Rolls-Royce

Ultrasonic Inspection

The use of ultrasound in Non-Destructive Evaluation

COMMISSIONING AND IN-SERVICE SUPPORT

What is Ultrasonic Inspection?

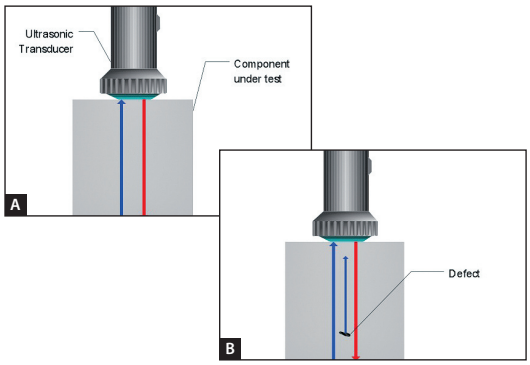
Ultrasound relates to pressure waves that propagate at frequencies beyond the audible range of the human ear. Figure 1 shows the basic principle of ultrasonic inspection using a single transducer.

When the ultrasonic wave encounters a defect within the component the wave is reflected and scatters, changing the nature of the ultrasonic signal that is obtained by the receiver.

The signal recorded by the receiving transducer is known as an A-Scan, this signal represents the intensity of the ultrasonic energy that reaches the receiver in a fixed time window. Examples of the A-Scans obtained are shown in Figure 2.

Rolls-Royce utilises the basic operational principle of ultrasound to inspect a wide range of different components. A number of bespoke, automated scanners have been developed to improve the accuracy, speed and reliability of the inspection. Data is automatically recorded and analysis is completed remotely to reduce the exposure of personnel to ionising radiation.

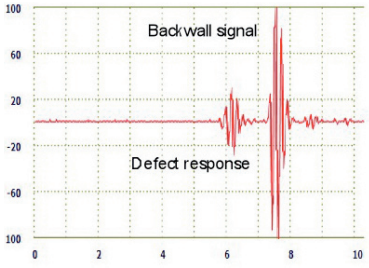
Figure 1. Ultrasonic flaw detection using a single transducer, a) for components with no defects, b) for a component containing a defect



- **Extensive experience of use of ultrasound in NDE**
- **Automated ultrasonic techniques to improve accuracy, speed and reliability**
- **Phased Arrays to reduce inspection time and cost**
- **Conformable phased array to inspect components with irregular surfaces**

Figure 2. Simulated A-scans

a) with no defect



b) with a defect present

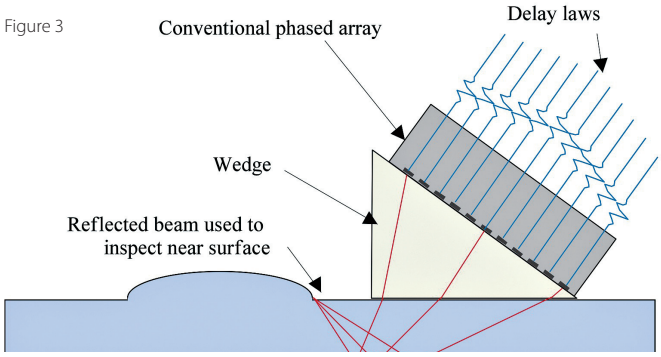
Ultrasonic Phased Arrays

Phased Array transducers typically consist of a large number of identical piezoelectric elements (array) where each element is excited at a slightly different time (phased) such that it is possible to steer and focus the ultrasonic beam; this is shown schematically in Figure 3.

A single phased array transducer can be used to generate a range of different beams; it can therefore be used for multiple inspections.

Phased arrays also allow electronic scanning of a component, which significantly increases inspection speed and hence reduces cost.

Figure 3



Metallurgical inspection Capability

- Improved accuracy
- Faster scanning
- Reduced inspection time and hence cost

Conformable Ultrasonic Phased Arrays

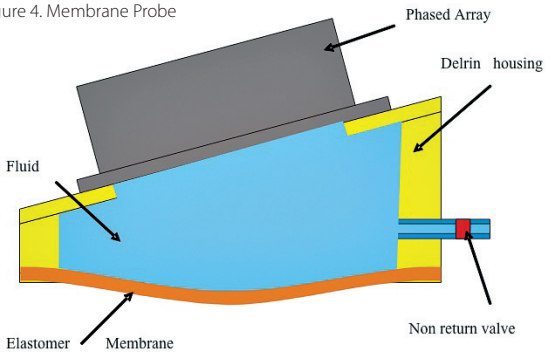
In contact ultrasonic inspection it is essential to maintain coupling between the transducer and the component under test.

When using conventional ultrasonic techniques it is not always possible to maintain contact and achieve 100% test coverage of components with irregular surfaces.

Rolls-Royce is working with Imperial College London to research and develop a new conformable phased array device that allows reliable ultrasonic inspection of components with complex geometries.

This low-cost membrane device, that uses a standard phased array, couples to the component surface via a fluid standoff encapsulated by a low-loss membrane and is shown in Figure 4.

Figure 4. Membrane Probe

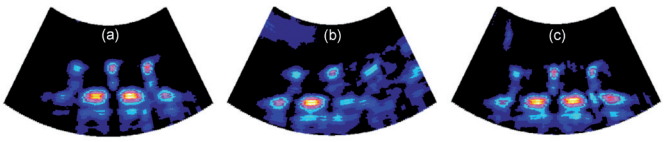


- Innovative research project in collaboration with Imperial College London
- Membrane probe benefits:
  - Accurate
  - Versatile
  - Low cost
  - Robust
  - Rapid Scanning

To maintain inspection performance it is essential to update the phased array delay laws in order to compensate for the irregular surface profile of the component under test; this effect is shown in Figure 5. This process can be extremely challenging; the research teams are currently working to develop advanced algorithms for more complex geometries and inspection techniques.

The membrane probe can be used for both surface profile measurement and inspection, allowing rapid scanning without the need for multiple angled probes and time consuming mechanical scanning.

Figure 5. Sector scan for compressional wave inspection of side drilled holes using Imperial membrane device



a) for plane surface test piece

b) test piece with weld cap when not updating delay laws

c) weld cap with updated delay laws

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