A Novel Combination of TOFD and Immersion for the Examination of Lower Thickness

R. Subbaratnam, B.Venkatraman and Baldev Raj
Indira Gandhi Centre for Atomic Research, Kalpakkam–603 102

Abstract

Time-of-Flight Diffraction (TOFD) Technique is used internationally for its unique ability of precise sizing of the discontinuities. Now codes of practice such as ASME and other international codes permit TOFD as one of the methods for assessment of welds, more than 12.5 mm (1/2").

The main problem that arises when TOFD is used to examine smaller thickness is that as the thickness of the specimen reduces, the four signals (lateral wave, diffracted signals from the tips of the defect and the back wall echo) merge together and as the diffracted beams cannot be identified clearly, it is very difficult to identify and size the discontinuity. Hence, a minimum probe separation is necessary. For example with a 45° conventional longitudinal probe, the minimum distance required between the probes is approx 4mm for a specimen thickness of 3 mm. This probe separation is not possible in contact TOFD with existing probes.

A probe holder with provisions to tilt the probe through required angles and also for precise x and y movements manually was fabricated in house.

The most important parameters to be considered and optimized were the probe tilt and probe separation. Probe tilt refers to the angular deviation of the probe to produce the required beam angle in the material through the water column.

Meticulous experimentation was undertaken to map the probe tilt and the corresponding beam angle in the material. Since it was desirable to reduce the amplitude of the lateral wave, the probe separation was varied through manipulation of probe tilt with the water path length being maintained a constant. The probe separation increases and the time difference between the lateral wave and back wall echo also increases. This is quite understandable since the increased probe separation results in longer transit time resulting in better separation of lateral wave and back wall echoes. An additional advantage of the water column was that the beam spread is not large in water. These results in better signal to noise ratio compared to conventional TOFD.
It was observed while performing the scanning with focused probes that, under certain conditions, lateral wave with higher amplitude and with side lobs increased in the time scale, reducing the near surface resolution.

The above experiments were repeated for shear wave mode also. Experiments were carried out varying the probe tilt and observing the time difference between the BW and LW. It was observed that after a probe tilt of 14.4°, there would not be any longitudinal mode exists in the material. Any angle more than this will be a better angle for the examination. A comparison of the shear wave mode compared to longitudinal wave mode indicates that shear wave mode is much better since for conventional angles like 45°, 60° and 70°, there is considerable probe separation and the time difference between the LW and BW is also more. This results in better spatial resolution.

The results of the experimental study clearly indicated that this simple and novel combination of TOFD and immersion could overcome the problem of thin section examination faced by conventional TOFD. The authors could image the side drilled holes and notches in 5 mm thick specimen and the 5% and 10 % notches in the 3 mm thick specimen very successfully. All the holes and notches in the 5 mm thick and 3 mm thick specimens could also be detected easily by both longitudinal and shear wave modes with accuracy for sizing and depth detection being better than ±10 %. While the advantages of TOFD have been preserved, the introduction of water column provided the necessary delay in ensuring the separation of the lateral wave and back wall echoes. Experimental results indicated that a lower optimum frequency of the order of 5 MHz coupled with longer water path length and smaller probe angle produces the best possible results.