Proceedings of Symposium on Ultrasonic Electronics, Vol. 33 (2012) pp. 477-478
13-15 November, 2012

Development of a Coiled Stator Miniature Ultrasonic Motor using a Partially Tapered Rotor

テーパ状ローターを用いる超小型コイル状ステータ超音波モータ

Tadashi Moriya[1†], Takasuke Irie[2], Masakazu Sato[2] ([1]Professor Emeritus of Met. Univ.,[2]Microsonic Co., Ltd.,)
守屋　正[1‡], 入江喬介[2], 佐藤　正和[2] ([1]首都大学東京名誉教授; [2]マイクロソニック㈱)

1. Introduction

Miniature ultrasonic motors may find applications in the field of medical field as well as industrial field. We have been developing a traveling-wave-type miniature ultrasonic motor using a helical coiled waveguide as a stator called CS-USM (Coiled Stator Ultrasonic Motor)[1-4]. In order to make the motor smaller, the structure of the motor must be as simple as possible. In the previous motor the diameter of the rotor or the stator has a constant diameter. Since the rotor moves in the axial direction, a mechanism to suppress the axial movement is necessary. An addition of a new part to suppress the movements makes the structure of the motor complex.

In this paper we report an attempt to construct a motor suppressing the axial movement without using a new part but using a tapered rotor coiled stator ultrasonic motor (Tapered rotor CS-USM).

2. Basic structure of tapered CS-USM

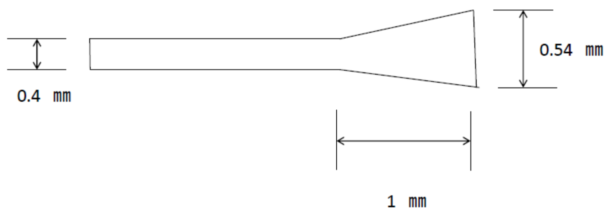
Figure 1 (a) shows the basic form of the rotor used in tapered rotor CS-USM. Fig.1. (b) shows the assembled tapered CS-USM. The motor is a traveling wave type ultrasonic motor. Therefore flexural wave propagating along the stator drives the rotor for the rotation. Due to the longitudinal component of the particle movements drives the motor along the axial direction too. In this motor, a stopping plate is placed on the end of the stator. PZT generates a flexural wave, and the wave drives the rotor to rotate. The second PZT is placed on the other end of the motor. This PZT is used to drives the rotor to rotate the reverse direction. The PZT acts as an absorber of the transmitted flexural wave.

3.Fabrication of tapered CS-USM

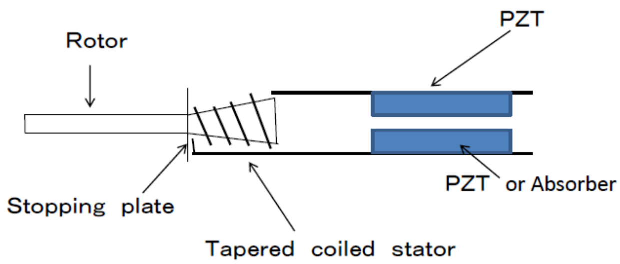
The rotor was fabricated by machining. A jig was fabricated for the production of the stator. A wire rotor was fabricated due to the spring production process, using a 1mm diameter SUS 304 wire.

mry_1qf3@yahoo.co.jp

A stator using a rectangular slab lime was manufactured manually. In this case the form of the tapered section is the same with the stator. A pattern was fabricated by machining 0.15mm thick Ti-Cu plate, and the pattern was wound around the jig manually.



(a)



(b)

(a) Tapered rotor (b) Ass
(b) nmbled Tapered coiled stator ultrasonic motor
Fig. 1. Components of Tapered coiled stator USM.

Fabricated motors are shown in Fig.2 through Fig.4. Fig. 2 shows a conventional CS-USM, the diameter of the rotor and the stator is constant, and the stator was made of Ti-Cu with 0.15 thick and 0.2mm width. The waveguide was wound around the rotor by 6.5 turns. The transducer was made of PZT (Lead Zirconate Tinanate ceramics) ceramics (Fuji Ceramics C-213, polarized in the thickness direction) of 0.6 mm width, 4 mm length, and 0.25 mm thickness. The k_{31} of the transducer was 34 %. Fig.3 shows the tapered rotor CS-USM, the stator being made of SUS 304 wire with 0.1mm diameter. The waveguide was wound around the rotor by 3.5 turns. Fig.4 shows a tapered rotor CS-USM, the stator being made of Ti-Cu plate with

0.15mm thickness and 0.2 mm width. The waveguide was wound around the rotor by 6.5 turns. In Fig.3 and Fig.4, the transducers were PZT (Lead Zirconate Tinanate ceramics) ceramics (Fuji Ceramics C-213, polarized in the thickness direction) of 0.6 mm width, 3 mm length, and 0.25 mm thickness.

Fig. 2. Straight coiled stator USM.

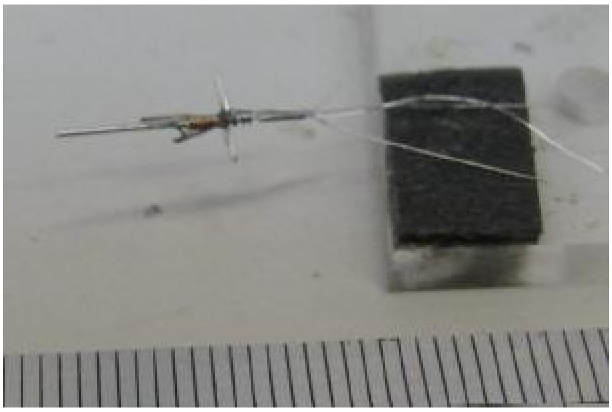


Fig. 3. Tapered coiled stator USM using wire.

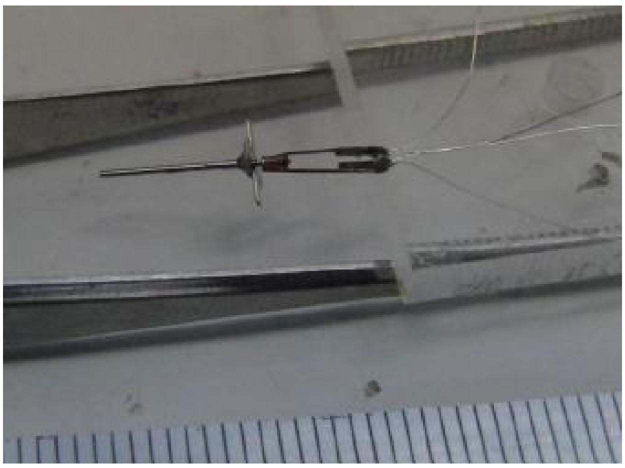


Fig. 4. Tapered coiled stator USM using slab.

4. Performance of tapered CS-USM

Rectangular signals having amplitudes of 50 V_{PP}, with frequency of 554 kHz were applied to the PZT in Fig. 3. Rectangular signals having amplitudes of 50 V_{PP}, with frequency of 564kHz were applied to the PZT in Fig. 3..In either case the torque was very small.

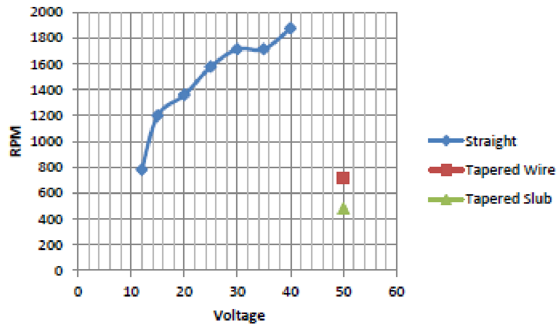


Fig. 4. Comparison of the perfprmance.

5. Conclusion

We fabricated and tested tapered stator CS-USM. The performance is very poor compared to the conventional CS-USM. The region of the tapered section must be small enough to suppress the axial movement.

Acknowledgements

We thank professor M. Yoshizawa and Mr. K. Kato at Tokyo Metropolitan College of Industrial Technology for their measurements and discussions.

References

1. T. Moriya, Y. Furukawa, Y. Akano, and A. Nakajima: IEICE Tech. Rep. US2005-29 (2005) [in Japanese].
2. M. Tanabe, S. Xie, N. Tagawa, T. Moriya, and Y. Furukawa: Jpn. J. Appl. Phys. **46** (2007) pp.4805-4808.
3. M. Tanabe, S. Xie, N. Tagawa, and T. Moriya: Jpn. J. Appl. Phys. **47** (2008) pp.4262-4264.
4. T. Moriya and Y. Furukawa, Japan Patent JP 4421721, US Patent US 7602103