DESIGN AND DEVELOPMENT OF PC-BASED TOFD ULTRASONIC SCANNING SYSTEM FOR WELDS INSPECTION

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Abstract

This paper describes the design and development of a portable PC-based ultrasonic scanning system for industrial applications. The system which is called TOFD Ultrasonic Scanning System (TOFUSS) is used to create a gray scale imaging techniques are applied to the RF (AC) signal phase and enables weld integrity to be observed in real time. TOFD consists of a separate ultrasonic transmitter & receiver. The Probes are aimed at the same point in the weld volume. The entire weld is flooded with ultrasound allowing inspection of the weld. With a time of flight path, the ultrasonic velocity and the spatial relationship of the two probes, location and height of the defects can be very accurately calculated. The algorithm and complete system were implemented in a computer software developed using Microsoft Visual BASIC™ 6.0.

Keyword: TOFD, Ultrasonic Scanning System, Weld

INTRODUCTION

The TOFD technique, first used by Silk in 1977, uses tip diffraction to identify the top, bottom and ends of a discontinuity in one pass. Silk chose to use an angled compression wave for the TOFD technique rather than a shear wave, for two reasons. Firstly, the tip diffraction signal is stronger than a shear wave diffraction signal, and secondly, a lateral wave is produced which can be used to measure the horizontal distance between the transmitter and receiver.

TOFD consists of a separate ultrasonic transmitter & receiver. The Probes are aimed at the same point in the weld volume. The entire weld is flooded with ultrasound allowing inspection of the weld. After emission of a compression wave from the transmitter, the first signal to arrive at the receiver is the lateral wave through the upper surface, in the absence of defects, the second signal to arrive at the receiver is the back wall echo. The diffracted signal generated at the upper tip of a defect will arrive before the signal generated at the lower tip of a defect. With a time of flight path, the ultrasonic velocity and the spatial relationship of the two probes, location and height of the defects can be very accurately calculated. Gray scale imaging techniques are applied to the RF (AC) signal phase and enables weld integrity to be observed in real time. Figure 1 and 2 shows a typical TOFD transducer set-up on a component with a vertical discontinuity and scanner with angle beam probe arrangement.

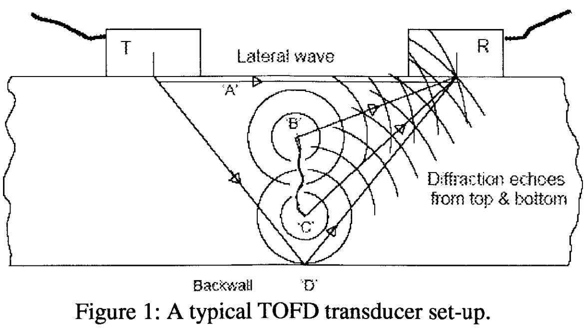

Figure 1: A typical TOFD transducer set-up.

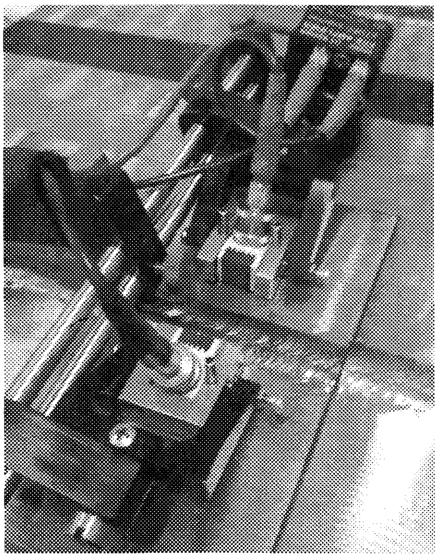

Figure 2: Scanner with angle beam probe arrangement.

EXPERIMENTAL WORK

Manual scanning were used for the examination of the samples along with 70° probes. The development of software "TOFD Ultrasonic Scanning System (TOFUSS)" was used for the data acquisition and analysis.

The probes were placed on the calibration block (Figure 3) so that the peaks or A-Scan were obtained as shown in Figure 4. There are two vertical lines, called cursors, on the oscilloscope used to calibrate the velocity as well as the position of the wave peaks. The left line cursor (red line) is moved to the highest point of the lateral wave and the right line cursor (blue line) to the second reverse peak point of back wall lateral wave. By entering the values of the transducer separation distance and thickness of the plate then by clicking the "Calculate" button the dialogue box for "TOFD Calibration", we can get the velocity value for the sample under test. The peaks are now calibrated for velocity and position.

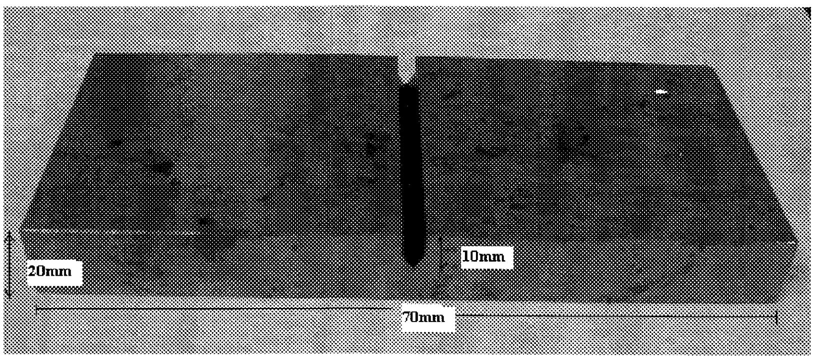

Figure 3: TOFD calibration block with thickness 20mm

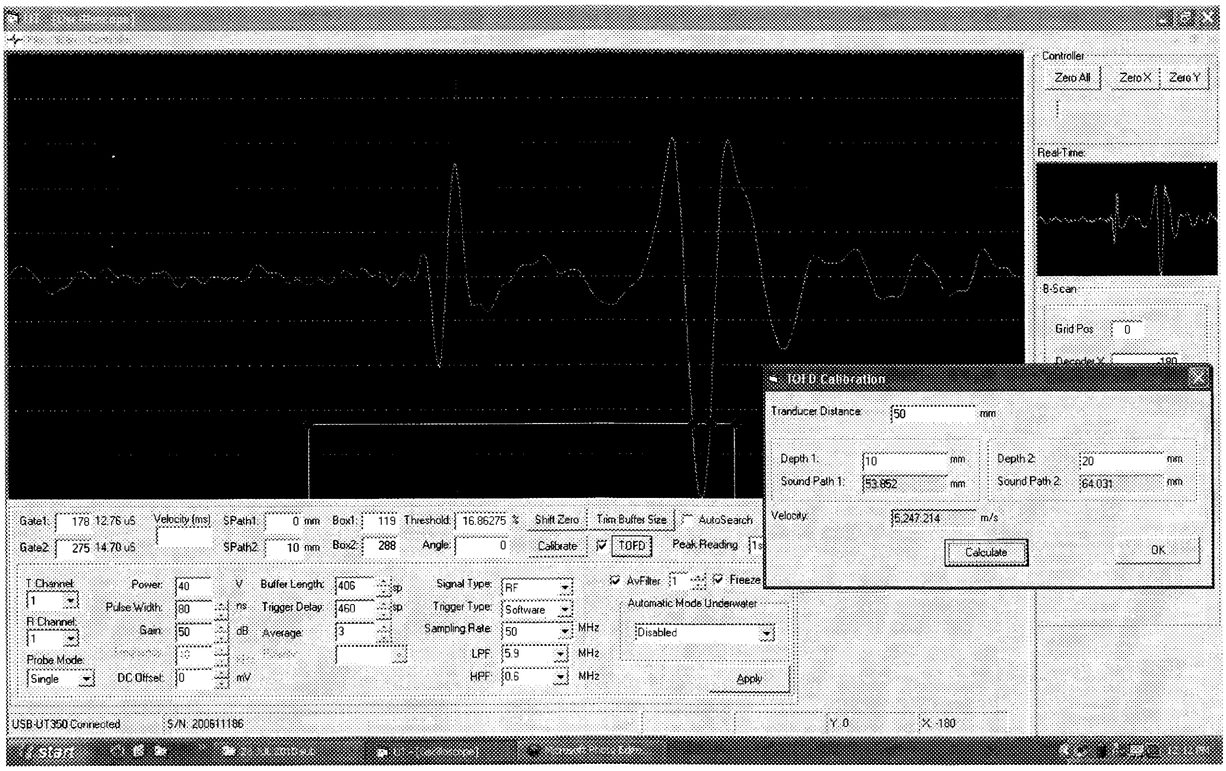

Figure 4: A scan of the Plate.

RESULTS AND DISCUSSION

The examination was performed on different welded samples having cracks, porosity, lack of fusion, lack of penetration and slag. After getting the TOFD image, the location of length or depth and distance of the defects can be easily determined with the software by just moving the cursor over the TOFD image of the defect.

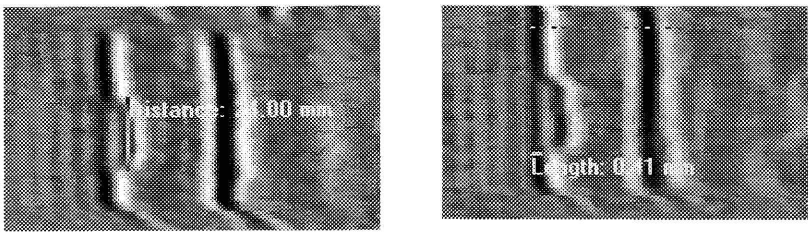

Figure 5: Depth and distance of the defects.

When the defect exists near the root such as a lack of penetration (LOP), the defect image will be as shown in the Figure 6.

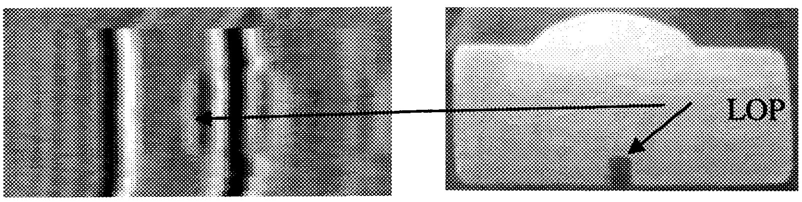

Figure 6: Location of the defects.

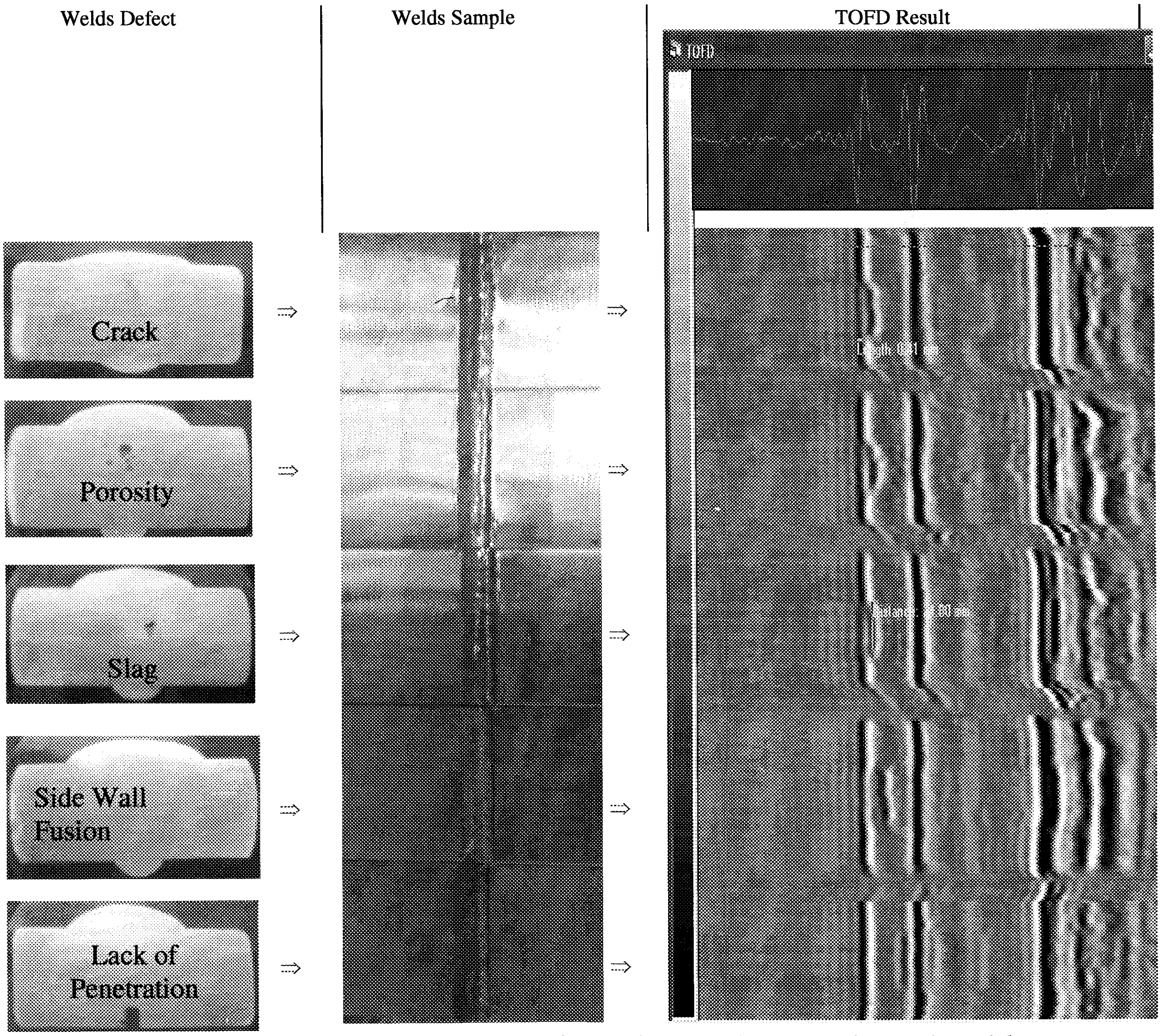

Figure 7: TOFD result on welded samples having cracks, porosity, lack of fusion, lack of penetration and slag.

CONCLUSION

The significantly TOFD image enables the application of the features to qualitatively classify the type of defects that is exhibited by the test specimen. For future improvement, we propose to validate the result with a larger number of test specimens, including automated classification method using Expert Systems and Artificial Neural Networks.

REFERENCES

K.G.Prabhakaran, Brian Stephen Wong, Time of Flight Diffraction - An Alternate Non-Destructive Testing Procedure to Replace Traditional Methods, SPIE Proceedings vol. 5852, 3rd Int. Conferences on Experimental Mechanics, Singapore.

Bill Browne "Time of Flight Diffraction-Its Limitations-Actual and Perceived" NDTnet-Spet.1997, Vol.2, No.09 www.ndt.net/v02n09.htm.