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Ultrasonic Inspection of Highly Attenuated Material Using Step Pulser
ステップパルサーを用いた高減衰部材の超音波探傷特性について

Koji Shimaya [1†], Tsuyoshi Mihara [2], and Hatsuzo Tashiro [2] ([1] Grad. Student, Univ. of Toyama; [2] Grad. School of Eng., Univ. of Toyama)
島谷孝志 [1†], 三原毅 [2], 田代発造 [2] ([1] 富山大院, [2] 富山大大学院)

1. Introduction

Ultrasonic inspection of a large attenuated material has been required in many structures, such as a composite material and concrete, and the low frequency ultrasound has applied to avoid the large attenuation. However, because of low directivity due to lower frequency, shape dependent noises apt to be increase and the measurement become difficult in many cases. Authors have been developed the step pulse excitation [1] and have confirmed the availability for highly attenuated materials. Furthermore, laminated transducer and a multi-burst pulser system for a large displacement ultrasound transmission have been developed as a nonlinear ultrasound measurement system [2]. In this study, we developed the multi-step pulser combining the above two techniques to apply high attenuated rocket solid fuel inspection.

2. Step pulser and sound field analyses

As the comparison of the spike and step pulsers, the excitation waveform, transmitted ultrasound waveform and the spectrum of the conventional spike pulser and the step pulser were shown in Fig.1 schematically. The most important property of step pulser is the broadband property in frequency. Thus transmitted amplitudes of both pulsers were large enough even after long traveling distance. On the other hand in large attenuated materials, larger attenuation especially in high frequency will occurred and ultrasonic

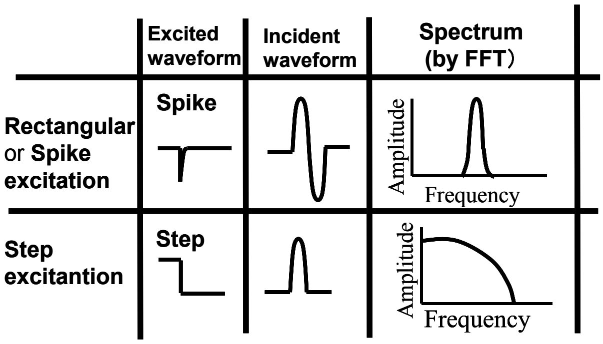

Fig.1 Basic properties of step pulser

measurement of spike pulser after long traveling become difficult. However in step pulser the ultrasonic energy of lower frequency remains enough to measure even after long traveling [1].

3. Large model of solid rocket fuel

Industrial solid fuel rocket in Japan is almost 2 m at most in diameter in cross-section with a designed shape of center cavity. Thus the ultrasonic travelling distances of this structure are 1 m in transmission measurement and 2 m in reflection measurement respectively. These long traveling distances in highly attenuated materials are one of the most serious problems in ultrasonic inspection of solid rocket fuel. Then in this study we prepared the large solid rocket fuel model replacing the ignition material to the glass bead with 3 artificial boid of ϕ20 mm in diameter at the position of 140, 405 and 620 mm in depth as shown in Fig.2.

Pulser	Transducer	Excitation
Spike	500KHz (single)	1000V
8ch Step	500KHz (8ch laminated)	350V

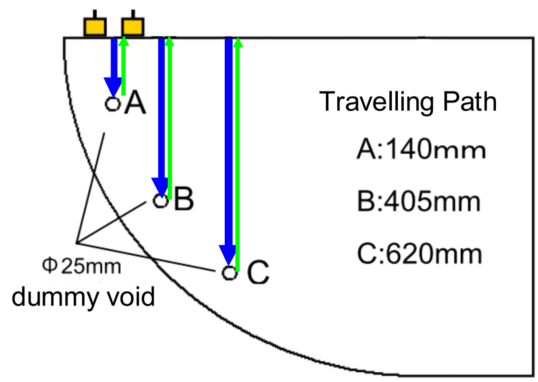

Fig.2 Applied pulser and solid rocket fuel specimen

4. Experiment anddiscussion

4-1 **Experimental setup**

Developed system of eight-channel step pulser and eight layers laminated transducer of 500 kHz was used for ultrasonic transmission and a conventional single step pulser was used for receiver with two transducers measurement. Obtained transmitted waveform was a almost designed half-wave however some noise after the first echo was observed as shown in Fig. 3. These noises will arise by the reflections of the back surface in laminated transducer because our transducer had no backing structure now. Improvement of the laminated transducer containing backing structure should investigate in future.

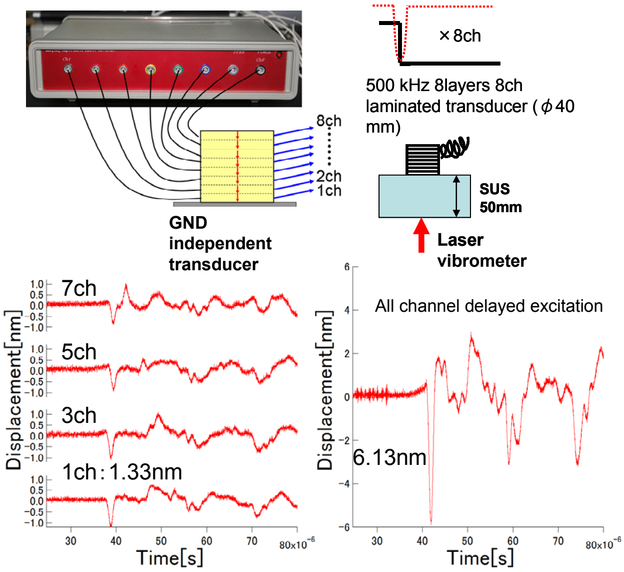

Fig.3 Experimental setup and incident waveform using new 8channel step pulser

4.2 Inspection of artificial boids

Three artificial boids of φ25 mm in diameter were introduced in a large solid fuel specimen with different depth from the surface of 140, 405 and 620 mm, respectively. Results of the inspections by a commercial spike pulser were shown in Fig. 4. An arrow in all figure show the supposed reflection echo positions according to the depth of boids. Receiving amplitude was 60 dB. Boid of 140 mm in depth can detect but deeper boid was difficult to detect. Some weak echoes observed in 405 mm and 620 mm depth boids near the arrow point however these were not the reflection echoes because these echo didn't move when we moved a set of transducers. On the other hand, same boids in large fuel model were inspected by a developed large ultrasonic displacement system using multi-channel step pulser as shown in Fig. 5. Void of 140 mm, 405 mm and also 620 mm in depth can be detected. About measurement of 140 mm, 405 mm and also 620 mm, we can detect all the boids in this experiment. However the noise near the base line was observed and will interrupt the detection of the voids of 405 mm and 620 mm in depth. These noises might be a delayed echoes from the side wall reflections. Because that 350 mm in thickness of the specimen recogniuze a large thickness for usual MHz ultrasound but it is not enough thick for such a lower ultrasonic frequency of 100 KHz due to the large attenuations of high frequency. However in industrial rocket fuel structures, as we have no side wall of 350 mm, these noises will be disappeared and SN ratio in detection of reflection echo will expect to be improved.

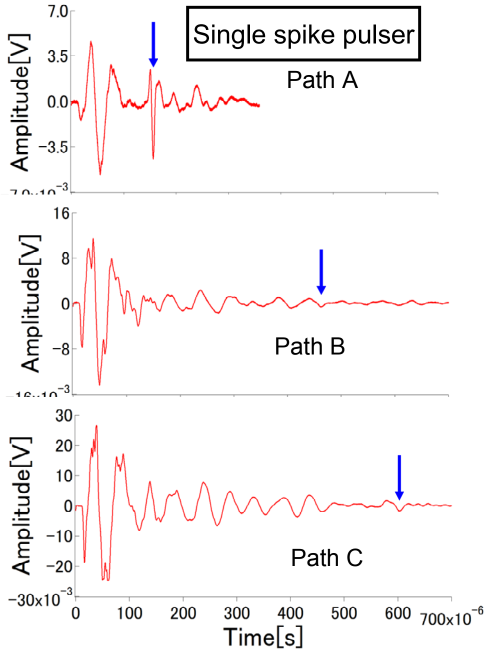

Fig.4 RF signal of inspection by spike pulser

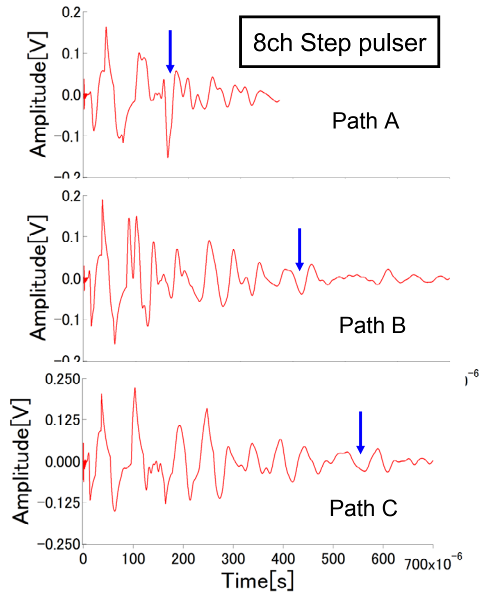

Fig.5 RF signal of inspection by step pulser

Acknowledgment

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References

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