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Improvement of SNR in Pulse-echo Measurements with Polygonal Buffer Rods

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1. Introduction

Although so-called ultrasonic buffer rod method is rather classical, it is still an attractive approach from the viewpoints of its simplicity, convenience, robustness and low cost. However, due to the interference of the mode converted waves, dispersion and diffraction within a long rod of finite diameter, trailing echoes are formed and deteriorates the signal-to-noise ration (SNR) of the main echo.[1-3] To overcome such a problem, polygonal buffer rods has been developed and their effectiveness for reducing trailing echoes is successfully demonstrated.[4]

For further improvement of the SNR and practical use of the buffer rod, it will be quite useful to discuss the cladding effect[1, 2] on the pulse-echo measurement with the polygonal buffer rods. In this work, such cladding effect on the SNR has been examined by numerical simulations. The influences of the thickness and acoustic impedance of the cladding layer fabricated onto the rod surface are systematically investigated for several types of polygonal rods.

2. Numerical Experiments

2.1 Influences of thickness and density of cladding

Fig. 1 shows the schematic of numerical simulation models showing straight cylinder buffer rods with 25 mm in length and 5 mm in diameter, equipped with an ultrasonic transducer (UT). The core is steel and the cladding is stainless steel to ensure the proper ultrasonic guidance in the core, while the pairing with steel is to match their thermal characteristics.[2] In the two dimensional finite difference analyses, the influences of the thickness and density of the cladding layer on the SNR of pulse-echoes in the rods are examined and performed for investigating the wave propagations at 5 MHz in pulse-echo mode. Wave2000 from CyberLogic, Inc. is used for the simulations.

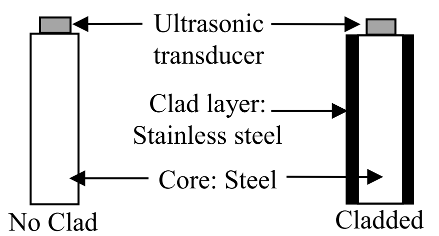

Fig. 1 Schematic of cylinder buffer rods with no cladding (left) and with a cladding layer (right).

2.2 Cladding effect on polygonal buffer rods

Several types of polygonal buffer rods having different cross sectional shapes, i.e., circle, triangle, square, pentagon, hexagon or heptagon, are used as specimens. The cladding effect on the wave propagation is numerically examined for the polygonal buffer rods. In the examinations, three dimensional finite difference analyses are performed at 5 MHz in pulse-echo mode. Wave3000 from CyberLogic, Inc. is used for the simulations. To obtain accurate results, a grit size of 0.03mm with the resolutions of 10voxel/mm is employed in the simulations.

3. Results and Discussion

3.1 Influences of thickness and density of cladding

Fig.2(a) shows the variations of the SNR with the thickness of cladding layer. The SNR rapidly increases with the thickness and then becomes stagnant when the value of thickness approaches to 1.0 mm which almost equals to the value of a wavelength. It has been found that the thickness of cladding layer should be larger than the value of one wavelength. For practical use, thickness approximately equals to one wavelength may be good enough for improving the SNR.

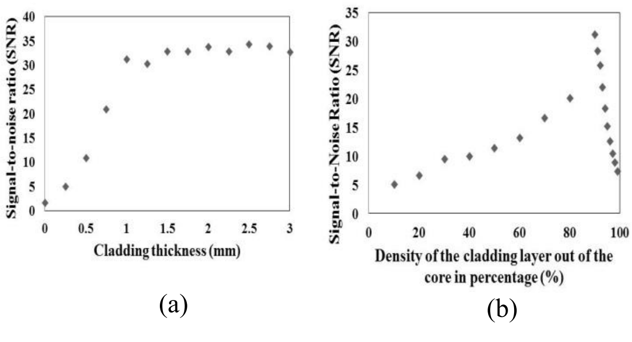

Fig. 2 Variations of the SNR with (a) thickness and (b) density of the cladding layer for a straight cylinder buffer rod.

Fig.2(b) shows the variations of the SNR with the density of cladding layer, where the density is changed in the range from 10 to 99 % of the core and the thickness of the cladding is 1.0 mm. The SNR gradually increase with the density (acoustic impedance) of the cladding and becomes maximum at 90 % density. This reveals that more ultrasonic waves (energy) will be refracted and transmitted into the cladding layer surrounding at the core-clad boundary as the value of the acoustic impedance approaches to 90 % of that of the core. Therefore, the formation of trailing echoes is prevented and then the SNR is improved. It is, however, considered that this effect to prevent the formation of trailing echoes becomes weaker as the value of the acoustic impedance almost equals to that of the core.

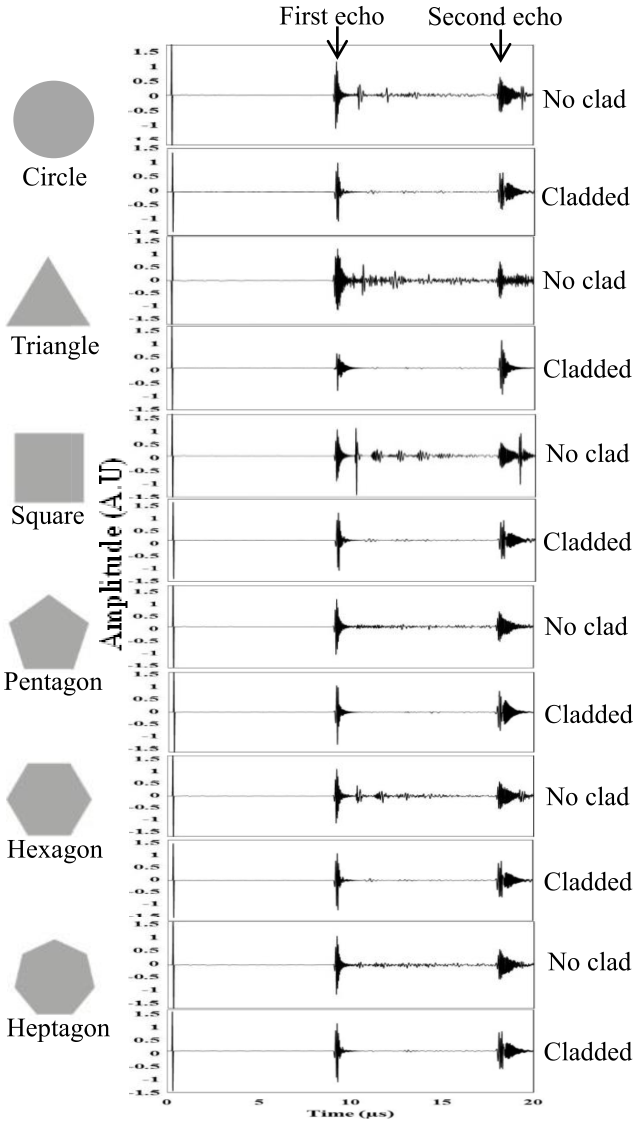

Fig. 3 Simulation results showing pulse-echoes for the straight polygonal buffer rods with no cladding and cladding layer having 1.0mm thickness and 90% density of the core.

3.2 The cladding effect on the polygonal buffer rods

Fig.3 shows the simulation results for all the straight polygonal buffer rods. It is clearly observed that the cladding is very effective to reduce trailing echoes and improve the SNR of the pulse-echoes, for all the buffer rods estimated here. It has also been found that the pentagon and heptagon rods have better SNR for the cladded as well as no clad. **Fig.4** shows the summarized result showing the improvement of the SNR for all the polygonal buffer rods.

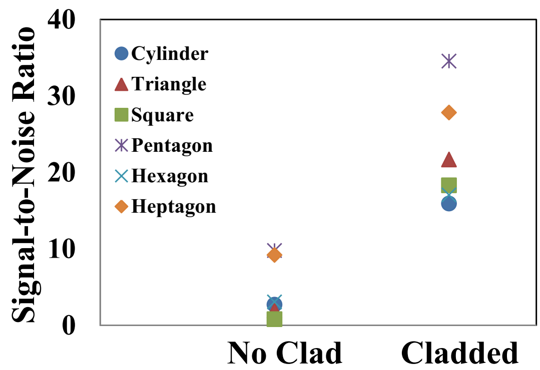

Fig. 4 Summarized result showing the improvement of the SNR for all the polygonal buffer rods.

4. Conclusion

The cladding effect on the polygonal straight buffer rods is numerically examined. It has been demonstrated that the trailing echoes are reduced and the SNR of the pulse-echoes in the buffer rods are significantly increased owing to the cladding effect.

5. Acknowledgment

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6. References

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