3P4-2

Proceedings of Symposium on Ultrasonic Electronics, Vol. 35 (2014) pp. 459-460
3-5 December, 2014

Study on Temperature Dependency for Driving Performance of the Ultrasonic Motor for Cryogenic Temperature

極低温用超音波モータの駆動特性の温度依存性

Masahiro Nakazono[1‡], Takefumi Kanda[1], Daisuke Yamaguchi[2] and Kouichi Suzumori[3] ([1]Graduate School of Natural Science and Technology, Okayama University, [2]Saitama University, [3]Tokyo Institute of Technology)
中薗　正浩 [1†], 神田　岳文 [1], 山口　大介 [2], 鈴森　康一 [3] ([1] 岡山大, [2] 埼玉大, [3] 東京工業大)

1. Introduction

Some studies have been conducted on ultrasonic motors for cryogenic temparature enviroment.[1-3] In the enviroment, the motor performance depends on temperature condition. The temperature gap generates a thermal stress at the transducer of the motor. The tranceducer needs to be regulated for cryogenic enviroment. However, to regulate the transducer in the cryogenic enviroment is difficult.

We have fabricated a transducer unaffected by thermal stress.[4] The transducer doesn't have to be regulated at cryogenic enviroment. Thus, without adjusting the transducer, it is possible to drive the ultrasonic motor at the condition from cryogenic temperatures to room temperature.

In this paper, we discuss temperature dependency for driving performance of ultrasonic motor. We have evaluated the starting toruqe, the rotation speed, and the efficency of the motor.

2. Structure and principle of ultrasonic motor

A structure of ultrasonic motor and transducer is shown in **Fig. 1**. This motor is composed by a transducer, a rotor, a coil spring, a bearing, and a case. The transducer is bolt-clamped Langevin-type transducer (BLT). The BLT is composed by a body with flange, a bolt, a nut, piezoelectric material rings, and electrode plates. As piezoelectric material parts are clamped by metal material parts. So, the transducer is composed without adhesive. Therefore, the transducer is able to use in cryogenic environment. The piezoelectric material is PZT. The body and nut of the BLT are made of SUS304, and, the bolt is made of Titanium. In the previous work, the previous transducer was made by SUS304.[5] The clamping torque of the transducer needs to be regulated as the temperature change. **Figure 2** shows changing optimal clamping torque by thermal stress. The preload of rotor needs to be regulated. The preload is regulated by inserting a copper plates between the rotor and coil spring. The diameter of the flange and the transducer is 22mm and 6mm, respectively. The length of the transducer is 16mm. The length of the motor is 30.5 mm.

The transducer vibrates in two flexural mode in each perpendicular direction when sinusoidal wave voltage which has phase difference at 90 deg was applied to electrodes. Thus, the traveling wave is generated at the tip of the transducer. The motor is driven by the frictional force between the transducer and the rotor.

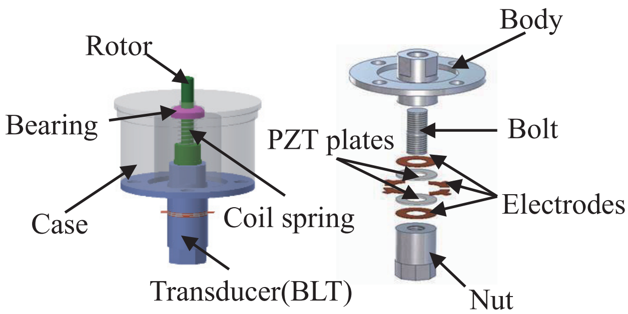

Fig.1 Structure of the ultrasonic motor and the transducer

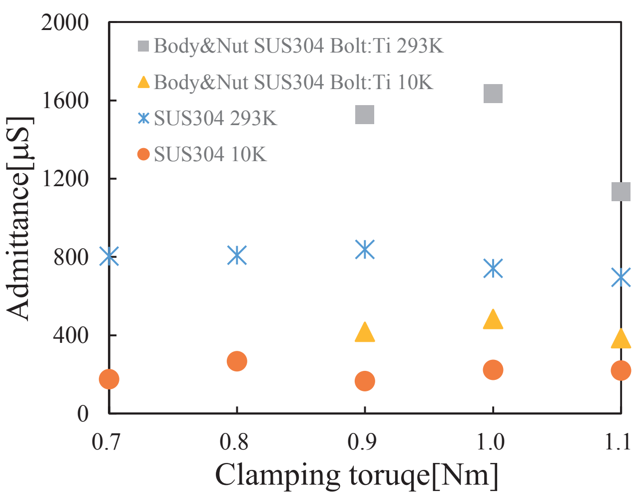

Fig. 2 Relationship between clamping torque and admittance of transducer at each temperature

nakazono13@act.sys.okayama-u.ac.jp

3. Experimental set up

Figure 3 shows the experimental set up. The temperature condition was regulated by the distance between the motor and the surface of the liquid helium.[2)] Additionally, the temperature was fine-tuned by a heater. The rotation speed was measured by slit disk which is fit out on a rotor. Slit number was read by using fiber optic sensors. The starting toruqe and the efficency were estimated from the rotation speed.

4. Experimental result

The rotation speed, the starting toruqe, and the efficency from room temperature to cryogenic temperature was evaluated about the fabricated motor. The applied voltage was 50 $V_{p\text{-}p}$.

Experimental result are shown in **Figs. 4 and 5**. The performance of the motor declines at low temperature. This is as same as the tendency shown in previous works.[2, 5)] The fabricated motor is successfully driven at the temperature from 4.5K to 293K without regulation of the transducer.

5. Conclusion

We have fabricated a transducer. The transducer doesn't have need to be regulated for the use in the temperature condition from 4.5K to 293K.

Additionally, we have fabricated a motor driven by the transducer. The fabricated motor is evaluated. We have succeeded in driving the ultrasonic motor at the temperature from 4.5K to 293K without regulating the transducer.

Acknowledgment

This work was partially supported by JSPS KAKENHI Grant No. 25420091.

References

1. X. Li, Y. Wu, Z. Chen, X. Wei, and H. Luo: J. Appl. Phys. **115** (2014) 144103-1.
2. D. Yamguchi, T. Kanda, and K. Suzumori: Sensor and Actuators A **184** (2012) 134.
3. B. Sanguinetti, and B. T.H.Varcoe: Cryogenics. **46** (2006) 694.
4. M. Nakazono, T. Kanda, K. Suzumori, D. Ymaguchi, Y. Noguchi, and M. Kuroda: JSME Machine Design and Tribology Division Meeting **14** (2014) 133. (in Japanese)
5. M. Kuroda, D. Ymaguchi, D. Takda, T. Kanda, and K. Suzumori: JSME Robotics and Mechatronics Conf. **30** (2012) 2P1-F03. (in Japanese)

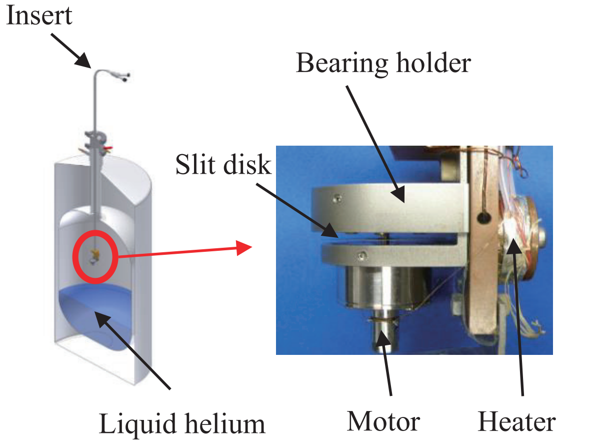

Fig.3 Schematic of the experiment of set up

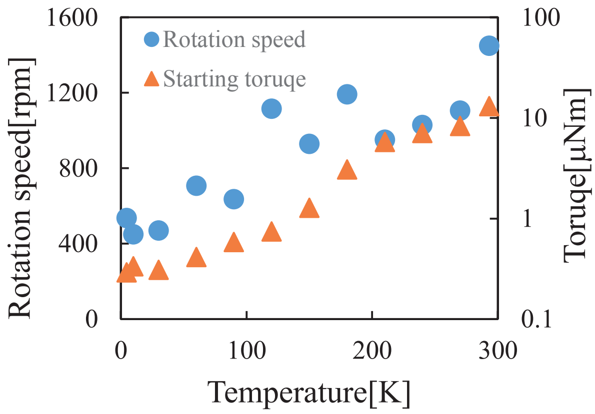

Fig. 4 Relationship between temperature and rotation speed and strating toruqe

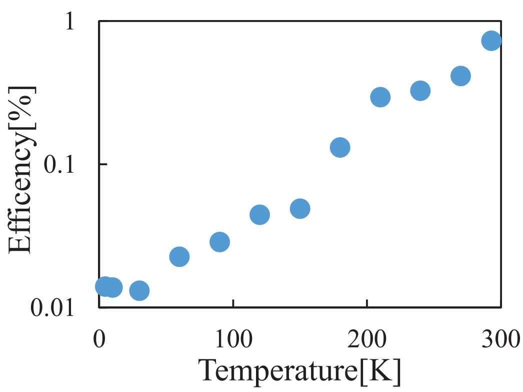

Fig. 5 Relationship between the temperature and the efficency of the fabricated motor