Detection of defects in aircraft wiring using long range ultrasonics

Publications

Introduction

Long range ultrasonics (LRU) is a non-destructive test (NDT) method that offers potential for the inspection of aircraft wiring. The method utilises ultrasonic waves, pulsed along a wave-guide, which become reflected at discontinuities. In current LRU applications, the wave guide is a pipe and the discontinuity is corrosion, but most elongated components can propagate ultrasound over distances, perhaps 100m in some cases, as long as the cross-section is symmetrical; a rail is an example.
An aircraft wire can act as a wave guide for ultrasound, but there are important differences over wave propagation through pipes. These have presented the challenges that have been overcome in the AWARE project.

Project challenges

The first important difference is one of geometry. Pipes are cylindrical and hollow, while wires are solid. The wave modes are therefore quite different. Ultrasound wave propagation though pipes has been investigated extensively. There are three basic modes; longitudinal, torsional and flexural (Figure 1). For wires, new numerical models were developed in AWARE for investigating ultrasound wave propagation through not only single, but also multiple wire strands (Figure 2). They showed the viability of the method.

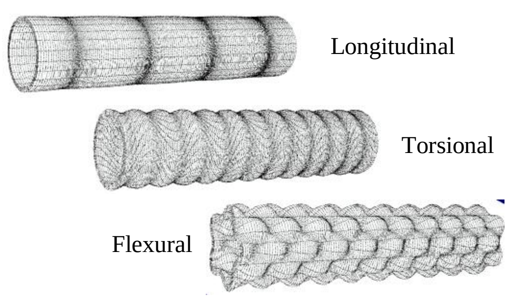

Figure 1 Ultrasound waves in pipes

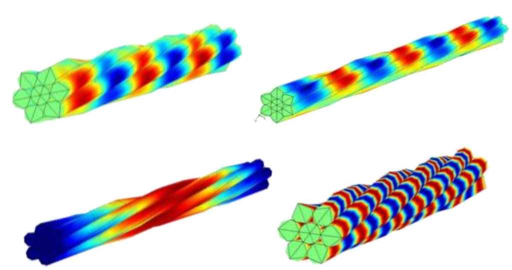

Figure 2 Numerical models of ultrasound waves through wires

The second important difference is one of dimension. Wires have a much smaller diameter than pipes. Guided waves propagate most effectively if they are symmetrical. In a pipe, this can be achieved by surrounding a pipe with a ring of several ultrasound transducers (Figure 3). The transducers are piezo-electric ceramics that are rigid and do not make good contact if the surface has a tight curvature.
In AWARE, an alternative transducer has been developed, called a macro-fibre composite (MFC), which is flexible and the wire can bed into the transducer to provide good contact (Figure 4).

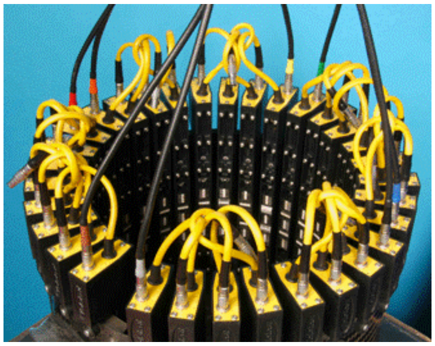

Figure 3 LRU transducers for pipes

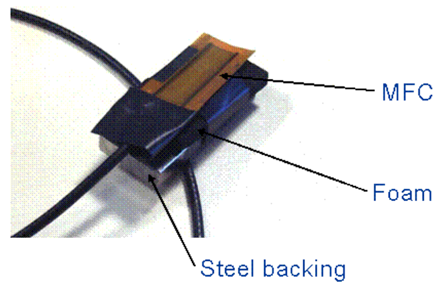

Figure 4 MFC transducer.

A third important difference is that wires are always surrounded by insulation. Plastics are very attenuative of ultrasound, and even if the bulk of the ultrasound energy is propagating along the wire metal itself, the energy will 'leak' into the surrounding plastic insulation. The level of attenuation decreases with frequency and in AWARE it was found that adequate test ranges of several metres could be achieved at frequencies of about 20KHz, which is only just above the audible range. Indeed, the propagation distances were much longer than expected and this has been attributed to the use of a polymer based transducer and consequently good 'acoustic impedance' matching between the transducer and the wire insulation.
Trials with prototype transducers in a simple clamp have been very successful (Figure 5). Test ranges of 6m have been achieved (Figure 6). A wide range of wire defects including abrasions, burns and cracks in single and multi-strand wires have been detected.

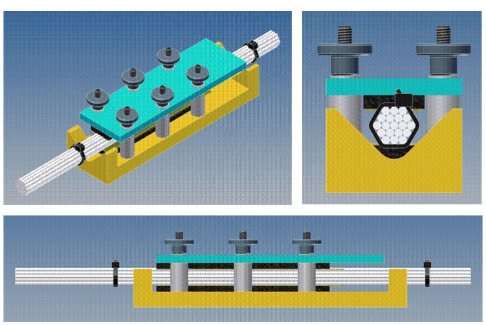

Figure 5 Prototype transducer clamp

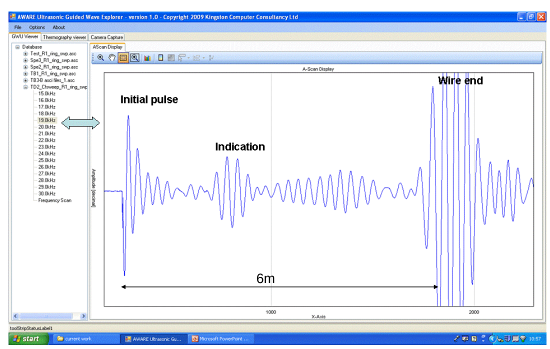

Figure 6 LRUT A-scan

Work on the design of a transducer clamp that can be used to tease individual wires out of a wire bundle is ongoing. The instrumentation is also under development. A simple hand-held instrument is foreseen.
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