Research On Dynamic Stability Of Vibrating Disk Worktable

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Abstract: This paper studies the influence of the material quality in the vibrating plate and the relative height difference of the leaf springs on the stability of the worktable, in order to obtain the disturbance law; firstly, the control variable method is adopted and the Ansys workbench software is used to determine the quality of different materials on the worktable under static force. Secondly, the deformation of the beam and the crossbeam was compared by a simulation test. The results showed that the heavier the material, the greater the deformation of the upper beam and the smaller the deformation of the crossbeam. Finally, the harmonic response method was used to study the effect of the height difference of the leaf spring on the deformation of the beam and the crossbeam of the worktable. The results show that the greater the height difference, the smaller the impact on the stability of the workbench.

1. Introduction

The vibrating plate is a typical mechanical feeding and feeding mechanism [1-3]. Its principle is to form a suction and reciprocating movement through the electromagnetic drop of the chassis and the plate spring on the hopper to drive the center of the vibrating plate in the hopper. Small parts move forward [4-7]; in some cases, the vibrating plate will be placed on the workbench to adapt to the height of the conveyor belt. Due to the vibration properties of the vibrating plate, it may affect the stability and practicability of the workbench. Certain disturbance and damage effects, especially when the vibrating plate resonates with the worktable, the damage to the worktable will be more serious, and its service life will be greatly shortened [8-9]; Li Dong [10] on the multi-ring vibrating plate The working mechanism and structure of the micro-gyro are studied, and nickel metal with larger mass is selected instead of silicon as the material of the micro-gyro vibrator of the multi-ring vibrating disk, thereby improving the performance of the vibrating disk; Zhang Liang [11] on the structural strength of the vibrating disk Checked and obtained the internal stress distribution and fatigue life of the vibrating plate; and further optimized the vibrating plate support tube; Yang Jiawu et al. [12] analyzed the mechanics of the vibration transmission of the vibrating plate, and established a vibrating plate through a three-dimensional drawing software. The three-dimensional model of the feeder, and the analysis of its natural frequency and harmonic response with ANSYS software, verify the rationality of its design parameters.

The above research seldom involves the study of the influence of the vibrating plate on the stability of the worktable. In response to this problem, this paper studies the influence of the change of the material quality in the vibrating plate and the relative height difference of the leaf spring on the stability of the worktable, and got its influence rule through the method of simulation test.
2. Structure composition and material mechanics analysis

2.1. Structural composition
The object studied in this paper is the combined model of cylindrical vibrating plate and worktable. Its overall structure is shown in Figure 1. Above is a cylindrical vibrating plate. This type of vibrating plate is generally used to transport workpieces with simple shapes and smaller sizes, like screws, switches, etc. because the structure of the workpiece is relatively simple and small, the diameter of the hopper of the cylindrical vibrating plate is not very large. The material is usually aluminum alloy, which is light in weight and low in cost [13]; the following is the vibrating plate Workbench; Among them, 1 is the damping pad, 2 is the base, 3 is the leaf spring, 4 is the electromagnet, 5 is the spiral track, 6 is the hopper, 7 is the vibrating disk workbench, when the vibrating disk is working, it is installed on the reciprocating movement of the three leaf springs on the upper part makes the hopper connected to it and do the same movement, due to the interaction, the worktable bearing of the vibrating plate will also be subjected to the corresponding reciprocating force, which can be simplified as a simple harmonic force.

![Figure 1 Overall combination structure](image)

2.2. Material mechanics analysis
It is easier to understand the working principle of the conveyed material by mechanical analysis. Figure 2 is a schematic diagram of the force of the material; the analysis of the force can be divided into two stages, one is that the material is stationary on the hopper track, and the other is when it is subjected to vibration. Forward jumping occurs; in order to prevent the material from sliding down when it is stationary and jumping forward when subjected to vibration force, the vertical value of the corresponding state can be obtained respectively.

The static conditions are:

\[ F = Mg \cdot \sin(a); \quad f = u \cdot Mg \cdot \cos(b); \quad f > F \quad (1) \]

The conditions of forward jump are:

\[ F_i = A \cdot \sin(\omega t); \quad F_i \cdot \cos(b) > Mg \cdot \sin(a) \quad (2) \]

Among them, \( F_i \) is the force given to the material by the leaf spring, \( Mg \) is the gravity of the material, \( F \) is the force required to slide upwards, \( f \) is the friction force, \( A \) is the angle between the material and the horizontal plane, and \( b \) is the angle between the force of the plate spring on the material and the sliding direction of the material.
3. Vibration table finite element model and Initial setting of model simulation

3.1. Finite element model
The vibrating plate is in direct contact with the worktable surface through three support seats. When working, the three plate springs of the vibrating plate are attracted by the high frequency of the electromagnetic coil to drive the hopper to perform reciprocating and simple harmonic motion, so that the worktable is also subjected to a simple harmonic motion. Harmonic reaction force, in order to reduce the workload of simulation, the vibrating plate is simplified as follows, which is simplified to three remote mass points at the leaf spring, each mass point has a self-weight of 6Kg, and the three remote mass points are vertical. The relative height difference between the two directions is H, the force of each point is a simple harmonic force, the amplitude is the same, the frequency is the same, and the phase angles differ by 120 degrees. $F_1$, $F_2$, and $F_3$ represent remote mass points 1, 2, and 3 respectively.

Then the corresponding expressions are:

$$F_1 = A \cdot \sin(\omega t); \quad F_2 = A \cdot \cos(\omega t + 30); \quad F_3 = A \cdot \sin(\omega t - 60) \quad (3)$$

Among them, $A$ is the amplitude, the unit is mm; $\omega$ is the angular velocity, the unit is rad/s; $t$ is the time, the unit is s.

According to the above analysis, the finite element model can be established as shown in Figure 3.

3.2. Initial setting of model simulation
To study the influence of the material quality in the vibrating plate and the relative height difference of
the leaf spring’s center of mass on the stability of the workbench, a reference basis must be selected as
the evaluation criterion; the magnitude of the stress is used as the basis for evaluation. Taking the
model under its own weight (material mass is zero) to select the structural deformation and stress as
the basic reference data for studying the material quality factors on the stability of the worktable. Due
to the effect of the simple harmonic force on the leaf spring, the relative height of the leaf spring, the
evaluation of the difference refers to a comparative study based on the different values of its own
variables.

In order to obtain the deformation and stress of the selected structure under its own weight, the
weight of the vibrating plate is first assigned to three remote mass points respectively, and the
deformation curve and stress curve of the two structural beams under its own weight can be obtained
through workbench calculations, as shown in Figure 4. As shown in 5.

![Figure 4 Reference curve of basic deformation](image1)
![Figure 5 Basic stress reference curve](image2)

It can be seen from the curve in Figure 4 that the maximum deformation of the upper beam of the
fixed support at both ends under uniform load. It is consistent in the middle, and because the beam is
farther away from the vibrating plate than the upper beam, its deformation is relatively smaller.

It can be seen from Figure 5 that without external force, the stress on the upper beam first increases
and then decreases, and it fluctuates irregularly. It is considered that it is caused by the irregular node
division, and the maximum stress on the beam is on both sides of the structure. The stress value first
decreases and then increases, and then decreases and increases.

4. Simulation test and analysis
This section focuses on the influence of the material quality and the relative height difference of the
leaf spring’s center of mass on the deformation of the upper beam and the cross beam, the simulation
method is used to replace the physical test, and then the two factors on the workbench are explored by
processing the results of the simulation test. The greater the amount of structural deformation, the
greater the damage to the workbench.

4.1. Research on the influence of material quality on stability
Because the simple harmonic force needs to be applied to the leaf spring, in order to reduce the
simulation work time, first analyze the influence of different material mass m1 under static load on the
evaluation structure, set m1 to 9Kg, 15Kg, 21Kg, and keep the center of mass of the leaf spring
relatively the height difference remains unchanged, and the relevant data can be obtained through the
simulation test. After processing, the curve shown in Figure 6 and 7 can be obtained.
4.2. Research on the influence of relative height difference on stability

The vibration principle of the vibrating plate-worktable model studied in this paper is that the vibrating plate performs periodic reciprocating motion through three leaf springs connected to the hopper. The essence of the reciprocating motion is the electromagnet on the vibrating plate body and the winding around it. High frequency current is switched on and off at a high rate to form an intermittent magnetic field of a given strength, which then adsorbs the leaf spring to make it perform high-frequency reciprocating motion, which in turn drives the hopper to respond accordingly; while the leaf spring in the structure is not in the same horizontal plane as its relative position. But it has the same height difference in the vertical direction, as shown in Figure 8.

In order to study the influence of the relative height of the three leaf springs on the stability of the worktable in the model; three different height difference models were established; the deformation of the above beams and crossbeams was used as the basis for judging the stability of the larger, the worse its stability. This simulation uses dynamic harmonic response analysis for simulation experiments; the corresponding simple harmonic forces are assigned at the three mass points, and the corresponding test results can be obtained by adjusting the relative height difference. The test data can be sorted and analyzed to obtain the following curve picture.

![Material quality and the amount of deformation at different positions of the upper beam](image1)

![Material quality and the amount of deformation at different positions of the beam](image2)

![Figure 8 Relative height difference of leaf spring](image3)

It can be seen from Figure 9 that the larger the relative height difference, the smaller the deformation, the more stable the structure, and the smaller the height difference, the greater the deformation, that is, the more unstable. When the height difference is 10mm, the deformation of the
upper beam structure The largest, the downward deformation is about 18mm, and it is located at 2/3 of the overall structure.

![Height difference-upper beam deformation](image)

![Height difference-beam deformation](image)

It can be seen from Figure 10 that the maximum deformation of the beam still occurs under the condition of a small height difference. Under the conditions of a height difference of 30mm and 50mm, the deformation and deformation trend of the beam are almost the same. When the height difference is 10mm, the maximum deformation is about 7mm, which occurs at about 1/5 and 4/5 of the overall position of the beam structure, and it is bent in an inverted S shape.

In summary, for the height difference of the leaf spring, the smaller the value, the greater the deformation of the worktable, the more unstable the structure; the greater of the height difference, the smaller of the structural deformation, and the smaller impact on structure, the smaller the damage is.

5. Conclusion

5.1 Using the controlled variable method, the material quality and the relative height difference of the leaf springs have been systematically studied on the influence of the stability of the worktable. The research on the material quality uses the static loading method and works under its own weight. The deformation and stress of the beams and beams on the platform are used as the reference basis, and the next parameter data of different material quality is obtained by the method of simulation test. Through analysis, the material quality is too large or too small will have a certain impact on its stability.

5.2 The effect of the relative height difference of the leaf springs on the stability of the worktable is studied by using the harmonic response method. The results show that the greater the relative height difference, the smaller the influence on the stability of the worktable. The reason is that when the leaf springs are all in the same in the horizontal plane, the structure resonates.

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