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ポリマー振動体を用いた超音波モータの負荷特性

Mechanical Characteristics of Ultrasonic Motors Using Polymer-based Vibrator

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1. Motivation

With the nature of low density and elastic modulus [1, 2], polymers are promising materials for making light weight and large output ultrasonic motor (USM) if the mechanical loss is low enough at ultrasonic frequency. Exploring the possibility of polymers as vibrator for USM, in this paper, we investigated the characteristics of USM using polymer vibrator experimentally and found several polymers suitable for high amplitude vibration in USM operation.

2. Experiment system

We tested polyetheretherketone (PEEK), polyphenylenesulfide (PPS) and polyphenylenesulfide filled with carbon fiber (PPS/CF) to make a bimorph to form a rotary USM (**Fig. 1.**), and compared its mechanical performances to the aluminum USM with the same structure and dimensions.

Two pairs of piezoelectric ceramic plates are bonded on the side surfaces of a rectangular bar made of polymers. Two orthogonal bending vibrations are excited with the 90-phase difference using a two-phase electrical source. A rotor pressed to the end side of the vibrator is driven by the elliptical motion of the vibrator end. By measuring the angular velocity versus the load, we obtained the mechanical characteristics under different preloads.

3. Results

The polymer-based USM successfully worked as in the same way of conventional metal-based USM. When preload is around 0.3 N, as depicted in **Fig. 2 (a)**, the maximum angular velocities of PPS-based USM was 36.9 rad/s, with load increasing, USMs stopped to rotate when torque reached 210.2 μNm. For PPS/CF-based USM, maximum angular velocity was about 30.5 rad/s and maximum torque reached 248.4 μNm. The slopes of PPS, PPS/CF-based USMs` mechanical characteristics suddenly dropped at high torque, which indicate that that friction was insufficient. Maximum torque of aluminum-based one was about 500 μNm, however, maximum angular velocity of aluminum-based USM was 12.5 rad/s, which was lower than PPS and PPS/CF-based ones. When torque was lower than 480 μNm, angular velocity does not have an obvious change, which means aluminum-based USM has a better velocity characteristic.

When preload reached around 0.77 N, as depicted in **Fig. 2 (b)**, maximum torque of PPS, PPS/CF and aluminum-based USMs all increased to twice of that under 0.3 N preload. The maximum angular velocities of PPS and PPS/CF-based USMs decreased to 34.1 rad/s and 30.3 rad/s, respectively. The mechanical characteristics of PPS and PPS/CF-based USMs turned into straight line. However, the slope of aluminum-based USM's mechanical characteristic dropped over 1000 μNm. Meanwhile, PEEK-based USM was totally truck at this preload.

When preload reached 2.44 N, PPS and PPS/CF-based USMs stopped, only aluminum-based one can rotate at a low speed. In **Fig. 2 (c)**, the maximum torque measured in experiment was over 1800 μNm and further more torque can also be achieved.

From the experimental results, we know that polymer-based USM has larger velocity and lower torque than aluminum-based ones and PPS can be treated as suitable material for vibrator in USM under low preload.

Reference

[1] P. Rae *et al.* , *Polymer* **48**, 598(2007).
[2] J. Bucher *et al*, *Plastic World* 55, 53(1997).

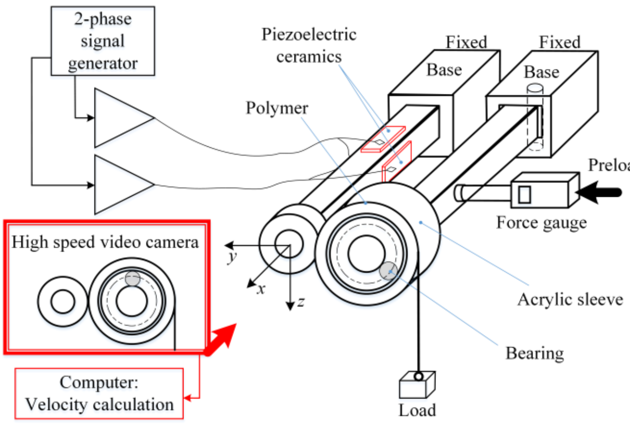

Fig. 1. Experiment system.

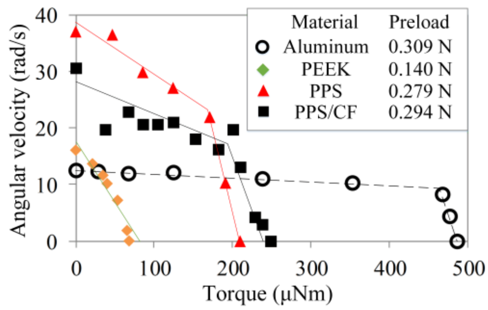

Fig. 2(a). Mechanical characteristics under preload less than 0.31 N.

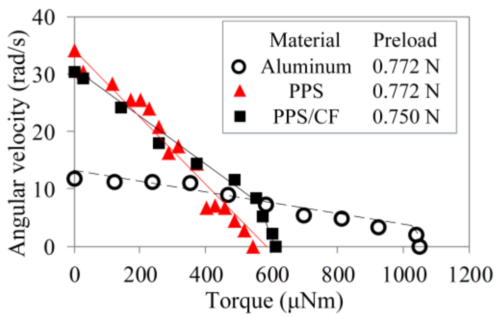

Fig. 2(b). Mechanical characteristics under preload 0.77 N.

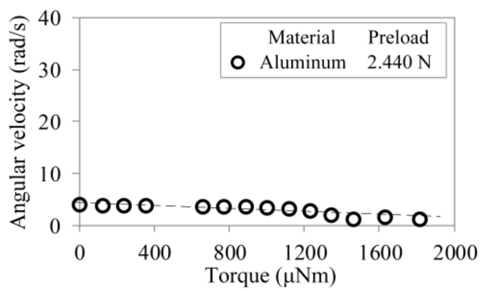

Fig. 2(c). Mechanical characteristics under preload 2.44 N.