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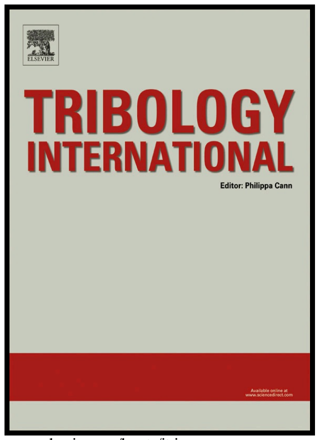

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Abstract

A low-cost pure pneumatic control is presented as a semi-active compensation to increase the stiffness of pneumatic air bearings. A prototype of the pneumatic control valve was developed for this purpose, and a rectangular air pad was selected for the experiments. Tests for the static performance of the controlled pad showed a significant increase in the stiffness of the bearings. A lumped mathematical model of the system was developed for a quick and accurate design of the pneumatic control. The comparison between the theoretical and experimental results is shown, and the effect of the main parameters on the static performance of the system is discussed.

Keywords: active air bearing, diaphragm valve, compensation method

1. Introduction

Due to their practically negligible friction, high positioning accuracy and long life, air pads are widely applied in machine tools, coordinate measuring machines (CMM) and wafer-steppers. The air pad design is addressed to meet the required load capacity, stiffness and air flow consumption.

The main drawback of the air bearings is their relatively low stiffness. Passive and active compensation methods have been presented as solutions to overcome this disadvantage [1].

Passive compensation methods can be obtained by modifying the geometry of the bearing feeding system, changing the shape of the bearing, and adding or modifying different types of grooves. For example, Wei Ma et al. [2] studied the influence of adding damping orifice to thrust bearing and it was found that these orifices can improve the pneumatic hammer stability. Also, Gao et al. [3] investigated the influence of orifice chamber shape on the behaviour of thrust bearings. Moreover, Colombo et al. [4] studied the effect of two supply holes configurations on the behaviour of journal bearings. In addition. Bassani et al. [5] studied the influence of geometrical parameters and of supply pressure on the behaviour of an aerostatic bearing mainly to increase its stiffness. Furthermore, Chen and Lin [6] developed an X-shaped groove aerostatic bearing with a passive disk-spring compensator to provide an increase in the stiffness and an improved dynamic performance. These methods are normally not able to achieve infinite stiffness, but it is possible with active compensation methods. These last methods can be put into two main categories: active and semi-active methods.

Basically, active compensation methods require feedback, such as the air gap height or the pressure inside the air gap from the pad during the working process, and the compensation is generated by the action of the piezoelectric actuators or different types of controlled restrictors. Aguirre [7] designed a thrust air bearing consisting of a thin plate with a central air feed hole. The pressure distribution in this pad will change with the deformation of the bearing surface to a concave shape by three piezoelectric actuators. The induced deflection produces a pressure air