論　文　内　容　の　要　旨

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In ultrasonic pulse-echo measurements with a long cylindrical buffer rod, it has been known that spurious echoes (also known as trailing echoes) are often generated due to diffraction and mode conversion of ultrasonic waves within the rod of a finite diameter. From the cross-sectional view of a cylindrical buffer rod, it is found that such trailing echoes are generated when the mode converted waves are parallel to each other and propagate to the side wall of the rod perpendicularly. Such trailing echoes are considered as noise and therefore, they deteriorate the signal-to-noise ratio (SNR) in the pulse-echo measurements because of their possible overlapping with the main echo while a pulse-echo measurement is being performed. Although tapering or cladding for the cylindrical buffer rod may be effective to reduce such trailing echoes, they are not always sufficient for practical uses of the buffer rod. In this work, a new idea of using polygonal buffer rods has been proposed as an alternative method to reduce the trailing echoes and result in improving the SNR.

In Chapter 1, the fundamentals of ultrasound are presented. Also this chapter reviews the literature study and related works on ultrasonic pulse-echo technique. In addition, some applications of buffer rod method in the pulse-echo measurements and some problems of using the buffer rod are described extensively. Based on such background, the scope of the present study is addressed.

In Chapter 2, the generation of trailing echoes in a cylindrical buffer rod is numerically and experimentally investigated. Such generation is verified from the numerical simulation where a three-dimensional finite difference method is employed. It is found that the generation of trailing echoes can be illustrated from the cross-sectional shape itself. A trailing echo can be generated when the mode converted shear waves propagate to the side wall of the rod perpendicularly and constructive interferences between the waves occur effectively. Thus, the generation mechanism of such trailing echoes are theoretically described. In addition, the validity and effectiveness of using the numerical simulation has been demonstrated experimentally.

In chapter 3, the cladding effect to reduce the trailing echo is examined numerically. It is found that the SNR changes drastically with the material combination for the cladding and core and the highest SNR is appeared when the velocity and density of the cladding are approximately 120% and 70% of the core, respectively. It should be noted that an appropriate SNR is obtained when the velocity of cladding is approximately 110% of the core regardless of the density value of the cladding on the condition that the density value is within the range from 75% to 150% of the core. This fact obtained here could be useful for reducing trailing echoes that are appeared in polygonal buffer rods developed in this work.

In chapter 4, polygonal buffer rods has been proposed to reduce the trailing echoes and result in improving the SNR in ultrasonic pulse-echo measurements. The idea is basically to use a polygonal rod whose normal sectional shape is a polygon such as a triangle, square, pentagon, hexagon or heptagon. The effectiveness of such polygonal rods is examined numerically and

experimentally. It is found from a three-dimensional numerical simulations based on a finite difference method that ‘odd polygons’ having sides any one of which is not parallel to any of the other sides, such as triangle, pentagon and heptagon, are effective to reduce the trailing echoes, because of less interferences among the mode converted waves in the rod. It should be noted that there still exist a certain amount of trailing echoes even in the odd polygonal rods where such trailing echoes are generated by the possible interference of the waves due to the bilateral symmetry shape of the odd polygons.

In chapter 5, to eliminate such remaining trailing echoes existing in the odd polygonal rods, an effective idea of using irregular polygons is proposed. Because the symmetry shape of the polygons results in generating trailing echoes, such generation can be prevented by distorting the half side of a polygon. The effectiveness of such irregular polygonal buffer rods on restraining the generation of trailing echoes is numerically and experimentally investigated. It is found that the trailing echoes are almost completely eliminated with the irregular pentagon and the SNR of the pulse-echo is approximately five times higher than the regular pentagon.

General conclusions and future prospects of the research are summarized in chapter 6.

Thus, it is highly expected that the polygonal buffer rods proposed in this work can be a promising tool for advanced ultrasonic measurements and evaluations.