

Design of a high stiffness hydrostatic bearing system with membrane-type restrictor for ultraprecision machines

Ta-Hua Lai, Ting-Yu Chang, Ya-Lu Yang, and Shih-Chieh Lin*

Department of Power Mechanical Engineering, National Tsing Hua University,
30013 Hsin-Chu, Taiwan (ROC)

E-mail: sclin@pme.nthu.edu.tw, Tel: +886-3- 5742920

Abstract

The need for ultraprecision machining continuously increased nowadays. The technologies enhance the capability for finishing parts or machining fine-featured patterns. In order to make ultraprecision machining to hold submicron tolerances capability, non-contact bearings are widely used, especially the hydrostatic bearing. Hydrostatic bearing can be characterized by the complete separation of the conjugated surfaces of a kinematic pair, by means of the fluid film, which provides virtually infinite motion resolution due to lack of static friction, very low straightness ripple, high squeeze film damping, potentially infinite working life, tolerance to ceramic swarf, good surface error averaging, and superior shock load capacity. However, a major impediment to the use of hydrostatic bearings is that there are no comprehensive optimal design standards that are available for engineering use.

In this presentation, it will be examined that a hydrostatic opposed-pad bearing may perform very high stiffness when two design parameters of membrane restrictors are properly given, the dimensionless stiffness of the membrane (K_r^*) and the other one is the design restriction ratio of the bearing system (λ). Analytical results showed that when $K_r^* = 1.33$ and $\lambda = 0.23$, the stiffness of the opposed-pad bearing should theoretically approach infinite in most application range. In the case where the upper pad and lower pad are equally designed, the displacement of the bearing can be maintained less than six percent of a non-loading clearance if the recess pressure extending to seventy three percent of the supply pressure.

Keyword: Hydrostatic bearing, Membrane restrictor, Opposed-pad bearing, High stiffness