3-D Finite Element Modeling Schemes For Design and Simulation Of VR Microactuator.

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ABSTRACT

This paper describes a 3-D finite element modeling scheme for the designing and analysis of a powerful variable – reluctance (VR) microactuator. The device to be modeled having the basic principles of operation of reluctance machine. A detailed description of the VR microactuator model is presented. The current design and operational principles are outlined in this paper, also simulation results are presented to demonstrate the output force characteristics of the actuator.

INTRODUCTION

The field of microelectromechanical systems (MEMS) is currently an area of intense research. Many important applications of MEMS pervade everyday life such as air bag accelerometers, ink jet printer heads, microrobotics, and biomedicine. The time to market of existing MEMES products is reported to be on the order of ten years. This has been widely attributed to the fact that there is a lack of sufficient computational prototyping tools, although there have been numerous recent efforts to generate simulation-based design tools for the MEM S community [1].

Microactuators are, together with microsensors, key components of modern microsystems. They represent complex three-dimensional devices, which achieve their functionality by coupling various physical quantities. Analytical analysis methods are often insufficient to reveal details of device operation and critical technological issues. The Simulation Of MEMS is challenging task due to the multiple requirements that need to be met. These include the solution of large coupled-equation systems that Aries from the discretization of the geometrically complex devices. The consistent treatment of surface electrostatic forces is necessary, since these effect are widely employed as the means of actuation due to the small air-gap sizes available in MEMS [2-3].

Many MEMS structures are geometrically complicated, electro-mechanically coupled, and inherently three - dimensional. The mechanical movement of the actuator structure often influences the field distribution responsible for the movement; this requires the application of stable iterative solution algorithms to achieve self-consistency. However, the calculation of forces and torque developed in MEMS actuator devices, and their variation with changes in position or excitation, is often what designer ultimately interested in. Many electrical machines and other electromagnetic devices can be modeled using finite elements. They can contain features such as magnetic nonlinearity, movement, geometric complexity and connection to an external circuit. The finite element can be used to treat these problems [4-5].

This paper examines the application of 3-D finite element electricomagnetic field models to design and simulate the VR microactuator with the initial aim of determining relationships between modeling complexity and accuracy in order to form a computationally efficient field model. The current design and operational principles are outlined in this paper, also simulation results are presented to demonstrate the output force characteristics of the actuator.

MAGNETIC STRUCTURE MODEL OF VR ACTUATOR.

The conventional VR actuator has simple magnetic structure. Figure 1 shows the cross sectional view of the actuator. It has four rotor poles and three phases wound on six stator poles. VR comprises a single stack and both stator and rotor are constructed from solid iron, and copper phase windings on the stator. Each phase is wound with the opposite magnetic polarity on symmetrically located stator poles. The excitation of a phase, that is, the presence of a current in that phase, magnetizes both the stator and the rotor. This produces a force which provides torque, causing the rotor to align its poles with those on the stator thereby minimizing the reluctance of the magnetic circuit. By utilising careful mechanical and magnetic design with efficient power electronics this actuator produces a high force for a given volume of actuator [6].

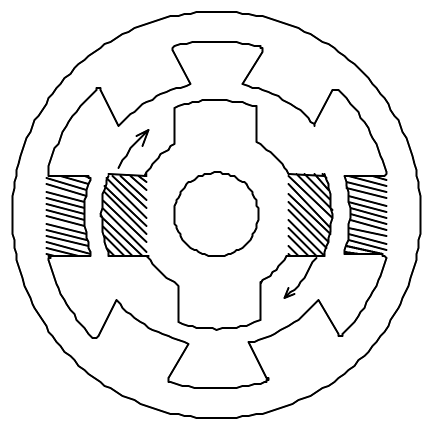

Fig. 1 A cross sectional view of VR actuator.

THE MAGNETIC FORCE MODEL.

The force developed in the air –gap of an electromechanical devices can be resolved into two components: normal and tangential. The resultant of the tangential component provides the useful electromagnetic torque, and the resultant of the normal component has to be accommodated in the bearings [7]. Force can be obtained from numerical field solutions.

CONCLUSION

The calculation of forces and torques developed in electromechnical devices, and their variation with changes in position or excitation, is often what the desinger is, ultimatly, interested in. In this paper we presented application of 3-D finite element electricomagnetic field models to design and simulate the VR actuator. The simulation results generated from the field model has been given and showed the validation of the applied model for obtaining the force charcteristic of the VR actuator.

REFERENCE

[1] L. Lin, A.P. Pisano, and R.T. Howe, "A system for the dynamic characterization of microstructure." IEEE. Journal of Microelectromechanical Systems, Vol. 6, No. 4, Dec.1997.

[2] A.J. Sangster and V.D. Samper, "Accuracy assessment of 2-D and 3-D finite element models of a double-ststor electrostatic wobble motor." IEEE. Journal of Microelectromechanical Systems, Vol. 6, No. 2, June 1997.

[3] D.L. De Voe and A.P. Pisano, "Modeling and optimal design of piezoelectric Cantilever microactuators." IEEE. Journal of Microelectromechanical Systems, Vol. 6, No. 3, Sep. 1997.

[4] D. Rodger, P.J. Leonard, H.C Lai,and N.Allen ,"Finite element modeling schemes for the design and analysis of electrical machines." Applied Computational Electromagnetics Society Journal, Vol. 12, No. 1, 1997.

[5] K. – J. Bathe, "Finite element procedures." Prentic - Hall International Inc., 1996.

[6] M. Crivii, M. Jufer, "Twd-Phase SR motor modelling using a finite element method coupled with driver", EPE'97, Trondhiem, Nov. 1997

[7] A. F. L. Nogueira, " Limitations of the conventional methods of force and torque prediction." Applied Computational Electromagnetics Society Journal, Vol. 12, No. 1, 1997.