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Detection of interface defects in laser-cladding coatings using laser ultrasonic method

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1. Experimental Methods

The substrate was 45 steel of 55 mm × 28 mm × 10 mm. Nickel-based alloy coating with a thickness of 0.6 mm was prepared on the substrate using laser-cladding technology. Two artificial defects with a diameter of 0.5 mm and two a diameter of 0.7 mm were made in the horizontal direction of the laser-cladding coating using an ultrafine drilling machine.

The LU equipment comprised a pulsed laser emitter, laser interferometer, two-dimensional stepping displacement stage, rotating XYR-triaxial combined displacement stage, filter, personal computer, and other equipment, as shown in Fig. 1.

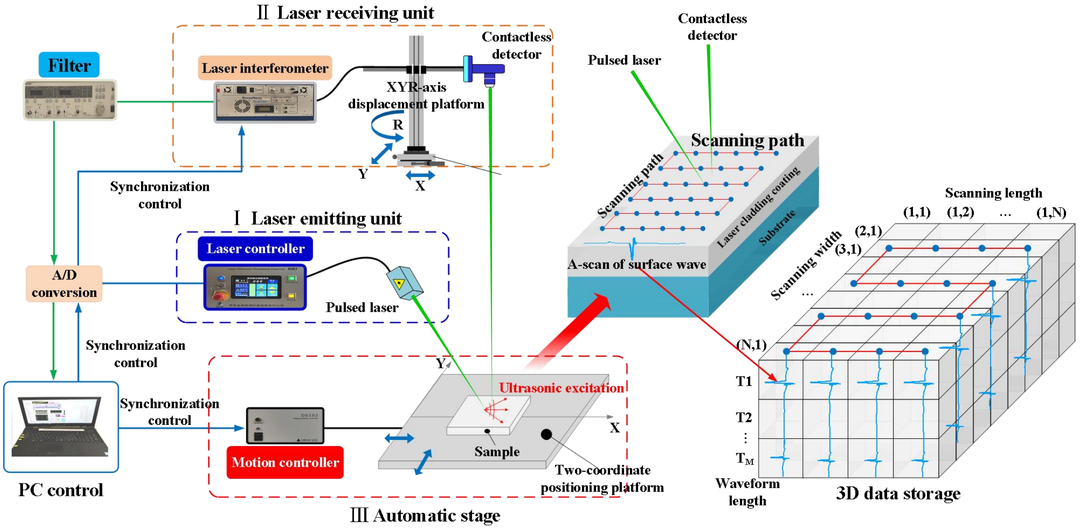

Fig. 1. Equipment and implementation principle of laser ultrasonic C-scan.

2. Results

Fig. 2 shows the received signals passing through defects with different diameters. Based on the FEM and LU results, the amplitude and time of the negative peaks of the SAWs decreased as the defect diameter increased. Therefore, the amplitude and time of the negative peaks could be used as the eigenvalues of the C-scan image to detect interface defects in laser-cladding coatings.

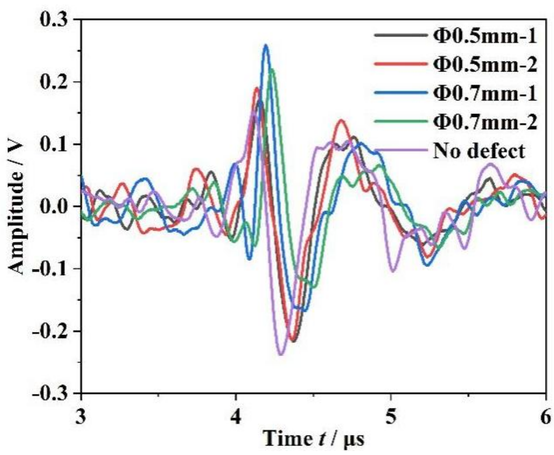

Fig. 2. Time signals of SAWs received without defects and with defects of 0.5

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and 0.7 mm diameter using LU method.

Fig. 3 shows a C-scan image with a scanning area of 20 mm × 10 mm, where the colors represent the amplitude of the negative SAW peaks. Two defects with a diameter of 0.7 mm were located at approximately 13.0 and 18.5 mm, and two with a diameter of 0.5 mm were located at approximately 3.0 and 8.0 mm. The transverse stripes in the x-axis (Fig. 8) were attributed to the process characteristics of the laser-cladding technology.

Fig. 4 shows a C-scan image with the same scanning area, but the colors represent the time of the negative SAW peaks. The time of the negative peak can also be used as the eigenvalue from the A-scan signal. However, the defects were not presented clearly from the C-scan results (Fig. 9). Therefore, the time of the negative peak is not very suitable for defect detection.

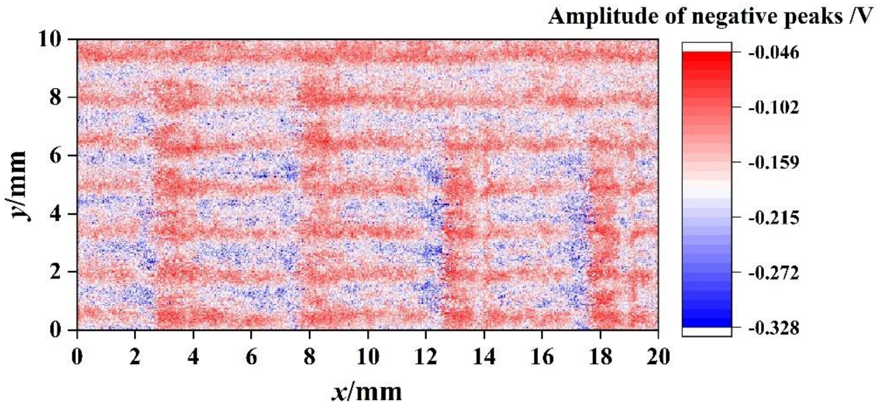

Fig. 3. C-scan images examined using LU method with scanning area of 20 mm × 10 mm, where colors indicate amplitude of negative SAW peaks.

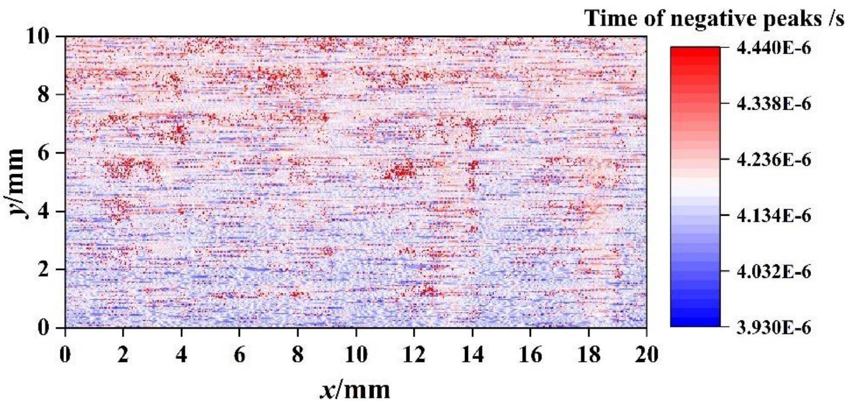

Fig. 4. C-scan image examined using LU method with scanning area of 20 mm × 10 mm, where colors represent time of negative SAW peaks.

3. Conclusion

In this study, interface defects in laser-cladding coatings were detected using the LU method. The main conclusions are as follows.

The amplitude and time of the negative SAW peaks decreased as the defect diameter increased. A defect with a diameter of 0.5 mm in the laser-cladding coatings was successfully detected using the LU method. The LU method has excellent prospects for the online detection of interface defects in additive manufacturing.