Proceedings of Symposium on Ultrasonic Electronics, Vol. 32 (2011) pp. 193-194
8-10 November, 2011

Ultrasonic Behavior of Rocket Fuel Model Using Multi-Channel Pulser and Laminated Transducer
多チャンネルパルサーと積層探触子によるロケット燃料の音響特性

Takumi Hamajima[1†], Tsuyoshi Mihara[2], and Akira Sato[3] , Hatsuzo Tashiro[2] ([1]Graduate Student U-Toyama; [2]Graduate School of Eng.U-Toyama; [3]IHIAeroSpace)
濱島　拓巳[1†], 三原　毅[2], 佐藤　明良[3],田代　発造[2] ([1]富山大学(院), [2]富山大学大学院, [3]IHI エアロスペース)

1. Introduction

Ultrasonic measurements for composite materials, concrete and welding structure of inconel alloy are difficult because of the highly acoustic attenuation. For these materials low-frequency ultrasound is generally used to avoid the larger attenuation because attenuation factors of scattering and absorption both depend on frequency. However kHz band ultrasound sometime make troubles due to the lower directivity and to lower signal to noise ratio. The authors have studied large amplitude ultrasonic transmission systems of MHz range for nonlinear ultrasound measurement combining the multi-channel pulser and laminated transducer[1,2]

In this study, we tried to investigate the availability of the large amplitude ultrasound incidence for highly attenuated materials using the model specimen of rocket fuel model. We compared the transmission echoes through the specimen using the conventional ultrasonic pulser and the multi-channel pulser system using laminated transducer.

2. Multi-channel pluser and laminated transducer system

Laminated transducer is widely used for an actuator and a medical transducer. [3,4] However the nominal frequency and electric impedance are both decreased depending on the number of lamination, thus the ultrasound of MHz range have not been used up to now. The authors focused on the advantage of the combination of laminated transducer and multi channel pluser that the frequency and the electric impedance doesn't decrease. Sample of the 8ch laminated transducer system that we developed for nonlinear ultrasound measurement was shown in Fig.1. Fig.2 was the comparison of the surface displacement waveforms of single channel excitation and multichannel excitation using calibrated hydrophone because surface displacement was too large to measure by laser Doppler interferometer.

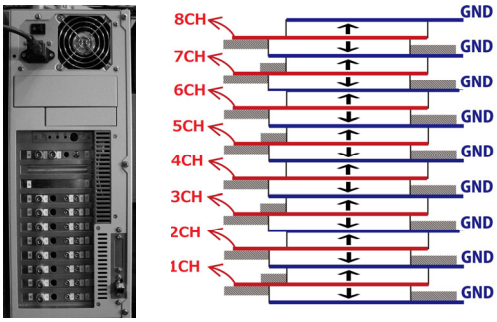

Fig.1　8 ch pulser and 8 ch laminated transducer

10 numbers of burst waves of 300 V was excited to the transducers with 690 kHz in frequency. Single channel in Fig.2 mean the limited excitation of only 1ch in laminated transducer as shown in Fig.1, and 8ch excitation in Fig.2 mean the delayed excitation for each channel to obtained the waveform with same phase. 7.7 times larger amplitude could be obtained using 8ch laminated transducer than that of single channel measurement.

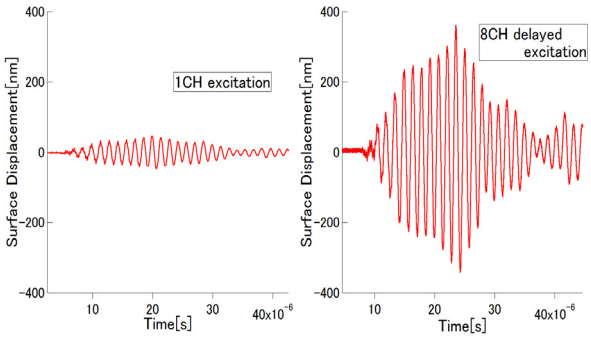

Fig.2 Comparison of single and 8ch laminated transducers

3. Rocket fuel model and experiment system

We prepared the rocket fuel model of 135×115×95 mm in dimension with large ultrasonic attenuation. Thickness of ultrasonic transmission is 115 mm. In this experiment, we compared the transmitting waveform using the conventional ultrasonic spike pulser with 1000 V excitation by 1 MHz transducer and the multi channel 10 wave burst pulser with 200 V excitation by 8ch laminated transducer. The waveforms after the transmission were

measured by laser Doppler interference meter as shown in Fig 3.

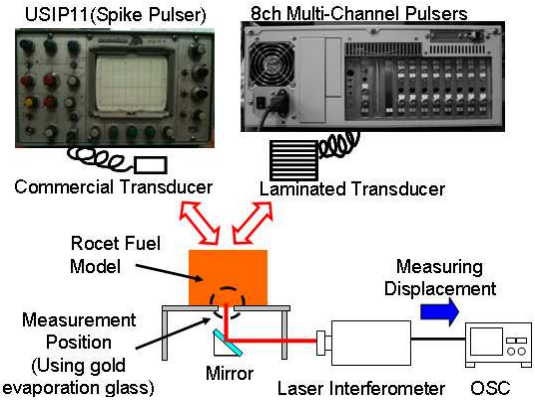

Fig.3 Excitation waveform acquisition equipment

4. Experimental results of the waveform

Since the surface displacement of laminated transducer was too large to measure by the laser Doppler interference meter, we estimated the transmitted waveform through SUS plate of 30 mm in thickness as shown in Fig. 4. Center frequencies of initial waveform were 400 kHz and 700 kHz respectively, due to the nominal frequency for the element. Maximum surface displacement of 33 nm for laminated transducer was ten times larger than that of single channel transducer of 3.5 nm.

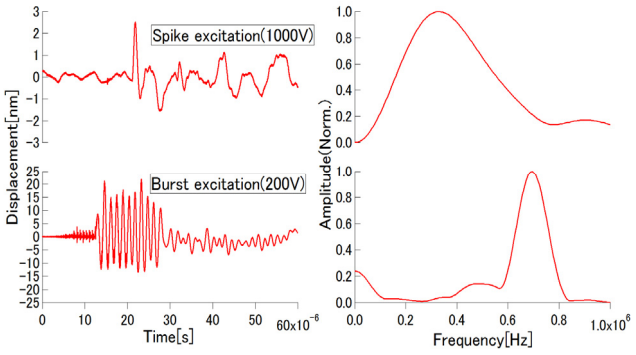

Fig. 4 Transmission waveform through SUS plate and spectrum

Transmitted waveforms and the spectrums through a rocket fuel model were shown in Fig. 5.

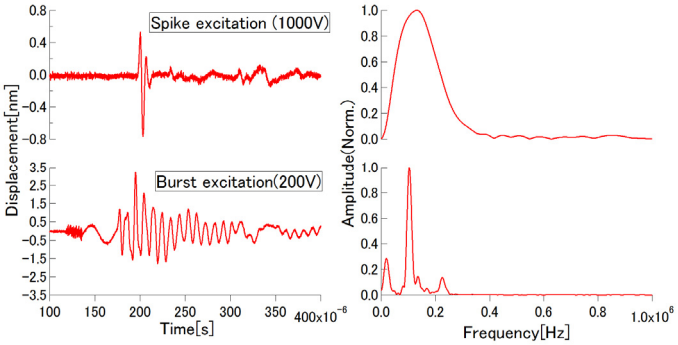

Fig. 5 Transmitted waveform through a rocket fuel model and spectrum

The center frequencies of both pulsers dropped to 100 kHz due to the large attenuation of the specimen. Since the excitation was by burst wave, the frequency band of the laminated transducer was narrow as shown in Fig.4. Thus shifted center frequency of 100 kHz range was poor in the initial waveform for laminated transducer comparing to the single transducer. As the results, maximum surface displacement of 4.5 nm for laminated transducer was 3 times larger than that of single channel transducer of 1.5 nm.

5. Consideration

In this experiment, almost 10 times of surface displacement was obtained using the combination of laminated transducer and multi pulser comparing the conventional transducer and spike pulser. The amplitude of transmitted waveform through the rocket fuel model specimen dropped largely and the center frequency were shifted to 100 kHz due to the large attenuation. As the results, the advantage of laminated transducer system to the conventional measurement decrease from ten times before transmission to three times after transmission. Regardless of the narrow band width around 100 kHz of shifted frequency for the initial waveform by the burst pulser, the advantage was still remained. Then further improvement can be expected by using multi channel wideband pulser system.

6. Conclusion

(1) Combination of laminated transducer and multi-channel pulser had the advantage of 3 times of lager surface displacement transmitted waveform trough the rocket fuel model comparing to the conventional system.
(2) Large amplitude ultrasonic transmission technique has the possibility to improve the measurement for the large attenuated structures.

References

[1]T.Mihara,H.Tashiro,Y.Kamiyama,Japan non-destructive inspection Assosiation 2010 fall season papers , p117-p118(2011)
[2]T.Hamajima,T.Mihara,Y.Kamayama,H.Tashiro,Procee dings of the 18th Symposium on Ultrasonic Testing、p23-p24(2011)
[3]R.L.Goldberg,S.W.Smith,IEEE Trans.Ultrason.,Ferroelec.and Freq.Contr.41(5)(1994)
[4]A.Cochran,P.Reynolds,G.Hayward,Ultrasonic 36(1998)969-977