IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 3, Issue 5, May 2016

Analysis of Aircraft Wheel Hub Assembly Using NDT Techniques

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Abstract: In aviation non-destructive techniques are used to prevent the failure of aircraft components, to find the cause of failure, how the failure has occurred and steps to be taken to prevent the failure of such components. Aircraft wheels take the impact during landings and assist in taxiing, take off etc. Fatigue cracks and pitting corrosion on the mating surface of aircraft wheel hub is found using eddy current inspection method and cracks on bolts (occurring on thread and shaft region) are found using either magnetic particle inspection or fluid penetrant inspection. The crack was found on the mating region the aircraft wheel hub.

Keywords: Wheel hub assembly, Fatigue crack, Non-Destructive testing.

I. INTRODUCTION

The typical modern two-piece aircraft wheel is cast or forged from aluminium or magnesium alloy. The halves are bolted together and contain a groove at the mating surface for an O-ring, which seals the rim since most modern aircraft utilize tubeless tires. The bead seat area of a wheel is where the tire actually contacts the wheel. It is the critical area that accepts the significant tensile loads from the tire during landing. To strengthen this area during manufacturing, the bead seat area is typically rolled to pre stress it with a compressive stress load. The main parts consist of the inner and outer wheel hubs, tie bolts, heat shields, O ring, over inflation valve, thermal relief valves, and disk alignment brackets. Non-destructive tests help to understand the condition of the aircraft wheel hub and make the necessary maintenance works which may increase the service life of the aircraft wheel hub. Non-destructive tests used mainly are eddy current inspection, magnetic particle inspection and visual inspection. Eddy current NDT can examine large areas very quickly, and it does not require use of coupling liquids. In addition to finding cracks, eddy current can also be used to check metal hardness and conductivity in applications where those properties are of interest, and to measure thin layers of nonconductive coatings like paint on metal parts.

Eddy current testing is limited to materials that conduct electricity and thus cannot be used on plastics. Eddy current and ultrasonic testing can be used together as complementary techniques, with eddy current having an advantage for quick surface testing and ultrasonics having better depth penetration. In an eddy current probe, an alternating current flows through a wire coil and generates an oscillating magnetic field. If the probe and its magnetic field are brought close to a conductive material like a metal test piece, a circular flow of electrons known as an eddy current will begin to move through the metal. The eddy current flowing through the metal will in turn generate its own magnetic field, which will interact with the coil and its field through mutual inductance. Changes in metal thickness or defects like near-surface cracking will interrupt or alter the amplitude and pattern of the eddy current and the resulting magnetic field. This in turn affects the movement of electrons in the coil by varying the electrical impedance of the coil. The eddy current instrument plots changes in the impedance amplitude and phase angle, which can be used by a trained operator to identify changes in the test piece. Magnetic particle inspection is a method of locating surface and subsurface discontinuities in ferromagnetic materials. It depends on the fact that when the material or part under test is magnetized, magnetic discontinuities that lie in a direction generally transverse to the direction of the magnetic field will cause a leakage field to be formed at and above the surface of the part. The presence of this leakage field, and therefore the presence of the discontinuity, is detected by the use of finely divided ferromagnetic particles applied over the surface, with some of the particles being gathered and held by the leakage field. This magnetically held collection of particles forms an outline of the discontinuity and generally indicates its location, size, shape, and extent. Magnetic particles are applied over a surface dry particles, or as wet particles in a liquid carrier such as water or oil.

II. INSPECTION METHODS

NDT inspection of aircraft wheel hub during routine check-up involves the inspection of aircraft wheel hub and its components. NDT inspection of the aircraft wheel hub inspection is shown in the flow chart figure 1.

Aircraft wheel hub can be inspected using eddy current inspection and liquid penetrant inspection. Tie bolts is inspected using magnetic particle inspection. Visual inspection is used to check the bearing, O ring, heat shields etc. First the wheel arrives at the maintenance workshop with the unserviceable tag. A visual inspection of the wheel hub assembly is carried out to know the condition of the wheel hub assembly. Then the wheel hub assembly is disassembled and the wheel hubs along with the other parts are sending for cleaning. After cleaning the wheel hubs and other parts are inspected using NDT methods.

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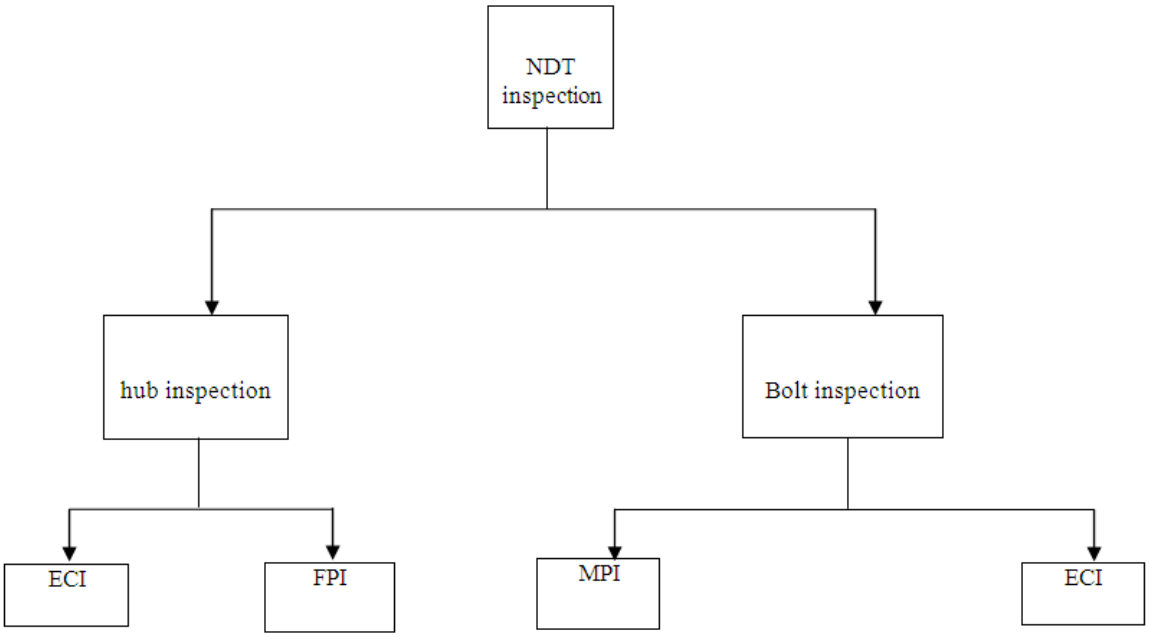

Figure: 1. Flowchart showing NDT methods in workshop

1. Eddy current inspection

Eddy current inspection is used for the inspection of aircraft structures using either shielded or un-shielded eddy current pencil probes. Generally a standard block of aluminium alloy with EDM notches of various depths is used for calibration of the instrument. The phase angle is adjusted such that the lift off signal is horizontal and going left to the screen. This allows us to look only the vertical component of the signal which has the defect information free from the lift off. Thus we can reliably detect small cracks even in the presence of inevitable probe wobble. Regions of the wheel hub where inspection is done are

1.1 Bead seat region

For the inspection of bead seat area special probes can be used. Figure 2 shows a bead seat probe used for eddy current inspection.


Figure: 2. Bead seat probe

1.2 The mating surfaces of wheel hubs

The mating regions of the wheel is inspected for any indications of cracks or initialization of corrosion. Pencil probes Figure: 3 are used to inspect the mating surfaces of the hubs. Inspection is carried out as per the NDTM manual. Region around the bolt holes is also inspected for any defects. Figure 4 shows the inspection around the bolt holes. Region around the bolt hole section have a chance to develop the crack. The bolt hole region is also inspected for any signs of crack.


Figure: 3. Pencil probes


Figure: 4. Inspection around the bolt hole

2. Magnetic particle inspection (MPI)

MPI is conducted on the Tie bolts of the wheel hub. The bolt with a crack or corrosion in the shank, radius or thread is rejected. MPI of the Tie bolts is done as per the manual and can be done only on ferrous materials. In this method the bolts are kept in the coil and magnetized. A bath (water containing magnetic particles) is introduced. Figure 5 describes the short coil experimental set up for the MPI. In this method the bolt is placed inside the circular coil and magnetized. The longitudinal magnetization of the bolt is done. The region of inspection of tie bolt using MPI is the thread region. Thread region is inspected for any cracks and if any cracks exist, then the bolt is discarded. If a cracked tie bolt is used then it may lead to the failure of the bolt which also may lead to the failure of the wheel hub.

DOI 10.17148/IARJSET.2016.3504

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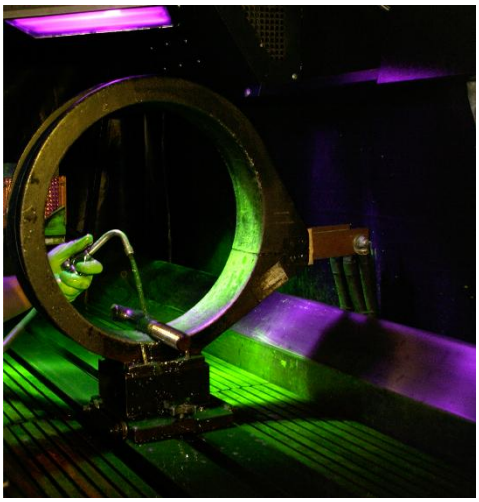

Figure: 5.Magnetic particle inspection

3. Visual Inspection

Visual inspection is done on aircraft wheel hub and its components like bearings, tie bolts, heat shields, thermal relief plugs, over inflation valves, O ring and retainer ring. The rollers, bearing cup race, bearing cone of the bearing is inspected for any spalled surface, nicks, dents, scratches, etched surface and any colour change. Bearings are also inspected for colour changes due to overheating. Tie bolts are inspected for any traces of corrosion on the shank and the radius. Bolts which are corroded than the allowed limits are discarded. Nuts are inspected by checking the self-locking capability. Heat shields are inspected for any cracks and if cracks exist beyond the allowed limits, heat shields are changed.

III. RESULTS

Figure 6 gives eddy current display of inspection of crack free region. Since no crack or corrosion is in the region of inspection there is no variation of vertical defect signal from the lift off line.

Figure 7 shows the eddy current display when the pencil probe was over a defective region on the mating surfaces of the wheel hub. Since there is a crack the defection of the eddy current signal from the lift off line is clearly visible.

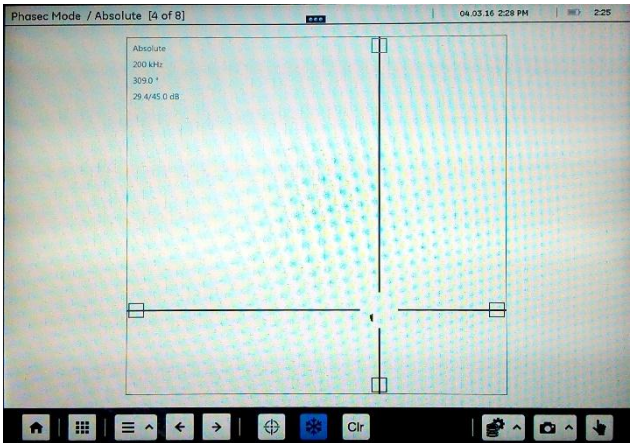

Figure: 7. ECI display with no variation from lift off line

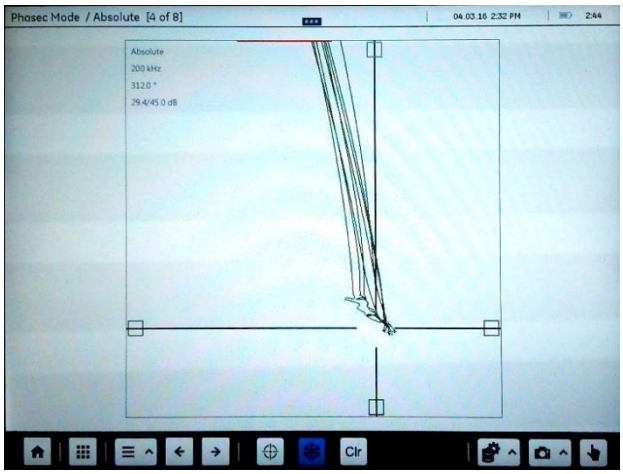

Figure: 8. ECI display with variation from lift off line

Magnetic particle inspection of the bolt gives the crack which can occur in the threads of the tie bolts. Figure 9 shows the crack on the tie bolt which can be seen by MPI.

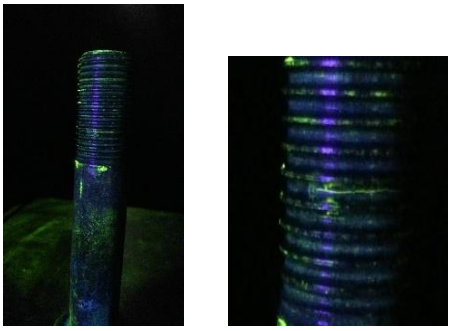

Figure: 9 Crack on tie bolt

Bolts with cracks on the thread region are discarded. Use of cracked bolts may lead to the failure of bolts which may lead to the failure of the aircraft wheel hub assembly.

Visual inspection of the tie bolts is done after MPI to find the corrosion. Corrosion of the tie bolts can reduce the strength of bolts which may lead to the breaking of the bolts. Figure 10 shows the corrosion of the tie bolts on the shank region. Corrosion pits can be regions of crack initiation.

Figure: 10. Corrosion on shank region of bolt

IV. CONCLUSION

Use of non-destructive tests during the routine maintenance check-up of aircraft structure and its components is mandatory. In this paper eddy current

inspection, magnetic particle inspection and visual inspection are used to detect the defects in aircraft wheel hub assembly. Cracks were found around the bolt hole region and in the mating surface of the wheel hubs. These cracks were due to the stress concentration.

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