2P2-12

Observation of the *Temperature of Intromission* at Water-Castor Oil Interface

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1. Introduction

Properties of acousitc propagation are characterized by an acoustic impedance of the medium, which is expressed as a product of the sound speed and the density of the medium. When acoustic signal is incident on the boundary between two different media, the acoustic reflection at the interface depends on the difference between the acoustic impedances of two media. Previous studies on the reflection at a bundary formed by two different media have mainly focused on the investigation of reflection properties as a function of grazing angle. In this study, we investigate on the reflection loss as a function of temperature between water and castor oil. In conclusion, the '*temperature of intromission*' is observed in the measurements, which is compared to the theretical model predictions.

2. Acoustic measurements

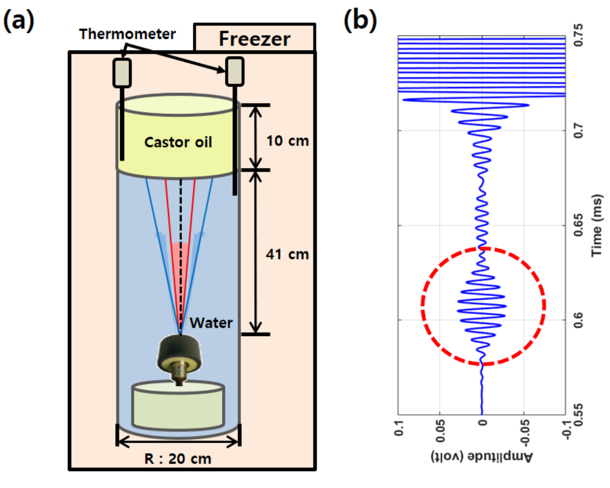

Fig. 1 (a) Geometry of acoustic measurements and (b) example of signal reflected from the interface between water and castor oil.

Acoustic measurements were made in the freezer to control temperature of water and castor oil in glass container(**Fig. 1**). Castor oil floats on water because the specific gravity of castor oil is smaller than that of water. A directional transducer(Simrad, 200-7G) was installed on the bottom of container as shown in Fig. 1(a) and 0.025ms-long, 200 kHz continuous wave was transmitted in the normal direction of the water-castor oil interface.

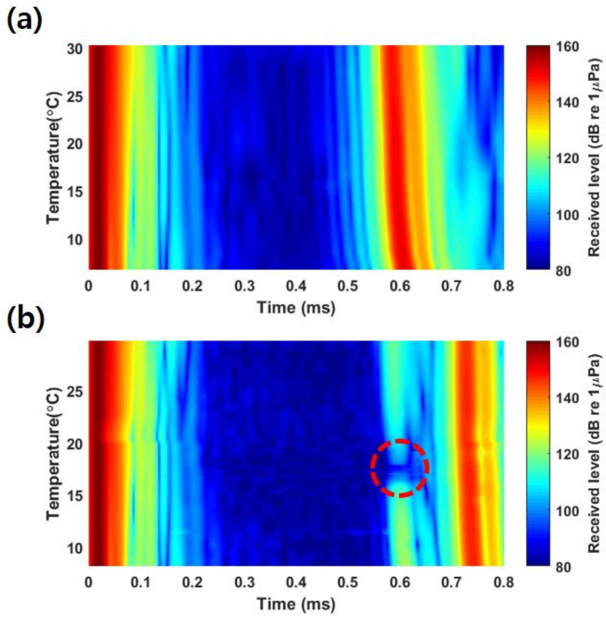

Fig. 2 Received levels as a function of temperature for (a) the water-air interface and (b) the water-castor oil interface. Note that *'Temperature of intromission'* is observed in red circle.

Sonar equation can be expressed by RL = SL−2TL−SPL, with SL being the source level, TL being the transmission loss from the source to interface, SPL being sound pressure level and RL being the reflection loss. In this study, RL was measured as a function of temperature. Because the source-receiver range was not enough to satisfy the far-field condition, TL from the source to interface was directly measured at the water-air interface, maintaing the same distance as that of water-castor oil interface case under the assumption that acoustic sound is perfectly reflected at the water-air interface with the reflection coefficient of −1.

Fig. 2(a) show the received levels as a function of temperature in case of the water-air interface. Since the sound speed in the water is directly proportional to temperature, it is seen that

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the arrival time of the signal reflected from the interface increases gradually. **Fig. 2(b)** show the received levels in case of the water-castor oil interface. Two main arrivals are observed at ~ 0.6 ms and ~0.7 ms, which are arrivals reflected from water-caster oil interface and castor oil-air interface, respectively.

Interestingly, it is observed that the signal reflected at the water-castor oil interface disappeared around 17.8°C, which is '*temperature of intromission'* and most energy is transmitted into the second medium at this temperature.

3. Modeling of '*temperature of intromission*'

The measured reflection loss is compared to the predictions obtained by the rayleigh reflection model[3], which is expressed by

$$R = \frac{\rho_o c_o / \sin\theta_2 - \rho_w c_w / \sin\theta_1}{\rho_o c_o / \sin\theta_2 + \rho_w c_w / \sin\theta_1}, \quad (1)$$

where ρ_o and ρ_w are densities of castor oil and water, respectively, c_o and c_w are sound speeds of castor oil and water, and θ_1 and θ_2 are the grazing angle and transmitted angle, respectively. As a result, the model predictions are in good agreement with the measurements (**Fig. 3)**, especially, predicting well the '*temperature of intromission*' around the temperature of ~16 °C.

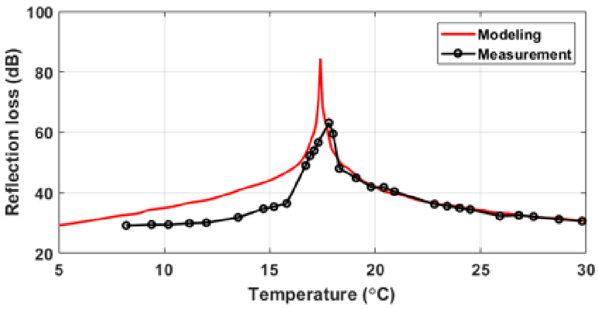

Fig. 3 Comparison of reflection-loss measurements (black circle line) to the model prediction (red solid line) obtained by the Rayleigh reflection model as a function of temperature.

Acknowledgment
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