디스크타입 초음파모터의 제작 및 특성평가

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The design and characteristics of disk-type ultrasonic motor

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Abstract : In this paper, disk-type ultrasonic motor using a combination of radial and bending vibration modes is newly designed and fabricated. The characteristics of the test motor are also measured.By means of travelingelastic wave induced at the surface of circumference of the elastic disk, a steel bar in contact with the surface of circumference of elastic disk bonded onto the piezoelectric ceramic disks is driven inboth directions by changing the sine and cosine voltage inputs. The stator of the motor is composed of two sheets of piezoelectric ceramic disk to bond onto both surfaces of a elastic disk, respectively. As the results, the diameter of elastic body is increased, the resonant frequency is decreased. The resonant frequency of the stator is about 92 kHz, which is composed with piezoelectric ceramic disks of 28 mm in diameter and 2 mm in thickness, and an elastic body of 32 mm in diameter and 2 mm in thickness. A driving voltage of 20 Vpp produces 200 rpm with a torque of 1Nm and an efficiency of about 10 %.

Key Words : Optical zooming, Auto Focusing,AF, piezoelectric, ultrasonic motor

1. Introduction

Recently, the demand of the precision motor is increased in the fields of optics and semiconductor industries. But, the conventional electromagnetic motor has the limitation inits resolution and size. An USM(ultrasonic motor) may be one of candidates for these applications. Various USM have already been developed and used in specific applications.

Compared with electromagnetic motor, USM has many advantages as follows: low profile, low power consumption, simple structure, no reduction gear, low speed at high torque, high controllability(high resolution), and so on. But, the conventional USM has some problems. because the structure of the stator is complex. That is, elastic body composed of the stator has generally the projector to enlarge the displacement in case of plate-type or ring-type USM. These kinds of stators are very complex and expensive. A novel linear USM is designed for applying to X-Y stage or Z stage in this paper, and it is focused on eliminating the projector of conventional linear USM. Also, newly designed USM is fabricated and its characteristics are measured.

2. Principle of operation

The structure of newly proposed USM is very simple as shown in FIGURE 1. Its stator is composed of two sheets of piezoelectric ceramic disks and an elastic disk. Two sheets of piezoelectric ceramic disks are bonded onto the upper and the lower surface of the elastic disk, respectively. The poling direction of each piezoelectric ceramic is opposite and normal to the stator face. In practice, it is important how to generate an elliptical motion of a given point mass at surface of stator in USM. As the input voltages with a phase difference of 90 degrees are simultaneously applied to each of the piezoelectric ceramics of the stator, a combination of two modes of vibration such as the radial extensionalvibration and the bending vibration forms an elliptical displacement at the surface of circumference of elastic disk of the stator.

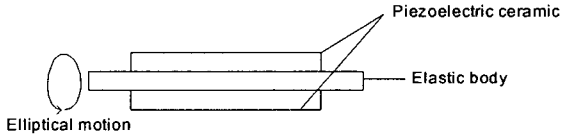
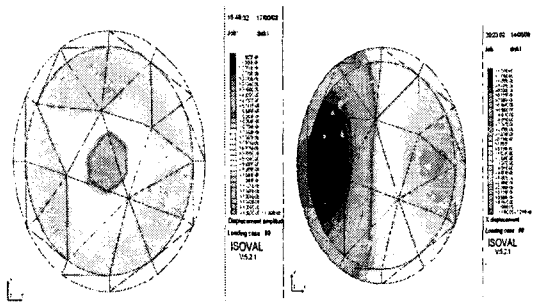


FIGURE 1. The structure of the proposed USM



(a) Z axis (b) X axis

FIGURE 2. The color index of displacement induced in the stator

The proposed USM in this paper is driven by a combination of radial and bending vibration mode. FEM(Finite Element Method) software, manufactured by Mag. soft is used to analyze the vibration mode of USM. FIGURE 2. shows the color index of the displacement of x axis and z axis induced in the stator of 32 mm in outer diameter. As shown in FIGURE 2(a) and 2(b), the stator is vibrated to the bending and radial extensional mode, respectively.

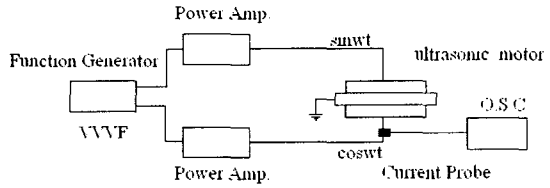


FIGURE 4. The driving system of linear USM

The block diagram of the driving system for the USM is shown in FIGURE 4. The applied voltage and the driving frequency are adjusted by function generator. Current and voltage aredirectly measured by current probe and oscilloscope.

3. Result and discussion

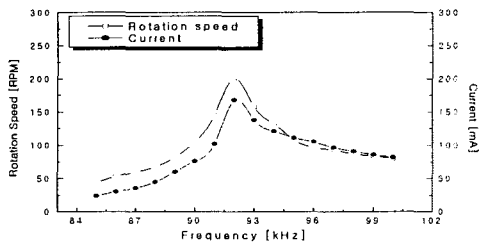


FIGURE 5. The changes of the rotation speed and the current according to the driving frequency

The variation of the rotation speed and the current of a test motor as a function ofthe driving frequency, when driven at 20 Vpp, are shown in FIGURE 8. The curve shows the typical resonance characteristics. A test motor exhibits a maximum speed of about 200 rpm and a maximum current of 170 mA at 92 kHz in driving frequency.

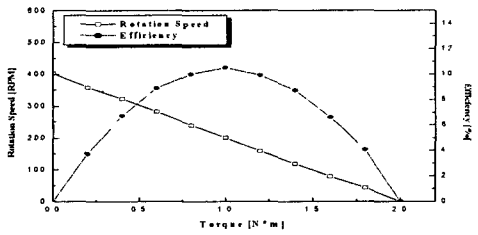


FIGURE 6. Velocity and Efficiency according to torque

The changes of velocity and efficiency according to torque, when driven at 20 Vpp and 92 kHz, are shown in FIGURE 6. The characteristics of velocity and efficiency vs. load torque are similar to those of general USM. The velocity is about 400 rpm at no load and the maximum efficiency is about 10 % at load torque of 1 Nm.

4. Conclusion

A disk-type ultrasonic motor using a combination of radialextension and bending vibration modes is newly designed and discussed its characteristics. as the diameter of elastic body increases, the resonant frequency decreases. The resonant frequency of the stator is about 92 kHz, which is composed of circular disk-shaped piezoelectric ceramic plate of 28 mm in diameter and 2 mm in thickness, and circular disk-shaped elastic body of 32 mm in diameter and 2mm in thickness. As a experimental result, a driving voltage of 20 V_{pp} produces 200 rpm with a torque of 1 Nm and 10 % in efficiency. The newly proposed USMcan be more simple and cheaper than the conventional USM having "teeth". And it is available to the application for the various precision machines.

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