VIBRO-ACOUSTIC EXPERIMENTAL ANALYSIS IN HARD DISK DRIVES

PACS REFERENCE:

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ABSTRACT
Vibro-acoustic interaction is one of the main issues facing the development of the hard disk drive (HDD) system as hard disk drives operate at ever-higher rotational speeds and seek rates. It has been shown that major sources of noise in a typical hard disk drive include idle noise and seek noise. In this paper, the mechanisms and characteristics of noise sources are investigated. Experimental investigation is carried out according to ISO standards for measuring HDD acoustic noise in both idle and seek mode. Results are obtained and analyzed.

MECHANISMS AND CHARACTERISTICS OF NOISE IN A HARD DISK DRIVE

Major sources of acoustic noise in a hard disk drive include, as shown in Figure 1:

- Idle noise
    a. The spindle motor and the ball bearings inside the spindle motor assembly.
    b. Sound radiation from the vibration of spinning disks.
- Seek noise
    a. The rotary actuator assembly.
- The top cover and bottom wall excited by the spindle motor or the rotary actuator. A very small component of the overall noise level emanates in directions leading away from the sidewalls.
- The amplification of spindle motor noise caused by vibration of the highly flexible printed circuit board (PCB) suspended below the base of the typical disk drive.

Though several experimental studies [1-3] have been carried out, the precise source mechanisms are not entirely well understood.

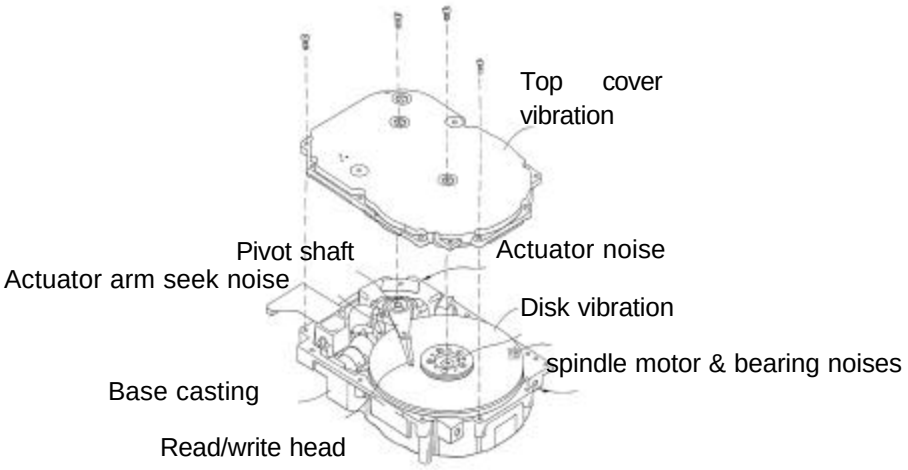

Figure 1 Noise sources in HDD

Electro-Magnetically Induced Vibration In Spindle Motor

The spindle motor's rotor carries a magnet in the form of a ring with changing polarities. The stator comprises of an armature core set and the electric windings. Due to interaction between the magnet and stator teeth or phase current switching with current fed to the windings, torque ripple is produced. This torque ripple is the cause of vibration in spindle motor. Lorimer and Hartman [12] presented common formulae for brushless DC motor vibration frequencies, considering a BLDCM with N_s slots and N_p poles.

Bearing Noises

Most hard disk motors use ball bearings. These are small balls that are placed in a ring around the spindle motor shaft. Because of the construction of a ball bearing, consisting of an inner and outer race, a series of balls and a cage to support the balls, there are a multitude of possible noise sources. Surface finish, roundness, alignment also play an important part in noise from a ball bearing. As the drive spindle speed continues to increase, noise from the contact of the ball bearings in the raceway increases, making idle noise an important contributor to the overall noise level and poor sound quality. Momono and Noda [13] provided a classification of vibration and sound in bearings.

Mechanism Of Electro-magnetically Induced Seek Noise

Current fed to the coil of voice coil motor induces electro-magnetic force. This force causes seek motion of the heads. During seek motion, servo system receives the address of the destination track and generates control signals that cause the heads to initially accelerate towards the destination track and subsequently decelerate as the heads approach such track. This causes vibration of the actuator arm.

Vibration Transmitted To The Casing And PCB

The base plate and top cover are attached using a number of small screws, usually around the perimeter of the cover. Additional screws are also used in the middle of the cover: one to stabilize the spindle motor shaft, and one to secure the axis of the actuator assembly. The PCB is normally mounted on the bottom of the base casting, exposed to the outside. It is separated from the base casting using foam or other cushioning material. A primary source of acoustical emissions from a disk drive is the amplification of these vibrations and especially of the spindle motor vibration by the top cover and the base of the disk drive.

EXPERIMENTAL INVESTIGATION OF NOISE IN HDD

Experiment Set-up

ISO standard adopted in HDD industry is ISO 3744. Figure 2 is a video photo of the set-up of the measurement and layout of the microphone positions. Western Digital's Caviar 2540 hard disk was used in the experiment.

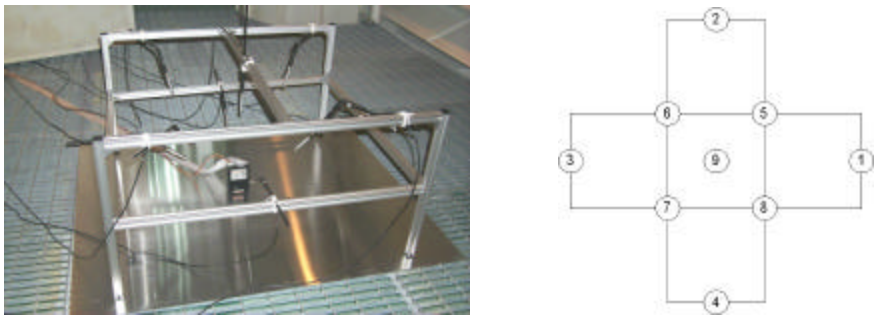

Figure 2 Experiment set-up and layout of microphone positions.

Experimental Results

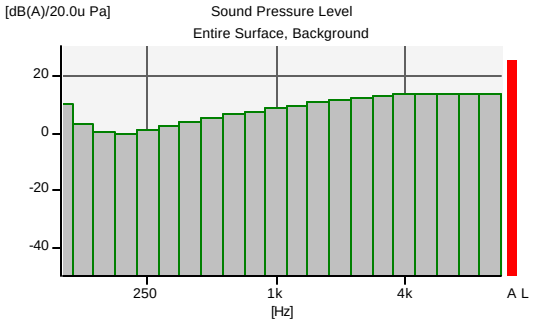

Figure 3 Sound pressure level - background noise

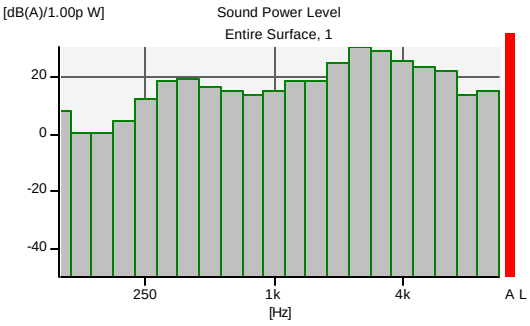

Figure 4 Sound power level - Idle noise

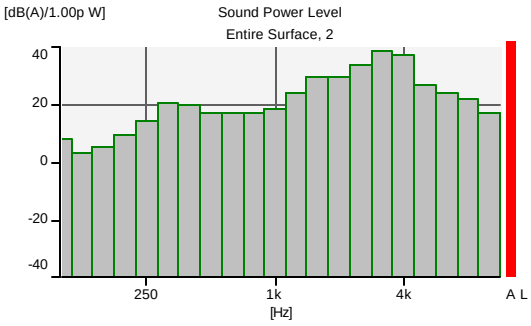

Figure 5 Sound power level -Seek noise

It can be concluded from the experiment results that overall seek noise level is higher than that of idle noise. This should be the case since when seeking the spindle motor is still working. Some peaks are found around 400Hz and 4KHz from the spectrum. Further studies will be focused on where these peaks come from and how they will affect the overall noise level, which is useful for reducing noise level in the future.

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