1. BACKGROUND AND MOTIVATION

There are several approaches for ultrasonic imaging of metal structures, depending on the geometry, accessibility, etc. For small structures, arrays can be used which are coupled directly to the surface. With the increase of the roughness and size of the surface, the quality of the coupling with a contact transducer decreases, and the wearing of the transducer increases. In such scenarios immersion tests are often preferred, which are performed in a water tank or using a water jet coupling when the immersion in a tank is not possible.

The traditional fixed focus approach gives the best resolution only at the focal zone. For applications where a good resolution has to be attained at a larger range of vertical distance from the transducer, the synthetic aperture focusing technique (SAFT) introduced by Prine (1972) provides a dynamic focusing with uniform resolution. In the basic SAFT approach, a synthetic focus is obtained in the post-processing of the pulse-echo signals acquired by scanning with a single-element transducer.

When performing immersion tests for SAFT imaging, using a large transducer improves the SNR but reduces the quality of the image due to refraction effects. A solution is to focus the ultrasound beam at the surface of the material, and consider the focal point of the transducer as the source, leading to the virtual source (VS) concept for synthetic aperture processing introduced by Passmann and Ermert (1996).

2. STATEMENT OF CONTRIBUTION AND METHODS

In this paper we present a novel technique that uses a transducer that focuses the sound at the surface of the sample, thus generating a diverging sound field in the sample. The novelty is in successfully applying the VS concept using water jet coupling for a large transducer. By focusing the sound field, the water jet probe can be built with a small nozzle opening, limiting the water consumption and making it viable for field applications. The annular geometry of the large transducer ensures the spherical wavefront assumed in the application of the SAFT algorithm, which usually limits the size of the transducer.

The frequency domain implementation of the SAFT algorithm discussed by Nagai (1984) requires that the sound speed is constant through the entire propagation medium. Therefore, the time domain implementation has been selected since different methods have been introduced for adapting the algorithm to the refraction which occurs at the interface between layers. Even if ray-tracing methods have been introduced by Johnson and Barna (1983) for the calculation of the travel time of the signal, it is preferred to use simpler approximations due to the reduced computational cost. The selection of the used approximation is usually influenced by the difference of sound velocities between the layers, and the Taylor approximation introduced by Schneider (1984) has been successfully used in the described setup.

3. EXPERIMENTAL RESULTS

Fig. 1 shows the result of imaging a block of aluminum with a side-drilled flat bottom hole of diameter 3.2 mm. The probe was positioned at the top of the sample at 57 mm distance and measurements were made in a 100 mm by 6.5 mm grid, with a spacing of 1 mm in the X axis and the following measuring positions in the Y axis: [0, 1.45, 2.3, 3.72, 5.1, 6.75]. We demonstrated a water jet coupling system in combination with a focused transducer suitable for imaging using SAFT algorithms. The system operates at 2.5 MHz and uses only 1-2 liters of water/minutes.
ACKNOWLEDGEMENTS

The research leading to these results has received funding from the European Union’s Seventh Framework Program managed by REA Research Executive Agency ([FP7/2007-2013] [FP7/2007-2011]) under grant agreement no 314949.

REFERENCES


