ASIATRIB 2002International Conference
JEJU ISLAND, KOREA

A FEM Analysis of Dynamic Behavior for a Slider with Ultra-Thin Air-Film

S. K. Lim and Y. C. Rhim

School of Mechanical Engineering, Yonsei University

Abstract-New type slider with optical components is coming on market for portable and high capacity drive, and it shows great potential in future high performance drive. It is very important that a slider should have a good dynamic behavior. In this paper the dynamic behavior and static characteristics of slider have been investigated numerically by in-house simulation code using FEM.

Keywords: FEM, Reynolds Equation, Dynamic Behavior of a Slider

1. INTRODUCTION

It is very important that new type slider with optical components has a good dynamic behavior unlike contact-start-stop (CSS) slider in portable and high capacity drive, because this kind of slider is heavier than conventional one for CSS and also requires good load/unload behavior. This paper presents the flying characteristics and dynamic behavior for an optical slider. Numerical simulations are performed with in-house simulation code using Finite Element Method (FEM).

2. NUMERICAL MODEL

2.1 Air Bearing

A Slider is one of applications of self-acting gas lubricated bearings. The modified Reynolds equation, which is used as governing equation in lubrication applications, is used to analyze the air bearing between the slider and rotating disk.

$$\frac{\partial}{\partial X}(PH^3Q_p\frac{\partial P}{\partial X})+\lambda^2\frac{\partial}{\partial Y}(PH^3Q_p\frac{\partial P}{\partial Y})=\Lambda_X\frac{\partial PH}{\partial X}+\Lambda_Y\frac{\partial PH}{\partial Y}+\sigma\frac{\partial PH}{\partial T} \quad (1)$$

But if the velocity change according to the radial position is considered, the Eqn. (1) is modified as

$$\begin{aligned}&\frac{\partial}{\partial X}(PH^3Q_p\frac{\partial P}{\partial X})+\lambda^2\frac{\partial}{\partial Y}(PH^3Q_p\frac{\partial P}{\partial Y}) \\ &=\Lambda_X\frac{\partial PH}{\partial X}+\Lambda_Y\frac{\partial PH}{\partial Y}+\sigma\frac{\partial PH}{\partial T}+\alpha PH\frac{\partial U^*}{\partial X}+\beta PH\frac{\partial V^*}{\partial Y}\end{aligned} \quad (2)$$

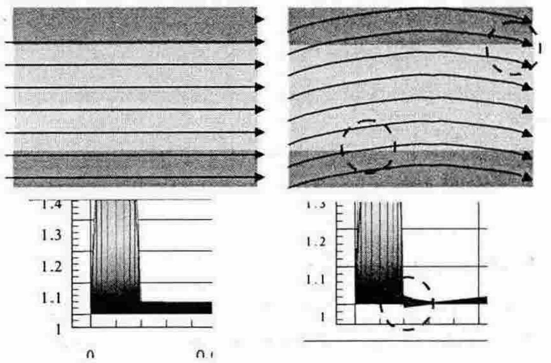

Fig. 1 Comparison of linearized and real velocity field under the two-rail slider

2.2 Slider Dynamics

The slider is attached to a suspension. Because of the constraints of the suspension, the slider's motion can be described as a system with three degrees of freedom- vertical, pitch, and roll - by the following dynamic equations:

$$\begin{aligned}&M\frac{\partial^2 Z}{\partial^2 t}+C_z\frac{\partial Z}{\partial t}+K_z Z=\int_A(P-P_a)dxdy-F_0 \\ &I_\theta\frac{\partial^2\Theta}{\partial^2 t}+C_\theta\frac{\partial\Theta}{\partial t}+K_\theta\Theta=\int_A(P-P_a)(X_0-X)dxdy-F_0(X-X_0) \\ &I_\Phi\frac{\partial^2\Phi}{\partial^2 t}+C_\Phi\frac{\partial\Phi}{\partial t}+K_\Phi\Phi=\int_A(P-P_a)(Y_0-Y)dxdy-F_0(Y-Y_0)\end{aligned} \quad (3)$$

3. Computational Results

3.1 Static Results

Figure 1 shows the difference of linearized and real velocity field under the two-rail slider and Fig. 2 shows differences of static characteristics between linear velocity and real velocity. Unlike minimum flying height and pitch angle, roll angle due to the real velocity component is quite different from that due to the linear velocity.

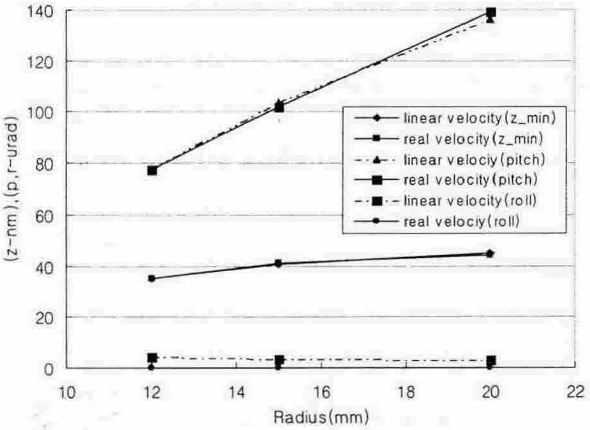

Fig. 2 Comparison of the static characteristics for linearized and real velocity field

3.2 Dynamic Results

Transient simulation is performed using dynamic equations and Reynolds equation. Considering the loading process, the slider is assumed falling from its initial conditions: initial falling velocity is zero, flying height is 3 μm, pitch and roll angle are 0 μrad. Figures 3, 4 and 5 show motions of slider according to time: vertical displacement, pitch and roll angle.

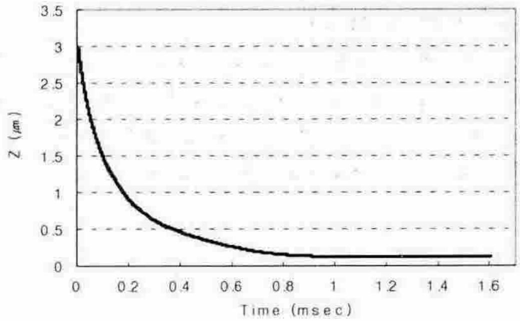

Fig. 3 Vertical displacement variation of the slider during falling from its initial position, 3 μm.

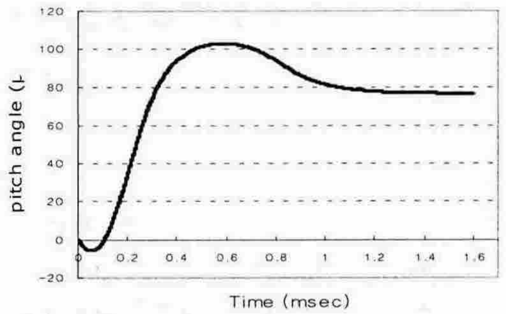

Fig. 4 Pitch angle variation of the slider during dynamic simulation

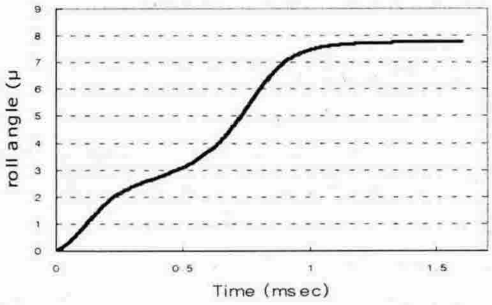

Fig. 5 Roll angle variation of the slider during dynamic simulation

4. Conclusion

The static characteristics and dynamic behavior of slider are investigated by numerical simulation.

1. Modeling of real velocity field can show more accurate static results.
2. Static behavior of slider can be predicted by FEM simulation at specific flying height
3. Dynamic behavior for a slider in load/unload process can be analyzed according to the air bearing surface of the slider.

5. REFERENCES

[1] Ono, K., 1975, "Dynamic Characteristics of Air-Lubricated Slider Bearing for Noncontact Magnetic Recording," ASME J. of Tribology, Vol.97, pp. 250-260.

[2] White, M., 1983, "Flying Characteristics of the "Zero-Load" Slider Bearing," ASME J. of Lubrication Technology, Vol. 105,pp.484-490.

[3] Jeong T. G and Bogy, D., "Numerical Simulation of Dynamic Loading in Hard Disk Drives." ASME J. of Tribology, Vol. 115,NO.3, pp. 370-375,1993.