Indian Society for
Non-Destructive Testing
Hyderabad Chapter

Proc. National Seminar on
Non-Destructive Evaluation
Dec. 7 - 9, 2006, Hyderabad

# Ultrasonic Phased Arrays: An Insight into an Emerging Technology

**Mark D Nel**
Technology Design Limited, Winsford, Cheshire, United Kingdom
e-mail: mn@technologydesign.com

## Abstract

The author makes no claim to this paper being a scientific or complete study and is purely a personal insight gained from experiences as a manufacturers representative. Phased array technology has emerged in recent years as an efficient, cost effective method of applying ultrasonics. The driving forces behind phased array are varied and as a relatively new technology in NDT these forces are dynamic and will change over time. One thing that is certain however is that phased array ultrasonics is forging ahead with remarkable momentum towards maturity.

**Keywords:** *Phased Array, NDT, Multi-element Transducer*

## 1. Introduction

Ultrasonic Phased Arrays have emerged in the past few years as a very powerful form of applied ultrasonic testing in NDT. Computerisation has played a key role in enabling the technology to develop and has provided a software platform for innovative data gathering and analysis tools to be developed. For a long time phased array technology was almost the exclusive domain of the medical world as the use of phased arrays in the NDT industry was considered too complex and the cost of producing phased array equipment prohibitive. However over the past decade the benefits of using phased arrays as a viable alternative to certain other NDT technologies have been realized.

For manufacturers of computerised ToFD and Pulse Echo equipment, Phased Array was a natural progression for integration with existing ultrasonic technologies or indeed for stand-alone systems. Whatever the design and marketing philosophies, there are now a plethora of phased array systems on the market with software as varied as the imagination.

## 2. Basic Principle

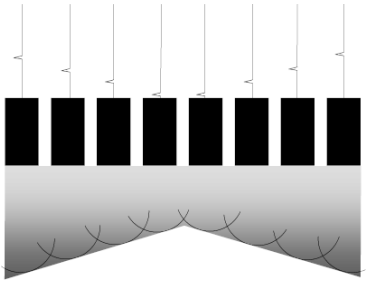

Fig. 1: Beam steering

Phased array ultrasonics is the use of multi-element transducers and instrumentation to steer and/or focus the sound beam. We can therefore produce an ultrasonic system that is capable of generating multiple angles from a single transducer at a focused point or focal zone. This remarkable ability is achieved by sequentially pulsing the individual elements or groups of elements at precise

time intervals known as ‘delays’. The delayed pulsing propagates a wave front in the desired direction through the material.

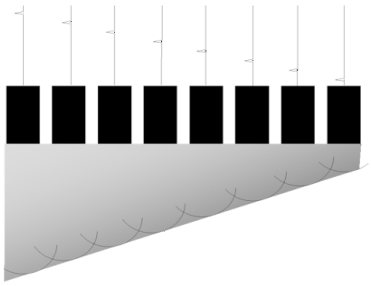

Fig. 2: Beam focussing

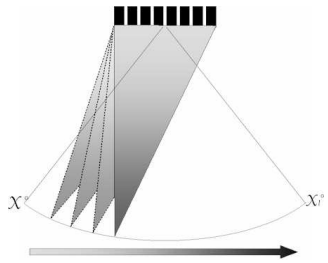

Fig. 3: Sectorial scanning

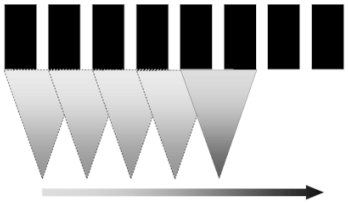

Fig. 4: Electronic scanning

A group of software settings that define an angle and/or focal point are collectively known as a ‘delay law’. By applying several delay laws in each cycle we can sweep the sound beam through an angular range (sectorial scan) or at a fixed angle along the length of the transducer array (electronic scan).

## 3. Drivers

Phased array technology is being driven by several factors, for example: the ease with which it can be slotted into existing procedures, technological flexibility (multiple angles from a single probe) that translates into less probes thus simplification & reduction in cost of mechanical manipulators, increased of composite materials and the emergence of internationally recognized standards such as ASME Code Case 2235 and others.

Continual pressure from plant operators and shareholders for more cost effective production solutions whilst maintaining safety standards will of course filter through to the service providers and this is where phased array comes into its own. Greater control over technique optimization will contribute to greater plant reliability and therefore increased confidence and lower insurance and operating costs.

## 4. Applications

This section aims to illustrate a very small sample of the growing body of applications in which phased array is used.

Fig. 5: Pipeline weld scanner

Certain industries took phased array ultrasonics onboard much quicker than others. The pipeline fabrication industry was one of the first to recognise the benefits of phased array for zone discrimination of welds. The ability to focus at different points in the material and define different angles with the same probe on different channels allows the use of fewer probes than conventional probe setups, with a resultant reduction in physical size and complexity of the probe manipulator.

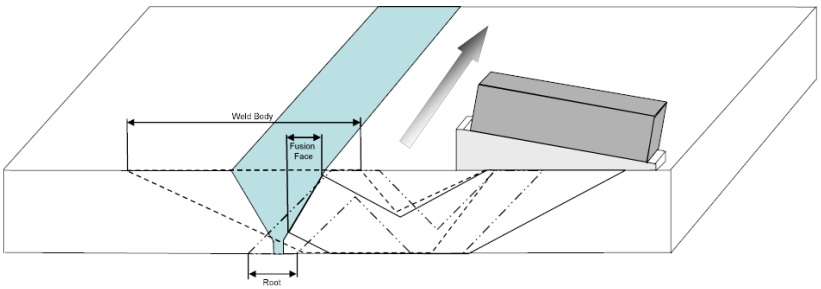


Fig. 6: Single pass weld coverage with phased array

There has been a sharp upswing in the sale of equipment specifically for use in pressure vessel fabrication over the past 2 years – largely due to the development and wider acceptance of codes geared towards the use of computerised UT in quality Control e.g. ASME Code Case 2235. The time to scan a weld is significantly reduced using phased arrays because coverage of the weld can be achieved without the need to raster the probes. Full weld coverage is achieved in one or several linear passes parallel to the weld using a combination of sectorial scans for the weld volume and linear electronic scans for critical areas, i.e. fusions faces, root etc.

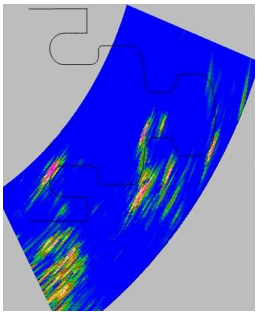

Fig. 7: Turbine blade inspection

Phased array has been used to good effect on in-situ turbine blade roots. The sound beam from a phased array probe, located on the accessible shoulder of the blade, is swept across the 'fir tree'. In this way costly dismantling of turbine rotor discs is avoided and the probability of detecting cracks or corrosion is increased.

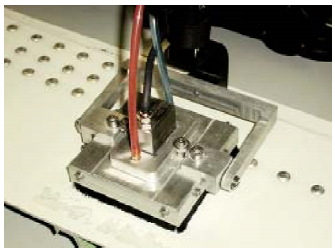

Fig. 8: Aerospace Material Scan

Large sections of flat metal plate or composites may be scanned for laminations or disbonding in a short time using large arrays and electronic scanning. Each pass could conceivably cover a width in excess of 100mm. Smaller phased array probes are used to scan composites with more complex shapes like wing structures or helicopter rotor blades.

## 4. The Future

1. Phased array in NDT is developing so rapidly that currently the manufacturers and suppliers seem hard pressed to keep up with the demand for systems, probes and scanning equipment. Coupled with the increasing service demand there is, and will be, a shortage of well trained and perhaps more importantly experienced operators worldwide. There is an immediate need for more training facilities and certification schemes to address the shortfall.

2. The positive side of increased demand is that innovation is stimulated and there is much research and development being

carried out into applications, simulation and post processing of raw data. As affordable computing power increases, the phased array operator of the future will have a much wider choice in storage, processing and presentation of data in limited time with high efficiency & increased accuracy.

3. In the past much of the user software development was centred around features to 'outdo the opposition' however with international standardisation, the emphasis will change in future to innovative ways to simplify user interfaces, reduce the size of the equipment and integrate phased array closer with complementary technologies and methods.

## 5. Conclusions

The NDT industry and indeed the engineering industry have embraced phased array ultrasonics and I therefore believe that the technology is secure. Phased array is not just another clever technology that will disappear into obscurity in a few years.

Phased array ultrasonics opens a wealth of opportunities that enhance the NDT engineer's ability to provide highly accurate data and flexible services while reducing overall costs for the customer.

In order for countries outside Europe and North America to successfully compete in these markets and gain an advantage within their own regions, it is not only vital to educate engineers and technicians, but also to participate in the routine use and applicational development of technologies like phased array ultrasonics.

Phased array ultrasonics is at the forefront of NDT's technological advancement but we must not fall into the trap of selling it as the 'answer to all problems' as certain other technologies were in the past, to their detriment. Phased array must be viewed as an additional tool in the toolbox of the NDT operator, to be used judiciously and to be complimented by other perhaps less glamorous inspection methods.

## 6. Acknowledgement

RTD Quality Services - Netherlands

Structural Integrity Inc. - USA

Lavender International.- UK