FREQUENCY SPECTRUM ANALYSIS OF ACOUSTIC EMISSION OF HARD DISK DRIVE HEAD/DISK INTERACTION

K.H. CHUNG, J.K. OH, J.T. MOON, and D.E. KIM [1]

[1]*Department of Mechanical Engineering, Yonsei University*
134 Shinchondong, Seodaemoon-gu, Seoul 120-749, KOREA

In order to evaluate the flying characteristics of slider, the acoustic emission (AE) as well as friction signals are typically utilized. In this work the frequency spectrum analysis is performed using the AE signal obtained during the head/disk interaction such as load/unload mechanism using ramp, impact situation in the presence of a bump on disk surface and other contact phenomena including particle interaction. It was shown that the influence of impact can be characterized effectively in the AE frequency spectrum. As a result of this work, frequency spectrum analysis will be utilized with better understanding for studying the head/disk interface (HDI) characteristics and monitoring the particle interaction in HDI effectively.

Keywords : Acoustic Emission, Frequency Spectrum Analysis, Head/Disk Interaction, Particle Injection

1. INTRODUCTION

The areal recording density of hard disk drive (HDD) has been rapidly increasing over the last decade. One of the important factors behind such a drastic increase in the areal density is the reduction of gap between the slider and the disk media. For recently developed HDDs the gap is less than 15 nm. The gap between the slider and the disk is maintained by the air bearing effect of the slider as it flies over the disk surface. Tribological properties at the HDI become critical since the gap is so small.

In order to assess the head/disk interaction, AE as well as friction signals are typically utilized. The friction signal can be used to identify the flying condition of the slider from the air bearing point of view. On the other hand, the AE signal gives very useful information of the instant contact between head and disk as well as the flying characteristics of slider because of its sensitivity. Typically, the rms and frequency spectrum of the AE signal are monitored. The shape of the rms signal during a slider take-off or landing process is used to assess the flying characteristics of slider on disk surface. The frequency spectrum of AE shows the dynamic characteristics of HDI system. It is found that AE peak in frequency domain represents the periodic laser bump excitation [1], the slider vibration mode [2], and the air bearing frequency [3]. In order to describe the head/disk interaction exactly, it should be mentioned that the transmission path, the natural frequency of the AE sensor itself, and the adequate filtering frequency should be carefully considered.

The load/unload mechanism can eliminate not only the stiction problem but also shock problem during non-operation. However, the problem associated with impact of the slider against the disk during the loading/unloading process can cause surface damage to both components. Numerous investigations of load/unload system have been introduced in recent years for the minimization of the damage due to impact [4-8]. The raw and frequency spectrum of AE signal are used rather than the rms signal for the load/unload performance assessment for the direct measurement of impact without averaging. However, for the better understanding of the head/disk interaction during impact situation, the analysis of the AE signal in various operating conditions is needed.

Because the particles injected in the HDI induce data loss due to the electrical and mechanical damage of the disk media, it is crucial to prevent the particle generation and intrusion. Especially, the magnetic head should be protected from the particles including wear debris. The contamination issues have been a concern of previous researches[9-12]. From the point of view of HDI reliability, it is critical to monitor the particle intrusion into the HDI.

In this work, the rms and the frequency spectra of AE signals were analyzed for load/unload mechanism as well as for impact situation in the presence of a burr or other contact phenomena in order to better understand the instantaneous head/disk interaction. Also, these results were compared with those of the conventional CSS test where continuous slider/disk interaction occurs. Particularly, the AE signal generation due to the particle was analyzed. This can be used to monitor the particle effect on the HDI performance effectively.

2. EXPERIMENTAL DETAILS

The experiments were performed using a Contact-Start-Stop (CSS) tester equipped with AE and friction sensors to monitor the interaction at the HDI. The CSS tester is capable of performing both load/unload and take-off/landing tests. The AE signals are acquired using a digital oscilloscope. In order to observe the impact situation, the impact during loading/unloading process using ramp, vertical loading from the height of 100~500 μm, and the impact due to the contact with a burr which was artificially made on the disk surface was compared. As for the particle injection test, SiC of about 1 μm diameter was injected from the leading edge of the slider and the particles were counted using a condensation particle counter (CPC). The rms signal and the frequency spectrum of the peak due to the particle were monitored. For all the experiments, Al_2O_3-TiC pico-slider, which has a nominal flying height of about 30 nm was used. The natural frequency of the slider was calculated by FEM analysis. The results showed that the first and second resonance frequencies are 1.25 MHz and 1.71 MHz, respectively. For the CSS test, Laser Zone Textured (LZT) disks that have 'W' type bumps were used.

3. RESULTS AND DISCUSSION

Fig. 1 shows the frequency spectrum of the AE peak during the unloading process. After consideration of the frequency due to the air-drag, AE sensor itself, and the measuring system, the results were compared with those of the CSS test which was influenced by the interaction with the laser bump on landing zone. Especially, 317 kHz peak frequency observed in every impact situation was not observed during the slider take-off in CSS test. From this result, the frequency spectrum concerned with the impact was characterized. Also, it was shown that the influence of impact can be observed more effectively in the AE frequency spectrum rather than in the AE rms profile. This method of analysis was further utilized to assess the severity of loading under various operating conditions. Finally, the frequency spectrum analysis of AE signals detected during slider contact against artificially created scratches on the disk surface showed that the signal could be correlated with the impact phenomenon.

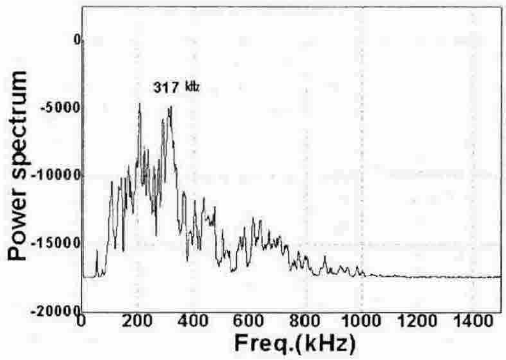

Fig. 1 AE power spectrum during unloading process.

The AE peak due to the particle injection was observed. Fig. 2 shows the AE raw data due to the particle interaction when slider was flying on the disk surface. With the consideration of particle size of about 1 μm, the particles can agglomerate on the leading edge of slider to a certain extent. This fact could be derived from the comparison of frequency spectrum before and after the impact. The results show that frequency spectrum analysis can be effectively used for monitoring the particle effect.

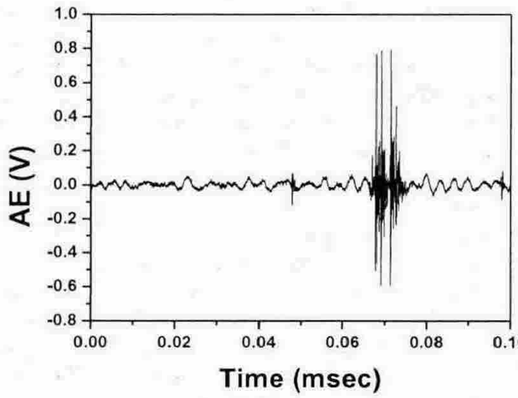

Fig. 2 AE peak due to the particle interaction

4. CONCLUSION

The frequency spectrum and the rms values of AE signal during the load/unload tests where the slider impacts against the disk surface were compared with those of conventional CSS test where continuous slider/disk interaction occurs. From the experimental results the frequency spectrum of the HDI system due to the impact was characterized. It was shown that the frequency spectrum analysis provided useful information in the case of impact situation. Also, the head/disk interaction due to the particle could be characterized using the AE signal. Furthermore, the particle behavior can be derived from the frequency spectrum analysis of AE signal.

5. ACKNOWLEGEMENT

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