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The trial of an array type acoustic impedance measuring device

アレイ型音響インピーダンス測定装置の試作

Kazuki Higuchi[1†], Kazuto Kobayashi[1] ([1]Honda Electronics)
樋口和樹 [1†]，小林和人 [1] ([1] 本多電子株式会社)

1. Introduction

Distance, thickness, speed of sound, until the opaque material, to use the ultrasonic measurement technology is widely used in the field of industry.

We have been developing a scanning acoustic microscopy for biomedical fine imaging. This microscope has been created in the high precision c-scope images for intensity, speed of sound, the acoustic impedance by mechanical scanning with ultrasound.

The request for observation of the mixing process of the substances, in cases that require real-time, it is difficult to apply the acoustic microscope. Therefore, we report an effectiveness of the prototype array type acoustic impedance measuring device that can be observed acoustic impedance in real-time and wide range that is achieved by contact with a hand-held sensor.

2. Measurement Method of Acoustic Impedance

Acoustic impedance is correlated with the speed of sound and bulk modulus, which is a parameter related to stiffness.

Transducer with polystyrene contact to the target or the reference pure water. At first, the reference pure water put onto the polystyrene and measure intensity. Next, the target liquid put onto the polystyrene and measure intensity.

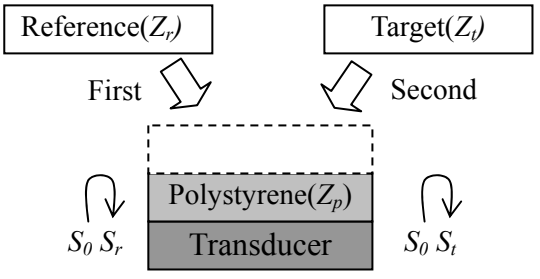

Fig.1 Measurement Setup

In Fig.1, S_0 is the transmitted wave. S_t is the reflected wave from the target, S_r is the reflected waveform from the reference. Z_t,Z_r,Z_p are acoustic impedance of the target, the reference, the polystyrene, respectively.

The target acoustic impedance is calculated using equation (1), by known acoustic impedance of the pure water and the polystyrene.

$$Z_t = \frac{1 - \frac{S_t}{S_r} \bullet \frac{Z_p - Z_r}{Z_p + Z_r}}{1 + \frac{S_t}{S_r} \bullet \frac{Z_p - Z_r}{Z_p + Z_r}} Z_r \quad (1)$$

3. Prototype of the measurement system

RF signal acquisition system (Fig.2) has 32sets of transmitters and receivers, 4GB receive buffer, and 128:32 electrical switch. This system can acquire more than 2000 frames per second.

Array transducer is used for measure the acoustic impedance. Sequentially drives multiple element, get the intensity of the reflected waveform by detecting the peak-to-peak.

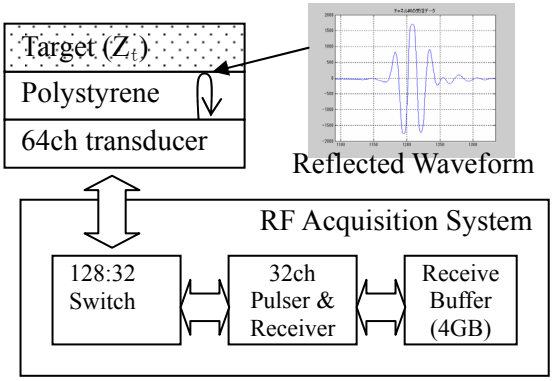

Fig.2 RF Acquisition System

4. The validity check of acoustic impedance presumption

Measuring the acoustic impedance of the saline of five different concentration by using array system. Shows the results of acoustic impedance measurement for each element in Fig 3.

Email:khiguchi@honda-el.co.jp

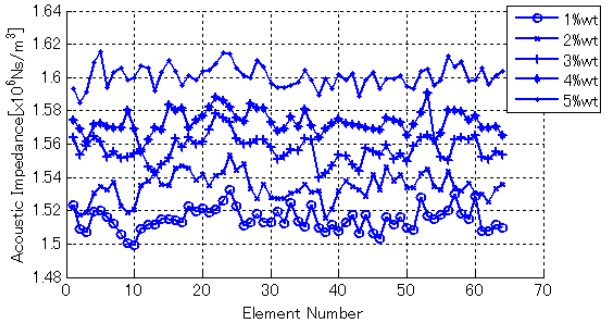

Fig. 3 Variation of Elements

Average of the measurement result with theoretical values are shown in Fig 4. The value is slightly lower, the error is suppressed to approximately 0.02×10^6 [Ns/m^3].

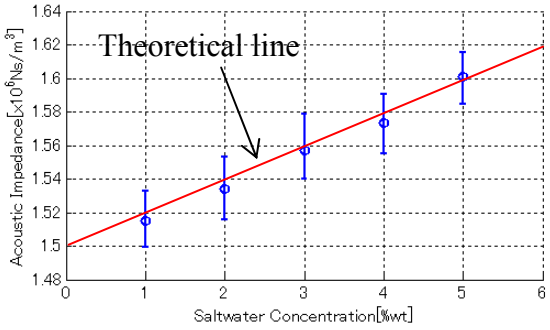

Fig 4 Measurement result of Saline

5. Observation of the mixed process of two kinds of liquids

Observed mixing process as two types clear liquid that is not suitable for an optical observation.

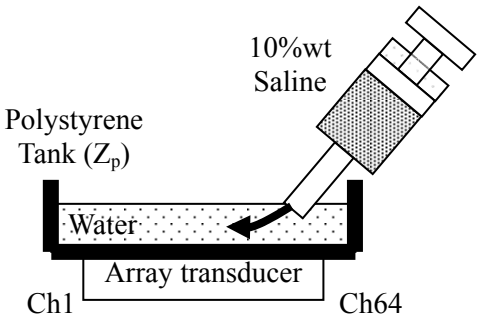

Fig.5 Experimental Setup

Array transducer was installed under the bottom of the polystyrene tank filled with pure water. The pure water is also used to take S_r. Injected 10%wt saline into the tank by syringe.

Fig 6 shows the time variation of acoustic impedance were acquired at a rate of 10 frames per second.

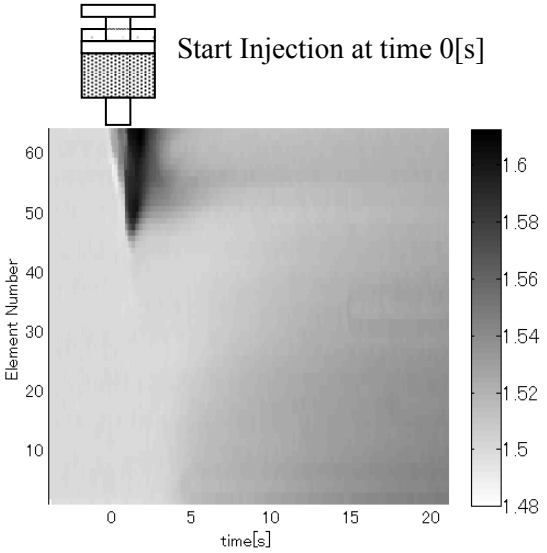

Fig. 6 Mixing process of liquids

Before saline injection, the entire element indicates a 1.50×10^6 [Ns/m^3]. Then saline was injected, acoustic impedance of the portion of the injected saline was rapidly rising. After that, gradually approaches the equilibrium state.

6. Conclusions

In this study, we realized real-time acoustic impedance measurement device. The prototype, we were able to obtain real-time performance is sufficient to observe the mixing process of the liquid. In addition, the adoption of handheld sensor, it has become possible to manually scan a large area.

Observation of the mixing process of liquid, such as different liquid detection, we will consider to achieve real-time applications that require performance, advancing the improvement of measurement accuracy and processing speed.

References

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