology*, 229-231.
4. Muhd Zaimi, M., Rosdi, I., & Dahdi, Y. (2019). Tensile Test on Sisal/Fibre Glass Reinforced Epoxy-based Hybrid Composites. International Journal of Innovative Technology and Exploring Engineering, 604-607.
5. Muhd Zaimi, M., Nazran, M., & Basit, R. (2019). Design and Testing UniKL MIAT CF 700 AFT Fan Turbofan Fuel Tank with Indicator. International Journal of Innovative Technology and Exploring Engineering, 590-595.
6. Azman, A., & Abdul Rahman, A. (2019). Potential and challenges of drop-in biojet fuel in Malaysia. International Journal of Innovative Technology and Exploring Engineering, 556-563.
7. Mohd Ali, M., & Ahmad Khairul Azman, N. (2019). Automated Deployable Protection Unit for Drones. International Journal of Innovative Technology and Exploring Engineering, 564-574.
8. Mohd Ali, M., & Husni, M. (2019). Efficiency of Solar Cells for UAV. International Journal of Innovative Technology and Exploring Engineering, 575-577.
9. Ya'acob, A., Razali, D., Anwar, U., Radhi, A., Ishak, A., Minhat, M., . . . Teh, C. (2017). Preliminary Study on GF/Carbon/Epoxy Composite Permeability in Designing Close Compartment Processing. *AeroMech17* (pp. 1-9). Pulau Pinang: IOP Publishing Ltd.
10. Ya'acob, A., Mohd Razali, M., Anwar, U., Mohd Radhi, M., Ishak, M., Minhat, M., . . . Teh, C. (2018). Investigation of closed compartment moulding for pull-winding process. *International Journal of Engineering and Technology*, 107-111.

11. Johari, M. K., & Jamil, N. Z. (2014). Personal problems and english teachers: Are they always bad? . *International Journal of Applied Linguistics and English Literature*, 163-169.
12. Khairuddin, M., Yahya, M., & Johari, M. (2017). Critical needs for piston engine overhaul centre in Malaysia. *IOP Conference Series: Materials Science and Engineering* (pp. 012013 (1-5)). Bristol: IOP Publishing Ltd.
13. Bardai, A., Er, A., Johari, M., & Mohd Noor, A. (2017). A review of Kuala Lumpur International Airport (KLIA) as a competitive South-East Asia hub. *IOP Conference Series: Materials Science and Engineering* (pp. 012039 (1-10)). Bristol: IOP Publishing Ltd.
14. Ishak, F., Johari, M., & Dolah, R. (2018). A case study of LEAN application for shortest lead time in composite repair shop. *International Journal of Engineering and Technology*, 112-119.
15. Azizan, M., Fard, M., & Azari, M. (2014). Characterization of the effects of vibration on seated driver alertness. *Non-linear Engineering-Modelling and Application Journal*, 163-168.
16. Amzar, M., Fard, M., Azari, M., Jazar, R., & Maeda, S. (2017). Influence of vibration on seated occupant drowsiness measured in simulated driving. *Applied Ergonomics Journal*, 348-355.
17. Abdul Samad, A., Johari, M., & Omar, S. (2018). Preventing human error at an approved training organization using Dirty Dozen. *International Journal of Engineering and Technology*, 71-73.
18. Muhd Zaimi, M., & Zulkifli, M. (2019). Analysis on the Aerodynamic Efficiency of Modified Blended Wingtip. International Journal of Innovative Technology and Exploring Engineering, 600-603.
19. Amzar, M., Fard, M., Azari, M., Benediktsdttir, B., Arnardttir, E., Jazar, R., & Maeda, S. (2016). Influence of vibration on seated occupant drowsiness. *Industrial Health Journal*, 1-12.
20. Raj Kumar, R., Subashini, K., Ragulkumar, J., & Sathish, E. (2017). Design and Development of SCR Firing Circuit for MPI Current Source. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, 1547-1559.
21. NDT Resource Center. (2009). Retrieved from Dry Particle Inspection: https://www.nde-ed.org/EducationResources/CommunityCollege/MagParticle/TestingPractices/Dry%20Particle.htm
22. DNV.GL. (2017, May). Retrieved from https://rules.dnvgl.com/docs/pdf/DNVGL/RP/2017-05/DNVGL-RP-G103.pdf
23. Dwivedi, S., Vishwakarma, M., & Soni, P. (2018). Advances and Researches on Non Destructive Testing: A Review. *Materials Today:Proceedings*, 3690–3698.
24. Singh, R. (2015). Magnetic Particle Testing. In *Applied Welding Engineering* (pp. 327–334). Amsterdam: Elsevier.
25. Universiti Kuala Lumpur Malaysian Insitute of Aviation Technology. (2006). UniKL MIAT Apparatus. Dengkil, Selangor, Malaysia: UniKL MIAT.