

STRAIN CORRECTING METHOD FOR PLANE MEMBER AND APPARATUS THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and an apparatus for efficiently and operatively correcting strain on a plane member.

2. Description of the Related Art

Fig. 5 shows a base plate 1 of a hard disk drive (HDD). In a case where the base plate 1 is manufactured by die-cast molding, strain is likely to be caused on the base plate 1 during a process in which molten metal of aluminum, zinc or the like is cooled and solidified. Further, it is essential to remove the strain on the base plate 1 prior to assembly of components into the base plate 1, in order to enhance the precision in the post-process and the precision of a finished molded article. For this reason, the strain on a plane portion 1a, an outer peripheral portion 1b or the like of the die-cast molded base plate 1 has been manually corrected by a skilled worker using a plastic hammer, thereby providing the base plate with high precision.

However, at present, a demand of the HDDs has been remarkably increased, and further it is required to supply the HDDs in more cost-effective fashion, and thus the manual strain correction is a bar to satisfy these requirements. Further, it is difficult to secure the skilled workers. Under these circumstances, effective solutions therefor have been looked for.

SUMMARY OF THE INVENTION

The present invention was made in view of the problems described above. An object of the present invention is to provide a method and an apparatus, which makes it possible to perform a strain correction operation on the plane portion of the plane member in a highly efficient manner, thereby manufacturing the plane member with high precision. The plane member includes, but not limited to, a base plate of a hard disk drive (HDD).

In a strain correcting method for a plane member according to a first aspect of the present invention, an objective surface to be corrected of a workpiece is compared with a preset standard surface to determine a strain amount at a predetermined position on the objective surface to be corrected, the most preferred die is formed one after another that is dedicated for the individual workpiece and

that causes a required amount of plastic deformation at a required portion on the objective surface to be corrected, and the workpiece is pressed onto the die to simultaneously performing correction entirely on the objective surface to be corrected.

In the present invention, in order to correct the objective surface, the standard surface and the objective surface are compared with each other for the individual workpiece, a strain amount at a predetermined position of the workpiece is determined, and then on the basis of the strain amount at the predetermined position, a correcting die is formed for the individual workpiece. Thereafter, the workpiece is pressed onto the correcting die for the individual workpiece with a predetermined force, whereby a required amount of the plastic deformation is caused on a required portion of the objective surface to be corrected for the individual workpiece. Further, the correction can be applied to the objective surface to be corrected entirely and simultaneously, thereby the correction process can be completed for a predetermined period regardless of differences in the areas, the correcting position, and the correcting amount of the objective surfaces of the individual workpiece.

In the strain correcting method for a plane member according to a second aspect of the present invention, the die is composed in such a manner as changing leading end positions of plural correcting pins that are to be contacted with the objective surface to be corrected of the workpiece.

In the present invention, the correcting die is constructed without using a continuous surface but with the use of a plurality of correcting pins that can press the required points on the workpiece. Accordingly, it is possible to easily change the contour of the die.

In the strain correcting method for the plane member according to a third aspect of the present invention, plural contacting elements are contacted with the objective surface to be corrected to obtain plural contacting points where the contacting elements are contacted, a plane is defined by three points arbitrarily selected from the plural contact points, a positional relationship of another one of the contacting points to the plane is recognized, the process described above is repeated to determine a strain position and a strain amount on the objective surface to be corrected of the workpiece, and a supplemental amount based on a predetermined parameter is added to the strain position and the strain amount to determine positions of the correcting pins.

In the present invention, points by which the flatness of the objective surface to be corrected of the workpiece is recognized are preliminarily selected at a plurality of positions, and those points are contacted with and measured by the contacting elements. Arbitrary three points are selected from the contact points with the contacting elements, to thereby define one plane. Subsequently, by recognizing a positional relationship of another contact point with respect to the plane, a strain amount at the other contact point with respect to the plane is recognized. By repeating this process while changing the selected points, the strain amount at a predetermined portion on the objective surface to be corrected is accurately recognized. Thereafter, the supplementary amount based on the predetermined parameter (for example, a correction amount for enabling the reliable transition from the elastic deformation region to the plastic deformation region, taking into account the material characteristic of the workpiece) is added to the strain position and the strain amount to position the correcting pins, and the correcting die is constructed for the individual workpiece.

In the strain correcting method for the plane member according to a fourth aspect of the present invention, the process described above is repeated plural times as the need arises. Even in a case where a sufficient correction amount is not obtained through one correcting process, the correcting process is repeated to do a required correction and to enhance the component precision of the workpiece.

In the strain correcting method for the plane member according to a fifth aspect of the present invention, the workpiece is a plane die-cast product. The plane die-cast product is likely to cause the strain on its plane portion during a course of process in which a molten metal is cooled and solidified. However, this method enhances the working efficiency in the strain correcting process for that product.

In the strain correcting method for the plane member according to a sixth aspect of the present invention, the plane die-cast product is used as an HDD base plate, and the working efficiency in the strain correcting process for the HDD base plate is enhanced.

A strain correcting apparatus for the plane member according to a seventh aspect of the present invention comprises fixed point supporting means for a workpiece, transferring means for the workpiece, measuring means having a plurality of contacting elements, correcting means having correcting pins and

pressing pins, and calculating means, and is designed to perform a sequential process in which:

- an objective surface to be corrected of the workpiece, which is supported on the fixed point supporting means, is measured by the measuring means;

- an optimum position and an optimum pressing force, which cause a required amount of plastic deformation on a required portion of the objective surface to be corrected, are determined based on a result of the measurement;

- the correcting pins are positioned to provide the pressing force at the position;

- the workpiece is transferred from the measuring means to the correcting means using the transferring means;

- the workpiece is clamped using the correcting pins and the pressing pins so that the objective surface to be corrected is subjected to the correction entirely and simultaneously.

According to the present invention, the objective surface to be corrected of the workpiece mounted on the fixed point supporting means for the workpiece is measured by the measuring means, and the measurement is always carried out onto the constant position with respect to each workpiece, and thus the measurement environment can be stabilized. The optimum position and the optimum pressing force, which cause the required amount of plastic deformation on the required portion of the objective surface to be corrected, are determined based on a result of the measurement, and the correcting pins are positioned to provide the pressing force at the position, so that the die for correcting the workpiece is formed for the individual workpiece. That is, the die that is dedicated for the individual workpiece and that corresponds to the strain amount which may vary depending on the workpieces is formed one after another.

The correcting die is constructed not to have a continuous surface but is designed to press the required portion on the workpiece. Accordingly, the contour of the die can be changed easily. The workpiece is transferred from the measuring means to the correcting means by the transferring means, and the workpiece is clamped using the correcting pins and the pressing pins to perform the correction entirely and simultaneously onto the objective surface to be corrected, and thus the correcting process which differs depending on the individual workpiece is performed for a short time period.

In the strain correcting apparatus for the plane member according to an

eighth aspect of the present invention, the measuring means contacts the plural contacting elements with the objective surface to be corrected to obtain plural contacting points where the contacting elements are contacted, the calculating means defines a plane by three points arbitrarily selected from the plural contact points, recognizes a positional relationship of another one of the contacting points to the plane, repeats these steps to determine a strain position and a strain amount on the objective surface to be corrected of the workpiece, and adds a supplemental amount based on a predetermined parameter to the strain position and the strain amount to determine positions of the correcting pins.

In the present invention, relevant points by which the flatness of the objective surface to be corrected of the workpiece is recognized are determined, and those points are contacted with and measured by the contacting elements of the measuring means. In the calculating means, arbitrary three points are selected from the contact points with the contacting elements, to thereby define one plane. Subsequently, by recognizing a positional relationship of another contact point with respect to the plane, a strain amount at the other contact point with respect to the plane is recognized. By repeating this process while changing the selected points, the strain position and the strain amount at the entire objective surface to be corrected is accurately recognized. Thereafter, the supplementary amount based on the predetermined parameter (for example, a correction amount for enabling the reliable transition from the elastic deformation region to the plastic deformation region, taking into account the material characteristic of the workpiece) is added to the strain position and the strain amount to position the correcting pins, and the die for correcting the workpiece is constructed for the individual workpiece.

In the strain correcting apparatus for the plane member according to a ninth aspect of the present invention, the above-mentioned sequential process is repeated as required. Even in a case where a sufficient correction amount is not obtained through one correcting process, the correcting process is repeated to do a required correction to enhance the component precision of the workpiece.

In the strain correcting apparatus for the plane member according to a tenth aspect of the present invention, the workpiece is a plane die-cast product. The working efficiency is enhanced in the strain correcting process for the plane die-cast product which is likely to cause the strain on its plane portion during a course of process in which a molten metal is cooled and solidified.

In the strain correcting apparatus for the plane member according to an eleventh aspect of the present invention, the plane die-cast product is an HDD base plate. The working efficiency is enhanced in the strain correcting process for the HDD base plate.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a schematic view showing a strain correcting apparatus for a plane member according to an embodiment of the present invention;

Fig. 2 is a schematic view showing major portions of the strain correcting apparatus for the plane member shown in Fig. 1;

Figs. 3(a) to 3(e) are explanatory views showing a sequence of correcting strain on the base plate using the correcting apparatus for the plane member shown in Fig. 1;

Figs. 4(a) and 4(b) are explanatory views showing a sequence of determining a position L shown in Fig. 3; and

Fig. 5 is a perspective view substantially showing an HDD base plate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described hereinafter with reference to the accompanying drawings.

Fig. 1 schematically shows a strain correcting apparatus 2 for a plane member according to an embodiment of the present invention. This strain correcting apparatus 2 includes, as shown in an enlarged manner as its major portions in Fig. 2, a fixed point supporting means 3 for a base plate 1, a transferring means 4 for the base plate 1, a measuring means 6 having a plurality of contact elements 5, a correcting means 9 having correcting pins 7 and pressing pins 8, and a calculating means (not shown). The apparatus further includes an unshown operation panel.

The fixed point supporting means 3 for the base plate 1 is exemplified by a palette jig, a clamp device set on a table of the strain correcting apparatus 2, or the like, which supports a fixed point of the base plate 1 so as to keep the posture of the base plate 1 constant. In a case where the fixed point supporting means 3 is constructed by the palette jig, the transferring means 4 includes the palette jig as a part of the conveying means, and which is constructed by an arm, a conveyer or the like that moves the base plate 1 together with the palette jig. In a case where the fixed point supporting means 3 is constructed by the clamp device on

the table, an arm or the like is employed which introduces the base plate 1 into the clamp device provided to the measuring means 6 and the correcting means 9.

The measuring means 6 is constructed by the plurality of the contact elements 5 disposed to be contactable with a site which is pre-selected to be suitable for the strain measurement from a surface suitable for the strain correction (hereinafter referred to as an objective surface to be corrected) such as a plane portion 1a, an outer peripheral portion 1b or the like (see Fig. 5) of the base plate 1 to be corrected. Since the base plate 1 carried by the transferring means 4 to the measuring means 6 is always supported by the fixed point supporting means 3 to have the constant posture, the measurement is always carried out onto the constant position and thus the measurement environment can be stabilized.

The plurality of the correcting pins 7 of the correcting means 9 are disposed to be contactable with a site which is pre-selected to be suitable for the strain correction from the objective surface to be corrected of the base plate 1. The correcting means is provided with a driving means, such as an electrically-driven actuator or the like, which can perform accurate positioning. By changing leading end positions of the correcting pins 7 in a direction toward the objective surface to be corrected of the base plate 1, a required amount of plastic deformation is caused on a required portion of the objective surface to be corrected. That is, the pins 7 serve as a die.

The pressing pins 8 of the correcting means 9 are positioned to be confronted with the respective correcting pins 7 with the base plate 1 interposed therebetween. A driving means is provided, which can accurately control a pressing force when the base plate 1 is clamped between the pressing pins 8 and the correcting pins 7. A hydraulic cylinder, an electrically-driven actuator or the like is suitable as the driving means.

Further, the unshown calculating means determines, on the basis of a measurement result obtained by the measuring means 6, an optimum position and an optimum pressing force for causing a required amount of the plastic deformation at a required location on the objective surface to be corrected, and gives the driving means of the correcting pins 7 a command for positioning the correcting pins 7 in order to apply the pressing force at the position. A command for applying a predetermined pressure is also given with respect to the pressing pins 8.

Here, a sequence for correcting the strain on the objective surface to be corrected of the base plate 1 by using the strain correction apparatus 2 is described with reference to Figs. 3 and 4.

First of all, as shown in Fig. 3(a), the plurality of the contact elements 5 are brought into contact with the objective surface to be corrected (the plane portion 1a or the outer peripheral portion 1b) of the base plate 1 supported by the fixed point supporting means 3 so as to obtain respective positions where contact elements 5 are point-contacted. Subsequently, using the transferring means, the base plate 1 is transferred from the measuring means 6 to the correcting means 9. During this movement, on the basis of the measurement result of the measuring means 6, the calculating means determines an optimum position L of each correcting pin 7 and an optimum pressing force to be applied by an pressing pin 8 in order to cause a required amount of the plastic deformation at a required portion on the objective surface to be corrected.

A sequence for determining the position L from the measurement result of the measuring means 6 is as follows: As shown in Fig. 4(a), the measuring means 6 preliminarily selects points A to F used for recognizing the flatness of the objective surface to be corrected, and measures the positions of those points by making the contact elements 5 in contact therewith. Then, one plane is defined using three points arbitrarily selected from the contact points of the contact elements.

For example, one plane S is defined by the points A, B and F which are points of measurement, and a positional relationship of a point C on the outer peripheral portion 1b with respect to the plane S is recognized. In a case where strain exists to offset the point C to a point C' as shown in Fig. 4(b), strain amount of the point C' relative to the point C is obtained as a consequence of comparison between the measured point C' and the point C of a standard surface that is a plane portion of a master workpiece preliminarily measured. Thereafter, the strain amount of the point C' is recognized in relation to the plane S. By repeating this process while changing the selected point, the strain position and the strain amount on the entire objective surface to be corrected are accurately determined.

Further, a supplementary amount based on a predetermined parameter (for example, a correction amount for enabling the reliable transition from the elastic deformation region to the plastic deformation region, taking into account

the material characteristic of the base plate) is added to the strain position and the strain amount of the objective surface to be corrected, thereby obtaining the optimum position L of the correcting pin 7 for applying the required correction amount onto the objective surface to be corrected. In addition, the number of points measured by the contact elements 5 is varied depending on the area, the configuration or the like of the plane portion 1a or the outer peripheral portion 1b which is an objective surface to be corrected.

As shown in Fig. 3(b), the leading end positions of the correcting pins 7 are positioned at the positions L determined by the calculating means. By aligning the leading end positions of the correcting pins 7 on the L in this manner, a die for correcting the base plate 1 is constructed for each workpiece.

Subsequently, as shown in Fig. 3(c), the pressing pins 8 are activated to raise the base plate 1, so that the base plate 1 is clamped between the correcting pins 7 and the pressing pins 8. Further, as shown in Fig. 3(d), the pressure of the pressing pins 8 is controlled so that the required pressing force determined by the calculating means is applied to the base plate 1, thereby causing such a deformation on the objective surface to be corrected as to enable the reliable transition from the plastic deformation region to the plastic deformation region. In this manner, the objective surface to be corrected is corrected entirely and simultaneously.

The strain of the objective surface to be corrected is corrected in the sequence described above, so that the base plate 1 with the high flatness can be obtained as shown in Fig. 3(e). If the sufficient correction amount is not obtained by one correcting process, the process from Fig. 3(a) to 3(d) is repeated twice or more times as required to enhance the component precision of the workpiece.

The functions and effects obtained by the embodiment of the present invention constructed as described above will be summarized as follows: In the present embodiment, in order to correct a strain of the base plate 1, the standard surface and the objective surface to be corrected are compared with each other for each base plate, a strain amount at a predetermined position of the base plate is determined, and then on the basis of the strain amount at the predetermined position, a correcting die is formed for each base plate by the correcting pins 7. Thereafter, the base plate 1 is pressed by the pressing pins 8 onto the correcting die with a predetermined force, whereby a required amount of the plastic deformation can be caused on a required portion of the objective surface to be

corrected for each base plate. Accordingly, the base plate having a high precision can be obtained.

Further, since the correction can be applied entirely and simultaneously to the plane portion 1a or the outer peripheral portion 1b which is an objective surface to be corrected, the correction process can be completed for a constant time period regardless of the area, the correction position and the correction amount of the plane portion which may vary depending on individual workpiece. Therefore, according to the strain correcting method and apparatus of the embodiment of the present invention, it is possible to efficiently manufacture the base plate 1 having a high precision.

The correcting die described above is constructed by changing the leading end positions of the plural correcting pins 7 to be contacted with the objective surface to be corrected of the base plate 1. By constructing the correcting die without a continuous surface but with the plurality of correcting pins 7 that can press the required points on the objective surface to be corrected, the contour of the die can be changed readily. Accordingly, it is possible to easily construct a dedicated die suitable for each base plate that requires the different individual correction amounts at the different individual correction positions.

Further, in constructing the correcting die, arbitrary three points are selected from the contact points with the contacting elements 5 to define the plane S, and the process for recognizing the positional relationship of another point with respect to the plane S is repeated, so as to accurately determine the strain position and the strain amount on the objective surface to be corrected. Thereafter, the supplementary amount based on the predetermined parameter is added to the strain position and the strain amount to position the correcting pins 7. This makes it possible to accurately construct the correcting die for each base plate 1.

Even if a sufficient correction amount is not obtained through one correcting process, the process from Fig. 3(a) to 3(d) is repeated twice or more times, thereby subjecting the base plate 1 to the required correction.

In the embodiment of the present invention, the correcting means 9 of the strain correcting device 2 is designed such that the correcting pins 7 are arranged above the base plate 1, whereas the pressing pins 8 are arranged below the base plate 1. However, the reverse arrangement is applicable. Further, it is not essential to clamp the base plate using the correcting pins 7 and the pressing pins

8 vertically. In a case where the rigidity balance of the base plate 1 is mainly carried by the outer peripheral portion 1b (see Fig. 5), the correction of the base plate 1 can be carried out more efficiently by disposing many of the contact elements 5 of the measuring means 6, and the correcting pins 7 and pressing pins 8 of the correcting means 9 at the positions facing the outer peripheral portion 1b of the base plate 1. Moreover, the objective workpiece to be corrected is not limited to the base plate 1, and can be any plane member made of such material as to be capable of eliminating the strain using the plastic deformation, in order to obtain the same function and effect as those described above.

The present invention thus constructed provides the following effects:

According to the strain correcting method for the plane member of the first aspect of the present invention, it is possible to efficiently perform the strain correcting process for the plane member without depending on a handwork of a skilled worker. Therefore, it is possible to provide a large number of the plane member products having high flatness in a cost effective manner.

According to the strain correcting method for the plane member of the second aspect of the present invention, a die suitable for an individual plane member can be constructed easily to efficiently perform the strain correcting process for the plane member. Further, according to the strain correcting method for the plane member of the third aspect of the present invention, the die for the individual plane member can be increased in precision, and thus the strain correcting process for the plane member can be carried out with high precision.

According to the strain correcting method for the plane member of the fourth aspect of the present invention, even if a sufficient correction amount is not obtained through one correcting process, the correcting process is repeated plural times as required, thereby enhancing the flatness of the plane member and improving component precision.

According to the strain correcting method for the plane member of the fifth aspect of the present invention, it is possible to enhance the working efficiency in the strain correcting process for a plane die-cast product, thereby providing a large number of the die-cast products having high flatness in a cost effective manner. According to the strain correcting method for the plane member of the sixth aspect of the present invention, it is possible to provide a large number of HDD base plates having high flatness in a cost effective manner.

According to the strain correcting apparatus for the plane member of the

seventh aspect of the present invention, it is possible to efficiently perform the strain correcting process for the plane member without depending on a handwork of a skilled worker. Therefore, it is possible to efficiently provide a large number of the plane member products having high flatness in a cost effective manner.

According to the strain correcting apparatus for the plane member of the eighth aspect of the present invention, it is possible to efficiently perform the strain correcting process for the plane member with high precision, thereby efficiently manufacture the plane member with high precision.

According to the strain correcting apparatus for the plane member of the ninth aspect of the present invention, even if a sufficient correction amount is not obtained through one correcting process, the correcting process is repeated plural times as required, thereby enhancing the flatness of the plane member and manufacturing the plane member having high component precision.

According to the strain correcting apparatus for the plane member of the tenth aspect of the present invention, it is possible to enhance the working efficiency in the strain correcting process for a plane die-cast produce, thereby providing a large number of the plane die-cast products having high flatness in a cost effective manner. According to the strain correcting apparatus of the eleventh aspect of the present invention, it is possible to provide a large number of HDD base plates having high flatness in a cost effective manner.



WHAT IS CLAIMED IS:

1. A strain correcting method for a plane member, comprising the steps of:

comparing an objective surface to be corrected of the workpiece with a preset standard surface to determine a strain amount at a predetermined position on the objective surface to be corrected;

forming a die that is dedicated for the individual workpiece and that causes a required amount of plastic deformation at a required portion on the objective surface to be corrected based on the strain amount at the predetermined position;

pressing the workpiece onto the die under predetermined pressure to simultaneously performing correction entirely on the objective surface to be corrected.

2. A strain correcting method for the plane member as claimed in claim 1, wherein the die is formed by changing leading end positions of plural correcting pins that are to be contacted with the objective surface to be corrected of the workpiece.

3. A strain correcting method for the plane member as claimed in claim 2, comprising the steps:

contacting plural contacting elements with the objective surface to be corrected to obtain plural contacting points with which the contacting elements are contacted;

defining a plane by three points arbitrarily selected from the plural contact points;

recognizing a positional relationship of another one of the contacting points to the plane;

repeating these steps to determine a strain position and a strain amount on the objective surface to be corrected of the workpiece; and

adding a supplemental amount based on a predetermined parameter to the strain position and the strain amount to determine positions of the correcting pins.

4. A strain correcting method for the plane member as claimed in any



one of claims 1 to 3, wherein said steps are repeated plural times as the need arises.

5. A strain correcting method for the plane member as claimed in any one of claims 1 to 4, wherein the workpiece is a plane die-cast product.

6. A strain correcting method for the plane member as claimed in claim 5, wherein the plane die-cast product is an HDD base plate.

7. A strain correcting device for a plane member, that comprises fixed point supporting means for a workpiece, transferring means for the workpiece, measuring means having a plurality of contacting elements, correcting means having correcting pins and pressing pins, and calculating means, and that performs a sequential process in which:

an objective surface to be corrected of the workpiece, which is supported on the fixed point supporting means, is measured by the measuring means;

an optimum position and an optimum pressing force, which cause a required amount of plastic deformation on a required portion of the objective surface to be corrected, are determined based on a result of the measurement;

the correcting pins are positioned so as to apply the pressing force at the position;

the workpiece is transferred from the measuring means to the correcting means using the transferring means;

the workpiece is clamped using the correcting pins and the pressing pins so that the objective surface to be corrected is subjected to a correction entirely and simultaneously.

8. A strain correcting device for the plane member as claimed in claim 7, wherein the measuring means contacts the plural contacting elements with the objective surface to be corrected to obtain plural contacting points with which the contacting elements are contacted, the calculating means defines a plane by three points arbitrarily selected from the plural contacting points, recognizes a positional relationship of another one of the contacting points to the plane, repeats these steps to determine a strain position and a strain amount on the objective surface to be corrected, and adds a supplemental amount based on a



predetermined parameter to the strain position and the strain amount to determine positions of the correcting pins.

9. A strain correcting device for the plane member as claimed in claim 7 or 8, wherein the sequential process is repeated as the need arises.

10. A strain correcting device for the plane member as claimed in any one of claims 7 to 9, wherein the workpiece is a plane die-cast product.

11. A strain correcting device for the plane member as claimed in claim 10, wherein the plane die-cast product is an HDD base plate.