Title:
Phased array probes for non-contact ultrasonic testing

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Abstract:
The non-contact ultrasonic testing using air-borne ultrasound has grown in importance during the last years especially due to the application of new composite materials. The main advantage of waiving couplants like water is set against the disadvantage of high coupling losses, which make the interpretation of testing results more complicated. Therefore improvements in the testing system and its components are necessary.

A promising approach is the application of the phased array technique to the contact-free ultrasonic testing. Using probes with multiple elements and a multi-channel instrument it is possible to adapt the ultrasonic sound field to the application and to improve the testing process. This technique is introduced and has proved its performance in industry and medicine since decades. However only a few systems are available for the use for non-contact testing. One reason is, that the design of non-contact probes differs from conventional probes. An adaption of the concepts of phased array probes to the design of such probes is necessary.

The novel SONOSCAN CF400 series includes a piezocomposite transducer of Ø20 mm. The mean frequency is 400 kHz. In the standard type the transducer is curved, leading to a focal distance of 50 mm. The corresponding sound field is given in figure 1. Typically these transducers are used in transmission technique, which gives an optimum distance of transmitter and receiver of 100 mm. A shorter focal distance cannot be achieved by a stronger bending of the transducer due to material limits.

Figure 1. Sound field of an conventionally focussed ultrasonic probe type SONOSCAN CF400. The dimensions of the scan are 100 mm x 20 mm.

Based on this probe the SONOSCAN CF400 3E type has been developed. Transducer dimension is the same. The electrode has been structured as an annular array with 3 equally-sized elements (see figure 2).

Figure 2. Annular 3-element array, which is integrated in the phased array probe type SONOSCAN CF400 3E. All elements are equally sized.
By applying a focal law of 0 ns / 900 ns / 1800 ns (outer to inner elements) the focal distance has been adjusted to 20 mm. The focal width has been measured with 3.2 mm. The corresponding sound field is shown in Figure 3.

Figure 3. Sound field of a phased array ultrasonic probe type SONOSCAN CF400 3E. The dimensions of the scan are 100 mm x 20 mm.

The advantage of electronic focussing phased array probes against conventional probes can be found in applications, where the distance between transmitter and receiver is limited by external restrictions. Because of interference in the near field of the probe, the presentation of scans using conventional probes will include artefacts. Phased array probes can avoid these.

A comparison between conventional and phased array probes is shown in figure 4. Both presentations are derived from scans made in transmission technique. Transmitter and receiver are positioned 20 mm off the test object. With the conventional probes the artificial defects cannot be separated as good as with the phased array probe due to the near field interferences in the sound field.

Figure 4. C-Scan presentation of a test object using a conventional probe type SONOSCAN CF400 (left) and a phased array probe type SONOSCAN CF400 3E (right).