A Basic Experiment of Head/Disk Interaction of Subambient Tri-Pad Slider by Using Acoustic Emission Test System

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Abstract: The object of the present work is the analysis of head/disk interaction during start/stop and constant speed operation using acoustic emission (AE). The frequency spectrum analysis is performed using the AE signal obtained during the head/disk interaction. The FFT (Fast Fourier Transform) analysis of the AE signals is used to understand the interaction between the AE signal and the state of contact.

Key words: Head/disk interaction, acoustic emission, FFT.

Introduction

Since contacts between slider and disk cause friction and wear, it is important to minimize the contact force at the head/disk interface. One of the most sensitive methods for the analysis of friction between sliding surfaces is acoustic emission (AE).

Acoustic Emission (AE) is the class of phenomena whereby an elastic wave, in the range of ultrasound usually between 20 KHz and 1 MHz, is generated by the rapid release of energy from the source within a material. The elastic wave propagates through the solid to the surface, where one or more sensors can record it. The sensor is a transducer that converts the mechanical wave into an electrical signal. In this way information about the existence and location of possible sources is obtained. The basis for quantitative methods is a localization technique to extract the source coordinates of the AE events as accurately as possible. AE analysis is a useful method for the investigation of local damage in materials. One of the advantages compared to other NDE techniques is the possibility to observe damage processes during the entire load history without any disturbance to the specimen.

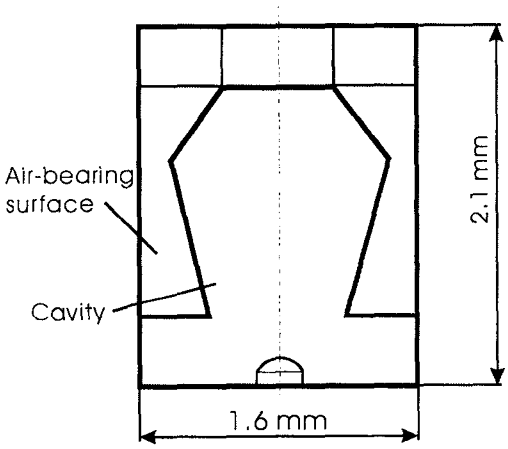
Kita et al. [1] first documented the use of acoustic emission for contact detection. Benson et al. [2] monitored the rms signal and AE frequency spectrum for different slider-disk combinations, suspension loads, and disk velocities. McMillan, Swain and Talke [3] in 1995 investigated the take-off velocity of slider using acoustic emission frequency spectrum. They showed that the frequency is a function of velocity and correspond to particular contact locations on the slider. Later Khurshudov and Talke [4] used acoustic emission to study of subambient pressure tri-pad sliders. They found that the contact force is inversely proportional to the slider flying height, and acoustic emission at the slider/disk interface is proportional to the work of the friction force per unit time. They also determined the dependence of contact force on flying height and disk velocity. Kum-Hwan Cha et al. [5] investigated the AE and friction signals related to the durability of head/disk interface. As we can see, acoustic emission studies have been widely used in the investigation of the tribology of sliding interface. In our work we used acoustic emission to study contact behavior of the slider during start/stop and constant speed operation.

Proximity recording sliders are designed to keep light contact with the disk during steady-state "flying". A typical example of a proximity recording slider is so called "tri-pad slider" which consists of two shortened air-bearing rails and a small air bearing center pad carrying the read-write element. Another slider design used for proximity recording application is so-called sub-ambient (negative pressure) tri-pad slider, consisting of a negative contour with an additional small center pad at the trailing edge [4].

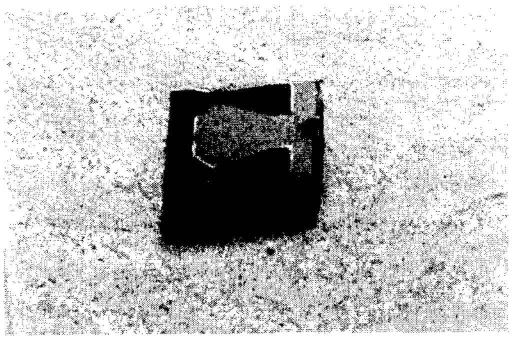
Experimental procedure

In our investigation, 50 percent negative pressure tri-pad slider (Fig. 1) was used.

The CSS tests were conducted with the PCA Contact-Start-Stop (CSS) tester. Fig. 2 presents the acceleration profile used in the experiment. As we can see from Fig. 2 each CSS cycle was 14.5 seconds at the maximum spindle speed of 4500 rpm. During start-up, the disk was accelerated in 3.5 seconds to its maximum speed. The disk was then kept at constant speed for 4 seconds, and was decelerated to a complete stop in 7 seconds. In all tests, AE sensor was attached to the base of the suspension (Fig. 3).



(a)



(b)

Fig. 1. (a) Schematic of subambient pressure tri-pad slider (b) Picture of the slider

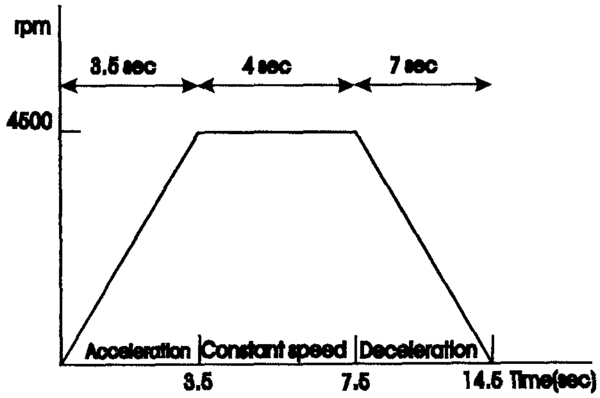


Fig. 2. Acceleration profile of CSS test

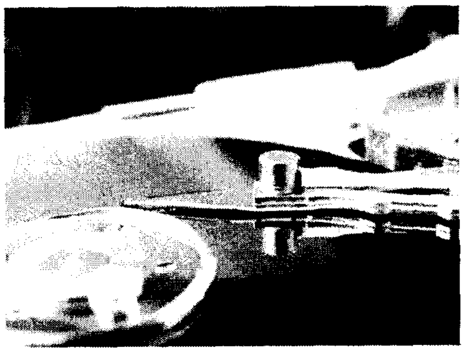


Fig. 3. AE sensor

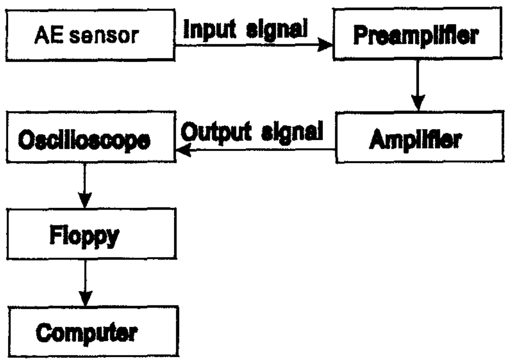


Fig. 4. AE signal processing (the block diagram of AE signal)

Fig. 4 shows the detected AE signal processing. The AE signals are acquired using a digital oscilloscope [7].

Results and discussion

Fig. 5 shows the AE signal versus time during a start/stop cycle. The AE signal shown as a function of time during a complete start/stop cycle and maximum disk speed 4500 rpm. As we can see there are two well-defined peaks on this AE signal. These peaks are depended on the contact force between slider and disk surface. Also we know that the acoustic emission signal is related to the flying height of the slider used. In addition, we note that the acoustic emission signal increases with velocity [4].

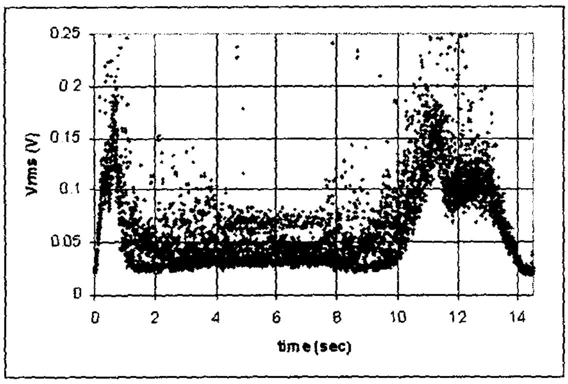
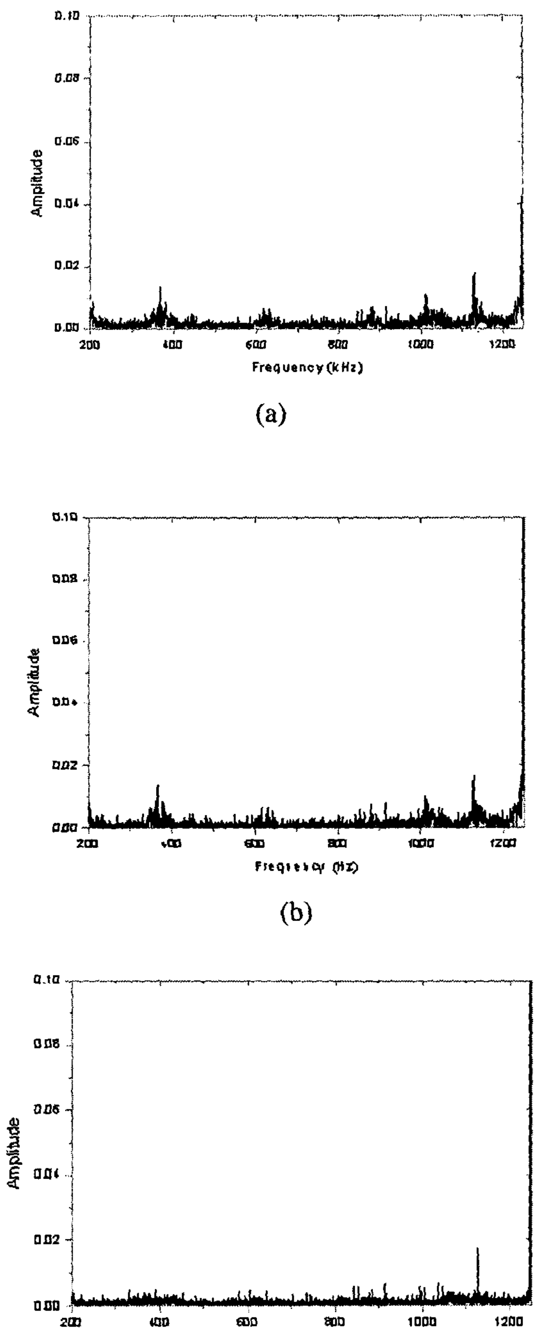


Fig. 5. AE signal versus time

After getting data of AE signal we used the Fast Fourier Transform (FFT) to determine the frequency range of acoustic emission signal. Fig. 6 shows the frequency spectrum of AE signal. Duration time was equal 4 ms; time interval between two points was equal 4 μs and number of points was equal 10 000. Under these conditions we have got the maximum frequency is equal 1.25 MHz.

FFT Analysis. As we can see in Fig. 6. (a) there are few peaks on the frequency spectrum of AE signal. In Fig. 6. (a) the AE signal frequency spectrum shows a broad transducer resonance peak at about 360 kHz. Vibrations at 630 kHz can be associated to the twisting mode of the slider body. Vibrations at 1.0 and 1.15 MHz have been associated to the transverse and longitudinal bending mode respectively [8]. In Fig. 6. (b) we observe two peaks in the AE signal. They are depended on



(a)

(b)

(c)

Fig. 6. The frequency spectrum of AE signal during (a) acceleration (b) constant speed (c) deceleration.

torsional and bending modes. First peak is depended on torsional mode and the second one is depended on bending mode. In Fig. 6. (c) we can see the same peaks of frequency with Fig. 6. (a). As we can see in Fig. 6 the frequency spectrum of AE signal during constant speed is smoother than during acceleration and deceleration because during acceleration and deceleration contact force occurs (Fig. 5).

Conclusions

The dynamics behavior of the tri-pad sliders produced many interesting features in the CSS AE and friction profiles. CSS test is viable method of testing the tribological characteristics of a head/disk system.

The AE spectrum was monitoring during a start/stop cycle. FFT analysis was used to get the frequency spectrum of AE signal. We observed two vibration modes. These are torsional and longitudinal modes of the slider. The frequency spectrum of AE signal during constant speed is smoother than during acceleration and deceleration because of the contact force.

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