Numerical Simulation and Experimental Study on the Effect of Ramp Profile, Friction and Flex-Cable Force on the L/UL Process for Small Form Factor HDD

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Introduction

So in developing a system with high areal density and that resist external shock and disturbances, the essential mechanism is L/UL system. L/UL system has many benefits when applied to a small form factor (SFF) HDD. It allows for higher areal density increase since it is possible to reduce the flying height of slider and eliminate the texture zone that is used for parking for contact-start-stop systems. In addition, it allows for lower power consumption and prevents the head-slap between slider and disk during non-operating conditions.

In this study, we developed an advanced L/UL simulation model using ANSYS/LS-DYNA. With this model, this paper examines the effect of ramp profile and friction coefficient which is changed by the repeated L/UL motion. We also analyze the effect of the flex-cable bias force in 1-inch microdrives. Note that the flex-cable bias has virtually no influence in 3.5 inch drives. In addition, the effects of ramp profile and flex-cable bias force are experimentally analyzed.

SIMULATION AND EXPERIMENT
A) Simulation Model

1) Ramp model

Figure 1 shows the ramp shape and the parameters used in the simulation and experiments. The parameters are obtained by measuring the ramp profile of a 1-inch microdrive. We divide ramp profile into 4 steps as shown in Figure 1.

2) FE L/UL model

This research developed a finite element (FE) L/UL system model using ANSYS/LS-DYNA program. The simulation model is modified by tuning the natural frequencies of simulation model to the experimental result. Second, the lateral velocity profiles are measured by using an in-plane LDV. Based on the measured velocity profiles, the previous tuned model is again modified by tuning the contact condition between ramp and suspension tab, the mesh size, the friction coefficient, etc. Figure 2 shows the L/UL dynamic models. Two FE models are created for load and unload processes because of different initial height and preload on the ramp. The air-bearing force during L/UL process is calculated by CML L/UL dynamic simulator. The dimple preload between about 1.52mN. The initial preload is 1.5g in step 1 of the loading process. The normal force is calculated by the deformation of suspension.

B) Simulation and Experimental results

1) Effect of friction coefficient

Figure 3 shows the cases 1, 2 and 3 with the friction coefficient of 0.3, 0.25 and 0.2, respectively. The increase in the maximum friction force is observed with increase in the friction coefficient. In case 1, the maximum friction is about 10mN and it is about 9mN and 8mN for the cases 2 and 3,
respectively. The large friction force is observed during these steps. The difference in the maximum friction force between the friction coefficients of 0.2 and 0.3 is about 2mN.

2) Effect of flex-cable bias force

Figure 4 (a) shows the effect of flex-cable bias force during the loading process. Case 1 represents the result of model without flex-cable. Cases 2 and 3 are the results of models which is 2/3, 1/2 flex-cable stiffness of full stiffness, respectively. And case 4 is for the full flex-cable model. As shown in Fig. 4 (a), the friction force reduces because of pushing force generated by the flex-cable in step 1. The flex-cable force also affects as the pulling force in step 4. However, the friction force does not decrease in case of flex-cable model with low stiffness in the same region. In addition, the maximum friction force in step 2 is relatively unchanged although the flex-cable stiffness changes.

Figure 4 (b) shows the effect of flex-cable bias force during the unloading process. The friction force reduces in [A] part because of pulling force generated by the flex cable. Similar to the result of the loading process, the flex-cable force largely affects steps 1 and 4 for the unloading process.

In the experiment, the lateral velocity increases in [A] part because the nominal flex-cable has a larger pushing force as shown in Figure 5. On the other hand, the effect of flex-cable pushing force becomes smaller in case of flex-cable models with 1/2 and 1/3 thicknesses. From the simulation results, the maximum friction force occurs in this region during the unloading process. Thus, by proper designing of the flex-cable stiffness, the maximum friction force can be reduced. As a result, the minimum loading velocity can also be reduced.

Figure 6 represents the lateral velocity profiles when unloading at 30mm/s. The flex-cable bias force has no influence during the initial step. The flex-cable effect however increases in steps 3 and 4. The accelerations in steps 3 and 4 are about -6.25mm/s² and -1.86mm/s² for case of the nominal thickness model, respectively. For the case of 1/3 thickness, the accelerations are -4.35mm/s², -1.43mm/s² for steps 3 and 4, respectively.

3) Effect of ramp profile

Figure 7 shows three ramp profiles with shape constraints. The three ramps have the same ramp height and length. Figure 8 shows the experimental results for the three designs. In case of design A, the air-bearing breaking time is the longest among three designs because the initial ramp slope is small. As a result, the width of unloading zone would be wide for this case. However, the design B has the shortest breaking time because of large ramp slope. And there is no dimple separation in case A and B. But the dimple separation happens in case C.

CONCLUSIONS

We created a numerical L/UL system model using the ANSYS/LS-DYNA. Through the model verification procedure, this study created an advanced L/UL simulation model. Through the advanced L/UL FE model, the effects of ramp profile and friction coefficient were closely examined. As the result of effect of friction coefficient, the increase of maximum friction force is observed with increase in the friction coefficient. We proposed that the ramp slope should be small in the area where the suspension tab impacts the ramp, but then the slope should made to be large after the air-bearing breaks.

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REFERENCES