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Emerging NDE Technology for Aging Aircraft

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Abstract

This paper presents an overview of several emerging nondestructive evaluation technologies that are being employed or considered for use to inspect commercial transport, commuter aircraft and military aircraft. An overview of the Federal Aviation Administration (FAA) Airworthiness Assurance NDI Validation Center (AANC) is described and how AANC teams with industry, universities, and other federal entities to assess these technologies.

Background

In 1991, the FAA Hughes Technical Center in Atlantic City, New Jersey established an airworthiness assurance technology validation center at the Albuquerque International Airport in Albuquerque, New Mexico. The center is managed and staffed for the FAA by Sandia National Laboratories, a Department of Energy (DOE) Federally Funded Research and Development Center (FFRDC). The AANC supports the FAA national research program by providing a central focus for validation and technology transfer of new inspection methods and maintenance techniques. AANC's charter covers a wide array of technical disciplines including nondestructive inspection, structural mechanics, repair principles, information technology, and fire safety.

The main goal of the validation center is to promote the efficient development and timely transfer of technology to its customers. To support this goal, the AANC has a 28,000 square foot hangar at the Albuquerque International Airport (Figure 1). The hangar facility replicates a working maintenance environment by incorporating both the physical inspection difficulties as well as the environmental factors which influence inspection reliability (Figure 2). The principal intent of the Center is to validate enhanced inspection techniques for transport and commuter aircraft. However, the center has been involved in other activities such as structural test and repair issues, maintenance reliability studies, responding to aircraft Certification Office requests, and hosting of various FAA and industry groups.

Over the first seven operating years, the center has built a vast library of test specimens. Each specimen is categorized by the type of defect it represents. The major categories are surface cracks, interlayer cracks, corrosion, and composite defects. AANC has acquired two aircraft testbeds; a Boeing 737-200 and a Fairchild Metro II (Figures 3, 4).

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Figure 1. Airworthiness Assurance Validation Center at Albuquerque International Airport.

Figure 2. Working maintenance environment which represents inspection difficulties that influence reliability.

Figure 3. Boeing 737-200 testbed used for inspection deployment issues.

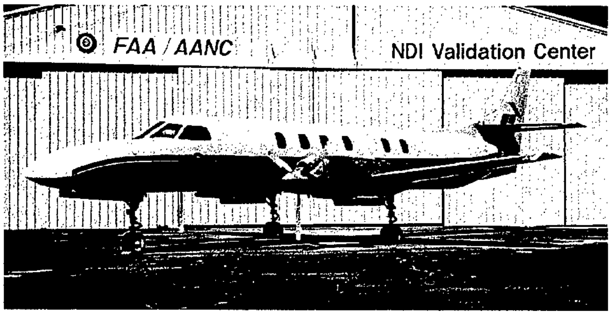

Figure 4. Fairchild Metro II aircraft used for visual reliability studies.

Emerging NDE Technologies

The purpose of this paper is to present a consolidated description of prevalent emerging nondestructive inspection techniques and discuss their potential applications to new or existing inspection requirements. Following are three emerging NDI technologies for aging aircraft.

Infrared Thermography

All objects with a temperature above absolute zero radiate energy as described by Planck's radiation equation [1]. An object radiating exactly as predicted by this equation is referred to a *blackbody*. The spectral output of commercial infrared cameras are in the operating range of 3-5 or 8-12 μm wavelength band. These cameras detect the change in temperature of a radiating surface by optically comparing its thermally emitted energy to that predicted by Planck's equation. The plot of spectral emission of most radiating surfaces will have a shape similar to that predicted by Planck's equation, but the total emitted power will be less. The ratio of the actual emitted power to ideal emitted power is the emissivity (ε) of the surface.

An infrared (IR) image of an unheated object in thermal equilibrium will normally reveal little information. However, if a heat source is applied to the surface, the resultant temperature and subsequent thermal decay of the sample will allow the camera to detect deviations. Defects in the material under test, which alter the thermal properties can be detected. The temperature distribution on a test sample can be measured optically by the radiation it produces at infrared wavelengths. Several inspection methods have been develop by universities and industry that use this temperature information to characterize the thermal properties of the sample being tested. Many defects found in aircraft affect the thermal properties of those materials. Examples are corrosion below the aircraft skin, tear strap debonds, impact damage, material thinning, and water ingress into composite or honeycomb materials [2, 3, 4].

Advanced Ultrasonic Imaging

Advanced ultrasonic techniques include conventional ways to generate and detect ultrasonic waves. The advancements in ultrasonic techniques are due mainly to portable computer systems which produce the ultrasonic signal, collect and process the data, and display the image. Most portable scanning systems can be applied either to the side or beneath the aircraft.

In some cases the flaw signal is hard to discriminate in an A-scan display. The flaw signal can be detected by applying signal processing techniques. The use of portable computers has increased the availability of flaw imaging capabilities by automated scanners. Most new systems utilize time and amplitude signals. Frequency domain information can also be collected about the flaw signal. After a scan area is completed, post processing algorithms optimize the signal. Many types of defects can be found using ultrasonic image processing. The images produced aid the inspector's decision abilities which increases effectiveness and reliability. Many types of defects can be characterized using ultrasonic image processing. Examples are cracks in multilayer structures, corrosion between bonded doublers, material thinning and delaminations in composite doublers [5, 6, 7].

Advanced Eddy Current

Eddy current techniques are applied on conductive aircraft materials to detect cracks and corrosion in aircraft skins and structural elements. An alternating electrical current flowing in a wire-wound coil induces a changing magnetic field (primary) around the coil. Placing the coil near a conductive material induces eddy currents (secondary) within the surface of the material. The secondary field opposes the applied primary field. This phenomena provides an overall effect in an impedance change measured by the coil. Flaws or thickness changes in the aircraft structure influence the flow of eddy currents and changes the impedance of the coil accordingly.

New advances in eddy current techniques employ pulsed eddy current, ferromagnetic shields between the drive and sensor coil, and multi-frequencies. These techniques increase inspection capabilities for fatigue cracks, and corrosion detection. The major area of emphasis is low frequency applications which can detect subsurface cracks or corrosion between two aircraft skins. Computerization and signal processing of eddy current signals are advancing the interpretation of low strength signals and pulsed signal responses by providing C-scan images or sweep signals. C-scan capabilities are becoming available through the use of encoded manual and automatic scanners. Commercial equipment is available that uses these inspection methods [9, 10, 11, 12].

Summary

The AANC provides a focal point for activities related to assessing emerging NDE methods and transferring the technology to aviation use. As these emerging technologies mature, the Center will continue to evolve and assess new technologies in order to fulfill the long term commitment to the FAA and aviation industry.

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