Vibration analysis of the camera holder with isolators in Auto Core Adhesion Mounting machine

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Abstract. This research aims to study the vibration analysis in the camera holder of Auto Core Adhesion Mounting machine that used in hard disk drive industry for attaching slider onto suspension (HGA). The base excitation of the machine occurs when manufacturing speed increases. This results in position error while image processing. The image processing finds the referent hole position of suspension before attachment slider onto suspension process, the impact of vibration is impact to 3\textsuperscript{rd} camera holder at 43 Hz and 100 Hz. Then four models for the analysis of vibration signal and isolators selected for reducing vibration of camera holder. The 4\textsuperscript{th} model isolator shown best performance to reduce vibration and improve the efficiency of image processing.

1. Introduction

Thailand is the second largest manufacturer and exporter of hard disk drives. The head gimbal assembly (HGA) process is the process that one of the key components in mechanical hard disk drive (HDD). The HGA is the one of read/write components that operates above the media or platter while the media were rotated by spindle. The HGA consist of 2 main components which are “slider” is the magnetic head and suspension. The function of the HGA process is to join major components together. The slider attachment to suspension is vital process since the HGA has to fly over the magnetic media, which is spun with the speed at 7,200 RPM and reading data from and writing data to the magnetic media.

Therefore, this paper focuses on an improving the suspension hole image quality on the Auto Core Adhesion Mounting machine (ACAM). ACAM machine process is using machine visions to justify the alignment position for attachment slider to suspension. The vibration was taking place into machine, it decreased an efficiency of machine to alignment the HGAs. Thus, the structural dynamics properties must be considered when we have to design the machine. For example, the ACAM machine of Western Digital also facing with this problem as shown in figure 1 (a). The vibration is affected to the image quality of sampling picture and it is decreased the reliability of this machine. The image processing, edge detection is used to find the CU hole, B Datum hole and find the position in suspension for making point attach slider. From figure 1 (b) image blur, which is affected to find the
CU hole and B Datum hole. However, the image processing error occurs due to the wrong position of suspension when attaching the slider and it will cause the HGA to misalignment.

![CU Hole and B Datum](image)

**Figure 1.** (a) Machine speed running <1000 UPH. (b) Machine speed running >1000 UPH.

This process needs high accuracy for attachment slider onto suspension process. The camera is applied to the find position of marking point on the suspension which is camera along with a camera holder mounted on the table that is used to install the parts of ACAM as shown in figure 2. The cause of suspension blur is due to the lot of moving parts in ACAM when the unit per hour (UPH) increases. This is the main reason that cause ACAM to increases vibrate and increases base excitation at the camera holder, which cause the result of blur images.

![Camera holder and parts of ACAM](image)

**Figure 2.** Camera No.3 in ACAM machine.

The analysis and design isolator near the resonance region when the disturbance frequency is below $\sqrt{2}$ times of isolator natural frequency, and as small as possible in order to obtain a better isolation effect when the frequency is over $\sqrt{2}$ times of isolator natural frequency [1]. The research about the dynamic relation of asymmetric multi-supported vibration isolation system with elastic foundation establishes the passive and active control model for the system by using the effective matrix analysis method, analyzes and calculates the transmission mechanism and characteristic of vibrational power flow in the flexible vibration isolation system under passive control [2]. The vibration modal analysis using ANSYS software gaining natural vibration frequency of each order of pipe-die and the corresponding vibration mode [3]. The analysis about a plate dynamic model along with experimentally identified damping ratios for an annular work piece under constraints emulating those of a duplex turning machine. Formulated as a dimensionless boundary value problem verified with finite element analysis provide a rational basis for identifying key cutting process parameters and quantifying their effects on thin-wall component vibration sensing [4]. The control vibration the
suppression method of anti-resonance and resonance caused by use of air springs, which are the actuator of a pneumatic vibration isolator. Although the relative displacement derivative (RDD) positive feedback control is effective for the suppression of the anti-resonance and resonance, a control system is not causal under the condition that the time delay of response of air springs is present [5]. The new design the vibration isolation device based on the theory of vibration isolation and finite element analysis. The process of simulation analysis and verification of its vibration isolation performance, whose result worked well, is made in the last [6]. Studied on the different model effect in isolation design using Transfer Matrix Method for Multibody Systems (MSTMM) and passive control techniques to conserve the power consumption for enlarging the power batteries life [7-8]. This paper attempts to improve the changes the natural frequency of machine structure and design to reduce base excitation of the camera holder in ACAM machine at the 1000 UPH for the efficiency of image processing.

2. Methodology

2.1. Measurement vibration
The experiment is conducted by the vibration in the ACAM machine will affected to decrease the performance bonding accuracy. The measurement vibration test at 1000 UPH for defining the frequencies that affects camera holder and measuring points as shown in figure 3. The measurement vibration equipment uses Iotech analyzer 640u (Analyzer vibration), PCB 356A32 (Triaxial IEPE accelerometers), Ez Analyst software (software for measurement vibration).

**Figure 3.** Measuring point on the camera holder in ACAM machine.

The measuring point on the camera holder at the speed of 1000 UPH is shown in figure 3. Each measuring point on the camera holder shows the maximum amplitude of the base at frequency of 100 Hz. The vibration measurement results are shown in figure 4. The maximum amplitude of vibration at Beam A and Beam B occurs at frequency of 43 Hz. The camera holder attaches on the Beam B. Thus, the vibration of the Beam B is most affected to quality of image processing at frequency of 43 Hz in the direction of x axis and z axis.
2.2. Modal analysis

Modal analysis of holder camera in the ACAM machine is used to define natural frequencies based on structural testing as shown in figure 5. The vibration analysis equipment consists of Iotech analyzer 640u (Vibration analyzer), PCB 356A32 (Triaxial IEPE accelerometers), Kistler Type 9726 A20000 (Modal hammer), and Ez Analyst software.

The natural frequency of the camera holder discovered four frequencies in range 0-150 Hz from impact testing as shown in figure 6 (a) and the fundamental natural frequency is frequency of 48.75 Hz. The mode shapes of the camera holder in each frequency are applied by ANSYS program as shown in figure 6 (b) [8-9].
2.3. Designs

The results of vibration measurement and impact test occurred high amplitude and the fundamental frequency at 43 Hz as first mode of camera holder. Thus, the criteria for selection isolator model is considered force transmissibility($T_r$) in frequency range 40-60 Hz. The selected isolator is based on the weight 32 kgf of camera holder and the force transmissibility less than 10% as shown in figure 7-8. For large values of frequency ratio and low values of damping ratio, the force transmissibility is given by

$$T_r \approx \frac{1}{r^2 - 1} \tag{1}$$

when $r = \omega/\omega_n$ – frequency ratio, $\omega_n$ – natural frequency (rad/sec), $\omega$ – machine speed (rad/sec).

The optimal isolator range is most effective as $r \geq \sqrt{2}$ [9]

![Image](a.png) (a) Impact test. (b) Mode shapes.

**Figure 6.** (a) Impact test. (b) Mode shapes.

![Image](data.png) (a) Vibration transmissibility data isolator model 1-3. (b) Vibration transmissibility data isolator mode 4.

**Figure 7.** Vibration transmissibility data isolator model 1-3.

**Figure 8.** Vibration transmissibility data isolator mode 4.
2.4. Measurement vibration with isolator
The selected isolator models are installed in the ACAM with machine speed of 1000 UPH for comparing the vibration reduction of each isolator model as shown in figure 9.

![Figure 9](image_url)

**Figure 9.** (a) Isolator model 1. (b) Isolator model 2. (c) Isolator model 3. (d) Isolator model 4.

3. Experimental results
In addition, figure 10 presents the vibration measurement at frequency of 43 Hz for all models in the x-axis and z-axis before and after install isolator.

![Figure 10](image_url)

**Figure 10.** Compare result measurement after and before install isolator.

![Figure 11](image_url)

**Figure 11.** Compare result measurement install isolator each model.
After the isolator is applied, the all isolator models can be reduced vibration at first mode of natural frequencies as shown in figure 11. In comparative of the results experiment as shown in table 1, the vibration reduction of each isolator model can be reduced vibration in range of 40-60 Hz. but some isolators are increased vibration in frequency of 100 Hz. It is necessary for further isolator design

| Isolator | % Reduce vibration at 43 Hz | % Reduce vibration at 100 Hz |
|----------|-----------------------------|-----------------------------|
|          | X axis | Y axis | Z axis | X axis | Y axis | Z axis |
| Model 1  | 87.95  | 42.72  | 83.83  | 42.68  | 16.37  | 126.36 |
| Model 2  | 49.66  | 39.48  | 56.98  | 1.72   | 13.7   | 2.4    |
| Model 3  | 37.11  | 44.37  | 13.35  | 61.88  | 52.09  | 46.06  |
| Model 4  | 98.42  | 79.78  | 93.50  | 92.67  | 86.31  | 87.96  |

*The isolator increase vibration

4. Conclusions
The vibration analysis of the ACAM machine make practical use impact test and ANSYS program. Mode shapes of the camera holder and vibration transmissibility of each part have useful for isolator selection guide. The results showed that all isolators reduced base excitation of camera holder at frequency of 40-60 Hz and increased efficacy quality of image processing.

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