Advances in Science and Technology Research Journal
Volume 7, No. 20, Dec. 2013, pp. 23–28
DOI: 10.5604/20804075.1073049

Original Article

NON-DESTRUCTIVE TESTS OF LOCK TONGUES USED IN ATR-72 AIRCRAFT LANDING GEAR BASED ON MAGNETIC METHOD

Mirosław Malec[1], Tomasz Cieplak[2], Sławomir Walczuk[3]

[1] Fundamentals Technology Faculty, Lublin University of Technology, 38 Nadbystrzycka Str., 20-618 Lublin, Poland , e-mail: m.malec@pollub.pl

[2] Management Faculty, Lublin University of Technology, 38 Nadbystrzycka Str., 20-618 Lublin, Poland , e-mail: t.cieplak@pollub.pl

[3] Graduate student of Fundamentals Technology Faculty, Lublin University of Technology, Poland

Received: 2013.09.19
Accepted: 2013.10.14
Published: 2013.12.06

ABSTRACT
The purpose of this work is to highlight the opportunities of using and analyzing process progression of Non-destructive Testing in aeronautical industries and technologies. This paper concentrates on magnetic-fluorescent method, which is used to showcase the practical test of lock tongue installed in ATR-72 aircraft landing gear.

Keywords: NDT research, magnetic-fluorescent method, wear and tear.

INTRODUCTION

Non-destructive Testing (NDT) techniques enjoy widespread use in the field of aeronautical technologies due to meeting safety requirements for the duration of aeronautical activities as well as fulfilling the need to provide high degree reliability of operations and the highest possible utility readiness. In addition to these factors, manufacturers and users of the aircraft have started to put significant emphasis on economic considerations recently. Non-destructive tests conducted over the course of operating the aircraft allow for technical inspection of multiple components without the need to disassemble the craft or with a limited disassembly. This proves to be of great significance as NDT methods enable engineers to take advantage of these tests at any point during the utilization of aircraft and they do not interfere with their exploitation and prevent conducting aeronautical operations only to a marginal degree.

This paper highlights the process and results of the conducted NDT tests using magnetic-fluorescent method. The tests have been carried out in compliance with current legal provisions and norms.

TEST OBJECT CHARACTERISTIC

The object of this test was an aircraft lock tongue responsible for blocking the landing gear hatch of ATR-72 airplane. It cooperates with a capstan and an electromagnetic lifter. Each opening of the lock is signaled by the pressure on the capstan and relay contacts, the joining of which is further relayed in the cockpit and interpreted as the opening of the hatch.

The tongue performs the function of a lock block, preventing the hatch from opening during the flight. It is made of the tool steel NC11X-210Cr12 and its dimensions are 150×60×20 mm. Due to the function of this device any damage to this element preclude it from further use. Figure 1 presents this component. All tests of this element have been conducted in NDT research laboratory, furnished with tools and specialized equipment necessary to conduct the tests based on magnetic-fluorescent method.

A device critical to perform these tests is a magnetic defectoscope Contrmag CM-152 manufactured by Srem company. For the purpose of this research a number of other devices were used: a demagnetizing device, Berthold’s model, Block A model, sedimentation containers ASTM D 96,

Fig. 1. The tested component – a lock tongue of a landing gear

magnetic field meter, a source of white light, an ultraviolet radiator UV/A, a lighting intensity meter, UV/A radiation measuring tool, ultrasonic cleaner, magnetic suspension and cleaning liquids.

PREPARATIONS AND THEIR PROGRESS

The preparations for the main test have been opened by confirming the expiration date of magnetic suspension Fluxo 6C used in the test procedures and the quality of the tested liquid. To this end 100 ml of Fluxo 6C liquid was poured into a sedimentation container ASTM D 96 which is used to determine to level of concentration of the magnetic fraction in the liquid carrier – in this case, kerosene. The test took 30 min, and the measured value was set between 0.1–0.7% magnetite corpuscles. The final result amounted to 0.1% which signifies that the tested liquid fulfilled all usage requirements. In the course of the test the intensity of day lighting and ultraviolet radiation was measured, the latter of which was generated by ultraviolet radiator installed on a test stand. The test was conducted using a universal measuring device Pollux 707. Considering currently accepted norms the intensity of ultraviolet light should be greater than 1500 $\mu W/m^2$. The final result of UV radiation is 2500 $\mu W/m^2$. In addition, the intensity, which does not to exceed 20 lx, was estimated to value 5 lx.

VERIFICATION OF CM – 152 DEFECTOSCOPE PERFORMANCE

The next stage of the preparation for the testing process is the verification of the defectoscope performance used in NDT. In this case, the subject of inspection is CM – 152 magnetic defectoscope. The aforementioned inspection is twofold: it involves assessing the direction of magnetization and its thoroughness. The direction of magnetization was verified with Berthold Magnetic Field Indicator (Figure 2). This indicator is a simple measuring device, which enables researchers to determine approximation of measurements in the test conducted with the use of magnetic powder and helps to verify the direction of magnetic field. Berthold's Magnetic Field Indicator comprises: a ring, which is to be free of any magnetic residue, and a cylinder of soft steel set into it, which consists of four segments. These segments are separated from each other by non-magnetic facets which create two perpendicular fissures. A membrane with a thin brazen lid is screwed onto the cylinder. As the membrane turns the lid's position relative to the ground becomes shifted. In order to conduct the measuring the indicator must be placed on a magnetized object; as a result a fraction of magnetic field lines will flow through the cylinder made of soft steel. After the powder of magnetic suspense is applied, depending on the direction of the field the membrane reflects one or two lines of cross fissure. As the membrane is moved away upwards without the loss of measurements, the measurements taken using this method are proved to be more accurate as a result of higher current intensity or the quality of the magnetic suspense. The model component rotates slowly around the cylinder's axis until the fissure becomes clearly reflected. In this position the

Fig. 2. Berthold's Magnetic Field Indicator

magnetic field goes perpendicularly in relation to reflected fissure. The estimation of the direction of magnetization using the abovementioned indicator has been supplemented with the evaluation of the thoroughness of magnetization with Block A model. Block A model is a steel cuboid measuring 30×110×20 mm, with multiple holes 1.5 mm in diameter each.

If the location of damage is known it is easy to determine the thoroughness of magnetic test. The abovementioned model – Block A – has been placed into the clip of the defectoscope CM – 152 after which it has been subjected to magnetization three times, with a 2.7 kA/m current within the duration of 5 seconds each time (Figure 3).

Fig. 3. Model – Block A

Furthermore, in order to perform additional check of the direction of magnetization a Berthold's Magnetic Field Indicator was applied onto Block A. Using MDC3 and MF300 H gauge the value of magnetic field was measured. The value of intensity of the magnetic field in an appropriately conducted test should be between 6400 –12800 A/m. This value in a given test amounted to 9000 A/m. It is of paramount importance that during this stage of the test the gauge probe was placed in accordance with the direction of the forces of magnetic field, as this ensures correct readings of its values. Otherwise there is a chance of distortion and the tested item may become undermagnetized or overmagnetized, which will result in defectograph inaccurate. In the course of the magnetization procedure a magnetic suspension solution was applied on Block A. After magnetization was completed the results were acquired; The results are presented in Figure 4.

Circular magnetization is the next step in test preparations. The process involves a shift of the magnetization angle by 90° in relation to the former position and evaluation of the efficiency of the process. In order to assess the thoroughness of magnetization a Ketos Ring was placed on a copper electric conductor, after which the current of 8 KA was switched on for the duration of 2 seconds – this procedure was repeated three times. Ketos Ring is a metal ring, 127 mm in diameter with drilled holes located 1.78–21.34 mm from the outer rim. Just as during model – Block A check, in this case the quality of defectograph was determined. After the test had come to an end it was possible to pinpoint deliberately damaged segments. A number of lines appeared on the rim of the ring, which signified that the test was conducted appropriately. The intensity of the field on the tested component was 1000 A/m. Figures 5 and 6 present, respectively, Ketos Ring and the way it looked after magnetization.

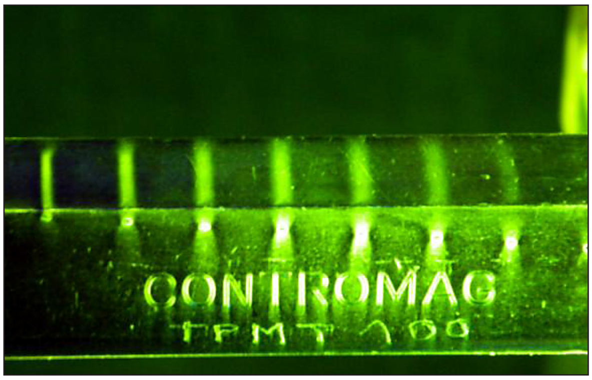

Fig. 4. The model Block A in UV lighting after completed magnetization and application of magnetic suspension

Cleaning the tested object from all kinds of waste, such as grease, dirt, oils and anticorrosive countermeasures is a crucial step in the testing process. In particular anticorrosive paints with ferromagnetic characteristics must not be left on the object. The object in question was first cleaned with a cloth wetted in special clearing salve, and then placed in an ultrasonic cleaner. Overall cleaning took 30 minutes. Next the researches proceeded to initial inspection of the tested object. The purpose of this test phase is to locate any defects which were revealed after the cleaning process was complete. The initial evaluation was conducted using magnifying glass in 5× magnification. The test did not reveal any defects so the researches proceeded to the next step. This stage involves demagnetization of the component in laboratory conditions using a demagnetizer so that the residual magnetism does not exceed 500 A/m. By default, residual magnetism of the tested object was 600 A/m. After demagnetization the levels of the object's magnetism decreased to 100 A/m.

Fig. 5. Ketos Ring

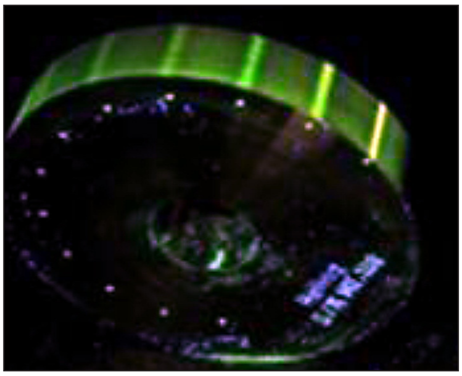

Fig. 6. Ketos Ring in UV lighting after magnetization and application of magnetic suspense

LONGITUDINAL MAGNETIZATION OF THE TESTED OBJECT

The next phase involves magnetization of the test tongue. First, longitudinal magnetization was performed. As a result, all defects located perpendicularly to the direction of the magnetic field should be visible once magnetization and application of the magnetic suspense has been completed before radiating the object with a UV radiator. To this end the object was inserted in the grip of CM-152 magnetic defectoscope (Figure 7). The object was subjected to three doses of magnetization with 400 A current, which took 5 seconds each time. The intensity of the magnetic field in the object was 11000 A/m. During the two first cycles of magnetization the tested object was poured in magnetic solution, while the third magnetization did not involve this process in order to stabilize the defectograph. Once magnetization was finalized, the object was removed from the grips and subsequently underwent inspection in UV lighting.

No defects were found. Once the inspection was finished, in order to ensure accurate readings

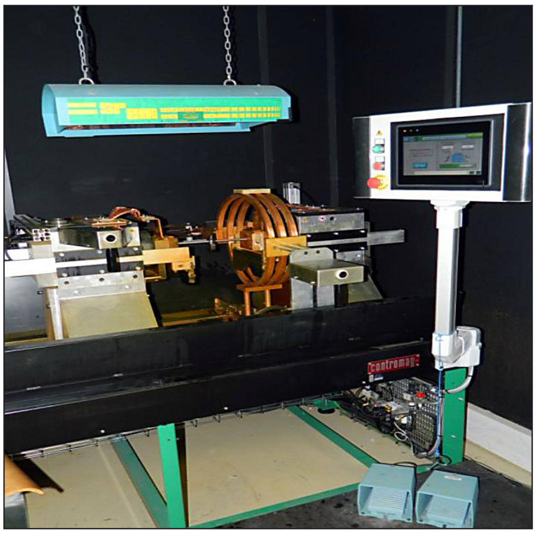

Fig. 7. CM 152 magnetic defectoscope

the lock tongue was subjected to demagnetization. For this reason it was placed in a demagnetizer. As mentioned before it is important to ensure that the value of residual magnetic field does not exceed 500 A/m. The measuring was performed using Magnetis residual magnetic field gauge. The final value of the magnetic field during this test amounted to 95 A/m.

CIRCULAR MAGNETIZATION OF THE TEST OBJECT

Circular magnetization is the next stage of the test. The tested object is placed on a copper rod, which in turn is placed in the grips of a magnetic defectoscope. The object was once again subjected to magnetization with 400 A current for the duration of 5 seconds – the process was repeated three times. The intensity of magnetic field in the test object reached the value of 9000 A/m. The angle of direction of magnetic field had shifted in comparison with previous test by 90°. As in previous stage, this time during the first two cycles of magnetization the component was covered with magnetic solution, while the third cycle did not involve this process in order to stabilize the defectograph. Once magnetization was completed, the object was removed from the grips and it underwent inspection. The control component was once again subjected to UV radiation, which this time revealed accumulation of the ferromagnetic liquid at the joint between that tongue and control lifter. As referred above, during the inspection and after magnetization no defects were found, whereas after performing circular magnetization a major accumulation of ferromagnetic solution was revealed in one of the parts of the joining. The exact location of the suspected defect is visible in Figure 8. The spot underwent additional thorough scrutiny which confirmed the appearance of a crack across the lifter in the tested lock tongue.

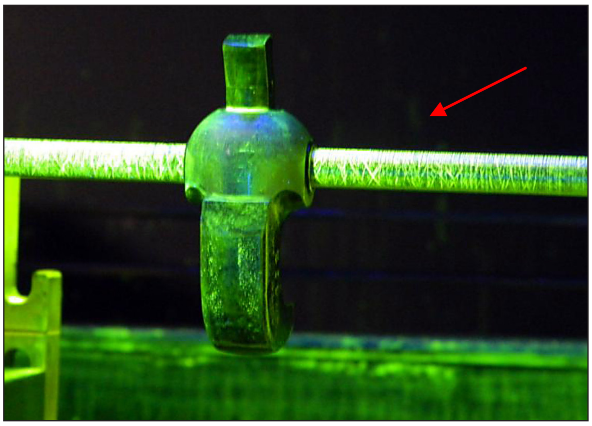

Fig. 8. Location of the defect in the test lock tongue

In order to record the conducted test the documentation on performed activities is drafted. At this stage a report was filled in, which constitutes a record of accomplished tasks. Every aeronautical organization responsible for conducting Non-destructive Tests has a different set of documents, which are then validated by National Aviation Office. In the case Polish Civil Aviation Office is the competent body. Regardless of the country, the tests are conducted in, such a document ought to account for certain sets of rudimentary data, including:

- date of the test;
- test method;
- sketch of the tested item;
- name of the researcher;
- result of the test;
- evaluation skating whether the component was faulty or operational.

The last stage of the test based on magnetic method is the final demagnetization of the test component (Figure 9), and clearing it from the suspension. The final demagnetization is very important, because the value of magnetic field intensity must not exceed 240 A/m. The test object – a damaged lock cap – was isolated from other, flawless components used in the test and subjected to thorough clearing, which involved using cleaning salve and clearing in an ultrasonic cleaner. The object was supplemented with an information card, which contained rudimentary information concerning the damaged component, its origins (name, series no.), the date of the test and the name of the research responsible for the undertaking. Separation of the broken component is the last step in the test procedure.

Fig. 9. The final measurement of residual magnetism in the tested component

CONCLUSIONS

This paper concentrated on the procedure of Non-destructive test based on magnetic-fluorescent method, which is frequently used in aviation and aeronautic industry. In particular the work highlighted stages of conducting thorough test of a lock tongue installed in the a landing gear of ATR-72 airplane. The conclusions accumulated after successful completion of the procedure are twofold. First, there are the tangible benefits stemming from the application of this method in aeronautic technologies. The authors of this paper conclude that the most important of them are: the reliability of the accumulated results of the test, high level of detection of defects, low expense threshold of conducting the test, capacity to perform the tests directly on board of the aircraft using portable defectoscopes and fluorescent powder. Second, there are practical conclusions which came about over the course of the test: approachability of the method and simplicity of the test procedure. It is important, however, to pay particular attention to certain aspects of the tests which, if done inappropriately, may result in inaccurate readings. One must account for: checking expiration date and the quality of magnetic liquid, controlling the intensity of white light and UV/A radiation, controlling the intensity of magnetic field in the test object during magnetization, demagnetizing the test object between longitudinal and circular magnetization, and correct choice of direction of magnetization, which depends on the shape of the object.

If all of the aforementioned requirements are met the resulting research may be deemed as reliable - which means they give the true information on any defects, as well as wear and tear of a given object The subject of the analysis in this paper was the technical condition of the lock tongue installed in the landing gear of ATR-72 aircraft. In the given test case a 14 mm crack on the joining of the lifter was revealed, which precludes the component from any further use. In spite of apparent simplicity and approachable principles of the highlighted magnetic method it is important for further develop diagnostic equipment, which will ensure greater reliability and accuracy of the gathered test results. This, in turn, will improve safety of aeronautic undertakings and safeguard human lives, what is of paramount importance.

REFERENCES

1. Deputat J. Nieniszczące metody badania własności materiałów. Biuro Gamma, Warszawa 1997.
2. Lewińska-Romicka A. Badania magnetyczne. Podręcznik, t. 1 i t. II. Biuro Gamma Warszawa 1998.
3. Norma PN-EN ISO 9934-1 Badania nieniszczące. Badanie magnetyczno proszkowe – Część 1. Zasady ogólne.
4. Norma PN-EN ISO 9934-2 Badania nieniszczące. Badanie magnetyczno proszkowe – Część 2. Środki wykrywające.
5. Norma PN-EN ISO 9934-3 Badania nieniszczące. Badanie magnetyczno proszkowe – Część 3. Aparatura.
6. Norma PN-EN ISO 3059 Badania nieniszczące. Badania penetracyjne i magnetyczno-proszkowe. Warunki obserwacji.
7. Norma: PN-EN 571-1 Badania nieniszczące – badania penetracyjne. Zasady ogólne.
8. Pawłowski Z. Badania nieniszczące. Poradnik. Wydawnictwo SIMP, Warszawa 1988.