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Crack Analysis of Aircraft Slat and Flap Sections Using NDT Techniques

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Abstract: Non-destructive testing (NDT) is the most economical way of performing inspection. NDT is used in aircraft maintenance to detect cracks in aircraft. In this paperNDT techniques are used for inspection in Boeing 757-200 aircraft wing for detecting cracks in slat and flap section of the wing. The inspection is carried out by using two main NDT methods, ultrasonic bond testing and eddy current testing. As a result slat section inspection reveals the skin to core disbonding of wedge after particular flight cycle. Flap section shows cracks in support fitting assembly of inboard flaps. The inspection is carried out using two main NDT methods, ultrasonic testing and eddy current testing. Eddy current testing is used in flap section, and is mostly used for detection of fatigue cracks or stress corrosion. These failure of slats and flaps section causes reduced controllability of the aircraft.

Keywords: Non-destructive testing, disbonding, bond testing, eddy current inspection.

I. INTRODUCTION

In the aviation industry, as with other transportation industries, NDT can make the difference between life and death. Aircraft components are inspected before they are assembled into the aircraft and then they are periodically inspected throughout their useful life. Aircraft parts are designed to be as light as possible while still performing their intended function. This generally means that components carry very high loads relative to their material strength and small flaws can cause a component to fail. Since aircraft are cycled (loaded and unloaded) as they fly, land, taxi, and pressurize the cabin, many components are prone to fatigue cracking after some length of time. Cracking can also occur due to other things like a lightning strike. Aircraft have some protection against lightning strikes.Another problem that aircraft have is that they are under the constant attack of corrosion. When an aircraft lands and the door is opened, the inside of the plane often fills with warm moist air. When the plane takes flight, and reaches altitude, the skin of the aircraft becomes very cold due to the temperature of the outside air. This cause the moisture held by the air inside the cabin to condense on the inside of the aircraft skin. The water will collect at low areas and serve as the electrolyte needed for corrosion to occur. The good news is that aircraft are designed to withstand a certain amount of damage from cracking and corrosion without cause for concern, and NDT inspectors are trained to find the damage before it becomes a major problem will not be affected. The job of the NDT inspector is to find the damage while it is within acceptable limits.The rigorous process used to design aircraft either allows for a certain amount of damage to occur before a part fails, or in many cases, a part can fail completely and performance of the aircraft will not be affected. The job of the NDT the NDT inspector is to find the damage while it is within acceptable limits. As the use of adhesively bonded joints and fittings has increased in the aerospace, automotive and marine industries, the need for testing bond integrity has grown. Metal to metal bonded joints, sandwich constructions with various skin and core materials, bonded carbon fiber composite structures have all become important in manufacturing as well as in-service repair patches and adhesively bonded re-enforcements. The integrity of these bonds is critical to the quality of the final product. Conventional ultrasonic methods can be limited for these applications and so a variety of alternative methods have been developed to handle this range of material combinations.Because there is reflection at an interface, and since the amount of reflection varies with the material on either side of the interface, bond integrity can be assessed with ultrasonic techniques. In its simplest form, the increase in signal height at a bond line will usually indicate a lack of bonding. This is due to a change in the acoustic impedance between the two (or more) layers. A change in impedance also causes a change in the phase of the signal. Special equipment is available that is designed specifically to detect these changes. Multiple bond layers can be interrogated from one surface. An example of this is multiple layer “skin” on aircraft bodies.The pitch-catch modesare used to inspect composite materials containing honeycomb structures.

Eddy current tests are important test & widely used method within the broad field of non-destructive materials & evaluation. This method is particularly well suited for the detection of service induced cracks usually caused either by fatigue or by stress corrosion. Eddy current inspection can be performed with a minimum of part preparation and a high degree of sensitivity.The electrical conductivity & magnetic permeability of a material is influenced by its chemistry & heat treat condition. Mixed lots of materials or parts subjected to fire or excessive heat damage can be quickly & easily separated (conductivity testing). Changes in the geometry & homogeneity of the test object will change the magnitude & distribution of the eddy currents. By monitoring these changes, the presence of cracks & other flaws can be detected.

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II. TESTING METHOD

Inspection of slats and flap section is done during schedule maintenance of aircraft. A flap failure message is shown on the Engine Indication and Crew Alerting System (EICAS) when there is an abnormality of flap operation. A task card is issued for the proper inspection of flaps or slats.

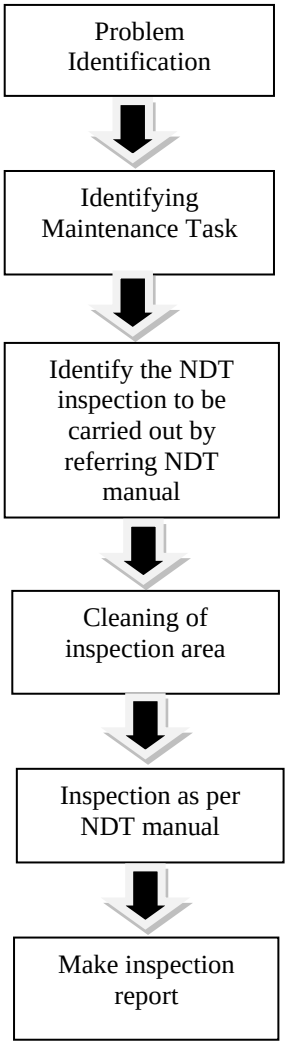

Figure 1: Work flow chart

The NDT manual is referred for the procedures to be followed for the inspection of slats and flaps. Prior to inspection, the region to be inspected is cleaned. The cleaning is done with the help of cleaning agents and solvents. Calibration of the test equipment is carried out in reference with standards. Inspection is carried out according to the approved NDT manual. An inspection record about the defects and actions taken to detect snags is made. The methodology which is followed in this paper is shown in the work flow chart (Fig.3.1)

III. RESULT

In this paper testing is done by using two NDT methods. Slats section inspection is done using bond testing method and flap section is done using eddy current testing

1. Bond testing

Bond integrity can be assessed with bond testing. In its simplest form, the increase in signal height at a bond line will usually indicate a lack of bonding. This is due to a change in the acoustic impedance between the two (or more) layers. A change in impedance also causes a change in the phase of the signal. Special equipment is available that is designed specifically to detect these changes. There are two types of display mode they are wave form display and vector point display.

1.1 Wave form display

A waveform display is a special type of oscilloscope. It is typically used to measure and display the level, or voltage, of a video signal with respect to time. The level of a video signal usually corresponds to the brightness, or luminance, of the part of the image being drawn onto a regular video screen at the same point in time. A waveform monitor can be used to display the overall brightness of a television picture, or it can zoom in to show one or two individual lines of the video signal. It can also be used to visualize and observe special signals in the vertical blanking interval of a video signal, as well as the color burst between each line of video.

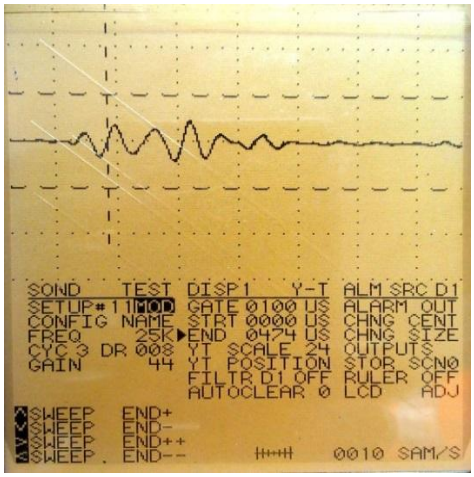

Figure 2: Bonded signal.

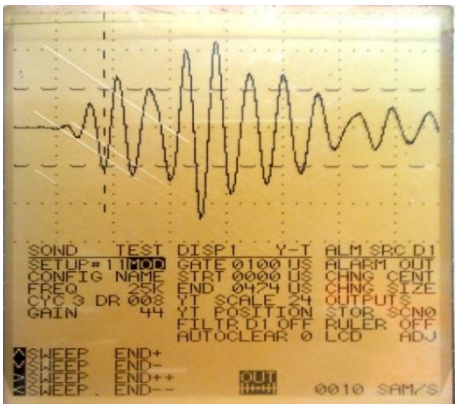

Figure 3: Disbond signal

The Figure 3 represent bonded area in the composite structure were there no disbond figure 3 represent disbonded area in composite structure. In a bonded condition, a portion of the acoustic energy is attenuated by

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the components of the structure. When the probe is placed over a disbonded area, the amount of energy returned to the receiver is greater, resulting in an amplitude change.

1.2 Vector point display

A vector point display is a special type of oscilloscope used in both audio and video applications. Whereas an oscilloscope or waveform monitor normally displays a plot of signal vs. time, a vectorscope displays an X-Y plot of two signals, which can reveal details about the relationship between these two signals. Vector scopes are highly similar in operation to oscilloscopes operated in X-Y mode; however those used in video applications have specialized graticules, and accept standard television or video signals as input.

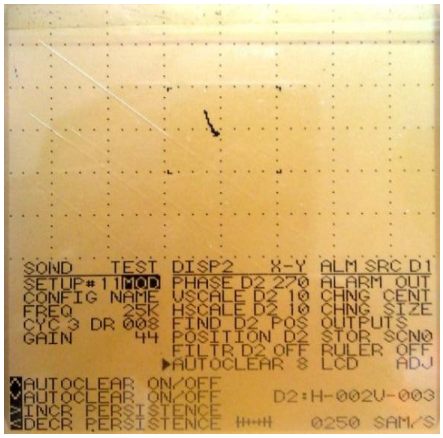

Figure 4: Bond signal

In figure 4 bonded area there is attenuation so the signal receiver in the probe is low.

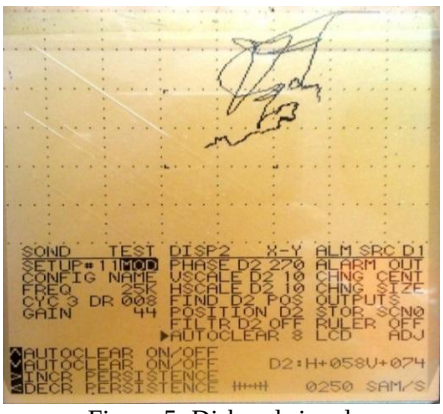

Figure 5: Disbond signal

2. Eddy current inspection

The figure 6corresponds to signal when the probe is above the surface where there is no cracks .Eddy currents are created through a process called electromagnetic induction. When alternating current is applied to the conductor, such as copper wire, a magnetic field develops in and around the conductor. This magnetic field expands as the alternating current rises to maximum and collapses as the current is reduced to zero. If another electrical conductor is brought into the close proximity to this changing magnetic field, current will be induced in this second conductor. If there is no crack In the surface then there is no in eddy current. so there is no signal variation that section.

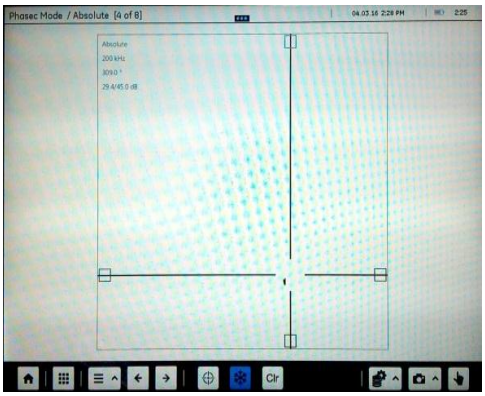

Figure 6: Signal without crack

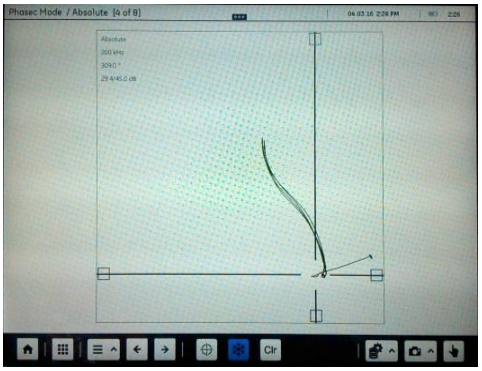

Figure 7 Signal with crack

The Figure7 shows if there is any discontinuity that appreciably alters the normal flow of eddy currents can be detected by eddy current inspection. With the encircling coil inspection of either solid cylinders or tubes, surface discontinuities having a combination of predominantly longitudinal and radial dimensional components are readily detected.

IV. CONCLUSION

Slat and Flap are the two secondary control surface of aircraft. Proper inspection is required during the scheduled inspection, these increase the efficiency of control surface and avoid malfunction of control surface. ECI and bond testing provide an advanced Non-Destructive testing techniques for detection of cracks in the control surface . NDT methods are important for the detection of defects and its components and it can be used for various kinds of material. By improving this method of inspection will improve crack detection more effectively, thereby reducing aircraft downtime.

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