Study the factor from tolerance with the result to Gram load of Head Stack Assembly

Presented in 1st Data Storage Technology Conference (DST-CON 2008)

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Abstract

Nowadays, Hard Disk Drive industrial is growing with research and development, which focus on a cost reduction and an increase of process performance. Main problem that occurs in the assembly process is the inappropriate tolerances, which cause to Gram Load value. This research studies the dimension and tolerance that relate to Gram Load value. The tolerances are generated in the Head Stack Assembly process. In addition, the mathematical model is generated to explain the relative of each parameters and it could be used for control and decrease the error of the assembly process.

Keywords: tolerance study, Gram load, mathematical model.

Introduction

Disk drives are multi-component products in which product build variations directly affect quality. Dimensional management to predict and optimize critical parameters in head stack assembly. It applies statistical techniques to predict the amount of variation that can occur in the disk drive due to the specified design tolerances. In the past, the cumulative tolerance at the development stage for parts assembled together was verified by manual root extraction from the sum of squares in a two-dimensional drawing. Generally, however, the complicated structure parts of Hard disk drive cannot be accurately estimated by the conventional calculation procedure. One problem that occurs in the process is inappropriate tolerances, which affect the suitable Gram Load.

The physical realization of any part always yields imperfect forms with respect to the ideal geometry specified in the engineering design. In order to describe and preserve functional requirements of design, the allowable variation is specified using modern geometric tolerances via tolerance zones. The syntax of the current geometric tolerance specification is complex with 14 basic symbols and 8 modifiers. The meaning of the syntax - the semantics - has to be interpreted based on the feature under consideration, such as cylinder, sphere, cone, slots, tabs, free-form surfaces and their 2D counterparts consider Figure 1(a) which illustrates a part with geometric tolerance specification. The shaded area in Figure 1(b) indicates the corresponding tolerance zone, as per the specification, within which the produced

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(actual) part should lie (Pasapathy et al.,; J.Meadows; The American Society of Mechanical engineering,).

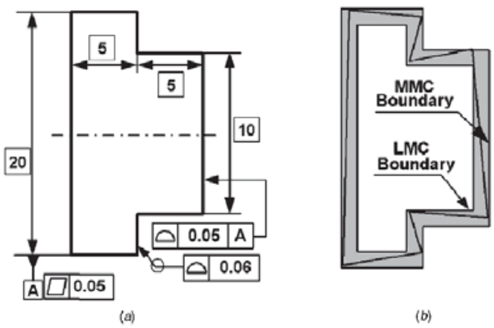

Figure 1. (a) A part with geometric tolerance callouts (b) An instance of the actual part that is acceptable as per specification provided in Figure 1(a)

This research is to study the influence of tolerance on Gram Load. The tolerances are generated in the Head Stack Assembly process from Actuator Assembly, Pivot Bearing, Head Stack Assembly, Hinge Thickness, Parallelism of Pivot, Base Plate Thickness etc. This paper presents tolerance analysis describing the measurement values produced and an analysis of the process capability, C_{pk}, to ensure robust designs (Deckert, 1990 ;Schlatter, 1996 ;Katsumaru et al., 2005.;Gao and Ang, 2006;Atkinson et al.,1999). Besides measurement error, another factor that plays an important role in the effectiveness of the gram load adjust process is the sensitivity of the flying height to the gram load. To understand the effect of these parameters, a Monte-Carlo simulation of the adjusted process was carried (Singh et al.,2001). The mathematical model is generated to explain the relation of each factor and the mathematical model could be used to control and reduce the error of the process.

Tolerance Stack-up Analysis

First, the capabilities and limitations of this methodology must be understood. Only after an assembly has been analyzed for nominal parts, tools, or assemblies variations are applied to determine whether the product functionality meets the design requirements. The tolerance analysis allows the designer to virtually build disk drives even before prototypes are made. This paper use tolerance stack-up analysis to seek the answer.

Tolerance stack-up analysis is an entirely different way of looking at assemblies. Unlike geometric dimensioning and tolerancing (GD&T) practices which analyze worst case boundaries, but best case assembly condition, tolerance stack-up calculates worst case boundaries and worst case assembly conditions. GD&T usually assumes the parts will be assembled optimally, so that even if part features are produced at their worst size, form, it still fits together. Tolerance stack-up looks at it differently. It not only consider that arts might be produced at their worst case size, form, orientation and location, but that they also assumes the most unfortunate assembly conditions. It determines what the worst case assembly conditions would be if we tried to push the parts in the assembly to their extremes.

The flow diagram of tolerance stacks up and generate mathematic model as shown in Figure 2 by starting with a design loop analysis for the head stack assembly. Next, parameters are listed and dimension to bilateral tolerance of each factor and specify multiplier computation. The multiplier is a changing shape factor which can be categorized as follows.

1. Geometric multiplier is any spatial multiplier that increases or decreases the applied

1.Generate design loop analysis for HSA assemblies

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2.List of concern parameters and convert all of dimension to bilateral tolerance design form and specify constant distance for Multiplier computation

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3.Compute statistic and Geometric multiplier for each dimension that relate to head stack assemblies dimension control

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4.Enter all of the dimensions that relate to loop analysis for C_{Pk} computation

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5.Generate mathematic model to explain the relationship of each factor.

Figure 2. Flow diagram of tolerance stacks-up

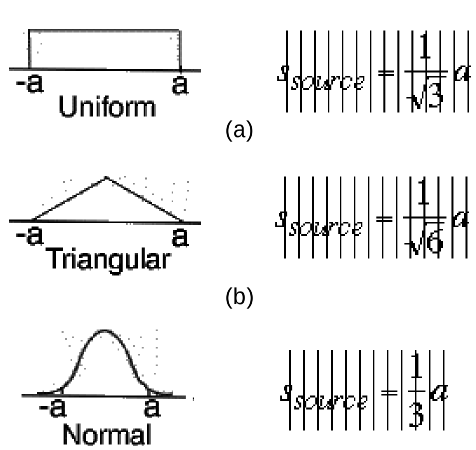


Figure 3. (a) Uniform distribution (b) Triangular distribution (c) Normal distribution

tolerance where the applied tolerance is affected by geometry.

2. Probability multiplier is a modifier that reduces the applied tolerance of a component depending on its orientation.

3. Statistical Multiplier uses the tolerance distribution multiplier.

After multiplier computation, a multiplier which includes the effect of measurement error is obtained. The statistic of parameters needed to be controlled is computed next where the statistical method used is the tolerance distribution and can be categorized as follow:

1. Uniform distribution leads to the most conservative estimation of uncertainty; i.e., it gives the largest standard deviation. The calculation of the standard deviation is based on the assumption that the end-points, ± a, of the distribution are known. It also embodies the assumption that all effects on the reported value, between -a and +a, are equally likely for the particular source of uncertainty as shown in Figure3 (a)

2. Triangular distribution leads to a less conservative estimate of uncertainty; i.e., it gives a smaller standard deviation than the uniform distribution. The calculation of the standard deviation is based on the assumption that the end- points, ± a, of the distribution are known and the mode of the triangular distribution occurs at zero as shown in Figure3 (b)

3. Normal distribution leads to the least conservative estimate of uncertainty; i.e., it gives the smallest standard deviation. The calculation of the standard deviation is based on the assumption that the end-points, ± a, encompasses 99.7 percent of the distribution as shown in Figure3 (C) (Atkinson et al.,1999)

After the multiplier and statistic are computed, all of dimension that relates to loop analysis for C_{Pk} computation must be gathered in order to generate a mathematic model. The outputs shown in Figure 3 contain statistics describing the measurement values produced during simulations, process capability (C_{Pk}), and a histogram showing the measurement values graphically. The tested distribution was normal and C_{Pk} was calculated as follows:

$$C_{pk} = \frac{mean - LDL}{3\sigma}$$

where mean and σ are the mean standard deviations of the sample data and LDL is lower design limit (Schlatter, 1996).

Application To Generate Mathematical Model

Shown in Figure 5 is a loop analysis of head stack assembly. This figure begins from slider arriving at the hinge. Symbol b and c refers to the thickness of hinge and base plate respectively. The actuator arm height is referred as symbol d. It begins from the top arm downwards to the bottom actuator arm. Last, symbol e is a pivot bearing height which the parameters and dimension of each parameter are shown in Table 1.

Table 1 Parameter and dimension

No.	Parameters	Nominal
a	Slider to Hinge	0.0453
b	Hinge Thickness	0.0254
c	Base Plate Thickness	0.1620
d	Actuator Arm - Height	0.9650
e	Pivot - Height	0.3100
f	Pivot : Perpendicularity of hole Actuator Arm	0.0000

The thing that takes interest is gap. It is variable in mathematical model which leads to multiply with stiffness constant of suspension will get Gram load. In order to generate a mathematical model, Table 2 is shown where each parameter are valuable tolerances and multipliers. It can be seen from table 2 that the hinge thickness, the base plate thickness and the actuator arm height have normal distributions. The normal distribution has a statistical multiplier which is related to the root sum of squares (RSS) where the tolerance analysis is based on the tolerances having normal (3 sigma) distributions. If a tolerance is to be controlled by C_{Pk}, then the minimum goal must have a C_{Pk} of 1.33 or 4 sigma, thus

$$\frac{3sigma(normal)}{4sigma} = 0.75$$

Any tolerance with a C_{pk} call out would have a statistical multiplier = 0.75. Next, compute geometric multiplier of Pivot perpendicularity of hole actuator arm shown in Figure 4 that

$$GeoMult = \frac{46.42}{12.56} = 3.70$$

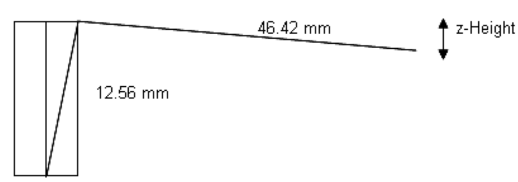
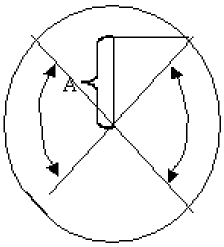


Figure 4. Geometry Multiplier of Perpendicularity

It would be too conservative to put the whole perpendicularity tolerance in the study in order to be able to calculate the probability multiplier, therefore, the tolerance with +/- 45 degrees was used as shown in Figure 5.



$$1=\sqrt{A^2+A^2}$$
$$1=\sqrt{2A^2}$$
$$A=\sqrt{\frac{1}{2}}=0.707$$

Figure 5. Probability Multiplier of Perpendicularity

Therefore, the probability multiplier is 0.707. From table 2 direction of dimensions are shown by assigning each dimension downward as negative (-) and upward as is positive (+). After the directions are assigned, we obtain vector of each dimension can be obtained which the worst of work (WOW) of effect tolerance and the root sum squares (RSS) can be found. A mathematical model generated from table 2 is show below:

$Gap = (1*1*1)a + (1*1*1)b + (1*1*0.75)c + (1*1*0.75)d + (1*1*0.75)e + (3.70*0.707*1)f$

$\text{Gap} = a + b + 0.75c + 0.75d + 0.75e + 2.616f$

Thus,

$$GramLoad = k*Gap.$$

where k is the vertical spring rate. Gram Load is the weight of head stack assembly before work.

The unequal values of the vertical spring rate depend on the hard disk drive production which the values are uncertain.

Table 2. Loop Analysis of Head stack assembly

No.	Nominal	Tol. (+/-)	Geo mult	Prop mult	Stat mult	Direction	Vector	Eff. Tolerance	Assumption Distribution
a	0.4530	0.0000	1.000	1.000	1.000	-1.00	-0.4530	0.0000	
b	0.0254	0.0025	1.000	1.000	1.000	-1.00	-0.0254	0.0025	Uniform
c	0.1620	0.0200	1.000	1.000	0.750	-1.00	-0.1620	0.0150	Normal
d	0.9650	0.0250	1.000	1.000	0.750	-1.00	-0.9650	0.0188	Normal
e	0.3100	0.0200	1.000	1.000	0.750	-1.00	-0.3100	0.0150	Normal
f	0.0000	0.0130	3.700	0.707	1.000	1.00	0.0000	0.0340	Triangle
						Gap.	1.9154	0.0853	WOW
								0.0443	RSS

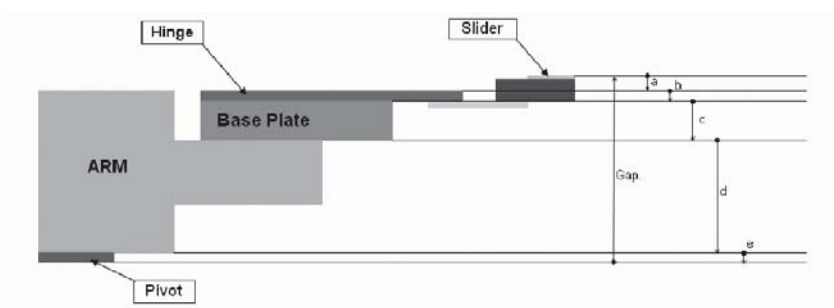


Figure 6. Loop Analysis of Head stack assembly

Summary

This paper presents a new approach to achieve the tight tolerances in the head stack assembly. The tolerance stack-up analysis is an adjusted technique which also provides a way to correct for the deviations caused by a multitude of parameters, after a head stack assembly or hard disk drive assembly. In order to approach to work effectively, one needs to generate a mathematical model. The tolerance analysis provides a valuable help and feedback to assist designers in understanding the effects of tolerance variations.

The mathematical model is generated to explain the relation of each factor and the mathematical model could be used to control and reduce the error of the process.

Acknowledgment

The authors wish to thank Mr. Therdthai Thienthong and Mr. Kiatfa Tangchaichit for helpful discussions. This work was possible due to the excellent research at Western Digitals (BangPa-In) Co., Ltd.

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