

Analyzing and exemplify the phenomenon of losing control in vibration experiment

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Abstract: With science and technology development, vibration testing as the most important item in reliability test is becoming more and more important, at the same time, vibrate condition becoming more and more complicated, the phenomenon increases that the output of controller goes beyond controlling range so that destroy the specimen. In this paper, some skills such as how to set the parameters of force controller, where to place the sensor, which material to be chosen and which skills to be used while making jigs were introduced to avoid the just matter. At last, some examples were given to prove the validity of the method proposed.

Key words: reliability; vibration; jig

1 Introduction

With the electronic technology developed and reliability improved in aeronautic product, vibration testing becomes more and more important. The purpose of vibration testing is to know whether the specimen still works well after endured vibrations from transporting, using and so on^[1]. And the specimen must go through different conditional vibrations to increase the reliability according to the related standards^[2].

Along with the control technology of products getting more and more complicated, the phenomena of losing control increased observably. This will lead to specimen destroyed and make the vibration system overload. The conflict will become more serious if the dynamic input signal is small. Operating skills are very crucial while solving the question. So the reason of losing control in vibration test will be analyzed in the following.

2 Analysis of the reason of losing control

In order to prevent the loss of control, we do research on several aspects such as numerical control system, jig design, the joint of jig, vibration worktable and the operating modes. It is concluded that the reason of losing control may exist in the following aspects:

The first reason is the resonance occurred between jigs and vibration worktable. In the course of vibration testing, resonance will occur if the testing frequency is

accordant with the natural frequency of the jig, which results in the output signals exceed the protecting upper limit, the vibration will stop right now, and thus the loss of control occurred. The controller still can work well that means the output signal can be kept between the upper and lower force limit while resonance occurred if the thrust is big enough that could compensate the shortcoming of the jig in a way.

The second reason is the unstuck connections among the vibration worktable, jigs and specimens. This is the major reason in causing loss control in testing.

During the complicated vibration testing, different parts of the measure system should be connected firmly. Otherwise, this will leading to impact among the loose connections; what's more, the measuring errors will increase greatly. If the loose components resonate in some certain frequencies, the measuring errors can reach to dozens percent or even to a hundred percent.

The improper fixing will result in the sensors falling off, the signal line breaking and the controller receiving no signals, and which leads to the output signal increased suddenly, and even the coil of vibration worktable be burned.

The third reason is that the gain of the controller or the power amplifier is too little, which makes an insufficient thrust and causes the loss of control in vibration^[3].

Further more, cracks on the jigs or worktable will lead to the loss of control in vibration^[4].

3 Solutions

Usually, each part of the vibration system is tested respectively to check whether it works well or not and the controller and vibration worktable will be firstly examined using the sine and random vibration without specimen on it. If the control output chart is normal and the worktable makes no abnormal sound, the controller and vibration worktable are in gear. Then the jigs, the installation of specimen and other factors are checked to looking for the reason of losing control^[5]. Based on our experiences, some advices are given in the following to find out the causes of loss of control in vibration.

3.1 Control method

There are three different control methods in vibration testing, single-point control, multi-point average force control and multi-point maximum force control. Sometimes, it also can be classified as worktable involved or not based where the sensors were placed.

Single-point control brings on bigger errors than the other two methods, which means the specimen is apt to be damaged.

What is multi-point control? Common numerical control system has several input-channels, one point on the specimen can be set as "control point", and the others be set as "measured points", then comparing the measuring results, and the points on specimen which have notable difference in phase will be draw up to one "control point".

Multi-point maximum force control is not used usually unless it is definitely required because it descended the vibration force passing to specimen.

Multi-point average force control, the method is often used in great components testing. Better effect can be obtained if it is applied rightly.

If different parts of specimen have the similar response characteristics, the multi-point average control does not take a good effect. In order to improve the efficiency of multi-point average control, control points with different response characteristics should be involved. Choosing the plane of worktable as the control point is the best choice according to specific testing conditions. The control method of placing one or several sensors on both the worktable plane and the specimen is called multi-point average control worktable involved and the control signals are the average of the sensors, and the peak of signals from specimen decreased after averaging the signals from worktable's, meanwhile, the valley points are heighten after averaging the signals of the worktable plane, driving force decreased at the demand of vibration worktable, and it

is ready for testing.

Fig. 1 shows the sine vibration chart in the testing experiments, the "over-value test" and "lack-value test" can be triggered at the resonance frequency 70 Hz and valley frequency 160 Hz respectively.

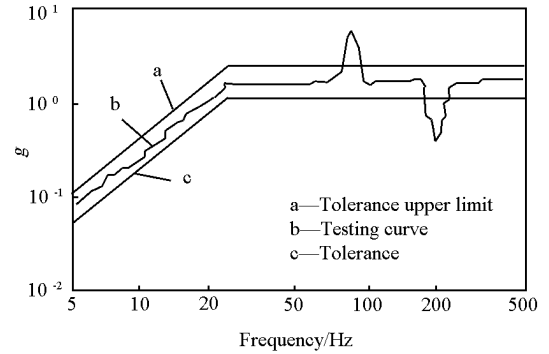


Fig. 1 Control chart of vibration testing

Fig. 2 shows the multi-point maximum force control that worktable is not involved, and Fig. 3 shows the multi-point maximum force control that worktable is involved, while the worktable involved, the error at peak and valley frequency is obviously less than the way worktable not involved.

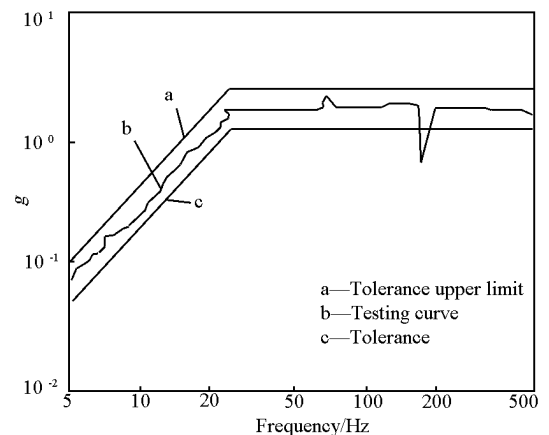


Fig. 2 Maximum control (worktable not involved)

Fig. 4 shows the multi-point average force control that worktable involved, and Fig. 5 shows the counter-point that worktable not involved. The error at peak frequency is approximately a quarter of single-point control, and the error at valley frequency is about twenty percent of single-point control, and it also has better effects than the multi-point maximum force control.

3.2 Installation of specimen

Several aspects on assembling procedure should be noticed to avoid resonance.

1) Adding the screws between jig and worktable, the jigs and the table should be solidly connected like a single rigid body.

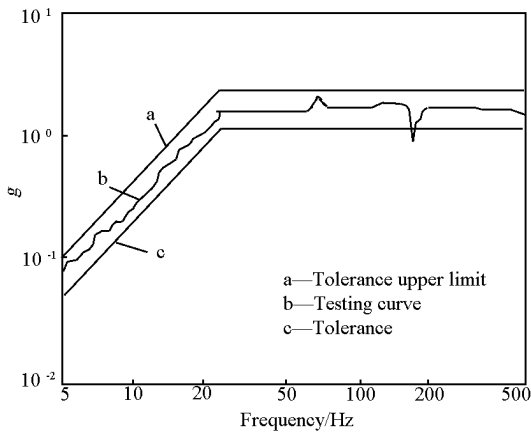


Fig. 3 Maximum control (worktable involved)

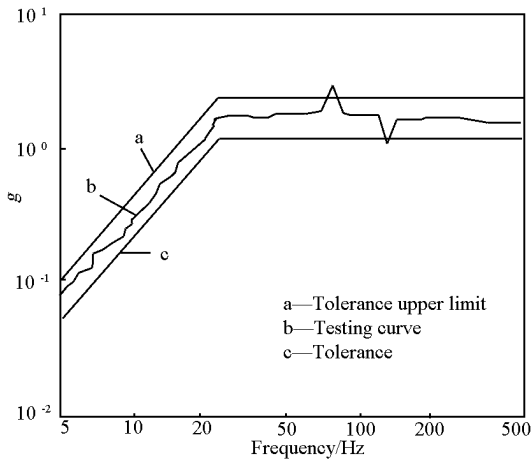


Fig. 4 Average control (worktable not involved)

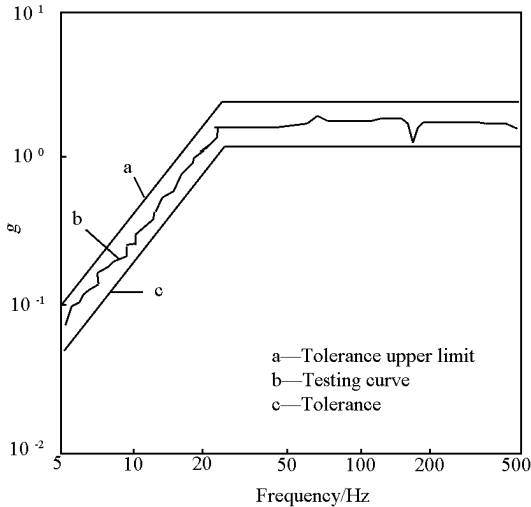


Fig. 5 Average control (worktable involved)

2) If it is possible, damped material can be filled between the jigs and worktable. Sometimes, the matching errors exist between the jigs and vibration worktable. To this situation, gaskets or silicone rubber can

be filled into the gap to compensate these errors. The silicone rubber is a good material to avoid rigidity collision between jigs and worktable, because it is liquid normally, and easily wiped off after it is solidified, and with the characteristics such as low and high temperature resistance, waterproof and insulation.

3.3 Jig designing

While designing jigs, it should be considered that the jigs' natural frequency must be higher than the biggest frequency of vibration test^[6]. The rate between Elastic modulus and density of the material directly determines the material's natural frequency, and it also affects the resonance frequency, the bigger the E/ρ and the bigger the resonance frequency. The best material is magnesium alloy, and the next is aluminium alloy^[7].

Some experiences have accumulated for jig designing in vibration testing.

- 1) The vibration test requires the jigs with high natural frequency. And thin wall jigs should not be used in the high frequency vibration test.
- 2) The vibration jigs made of a single piece of material are the cheapest and have the greatest performance. The whole molten or welding jigs are better, and the worst are the jigs connected with bolts.
- 3) Enough screws should be fixed between the jigs and worktable to ensure the connection between them closest. The outer diameter size of the contact face between the jigs and worktable should not exceed the maximal outer diameter of the worktable.
- 4) The height of the jigs should be kept as low as possible. The center of gravity of jigs and specimen should be placed as close as possible to the center of the worktable.

4 Conclusions

To reduce "loss of control" in the vibration test, several aspects should be concerned, for instance, choice of the places of control points and control methods, jig design and assembling and so on.

Usually, resonance will occur in vibration test. Redesign should be taken into consideration if the resonance inside the specimen so serious that the testing can not go through all right. If the resonance caused by outside factors, the skills introduced in this paper should be applied.

References

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