1. Introduction

Detection and classification of cylindrical targets using acoustical method have been studied by many investigators.\(^1\),\(^2\),\(^3\) In many cases, detection and classification process dependent target’s geometrical specifications. But there are many unnecessary objects in the actual ocean or river conditions and these objects may have very similar geometrical specification with the targets which we want to detect. Specially, there are many artificial structures or products which have cylindrical shape (pipe, sea main, metal bar, Etc.). So, for classifying these objects, we need to consider another acoustical characteristic except geometrical specification. In this study, target’s resonance property is considered. Acoustic resonance scattering is particularly dependent boundary conditions between target and inside material. Using this property, we can classify cylindrical shells shape targets filled with different materials which have same geometric properties (radius, thickness). Used target samples are air filled cylindrical shell, water filled cylindrical shell and solid aluminum circular bar. These targets inside materials represent gas, liquid and solid. Through this study, we try to classify cylindrical shells which have different inside material.

2. Experimental Measurements

Our purpose is to classify cylindrical targets which have same geometrical specification according to different inside materials. We used three cylindrical shell samples, each samples are filled with different materials. The insides materials are aluminum, air, water. These materials have large difference of density, sound speed. Each samples have same geometrical specifications which are L=30 cm, a=10 mm, b=8 mm (b/a=0.8). Other specification is showed Table 1. In this experiment, we used 1MHz broadband acoustic transducer. The wavelength of 1 MHz wave is about 1.5 mm, which is longer than thickness of aluminum tube and shorter than radius of aluminum tube. The cylindrical targets placed in laboratory water tank. The water tank is filled with degased water. Fig. 1 shows experimental settings.

Table 1 properties of cylindrical shells

<table>
<thead>
<tr>
<th>Inside material property</th>
<th>Cylinder A</th>
<th>Cylinder B</th>
<th>Cylinder C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer diameter (mm)</td>
<td>12.2</td>
<td>12.7</td>
<td>12.7</td>
</tr>
<tr>
<td>Inner diameter (mm)</td>
<td>-</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Inside material</td>
<td>Aluminum</td>
<td>Air</td>
<td>Water</td>
</tr>
<tr>
<td>Density (kg/m(^3))</td>
<td>2762</td>
<td>1.2</td>
<td>998</td>
</tr>
<tr>
<td>Sound speed (m/s)</td>
<td>6223</td>
<td>343</td>
<td>1475</td>
</tr>
</tbody>
</table>
3. Results and Discussion

Figures 2, 3 and 4 show average of specular echo spectrum amplitude and elastic echo spectrum amplitude. Incident sound wave creates modes caused by shell thickness (difference between outer diameter and inner diameter of cylindrical shells.). Each target’s modes have different acoustic resonance scattering properties caused by boundary conditions between target shell material and target inside material. According to these reasons, modes contribute amplitude of resonance scattering amplitude for frequency domain. Experimental results show how different the target’s resonance spectrum by inside materials.

![Figure 2](image2.png)
Figure 2 Backscattering spectrums of solid cylinder

![Figure 3](image3.png)
Figure 3 Backscattering spectrums of air filled cylindrical shell

![Figure 4](image4.png)
Figure 4 Backscattering spectrums of water filled cylindrical shell

4. Conclusion

We try to classify cylindrical shells which are filled different inside materials using acoustic resonance spectra. Unless used three samples had very similar geometrical specifications, acoustic resonance spectrums of each sample are different. Inside materials represent gas, liquid and solid. They have large characteristic impedance difference, so the boundary conditions between cylindrical shell materials and inside material are affected by this property. For this reason, inside material contribute acoustic resonance spectra, we can classify used samples by experimental method. Through this study we can find how to classify targets which have similar geometrical specifications using differences of inside materials.

Acknowledgment

This research was a part of the project titled “Development of Ocean Acoustic Echo Sounders and Hydro-Physical Properties Monitoring Systems”, funded by the Ministry of Oceans and Fisheries, Korea. This work also was supported by the project “Pilot study for construction of MT-IT convergence real-time observation system” (PE98911) at Korea Institute of Ocean Science and Technology (KIOST). 

References