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INTEGRATION OF NONDESTRUCTIVE TESTING IN AIRCRAFTS MENTENANCE

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Introduction

In aircraft maintenance programme it is important to inspect the mechanical damage and assess the extent of the repair work. But in schedule maintenance it is a difficult to finding the defects rapidly, as the maintenance of aircraft must be accomplished within scheduled time and same to be released in time for commercial operation.

During aircraft maintenance 'NONDESTRUCTIVE TESTING' (NDT) is the most economical way of performing inspection and this is the only way of discovering defects. In simply we can say, NDT can detect cracks or any other irregularities in the airframe structure and engine components which are obviously not visible to the naked eye.

Structures & different assemblies of aircraft are made from various materials, such as aluminium alloy, steel, titanium and composite materials. To dismantle the aircraft in pieces and then examine each component would take a long time, so the NDT method and equipment selection must be fast and effective.

In the present trend of NDT application on aircraft 70-80% of NDT is performed on the airframe, structure, landing gears and the rest carried out on engine & related components.

In order to maintain the aircraft defects free and ensure a high degree of quality & reliability and as a part of inspection programme, usually following NDT methods are applied: 1)Liquid penetrant 2)Magnetic particle, 3)Eddy current 4)Ultrasonic 5)Radiography 6)Visual/Optical 7)Sonic/Resonance 8)Infrared Thermography.

Different NDT methods

The Nondestructive Test Laboratory from Flight Test Center has been recently RACR certficated in 3 methodes, that are currently integrated (implemented) in the mentenance process of aircrafts:

1. Liquid Penetrant :

Liquid penetrant testing is one of the oldest of modern nondestructive testing methods & widely used in aircraft maintenance. Liquid penetrant testing can be defined as a physical & chemical nondestructive procedure designed to detect & expose surface connected discontinuities in 'nonporous' engineering materials.

The fundamental purpose of penetrant testing is to increase the visible contrast between a discontinuity & its background.

Portable Equipment used: Penetrants materials are available in 'Aerosol spray cans' in small containers for brush or wipe application. With these aerosol can penetrant testing are performed on installed parts on aircraft's, structure.

2. Magnetic Particle :

Magnetic particle testing is a sensetive method of nondestructive testing for surface breaking and some sub-surface discontinuation in 'ferro-magnetic' materials.

The testing method is based on the principle that magnetic flux in a magnetised object is locally distorted by the presence of discontinuity. This distortion causes some of the magnetic field to exit & re-enter the test object at the discontinuity. This phenomenon is called magnetic flux leakage. Flux leakage is capable of attracting finely divided particles of magnetic materials that in turn form an 'indication' of the discontinuity. Therefore, the test basically consists of three operations : a) Establish a suitable magnetic flux in the test object by circular or longitudinal magnetisation. b) Apply magnetic particles in dry powder of a liquid suspension; and c) Examine the test object under suitable lighting conditions for interpreting & evaluating the indications.

Portable equipment used: Electromagnet yoke (adjustable) : Suitable for inspecting irregular shaped parts for surface defects.

3. Ultrasonic nondestructive test in aircrafts

Ultrasonics plays a critical role in the inservice testing of aerospace structures. The applications can be routine or unique.

Eddy current, liquid penetrant, magnetic particle and other nondestructive test methods may be more appropriate for particular types of quality issues.

For the most part, ultrasound is best when inspecting for planar discontinuities lying parallel to the test surface. If the back surface of the object is also parallel, it simplifies the test. A EPOCH XT nondestructive high performance ultrasonic equipment is used .

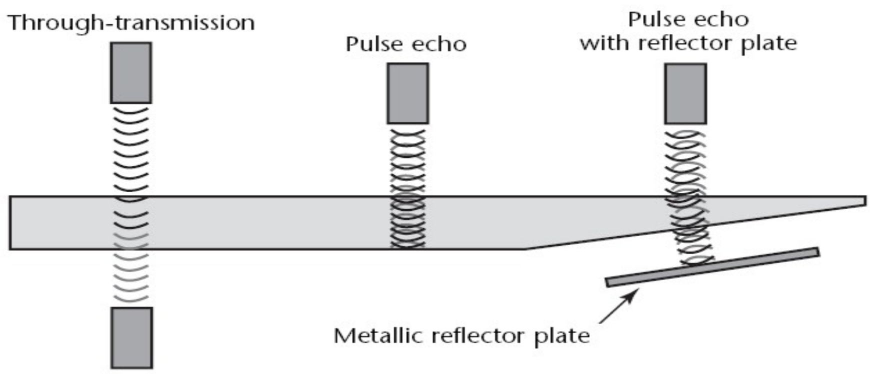


Fig. 1 Basic Ultrasonic test techniques

Therefore, airline operators require that the aircraft manufacturer provide a nondestructive testing manual with information and procedures for determining the condition of these structures. The manual supplies information about the possible locations of cracks and other service induced conditions and recommends applicable techniques for detecting them.

If the anticipated crack is on an accessible surface, test methods such as visual, liquid penetrant, magnetic particle or eddy current testing may be selected for detection. However, numerous locations throughout the structure are made up of multiple layers of detail components joined together by rivets or bolt fasteners. At these locations, it is possible for cracks to be generated in a subsurface member and go undetected until they propagate to a surface. Early detection of subsurface cracks is possible with ultrasonic and radiographic testing.

Reference Standards for Tests of Aircraft

Reference standards help establish instrument calibration and are used to ensure that particular discontinuities are detected with a predetermined sensitivity. Reference standards are used not only to facilitate initial adjustment but also to check periodically on the reproducibility of the measurement.

Testing Procedure :

For a typical ultrasonic test, the following steps are performed.

1. A reference standard is prepared for calibration.
2. The component is prepared for testing by removing loose paint and dirt.

3. The ultrasonic test instrument is set up, and the calibration standard is used to adjust controls and get a discontinuity pattern on the A-scan.
4. An appropriate couplant is selected and applied to the area of interest.
5. The test object is scanned according to detailed instructions specific to the component.
6. All indications of discontinuities are located and identified.
7. After testing, the ultrasonic equipment is withdrawn and the couplant is removed from the test surface.

Cracks detection methods implementation

Ultrasonic testing is often used on aircraft structure to detect discontinuities radiating from attachment holes in fatigue sensitive areas. Anticipated crack areas can be tested using one or more wave modes.

✓ Figures 2 and 3 show an example of a landing gear inspection; Figure 2(c) shows a standard created for this test.

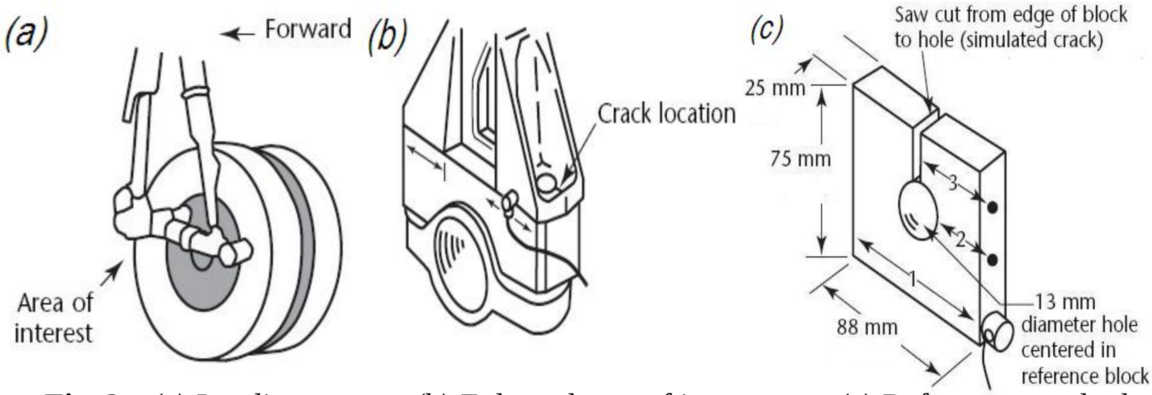


Fig. 2 (a) Landing gear ; (b) Enlarged area of interest ; (c) Reference standard .

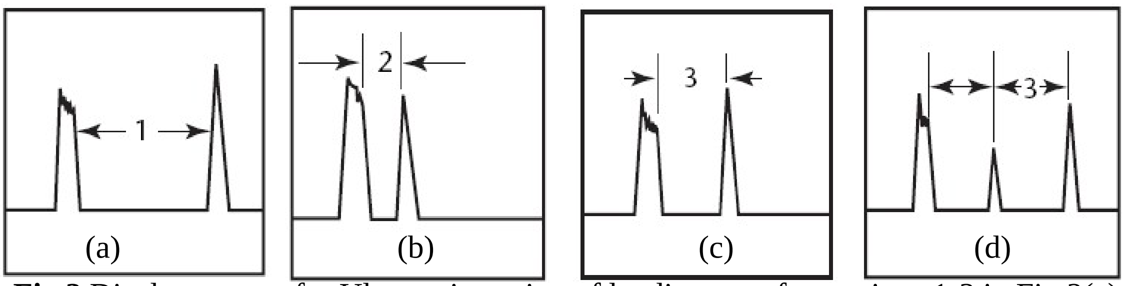


Fig.3 Display pattern for Ultrasonic testing of landing gear for sections 1-3 in Fig 2(c)

✓ Another example of Ultrasonic NDT implementation is the detection of cracks radiating from attachment holes in the curved attached fittings on the horizontal stabilizer, elevator, rudder, flap and aileron in Fig. 4.

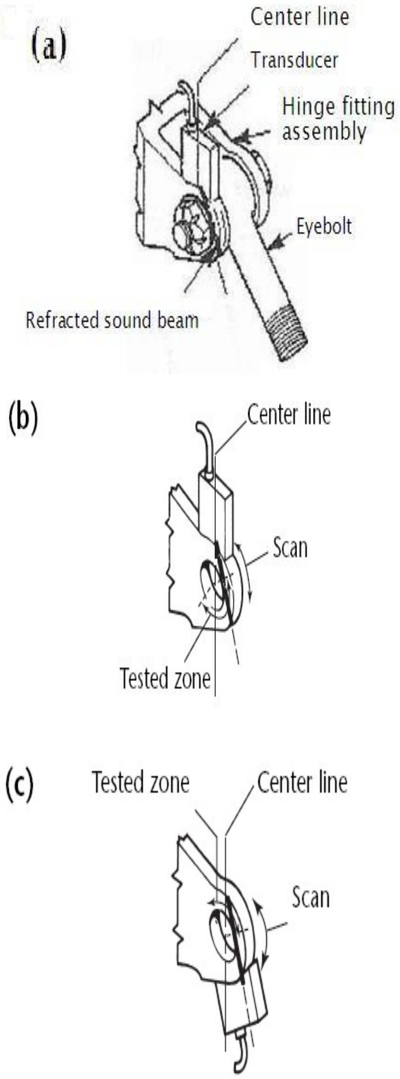
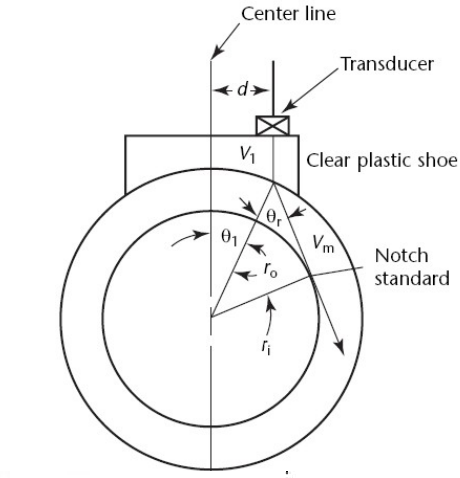


Fig. 4 Ultrasonic detection of cracks in hinge fittings: (a) test of assembly with eyebolt in place; (b) test from above; (c) test from below.

Several techniques may be used to establish the proper angle of the transducer. One of these techniques allows testing holes of different diameters with the same apparatus. The incident beam needs to be perpendicular to the axis of the hole and allow lateral movement of the transducer to achieve a refracted longitudinal wave tangential to the inner curved surface. Figure 5 shows this configuration.

Fig. 5 Transducer offset for longitudinal ultrasonic tests



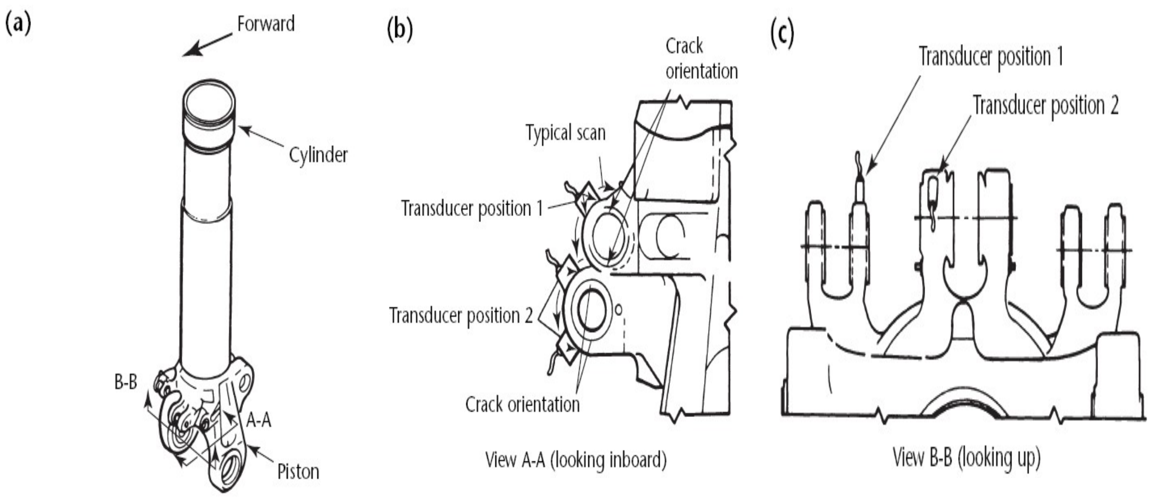
r_i = inner radius of tube or hinge (meter)
d = transducer offset from the centerline of tube or shoe (meter)
r_o = outer radius of tube or hinge (meter)
θ_1 = incident angle of beam in plastic (degree)
θ_r = desired refracted angle of the test beam (transverse θ_3 or longitudinal θ_2) for beam tangency at inside diameter surface (degree)
V_1 = velocity of sound beam in plastic offset shoe (meter per second)
V_m = velocity of sound beam in the tube or hinge (shear V_3 or longitudinal V_2) depending on critical angle (meter per second)

A clear plastic shoe must be fabricated to fit the outer radius of tire test object and to allow the transducer to move laterally in the shoe on a plane perpendicular to the center line of the shoe. The lateral motion of the transducer d within the plastic shoe effectively changes the angle of incidence and thus the angle of refraction at the curved interface.

The test object, unlike the reference standard, may have only a semicircular surface on which scanning can be accomplished. Therefore, to obtain maximum coverage around the hole, the transducer and shoe are moved around the entire curved surface in one direction and are then rotated 180 º, and the scan is completed in the opposite direction.

- ✓ A third example is a piston cylinder lug ultrasonic NDT inspection in which are used codes for modeling tests with a computer.

Fig.6 Ultrasonic testing of piston cylinder lugs:
(a) from side and above; (b) looking inboard; (c) from below



Such techniques use fundamental ultrasonic principles programmed into codes for modeling tests with a computer. Fig. 7 shows an example of using computer graphics to model the optimum angles. Once the geometry of the object is input into the program, the orientation of the transducer can be adjusted to peak the reflected signal.

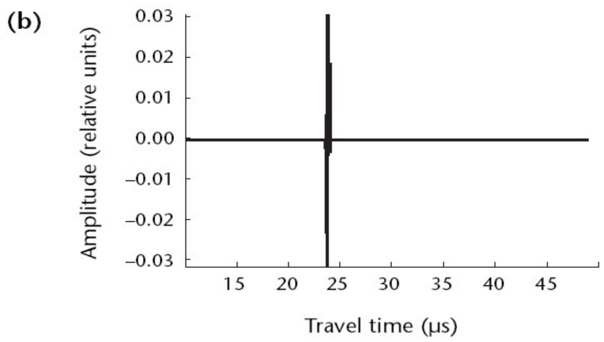
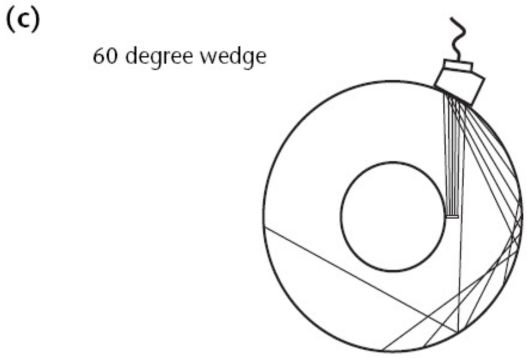
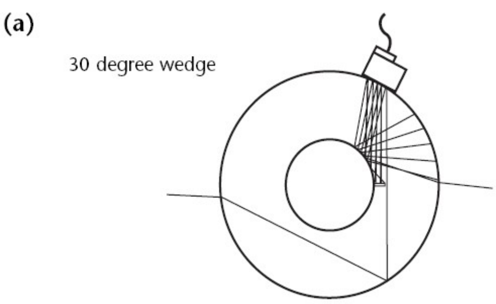
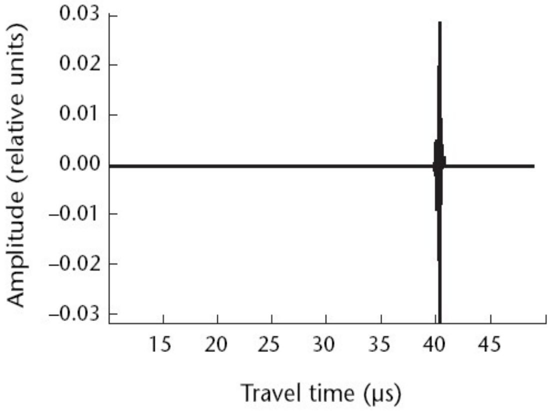


Fig.7 Computer model of ultrasonic testing: (a) 30º for longitudinal wave test;
(b) longitudinal peak signal; (c) 60 º for transverse wave test; (d) transverse peak signal.





(d)



In Fig. 7, the signal is peaked for either a longitudinal wave or a transverse wave test of the object. The angles of refraction where the signals are peaked are found by changing the parameters in the model. The model also provides estimates of the timing of the reflection which are useful to aid in interpretation. In some cases, echoes may be obtained by both the longitudinal and transverse waves. The model will help determine the source and timing of these signals.

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