Ultrasonic Motor with Ring Type Stator

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***Abstract*—All of us know that motor is machine which produces rotary motion or it is an arrangement of coils and magnet that convert electric energy into mechanical energy. Ultrasonic motors are next generation motors. Ultrasonic motors use the piezoelectric effect in ultrasonic frequency range to provide its motive force resulting in a motor with usually high torque and power to weight characteristics, low speed.**

The stator of ultrasonic motor contains two driving feet, sixteen pieces of piezoelectric ceramic plates and three rings inner ring, middle ring, outer ring. The ultrasonic motor forms elliptical movements on the driving feet by the superposition of stretching and bending vibration of metal rings by using finite element method. The ultrasonic motor is analyzed and designed by adjusting structure parameters of two working modes were turn to be close.

***Keywords*—Ultrasonic motor, finite element method, piezoelectric effect**

I.INTRODUCTION

Ultrasonic motors have so many merits compared to the traditional electromagnetic motors [1-2] and have replaced many electromagnetic motors in number of fields such as high accuracy platforms, robot joints and micro-electro-mechanical systems. Ultrasonic motors convert the electric energy intomechanical energy via converse piezoelectric effect of ceramic element, while traditional electromagnetic motors realize the energy conversion in magnetic field. Elliptical motion of driving feet is generated by mechanical vibration in stators and it can be transformed into rotary runners via frictional coupling at the interfaces between stators and runners. There have been various types with different structure such as ring shape, u shapes, and v shapes [3-6] etc.in the next work ring type stators are usually used for rotary driving. And most of them realize the bidirectional driving by forming travelling waves in the stator. The deformation principle of motor proposed [6] in the fig 1. The polarization of PZT ceramics is from + to -. S, C, G represents the sine signal, cosine signal, ground signal respectively. The sine and cosine signal can excite two standing waves in the PCB whose spatial phase shift and temporal one is both 90 degrees.The traveling wave can be formed by the superposition of these standing waves and nodes on the surface of stator will move an ellipse. The ring type of stator can realize driving and move bidirectional by the superposition of two standing waves. And the start is bonded type. Bonded type if motors are more easily fabricated than bolt-clamped type. The miniaturization of bonded motors can be realized more simply. Because of ring type of structure more compact but also the force on the runner is balanced. The presented work is classified into different parts in first section the actuator concept is explained, in the second part to accomplish the degeneration of those two modes takes place. And the next section represents the results of transient analysis.

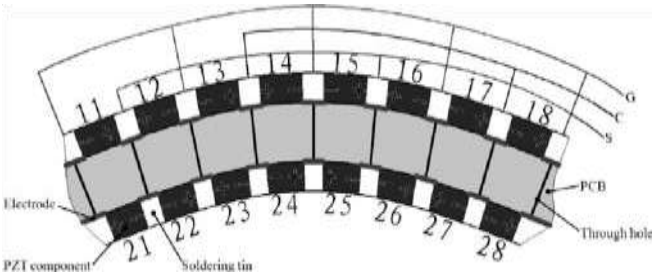

Figure 1: Deformation schematic of half-wave length stator ring

II.. CONCEPT OF ACTUATOR

A. Construction

Stator:

Stator is a stationary but vibrating part. It is constructed using a malleable material, generally, steel. It can be of ring, cylindrical or rod shaped.

Rotor:

Rotor is a rotating part, which acquires the energy conversion and produces the desire torque or [work] on the shaft. Rotor is made up of the same material as that of the stator and does have the same shape. Rotor and stator are coupled by a certain method called as frictional coupling which is much effective and simpler.

Casting:

Casting is used to protect the USM from external interferences, abrasive forces and extreme environmental conditions. They are made of non-corrosive alloys or fibre material. They also can be constructed in any of the desire shape as per requirement.

B. Geometry

The structure of motor is shown in paper. The motor consists of a sixteen pieces of perovskite material (PZT) ceramic plates and metal base which is composition of inner ring, middle ring, outer ring and two driving feet. For adjust the frequencies of vibration there are four holes in an outer ring. Along their thickness of direction and the sixteen pieces of PZT ceramic plates are polarized. For achieving maxima in

two driving feet are placed at the antinodes of the bending vibration.

C. Driving Principle

The basic principle of ultrasonic motor with ring stator is that active material excites a travelling flexural wave within the stator that leads to elliptical motion of the surface particles, generation of gross mechanical motion through the amplification and repetition of micro-deformation of active material. The active material induces an orbital motion of the stator at the rotor contact points and frictional interfaces between the rotor and stator rectifies the micro –motion of the rotor. The rectification of the micro-motion an interface is provided by pressing the rotor on top of the stator and the frictional force between two causes the rotor to spin. Working frequency - 20 KHz to 10 MHz and Amplitude of the actuator motion-20 to200nm.

By superposition, elliptical movement on driving feet can be formed by stretching and banding vibration. The motor is excited with help of two alternating voltage. Outer ring is excited by one voltage and inner ring by another voltage. When two voltage of same frequency and phase displacement of 90 degree, the elliptical trajectories are formed on driving feet. The PZT ceramic on inner ring excited by second order axial bending vibration mode, and inner ring excite by radial stretching vibration mode. The mid ring thickness and width are adjusted to limit the disturbance between them.

When outer ring of PZT's sine voltage is applied and on inner ring of PZT cosine exciting voltage is applied. Trajectories A and B shows movements of the Centre node on the interface. Runner move upward along the axis of rings and if reversing the phase shift the runner can move downward.

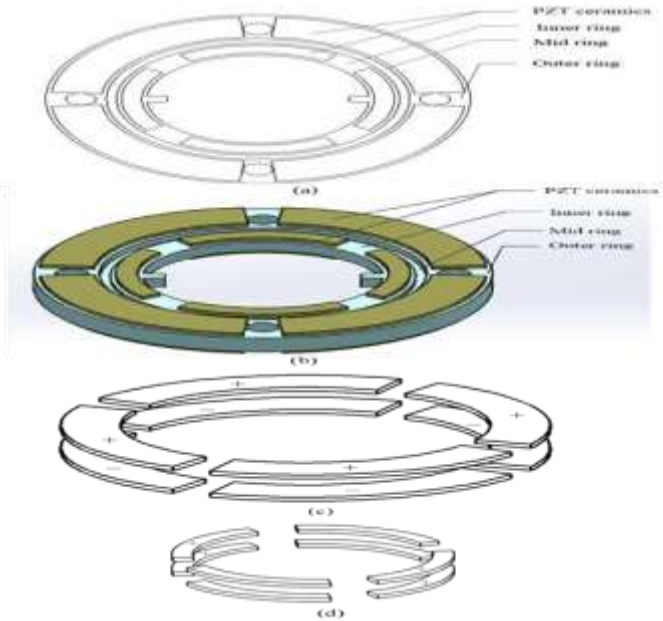

Figure 2: Structure of the USM a) The top view of USM b) The three-dimensional model c) The polarization of PZT ceramics attached on outer ring d) The polarization of PZT ceramics attached.

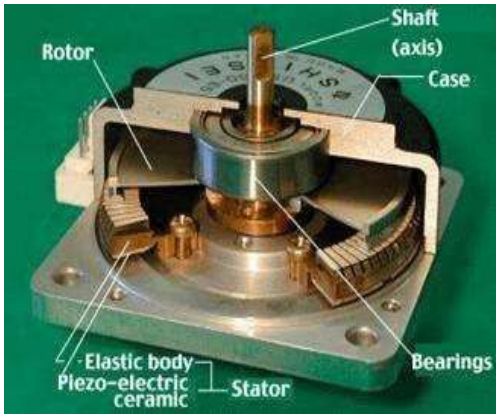

Figure3: construction of ultrasonic motor

III. TRANSIENT ANALYSIS

The motion trajectories of nodes on the interface generated by hybrid of the two modes. In order to demonstrate the feasibility of USM. It is necessary to verify that the motion trajectory are ellipses and transient analysis is used. The sine and cosine displacement voltage have resonance frequency of motor and effective value of 100 volt where applied on PZT ceramics. Three nodes on Centre line of every driving foot are used. The motion trajectory of six node are extracted to gain vibration characteristic of motor.

Fig 4a and Fig 4b shows the motion trajectories of all six nodes on the two driving feet are oblique ellipses.

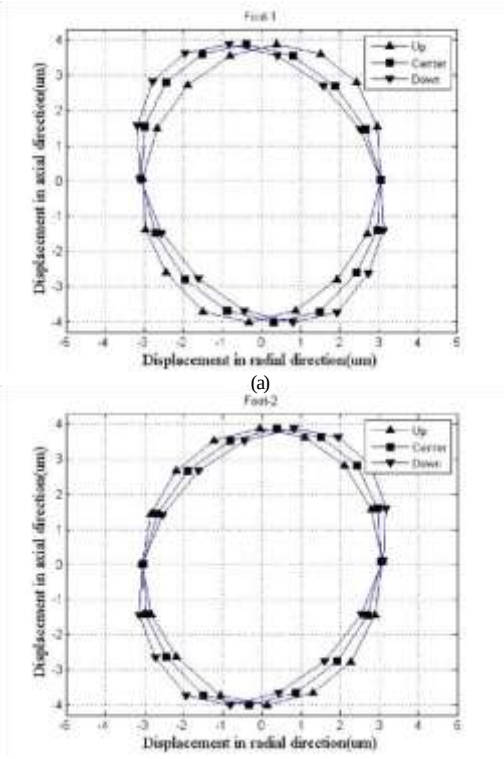

Fig: 4 motion trajectories of ultrasonic motor.

IV. CONCLUSION

The main contribution of the work presented in this paper consists in description development rotary traveling wave ultrasonic motor as structure, principle function and application form in according to its working characteristics. After 25 years of active search and nowadays piezoelectric rotary motors have considerable advantages and represent a truth concurrent for conventional electromagnetic motors.

For the new needs of applications domains, several types of piezoelectric ultrasonic motors have been suggested and designed and developed, to be used as standard as efficient, particularly the rotary traveling wave ones which are now commercially available t and applied as auto-focus cameras, in robotics, in medical domain and in aerospace.

REFERENCES

[1]. Ueha S. Ultrasonic Motors Theory and Applications. pp.120, Clarendon Press, Oxford, 1993.
[2]. Zhao CS. Recent progress in ultrasonic motor techniques. Journal of Vibration, Measurement & Diagnosis. 23: 1-5, 2004. (in Chinese)
[3]. Xing ZP, He B, Xu K, Wang J, et al. A Miniature Cylindrical Piezoelectric Motor with an Asymmetric Vibrator. IEEE Transactions on Ultrasonic Ferro electronics and Frequency Control. 60: 1498-1054, 2013.
[4]. Li X, Chen WS, Xie T, et al. Novel high torque bearing less two-sided rotary ultrasonic motor. Journal of Zhejiang University-Science A. 8: 786-792, 2007.
[5]. Jiang CR, Hu MQ, Jin L, et al. Finite element contact model of a hollow ring type traveling wave ultrasonic motor. Journal of Southeast University. 44: 99-103, 2014.
[6]. Peng TJ, Shi HY, Liang X, et al. Experimental investigation on sandwich structure ring-type ultrasonic motor. Ultrasonic. 56:303–307, 2015