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Configuration of an Ultrasonic Linear Motor Comprising Bolt-Clamped Langevin Transducers
ボルト締めランジュバン型振動子を用いた超音波リニアモータの構成

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1. Introduction

Configuration of a standing wave type ultrasonic linear motor comprising bolt-clamped Langevin type longitudinal vibration transducers (BLT) has been studied. In order to develop a large-output motor, we used BLTs. An ultrasonic motor is driven by frictional force. However, frictional force causes loss and wear at the driving surface. For a large-output ultrasonic motor, friction loss and wear appear markedly. These are main reason why the ultrasonic motor has not quite used. Solution to this problem is very important from the standpoint of developing a large-output ultrasonic motor.

There have been several investigations on reduction of friction loss and wear[1-3]. In this study, we attempted another way to reduce friction loss and wear. In order to solve friction problem, two BLTs were installed symmetrically. The vibration and driving characteristics of the ultrasonic linear motor were measured.

2. Principle and configuration

Fig. 1 shows the driving process of the ultrasonic linear motor. The driving process of the elliptical locus of the stator is roughly divided into a driving cycle and a retracting cycle. In the driving cycle, large pressure is desirable for increasing the driving force; in the retracting cycle, small pressure is desirable for decreasing the frictional force that is opposite to the sliding direction and disturbs the slide of the slider.

In order to decrease the pressure in the retracting cycle, two ultrasonic transducers were installed symmetrically. In the retracting cycle, two ultrasonic transducers recede from each other.

Fig. 2 shows a fabricated ultrasonic linear motor. In order to develop a large-output motor, we used BLTs (15 mm in diameter). A BLT is a common vibration source in high-power ultrasonic applications and features high strength and large amplitude. An ultrasonic transducer consists of a BLT and a conical horn. The transducer is statically pressed against a guide rail using a pressure source.

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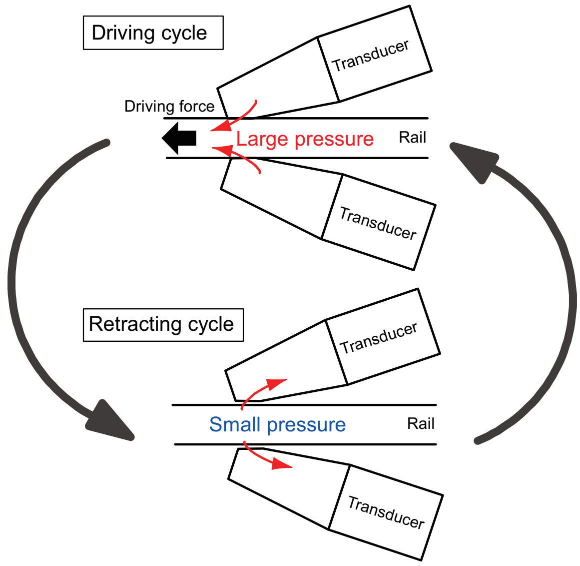

Fig. 1 Driving process of an ultrasonic linear motor.

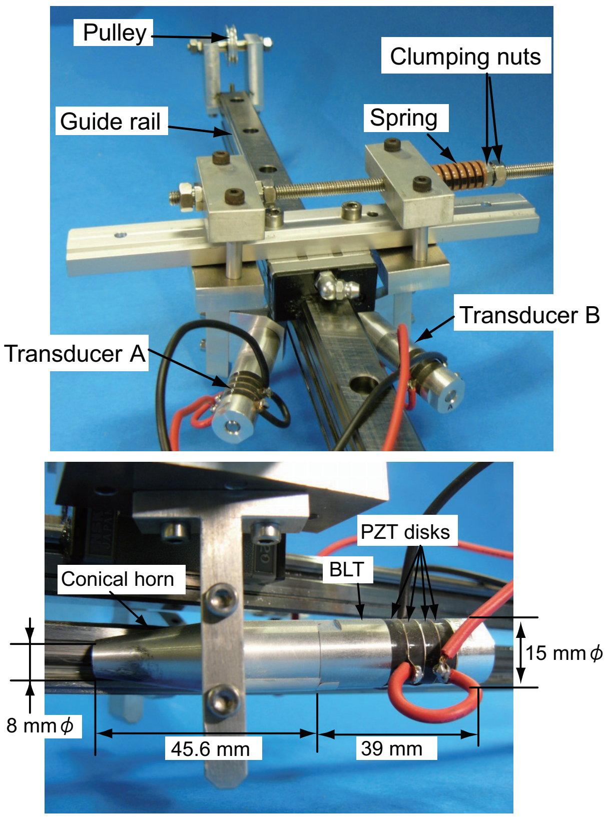

Fig. 2 Configuration of a ultrasonic linear motor comprising bolt-clamped Langevin transducers (BLTs).

3. Vibration characteristics

The vibration distributions and loci were measured using a laser Doppler vibrometer. Two BLTs were driven simultaneously. The driving voltage was kept constant at 10 V (rms).

Radial vibration distribution along the ultrasonic transducer is shown in **Fig. 3**. Nodes in the standing wave exist at the free ends of the BLT. Further, An antinode exists at the piezoelectric ceramic (PZT). This result indicates that the BLT was operated in a longitudinal vibration mode according to design.

Vibration amplitude distribution at the driving surface is shown in **Fig. 4**. Uniform distribution was not observed.

Vibration loci were observed at driving surfaces of the ultrasonic transducers A and B under no-load condition (**Fig. 5**). An elliptical locus was observed for transducer A. However, the vibration locus for transducer B was almost linear. It is desirable to have elliptical loci which are same form at both driving surfaces.

4. Driving characteristics

The driving characteristics of the ultrasonic linear motor were measured. No-load speed of 0.83 m/s and maximum output force of 50 N were obtained. Thrust was measured using a pulley and a weight.

5. Conclusion

In order to develop a large-output motor, we devised the standing wave type ultrasonic linear motor comprising two ultrasonic transducers. Further, in order to solve friction problem, two BLTs were installed symmetrically.

The vibration and driving characteristics of the motor were measured. No-load speed of 0.83 m/s and maximum output force of 50 N were obtained. It is possible to improve the performance of the motor by matching vibration distribution with those of the transducers. This matching appears achievable by improving machining precision. The ultrasonic motor will be open to utilization in various ways by improving its frictional problem.

References

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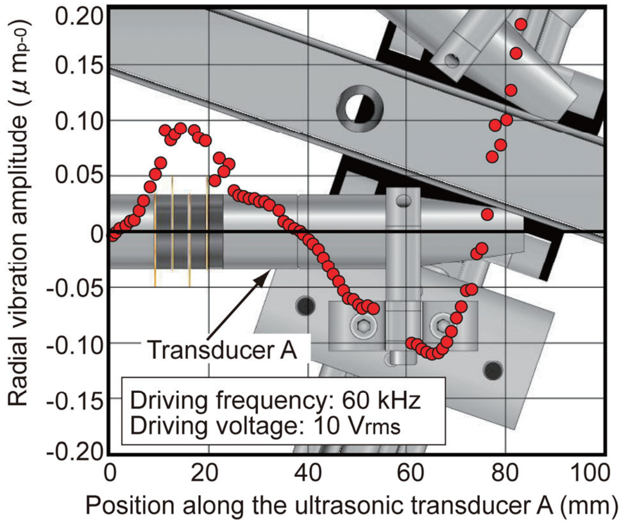

Fig. 3 Vibration amplitude distribution along the ultrasonic transducer A.

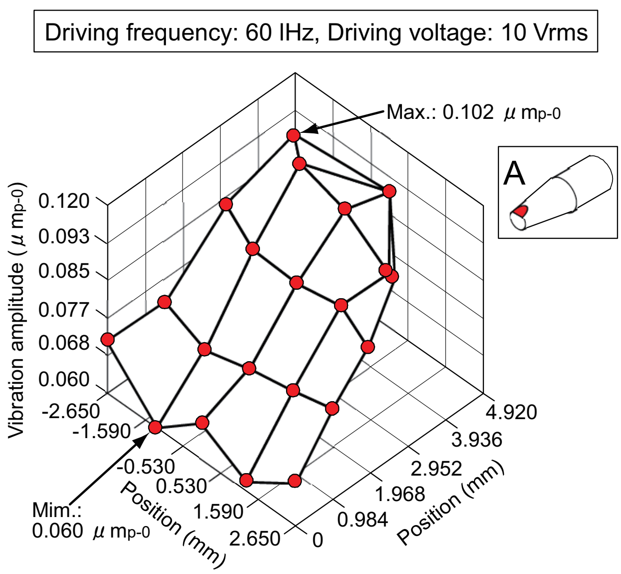

Fig. 4 Vertical vibration distribution at the driving surfaces of the ultrasonic transducer A.

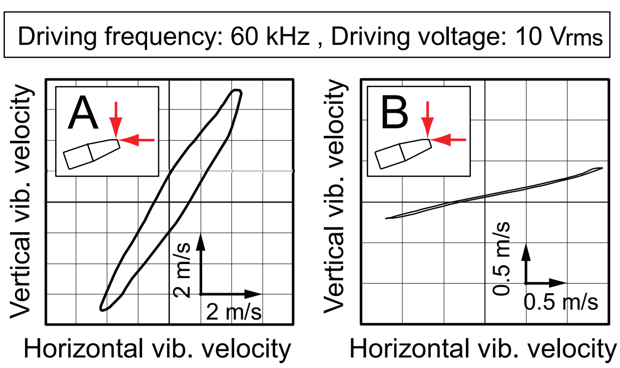

Fig. 5 Vibration loci of the ultrasonic transducers.