

DESCRIPTION

Method of Correcting Rotational Unbalance of Rotating Mechanism and Correcting Device of the Same

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Technical Field

The present invention relates to a method of correcting rotational unbalance of a rotating mechanism and a correcting device of the same. For instance, in a spindle motor used in a hard-disc-driving apparatus, rotational
10 unbalance is produced at assembling the motor or mounting a magnetic disc to a rotary shaft of the motor. The correcting device is used for adjusting that unbalance.

Background Art

15 Fig. 8 is a perspective view illustrating a structure of a conventional hard-disc-driving apparatus.

One or plural discs 311 are stacked up and mounted equidistantly to hub 321 driven by a spindle motor. Magnetic head 319 is movably disposed above a single side or both sides of disc 311. Head 319 is mounted to a tip of rotor-actuator 318 on which coil 320—an element of a voice-coil-motor—is disposed.
20 Spin of the spindle motor produces an airflow between the side of disc 311 and head 319, thereby floating head 319 slightly off the side of disc 311.

The voice-coil-motor drives head 319 around pivot 322 and moves above disc 311 in the radial direction, so that head 319 reads or writes data. Head
25 319 floats off the disc by a space ranging from several dozens nano-millimeters to several hundreds nano-millimeters. Dust between head 319 and disc 311 would damage both head 319 and disc 311. Therefore, hard-disc-driving

apparatuses are assembled in a clean room, and then the apparatuses are sealed with cover 317. The hard-disc-driving apparatus thus manufactured includes dimensional errors of each element and errors due to mounting those elements. Those errors misalign a gravity center of rotating members including discs with the center of a rotating shaft, thereby producing unbalance in rotating. This rotational unbalance produces vibration, which makes the head follow data-tracks on the disc less fidelity and increases noises. When this apparatus is incorporated in a computer hardware as an outer storage device, those problems caused by the rotational unbalance adversely affect other devices within the computer hardware.

Fig. 9 is a lateral cross section of a conventional correcting device of rotational unbalance of a rotating mechanism, when the device is used in a hard-disc-driving apparatus.

A basic structure of the spindle motor mounted to this hard-disc-driving apparatus is described with reference to Fig. 9. This spindle motor is a fixed-shaft type. Shaft 304 as a rotating center of the motor is fixed to base 301. Shaft 304 extends through inner wall 3051 of an inner-ring section of bearing 305, and an inner wall 3062 of cylindrical hub 306 fits into outer wall 3052 of an outer ring section of bearing 305. Hub 306 thus can revolve on shaft 304, and hub 306 per se is a rotary shaft of the spindle motor.

Outer wall 3071 of ring-shaped back-yoke 307 fits into inner wall 3081, i.e. a lower part of hub 306, and outer wall 3081 of ring-shaped rotor magnet fixedly fits into inner wall 3072 of back-yoke 307. Stator core 302 is fixed to base 301 coaxially with shaft 304, and faces an inner wall of magnet 308 via annular space. Stator core 302 is wound with coil 303. When coil 303 is powered, magnet 308, yoke 307 and stator core 302 produce magnetic field, which drives the motor. Yoke 307 can be eliminated, and instead, outer wall 3081 of ring-

shaped rotor magnet 308 is directly fixed to inner wall 3063 of hub 306. In this case, hub 306 also works as a back-yoke thereby actualizing the function of the spindle motor.

5 A rotating mechanism of the motor lays its gravity center on the rotating shaft in theory; however, in actual, the gravity center does not always meets the rotating shaft due to dimensional errors of each element and errors at mounting those elements. As a result, rotational unbalance is produced.

Next, a method of correcting the rotational unbalance of the spindle motor is described with reference to Fig. 9.

10 A rotor section of spindle motor is assembled as follows: hub 306 is mounted rotatably to shaft 30, where rotor magnet 307 and the like have been mounted to hub 306.

Then rotational unbalance of the rotor section is measured, and at least one weight 309 is inserted into adjustment hole 3061 which has been formed on
15 hub 306 in plural numbers. Hole(s) 3061 — accepting weight 309 — locates symmetrically to the unbalance position (i.e. gravity center) with respect to the rotating shaft or near to the symmetric position. Shaft 304 is then fixed to base 301.

In this method, adjustment holes 3061 have been formed on a concentric
20 circle of the rotating shaft at regular intervals, therefore, any unbalance position can be corrected. Weight 309 has versatile types and different weights so that any unbalance can be dealt with. Weight 309 can be fixed by adhesive, or inserted into adjustment hole 3061 being elastically deformed and can be fixed with frictional force produced by elastic force urging hole 3061.

25 The spindle motor of shaft-fixed type is discussed above; however, the conventional method of correcting unbalance can be also applicable to a shaft-rotating type by forming the adjustment holes on a rotor section in advance.

Fig. 10 is a lateral cross section illustrating a rotational unbalance correcting device used in a hard-disc-driving apparatus. This is another conventional device for correcting rotational unbalance produced in an assembly of a motor and a disc.

5 A spindle motor has the same structure as shown in Fig. 9. To be more specific, three discs 311 are mounted on hub 306 at regular intervals with disc spacers 312 in between. Disc 311 is fixed to hub 306 by urging clamp disc 313 with tightening screw 314 into hole 3064. Disc 311 thus rotatably fixed to hub 306 which works also as the rotating shaft of the spindle motor, and rotates
10 together with hub 306.

A conventional method of correcting rotational unbalance of the spindle motor is described with reference to Fig. 10.

A rotor section of spindle motor is assembled as follows: hub 306 is mounted rotatably to the shaft, where rotor magnet and the like have been
15 mounted to hub 306. Then discs 311 are mounted to hub 306.

Then rotational unbalance of the rotor section including the discs is measured, and at least one weight 309 is inserted into adjustment hole 3061 which has been formed on hub 306 in plural numbers. Hole(s) 3061—accepting weight 309—locates symmetrically to the unbalance position with respect to the
20 rotating shaft or near to the symmetric position.

In this method, adjustment holes 3061 are formed on a concentric circle of hub 306 at regular intervals in advance, therefore any unbalance position can be corrected. Weight 309 has versatile types and different weights so that any unbalance can be dealt with. Weight 309 can be fixed by adhesive, or weight
25 309 is inserted into adjustment hole 3061 being elastically deformed and can be fixed with frictional force produced by elastic force urging hole 3061. Another way of fixing the weight is this: weight 309 having a protrusion 3091 made of

highly elastic material such as rubber is elastically deformed and inserted into hole 3061 so that protrusion 3091 is disposed between clamp disc 313 and hub 306 for preventing weight 309 from coming off hole 3061 due to shocks.

Fig. 11 is a plan view illustrating an essential part of a conventional device of correcting rotational unbalance, used in a hard-disc-driving apparatus.

The following is the description of the way of reducing the weight or moving the weight close to the rotating center on a straight-line connecting rotating center 400 and gravity center 450 (unbalance position) of a rotating section or near the line.

In Fig. 11, a correcting device of rotational unbalance comprises the following elements:

- ring section 310 having a positioning hole 3103 fitting to rotating shaft 316 at the center thereof;

- a plurality of supporting sections 3102 radiating from ring section 310;
- and

- weight section 3101 formed at the tip of each supporting section 3102.

This correcting device for rotational unbalance is fixed to shaft 316, i.e. rotating center shaft of rotating section 311, coaxially and rotatably. Supporting sections 3102 are made of thermoplastic material shrunk by heating. The rotational unbalance of entire rotating section 311 including this correcting device is measured, then supporting sections 3102 on the straight-line connecting rotating center 400 and unbalance position 450 or near this line are irradiated with laser so that the supporting sections are heated and shrunk. As a result, the weight 3101 moves closer to the rotating center.

This operation is repeated until the unbalance decreases less than a given value, so that the unbalance is corrected. Instead, some supporting sections 3102 can be cut away with laser beam to correct the unbalance, in this case,

supporting sections 3102 are not necessary made of thermoplastic material to be shrunk by heating.

The correcting device discussed above still has problems as follows:

In the case of inserting a weight into an adjustment hole, numbers of
5 holes should be formed on the hub in order to deal with any unbalance position. Thus mechanical rigidity decreases in the hub, so that the hub is vulnerable to deformation, which causes excessive warpage or undulation on a disc. Further, various kinds of weights should be prepared for dealing with any unbalance, and this increases the cost of the apparatus and the time for selecting an appropriate
10 weight, and incurs a defective due to misplacing a weight.

In the case of fixing a weight, the adhesive used for fixing the weight produces gasses, and the gasses would corrode the head and discs.

In the case of inserting the weight deformed elastically into the hole, elaborate operations are required such as holding a weight deformed into a
15 given shape, and inserting it into a given hole. Thus it takes time to adjust the production equipment, and incurs errors at insertion.

In the case of reducing the weight or moving the weight closer to the rotating center, the following problems occur: The supporting section subject to laser radiation is made of special material, and this boosts the cost, and further
20 it is not easy to control the amount of shrinkage by heating the supporting section. In the case of cutting away the supporting section, dust and gasses are produced at cutting.

Summary of the Invention

25 The present invention addresses the problems discussed above and aims to solve them.

The method of correcting rotational unbalance of the rotating mechanism

of the present invention comprises the following steps:

a step of mounting fixedly disc-shaped plate—having a plurality of protrusions radiating from its outer wall equiangularly—to a rotating center shaft of the rotating mechanism coaxially; and

- 5 a step of obtaining rotational balance of the rotating mechanism by bending at least one of the protrusions inward of the disc-shaped plate responsive to unbalance of the rotating mechanism including the disc-shaped plate.

- 10 A correcting device of rotational unbalance of the rotating mechanism comprises the following elements:

a disc-shaped plate fixed coaxially to the rotating center shaft of the rotating mechanism; and

- 15 a plurality of protrusions radiating from the outer wall of the disc-shaped plate equiangularly and being bendable independently inward of the disc-shaped plate.

- The correcting method and correcting device discussed above of the present invention can correct unbalance of any amount and any place by the following preparation: When the correcting device is assembled, the disc-shaped plate having protrusions is mounted to the rotating mechanism, and the
20 protrusion is bent inward of the disc-shaped plate. This method and device are free from contamination which has been produced by a conventional method or device such as adhesive or cutting the material. Therefore, the unbalance can be corrected with simple structure and operation.

25 Brief Description of Drawing

Fig. 1 is a lateral cross section of a rotational unbalance correcting device of a rotating mechanism used in a hard-disc-driving apparatus in accordance

with a first exemplary embodiment of the present invention.

Fig. 2 is a perspective view of a weight plate for correcting unbalance in accordance with the first exemplary embodiment.

Fig. 3 is a plan view of the weight plate shown in Fig. 2.

5 Fig. 4A and Fig. 4B are lateral cross sections illustrating a positional relation between protrusions of the weight plate and a magnetic head in the hard-disc-driving apparatus in the first embodiment.

Fig. 5 is a lateral cross section of a rotational unbalance correcting device of a rotating mechanism used in a hard-disc-driving apparatus in accordance
10 with a second exemplary embodiment of the present invention.

Fig. 6 is a plan view of the weight plate used in a third exemplary embodiment of the present invention.

Fig. 7A is a lateral cross section of a rotational unbalance correcting device of a rotating mechanism used in a hard-disc-driving apparatus in
15 accordance with a fourth exemplary embodiment of the present invention.

Fig. 7B is an enlarged view illustrating a recess section formed on a protrusion of the weight plate for correcting unbalance in accordance with the fourth embodiment.

Fig. 8 is a perspective view of a conventional hard-disc-driving apparatus.

20 Fig. 9 is a lateral cross section of a conventional rotational unbalance correcting device of a rotating mechanism used in a hard-disc-driving apparatus.

Fig. 10 is a lateral cross section of another conventional rotational unbalance correcting device of a rotating mechanism used in a hard-disc-driving
25 apparatus.

Fig. 11 is a plan view illustrating an essential part of the conventional rotational unbalance correcting device used in a hard-disc-driving-apparatus.

Detailed Description of Exemplary Embodiment

Exemplary embodiments of the present invention are demonstrated hereinafter with reference to the accompanying drawings.

5 (Exemplary Embodiment 1)

Fig. 1 is a lateral cross section of a rotational unbalance correcting device of a rotating mechanism used in a hard-disc-driving apparatus in accordance with the first exemplary embodiment of the present invention. Fig. 2 is a perspective view of a weight plate for correcting unbalance in accordance with
10 the first embodiment. Fig. 3 is a plan view of the weight plate shown in Fig. 2. Figs. 4A and 4B are lateral cross sections illustrating a positional relation between protrusions of the weight plate and a magnetic head in the hard-disc-driving apparatus used in the first embodiment.

In Fig. 1, a spindle motor has approx. the same structure as the
15 conventional one shown in Fig. 10 except the following points: In this first embodiment, clamp disc 13 is disposed for clamping three discs 11 on hub 6 with two disc spacers 12 between respective discs.

On top of clamp disc 13, disc-shaped weight plate 15 for correcting unbalance is placed, and screws 14 for tightening the clamp disc fix this weight
20 plate 15 together with clamp disc 13 to hub 6. Weight plate 15 is thus fixed to hub 6, i.e. a rotating shaft of the spindle motor, coaxially so that plate 15 can revolve around shaft 4.

After the discs are assembled to the motor, rotational unbalance of this assembly is measured. Then at least one of the protrusions 151 is bent inward
25 and deformed plastically on a straight-line segment connecting the rotating center and the gravity center or around this segment so that the unbalance can be corrected.

Weight plate 15 is detailed hereinafter with reference to Fig. 2 and Fig. 3.

Weight plate 15 is a disc-shaped plate having hole 156 at its center for fitting to shaft 4 rotatably. Numbers of protrusions 151 are formed on the outer wall of plate 15 equiangularly and protrusions 151 radiate from the outer wall.

5 Three mounting holes 157 are punched on plate 15 for being fixed to hub 6 with screws 14. Two positioning holes 155 for determining a rotational direction are formed symmetrically with respect to hole 156. Plate 15 is made of metal, and produced just by stamping a sheet of metal. Weight plate 15 can be thus manufactured in volume at a low cost.

10 Next, a method of correcting rotational unbalance is demonstrated.

Hub 6, magnetic discs 11, spacer-disc 12, clamp disc 13 and weight-plate 15 are assembled into a rotating mechanism, then rotational unbalance of the rotating mechanism is measured. Based on the measurement, at least one of the protrusions on weight-plate 15 is bent inward—the bendable protrusion is
15 on or near a straight-line connecting the rotating center and an unbalance position—so that the gravity center of protrusions 151 are moved closer to the rotational center. As a result, the rotational unbalance is corrected.

Regarding the plan positioning of weight-plate 15 at assembling, plate 15 is coaxially mounted to the assembly of the motor and the discs by inserting
20 shaft 4 into engaging hole 156. Therefore, an error of correction due to a difference of distances between the rotating center and any protrusion 151 can be a negligibly small amount, and any bent protrusion 151 would result in the same corrected amount. Regarding the positioning in the rotational direction of weight-plate 15 at assembling, straight-line segment 250 between two
25 positioning holes 155, as shown in Fig. 3, is treated as a reference line, and angle 200 formed by this reference line 250 and each protrusion 151 is determined. Therefore, the unbalance correction is free from an error and

defect due to miss-selection of a protrusion to be bent as well as defective bending due to displacement of bending jig on the protrusion. As a result, the unbalance can be corrected accurately. Meanwhile, this weight-plate 15 is shaped symmetrically with respect to the axial direction, and has no unbalance per se.

Regarding protrusions 151 of weight-plate 15, a correctable amount of unbalance increases at a greater distance from the rotating center or at a greater mass of the protrusions. On the contrary, a correctable amount of unbalance decreases at a shorter distance from the rotating center or at a smaller mass of the protrusions, thus an unbalance is finely adjustable. The mass of protrusion 151 is optimally determined based on the maximum unbalance producible from the design and assembly viewpoints as well as a specified amount of the unbalance.

Fig. 4A and Fig. 4B illustrate a positional relation between protrusions 151 and magnetic head 19 in accordance with the first embodiment. Regarding a space between disc 11 and protrusion 151, if protrusion 151 interferes with head 19 because of height limitation, tip 153 of the protrusion is shortened in the radial direction so that protrusion 151 does not interfere with head 19, as an arrow mark shows in Fig. 4A. Every protrusion 151 can be bent upward by a given length, as an arrow mark shows in Fig. 4B, in order to widen the space between tip 153 and the disc.

As such, weight-plate 15 has some flexibility in mechanical design which is specified for actualizing a location and mass of protrusion 151 based on the maximum unbalance producible from design and assembly viewpoints as well as the specified amount of the unbalance. In this first embodiment, a spindle motor of shaft-fixed type is used; however, a shaft-spin type spindle motor produces the same effect.

(Exemplary Embodiment 2)

Fig. 5 is a lateral cross section of a rotational unbalance correcting device for a rotating mechanism used in a hard-disc-driving apparatus in accordance with the second exemplary embodiment of the present invention.

In the rotational unbalance correcting device in accordance with the first embodiment discussed previously, if bent portion of protrusions 151 would disperse, then corrected amounts also disperse and the unbalance cannot be corrected as guaranteed. In general, bending process is practiced by attaching a jig to the member for determining which part should be bent.

In Fig. 5, root 152 of protrusion 151 has thinner thickness than tip 153, and the thickness of root 152 is the thinnest among other portions so that root 152 has the least stiffness to bending. Therefore, moment of bending applied to any portion of protrusion 151 results in bending at root 152 without using the jig attached to the protrusion. As a result, the unbalance can be corrected in a stable manner with less errors.

Protrusion 151 can be shaped in such that the thickness thereof decreases from tip 153 to root 152 linearly, as shown in the right hand side of the rotating center shaft in Fig. 5. Protrusion 151 can be also shaped in such that recess 154 is formed at root 152 as shown in the left hand side of the rotating center shaft in Fig. 5. Both shapes produce the same effect.

(Exemplary Embodiment 3)

Fig. 6 is a plan view of a weight plate used in the third exemplary embodiment of the present invention.

In Fig. 6, in order to alleviate the positional disperse at bending protrusion 151 of weight-plate 15, root 152 of protrusion 151 has a narrower

width than tip 153, and the width of root 152 is the narrowest among other portions of protrusion 151. Therefore, root 152 has the least stiffness to bending, and moment of bending applied to any portion of protrusion 151 results in bending at root 152. As a result, the unbalance can be corrected in a stable manner with less errors. Protrusion 151 can be shaped in such that a recess is formed on at least one of side faces of root 152.

(Exemplary Embodiment 4)

Fig. 7A is a lateral cross section of a rotational unbalance correcting device of a rotating mechanism used in a hard-disc-driving apparatus in accordance with the fourth exemplary embodiment of the present invention. Fig. 7B is an enlarged view illustrating a recess section formed on a protrusion of the weight plate for correcting unbalance in accordance with the fourth embodiment.

In general, bending process entails expansion and shrinkage, both being bordered by a neutral line, and the material broken by the expansion produces fine metallic powder. In a hard-disc-driving apparatus, this powder damages the head and discs. Therefore, weight-plate 15 must use a material allowing a large expansion before it is broken; however, the shape as shown in Fig. 7A or 7B allows plate 15 to withstand the breakage thereby widening a range of selective materials.

In other words, a recess of which cross section shows an arc or a part of oval is preferably formed on a back of a bendable portion of protrusion 151. This structure allows original length 271 to be elongated by bending root 152, and protrusion 151 is thus bent with less expansion. Thanks to forming this recess, materials more vulnerable to breakage can be selected, and when protrusions made of the same material, the protrusion having this recess is

harder to be broken and thus less metallic powder is produced. As a result, the protrusion with the recess achieves higher reliability.

The rotational unbalance correcting device for a rotating mechanism of the present invention, as discussed previously, can deal with a rotational
5 unbalance of any position and any amount by the following preparation: At assembly of the rotating mechanism, a weight-plate having protrusions is mounted to the rotating mechanism, and the protrusions are bent inward responsive to the rotational unbalance. This simple structure is free from producing contamination by adhesive or cutting the material, and realizes the
10 unbalance correction by simple work.

Industrial Applicability

The present invention is applicable, for instance, to a hard-disc-driving apparatus, and achieves rotational balance for a rotating mechanism of the
15 apparatus. A disc-shaped plate—having a plurality of protrusions disposed equiangularly and radiating from its outer wall—is mounted fixedly to a rotating mechanism, such as a hub, coaxially with mechanism's rotating center shaft. At least one of the protrusions is bent inward of the disc-shaped plate responsive to unbalance of the rotating mechanism including the disc-shaped
20 plate thereby adjusting rotational balance. This simple structure can correct the unbalance of the rotating mechanism by simple work and free from contamination.



CLAIMS

1. A method of correcting rotational unbalance of a rotating mechanism comprising:
 - 5 mounting a disc-shaped plate — having a plurality of protrusions disposed equiangularly and radiating from an outer wall thereof—to a rotating center shaft of a rotating mechanism fixedly and coaxially;
bending at least one of the protrusions inward of the disc-shaped plate responsive to rotational unbalance of the rotating mechanism
10 including the disc-shaped plate for achieving balance of the rotating mechanism including the disc-shaped plate.
2. The method of correcting rotational unbalance as defined in Claim 1 wherein the bending step includes bending a portion formed on the
15 protrusions, the portion tending to be bent comparing with other portions on the protrusions.
3. The method of correcting rotational unbalance as defined in Claim 1 wherein the bending step includes bending a recessed portion formed on
20 a back of a bendable portion of the protrusions.
4. A rotational unbalance correcting device of a rotating mechanism comprising:
 - a disc-shaped plate mounted fixedly and coaxially to a
25 rotating center shaft of said rotating mechanism; and
a plurality of protrusions disposed equiangularly and radiating from an outer wall of said plate, said protrusions being independently



bendable inward of said plate.

5. The rotational unbalance correcting device as defined in Claim 4 wherein a portion tending to be bent is formed on said protrusions.

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6. The rotational unbalance correcting device as defined in Claim 4 wherein a recess is formed on a back of a bendable portion of said protrusions.

7. The rotational unbalance correcting device as defined in Claim 4
10 wherein said rotating mechanism comprises:

a hub rotated by a motor; and

a disc fixedly mounted to said hub via said disc-shaped plate.

8. The rotational unbalance correcting device as defined in Claim 7
15 wherein a portion tending to be bent is formed on said protrusions.

9. The rotational unbalance correcting device as defined in Claim 7 wherein a recess is formed on a back of a bendable portion of said protrusions.