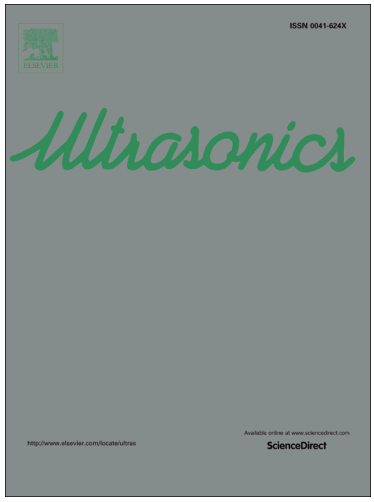

A Ring-type Multi-DOF Ultrasonic Motor With Four Feet Driving Consistently

Shengjun Shi, Huaiyin Xiong, Yingxiang Liu, Weishan Chen, Junkao Liu

PII: S0041-624X(17)30009-4
DOI: http://dx.doi.org/10.1016/j.ultras.2017.01.005
Reference: ULTRAS 5453

To appear in: *Ultrasonics*

Received Date: 15 March 2016
Revised Date: 4 January 2017
Accepted Date: 4 January 2017

Please cite this article as: S. Shi, H. Xiong, Y. Liu, W. Chen, J. Liu, A Ring-type Multi-DOF Ultrasonic Motor With Four Feet Driving Consistently, *Ultrasonics* (2017), doi: http://dx.doi.org/10.1016/j.ultras.2017.01.005

A Ring-type Multi-DOF Ultrasonic Motor With Four Feet Driving Consistently

Shengjun Shi[1,*], Huaiyin Xiong[1], Yingxiang Liu[1,2,*], Weishan Chen[1], Junkao Liu[1]

[1] School of Mechatronics Engineering, Harbin Institute of Technology, Harbin 150001, Heilongjiang Province, China

[2]State Key Laboratory of Digital Manufacturing Equipment and Technology, Huazhong University of Science & Technology, Wuhan 430074, China

*****Correspondence: sirssj@hit.edu.cn; Tel.: +86-451-8641-6119; Fax: +86-451-8641-6119

liuyingxiang868@163.com; Tel.: +86-451-8641-7891; Fax: +86-451-8641-6119

***Abstract* — A new type of multiple-degree-of-freedom (multi-DOF) ultrasonic motor was developed aiming at high output torque and compact structure. To reach this purpose, a ring type composite stator was proposed with four driving feet uniformly arranged in the inner circumference of the ring stator. The stator employs two orthogonal axial bending modes and a radial bending mode, by exciting two of them simultaneously, to generate elliptic trajectories on driving feet tips and to push sphere rotor around *x*, *y* and *z* axis respectively. Based on the deduced criteria, a specific combination of the A(0, 5) axial bending modes and R(0, 2) radial bending mode were chosen to realize that the rotating directions of the elliptical driving trajectories on four feet tips can push the sphere rotor to spin in the same direction consistently, thus the efficiency and output performance will be improved by decreasing the slip between feet and rotor. FEM was used to design the motor including selecting key parameters to tune the resonant frequencies by sensitivity analysis, and a prototype was fabricated and tested. The experiment results showed that the maximum output torque of the motor is 0.118 N·m and the maximum speed is 55 r/min.**

Key words —ultrasonic motor, multi-DOF, consistent driving, ring-type stator, FEM

1. Introduction

With the increasing applications of flexible equipment in manufacturing areas such as industrial robots, there exists increasing demands for multi-DOF driving mechanisms. Mostly, the traditional methods of constructing multi-DOF systems are connecting several single-DOF electromagnetic motors with hinges and connecting bars mechanism. Due to the connecting components, structures of these systems are always so complicated as to hinder their applications in real engineering projects. In order to solve this problem, some multi-DOF actuators have been proposed and applied, including multi-DOF permanent magnetic (PM) actuators [1-3] and multi-DOF ultrasonic actuators [4-13]. Due to the complicated structures of the multi-DOF PM actuators, they are not compact enough for miniaturization. Compared with multi-DOF PM actuators, multi-DOF ultrasonic actuators exhibit merits such as compact structures, precise positioning accuracy and lack of electromagnetic interference