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The effect of HDD pivot bearing assembly process on actuator arm modal frequency

Khosak Achawakorn*[1)] Thira Jearsiripongkul and Krairoek Fanchaeng[2)]

*[1)]Department of Mechanical Engineering, Thammasat University, Rangsit Campus, Pathumthani, Thailand, 12120

[2)]Belton Industrial (Thailand) Co., Ltd. Pathumthani, Thailand,12120

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Abstract

To find the relationship between the modal frequency of HDD actuator arm and the interested process parameter, the pivot bearing insertion process has been investigated. The non-conformance condition could be induced by various parameters such as the dimension of parts, and the friction inside the bearing. One of the interesting parameter is the depth of the glue groove between the pivot bearing and the actuator arm. The objective of this research is to prove the existence of relationship between depth of the glue groove and the actuator arm modal frequency. The variation of the modal frequency of actuator arm is investigated by the experiment and FEM. Representing the variation of the controlled parameter, the depth of the glue groove has been varied. The modal frequency of each specimen is measured and is compared to the expected standard condition. The experiment shows that the modal frequency of some vibration mode is significantly different in each group of specimen. The experiment results and the FEM results show the relationship between the variation of controlled dimension and the modal frequency of the Actuator Arm.

Keywords : Pivot bearing, Actuator arm, HDD, Modal frequency

1. Introduction

The resonance in the HDD actuator arm is needed to be avoided, since it leads to reliability and durability problem of HDD. Many parameters are considered such as geometry of the component and material properties. The assembly method of the actuator arm is another important factor that affects the natural frequency of the actuator arm. Different manufacturer use various design and method to assembly the actuator arm and its pivot bearing. To keep the best precision and least vibration the various techniques of pivot bearing assembly methods have been invented [1-3]. Even they have been reduced by many methods, the natural frequency is still exist. The HDD manufacturers live with the natural frequency by avoiding the use of those frequencies in their HDD. The notch filter and other techniques are applied. To make this idea correct, every HDD in the same model must have the same natural frequency.

The vibration of the HSA is subjected to the vibration of every component from the suspension to the pivot shaft. The actuator arm is assembled to the pivot bearing and rotates together with the pivot shaft and other related parts. The actuator arm is

Corresponding author: Tel.: +66 (0) 2579 1111 ext. 2282; Fax: +66 (0) 2579 1111 ext. 2147

Email address: khosak.ac@spu.ac.th.

manufactured, considering the natural frequency as one of the quality control parameter.

The pivot bearing is one component that influences the natural frequency of the HSA. The pivot bearing is studied by many researchers [4]-[5]. The pivot bearing stiffness that affect HSA vibration is presented in [6]. The vibration study in HDD is done to specify the factor that relate to the vibration mode [7-9]. The simulation of the pivot bearing is also studied [10]. This research presents the effect of the pivot bearing assembly process using tolerance ring on the natural frequency of the actuator arm.

The pivot bearing and actuator arm assembly process is now done in two favourite methods i.e. using adhesive and using tolerance ring. Objective of both methods are to withhold the pivot bearing and the ACA (Arm Coil Assembly) together.

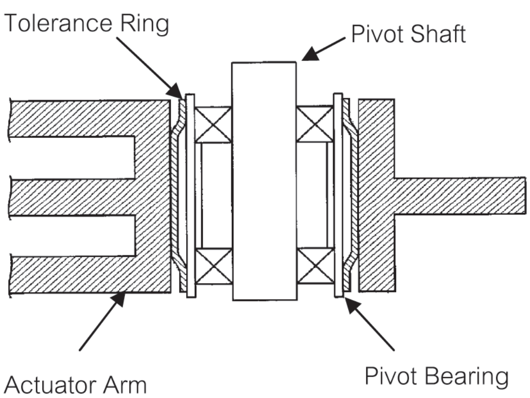

Figure 1 The Pivot Bearing Assembly Using Tolerance Ring

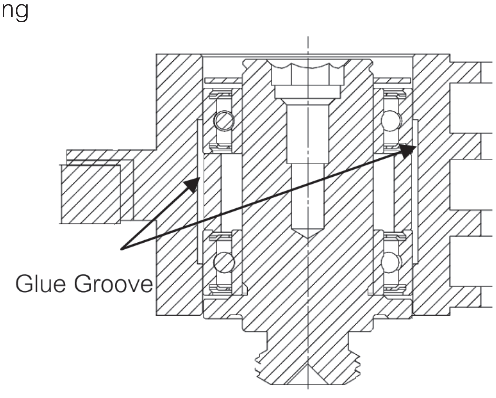

Figure 2 The Pivot Bearing Assembly Using Adhesive

The tolerance ring, that is a spring like metal ring, is inserted between the pivot bearing and ACA as illustrated in Figure 1. The tolerance ring fixed the pivot bearing and the ACA together by the friction of its surfaces. Another method is the adhesive injection method, illustrated in Figure 2. The adhesive is injected into the space between the pivot bearing and the ACA that is usually called glue groove. This research focuses on the glue injected method.

2. Experiment

This research objective is to find the relationship of the adhesive and the natural frequency of the actuator arm. The adhesive role is to withhold the pivot bearing and the ACA together. After injected, the adhesive is assumed to be a hollow cylinder locates between the pivot bearing and the ACA. So, the vibration between pivot bearing and ACA is transfer through this hollow cylinder.

2.1 Assumption

The assumption of the experiment is listed below:

- The modal frequency of the actuator arm is related to the depth of the glue groove.
- In the experiment, the material property of adhesive is considered to be uniform and invariable.

2.2 Experiment Setup

To vary the thickness of the adhesive hollow cylinder, the inside diameter of the ACA is categorized into five different size, as shown in Table 1. Since the tolerance of the inside diameter of ACA is ± 0.075 mm. so, all group of specimen are the quality conformance part. Each group of the specimen consist of five samples. The ACAs were tested for the modal analysis. The ACA level test results show none of significant different in modal frequency. Since, there is none of the modal frequency shift come from the variation of the inside diameter of ACA then, the Actuator Arm assembly process have been pursued. Figure 4 illustrates the experiment setup. The excitation is periodic function generated by the signal generator and is directly connected to the voice coil of the Actuator Arm. The vibration is measured using the LDV (Laser Doppler Vibrometer) and SLDV (Scanning Laser Doppler Vibrometer). The vibration analysis of the actuator arms has been completed.

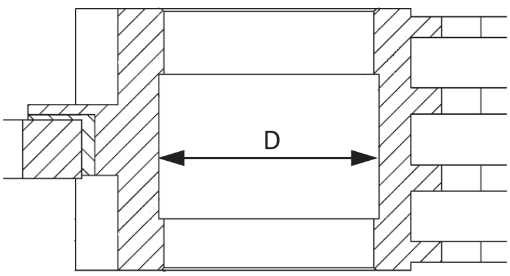

Figure 3 The inside diameter of ACA in the cutaway view

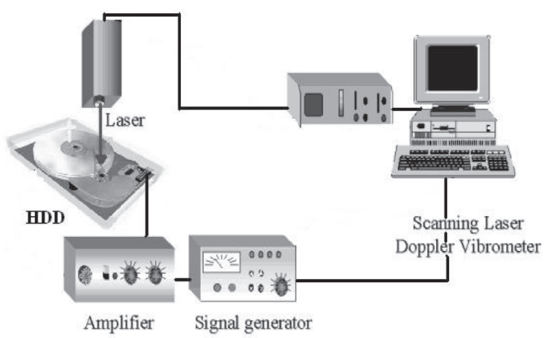

Figure 4 The experiment setup

Table 1 Inside diameter of ACA at glue groove

Group	Inside Diameter (mm.)
1	STD.+0.075
2	STD.+0.05
3	STANDARD SIZE
4	STD.-0.05
5	STD.-0.075

2.3 Finite Element Model

The Finite Element Model of the actuator arm and pivot bearing are also developed. The 6-DOF model is constructed by the FEA software. The 4-node tetrahedral element mesh is applied. The contact boundary of the system is set to the fixed contact at the inside of the pivot bearing. The FEM modal analysis results are compared with the experiment result.

3. Result

3.1 Experiment Result

Table 2 is the mean of measurement results of the modal frequency at each mode of each group. The experiment shows that the modal frequency of mode 5 and mode 6 is significantly different in each group of specimen. Figure 5 - 7 illustrate the mode shape of the actuator arm.

3.2 FEM Result

Table 3 show the modal frequency form FEM. The FEM result presents the same mode shape as the mode shape from the experiment result but give slightly different modal frequency. Table.4 shows the percent of different between the modal frequency from experiment and from FEM.

Table 2 The measured modal frequency (Using SLDV)

Mode	Modal Frequency of Each Group (kHz)				
	1	2	3	4	5
1	11.795	11.464	11.325	11.827	11.720
2	20.552	20.488	20.573	20.419	20.699
3	26.664	26.824	26.856	26.824	27.005
4	28.083	28.264	28.317	28.360	28.509
5	34.952	35.069	35.315	35.380	35.485
6	41.149	41.459	41.619	41.352	41.683

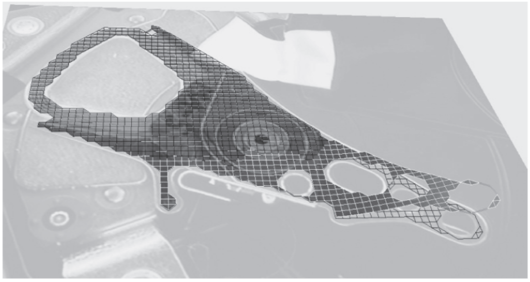

Figure 5 The example of mode shape of the actuator arm bending mode at 11.7 kHz

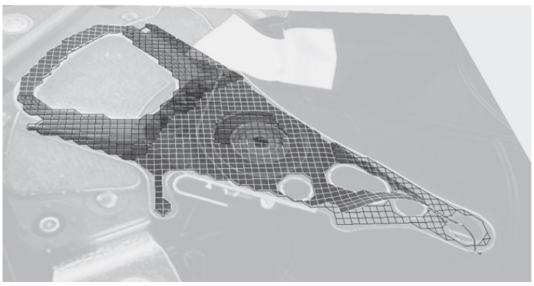

Figure 6 The example of mode shape of the actuator arm torsion mode at 20.5 kHz

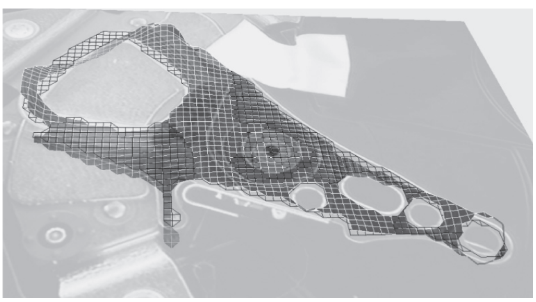

Figure 7 The example of mode shape of the actuator arm torsion mode at 35.3 kHz

Table 3 The Modal Frequency (FEM)

Mode	Modal frequency of each group (kHz)				
	1	2	3	4	5
1	11.975	11.964	11.949	11.927	11.920
2	21.452	21.584	21.719	21.849	21.899
3	27.864	28.024	28.156	28.324	28.405
4	29.283	29.464	29.717	29.960	30.309
5	36.552	36.769	36.915	37.180	37.385
6	43.449	43.759	44.019	44.452	44.883

Table 4 Comparison of the result

Mode	Modal Frequency of Group 3 (kHz)		% error
	experiment	FEM	
1	11.325	11.949	5.22
2	20.573	21.719	5.28
3	26.856	28.156	4.62
4	28.317	29.717	4.71
5	35.315	36.915	4.33
6	41.619	44.019	5.45

4. Conclusion

To find the root cause of non-conformance condition, the dimensions of the component are discussed and are set up as the experiment parameters. The results show the relationship between variation of the depth of glue groove and the natural frequency of the actuator arm. Since, the modal analysis of the ACA showed none of the significant different of modal frequency then, the depth of glue groove is one of the root causes of modal frequency shifting in ACA. The FEM result is agree with the experiment result.

For the further research, some other parameters should be considered. The vibration in the vertical plane should be measure. The material property of the adhesive must be known to give the more accurate FEM result. The difficulties of the experiment is controlling of the quality of the specimens, since there are a lot of part in the HDD could affect the modal frequency.

5. Acknowledgement

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