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Non-Adhesive Dry Couplant for Ultrasonic Testing

Akiko Hirao, Noriko Yamamoto, and Tomio Ono
Transducer Tech. Lab, Nano materials & Frontier Labs, Corporate R&D Center, Toshiba Corp.

1. Introduction

In ultrasonic non-destructive testing, couplant gel is applied between the ultrasonic transducer and the test specimen to efficiently transmit ultrasound. Even a very thin air gap reflects ultrasound and stops sound propagation between the transducer and the test specimen, because of the large acoustic impedance mismatch between transducer, specimen, and air. The couplant gel fills in the air gaps and enables sound propagation into the test specimen. However, the couplant gel may contaminate the test specimens, and has to be removed after inspection. To overcome this inconvenience, we propose to replace the couplant gel with a non-adhesive dry couplant named sliding sheet-lattice matrix (SSLM). SSLM allows to integrate ultrasonic propagation with sliding capability, two aspects that are normally incompatible [1]. The SSLM is composed of two layers: a soft elastomer sheet which allows efficient ultrasound propagation, and a sliding lattice material with low friction coefficient which enables sliding over the test surface (Fig. 1). During ultrasonic testing, a load is applied to the transducer to press it against the test specimen that is being inspected. Under load the elastomer squeezes through the sliding lattice material and protrudes from its openings, adhering to the test specimen and filling the small air gaps, therefore enabling ultrasonic wave propagation. When the load is released the elastomer retreats from the sliding lattice material, that can then slide to another position for a new inspection.

Here, we report the response performance and durability of non-adhesive dry couplant SSLM, which are important characteristics to speed up ultrasonic inspection.

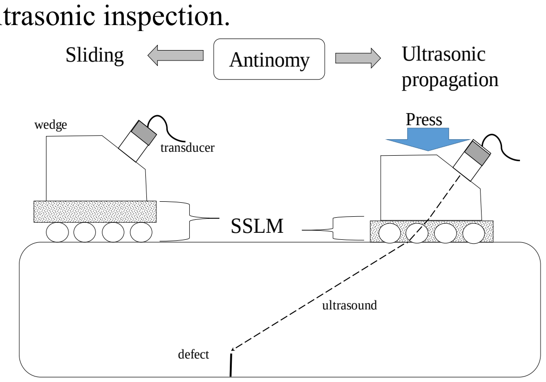

Fig. 1 Conceptual scheme for non-adhesive dry couplant named SSLM.

2. Experimental

2.1 Response

The response time of a 2 MHz angled beam transducer equipped with the SSLM was measured as follows. The transducer with the SSLM is placed at a position where an echo signal from a notch in the test specimen is observed. The transducer is loaded by a solenoid actuator for 400 ms. The pulse repetition frequency for the transducer is 2 kHz, and echo signals are taken into a data logger by using the applied voltage for the solenoid actuator as a trigger. An example of echo signal waveform is shown in Fig. 2. The voltage of the echo signal, Vpp was detected in the waveform of Fig. 2 collected repeatedly at 0.5 ms interval, and it was plotted for the elapsed time from the trigger signal.

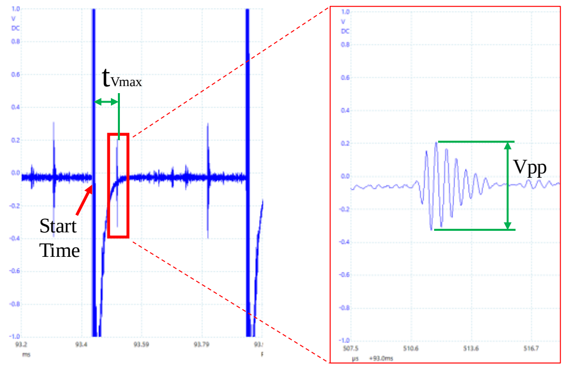

Fig. 2 The typical signal in the measurement of the response time. The echo signals, Vpp are detected a 0.5 ms interval.

2.2 Durability

The durability evaluation of the SSLM was carried out using a dynamic fatigue testing machine. A load of 30 kPa was repeatedly applied 43,000 times at a frequency of 10 Hz. The echo signal was compared between SSLM that underwent the durability test and unprocessed SSLM.

akko.hirao@toshiba.co.jp

3. Results and discussion

3.1 Response

Figure 3 shows a typical SSLM response by a load of 18.2 kPa. The time t=0 is the time when the voltage is applied to the solenoid actuator to press the transducer against the test specimen. As a result, the elastomer sheet protrudes from the opening of the sliding lattice material and adheres to the test specimen. A large Vpp value is observed within about 50 ms, so the response time is sufficiently fast for ultrasonic testing.

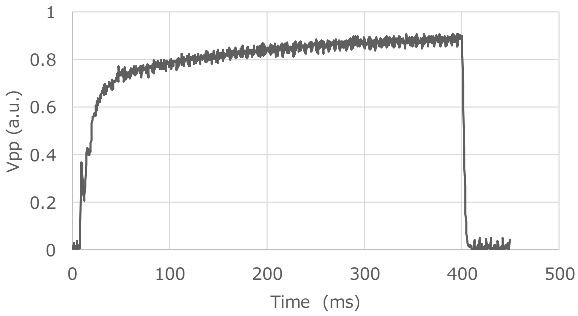

Fig. 3 Vpp of echo signal *vs.* time for SSLM.

If only an elastomer sheet is placed between the transducer and the test specimen instead of the SSLM, the response is as shown in Fig. 4. The Vpp increases gradually, and even after the load is released at t = 400 ms the Vpp is still observed. This behavior originates from the adhesive properties of the elastomer sheet. The elastomer sheet adheres to both the transducer and the test specimen, therefore enabling ultrasonic wave propagation. In the case of the SSLM, the arrival times of the echo signals defined by t_{Vmax} in Fig. 2 were almost the same throughout the time interval from 50 to 400 ms. On the other hand, in the case of elastomer sheet alone, the arrival time became gradually shorter. We consider that the structure of SSLM is therefore more stable than that of the elastomer sheet alone.

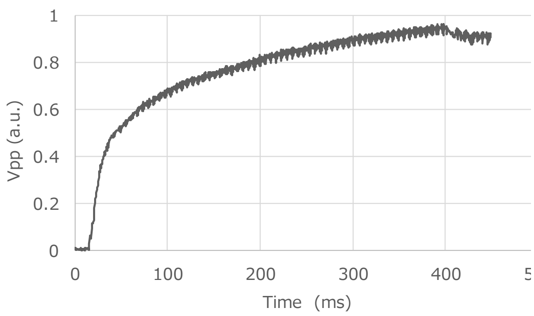

Fig. 4 Vpp of echo signal vs. time for an elastomer sheet alone.

3.2 Durability

The result of durability evaluation is shown in Fig. 5. Each point represents a different material for the sliding lattice material. No significant changes are observed in the amplitude of the echo signal after 43,000 load cycles.

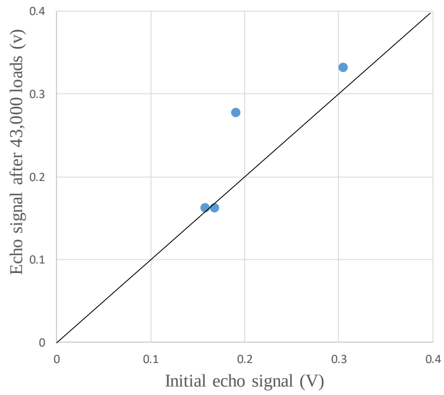

Fig. 5 Echo signal after 43,000 times fatigue test *vs* initial echo signal.

4. Conclusion

The non-adhesive dry couplant named SSLM enables both surface sliding and ultrasonic propagation simultaneously. Response performance and durability of SSLM have been measured, which are important characteristics to rapidly realize ultrasonic inspection. The SSLM interface provides an echo signal, is sufficiently fast for ultrasonic testing, and shows excellent durability with no decay in signal after many loading cycles. Therefore, SSLM is a highly promising couplant to simplify and speed up ultrasonic testing.

References

1. Akiko M. Hirao, Noriko Yamamoto, Tsuyoshi Kobayashi, and Tomio Ono, The 82nd JSAP Autumn Meeting 2021, 11p-S401-3, "Non-adhesive Dry Couplant for Ultrasonic Testing".