

METHOD OF STRAIGHTENING ANNULAR METALLIC SHEETS

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a method of straightening annular metallic sheets. More particularly, the present invention relates to a method of straightening blanks made of aluminum or an aluminum alloy used for a magnetic disk substrate for computer.

2. Description of the Related Art

An annular metallic sheet having a hole pierced at the center thereof such as a blank used for a magnetic disk substrate made of aluminum or an aluminum alloy is prepared in general by stamping a rolled sheet into an annular disk. This as-stamped blank has a convex or concave curved shape. A magnetic disk substrate is required to have a very high flatness, so that is it necessary to straighten the as-stamped blank to remove strain caused by stamping.

A commonly adopted method of straightening a blank known as the pressure-annealing method comprises, for example, placing a plurality of blanks to be straightened between flat stools, piling a plurality of such assemblies, and annealing the same while vertically applying a pressure.

Japanese Unexamined Patent Publication No. 61-44162 discloses a method of straightening a blank comprising the steps of piling blanks on a lower stool connected to vertically movable pressing means, raising the same, charging the same into an induction heating furnace, and applying a pressure by bringing the same into contact under a pressure with an upper stool formed integrally with the heating furnace. Japanese Unexamined Patent Publication No. 62-240112 discloses a method comprising the steps of piling a plurality of blanks on a lower stool, placing an upper stool onto the blanks, holding the blanks, and heating and annealing the blanks while applying a pressure to the upper and the lower stools via a heat resistant spring. While it is the general practice to use flat stools for holding the piled blanks in between, a method is available of using stools tapered into a concave or a convex shape (see Japanese Unexamined Patent Publication No. 5-263201). In addition, there is proposed a method comprising the steps, upon stamping a blank, of pressing the blank at the center to cause the same to deform into a wide frustconical shape, thereby causing a uniform plastic deformation by such expansion, eliminating slight strain under the effect of this plastic elongation, and then conducting annealing under pressure (see Japanese Unexamined Patent Publication No. 6-285554).

In these conventional straightening methods of blanks, however, blanks are piled so that the convex side is in contact with the concave side for each blank, and the thus piled blanks are pressure-annealed for straightening.

In this manner of piling a plurality of blanks so that a convex side is in contact with a concave side, the contact area between blanks is large and the apparent blank thickness is regarded as the lamination thickness of the piled sheets, thus leading to a very large pressing force required for straightening. Furthermore, the blank after straightening may show an insufficient flatness.

The present invention was developed to solve the problems described above, and has an object to provide a method of straightening annular metallic sheets, which requires only a slight pressing force for straightening annular metallic sheets, permits easy straightening, and gives a product excellent in flatness.

SUMMARY OF THE INVENTION

To achieve the foregoing object, the present invention provides a method of straightening annular metallic sheets, comprising the steps of putting a plurality of annular metallic sheets to be straightened each having a convex and a concave sides one on top of the

other; sandwiching the annular metallic sheets between stools having flat surfaces; and annealing the plurality of annular metallic sheets via the stools while applying a pressure; wherein at least part of the plurality of annular metallic sheets are piled by bringing a convex side into contact with another convex side and a concave side, with another concave side, and the thus piled sheets are annealed while applying a pressure. Lamination of the annular metallic sheets so that a convex side is in contact with another convex side and a concave side is in contact with another concave side and the pressure-annealing reduce the pressing force required for straightening the annular metallic sheets, permit easy straightening and give an excellent flatness of straightening, with reduced damage and wear and a longer service life of jigs used for straightening.

When applying this method, the annular metallic sheets may be piled by bringing a convex side into contact with another convex side and a concave side, with another concave side one by one, or by bringing a convex side into contact with another convex side and a concave side, with another concave side to form a unit, and bringing a convex side of this unit into contact with a convex side of another unit and a concave side of the unit, with another concave side of another unit. This permits effective

straightening of many annular metallic sheets with a satisfactory flatness without largely increasing the pressing force.

In the method of straightening annular metallic sheets of the present invention as described above, an elastic force of a heat resistant elastic material is utilized as the pressing force. By using the elastic force of the heat resistant elastic material for pressing, differences in expansion and contraction with temperature between the annular metallic sheets and the tightening jigs are absorbed, and it is possible to apply constantly a uniform pressing force during annealing, thus permitting stable straightening.

Now, the method of the present invention will be described further in detail with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a descriptive view illustrating an embodiment of lamination of annular metallic sheets adopted in the method of straightening annular metallic sheets of the present invention;

Fig. 2 is a descriptive view of a pressure-annealing step of annular metallic sheets adopting the embodiment of lamination shown in Fig. 1; and

Fig. 3 is a descriptive view illustrating another embodiment of lamination of annular metallic sheets.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The annular metallic sheets used in the present invention are blanks made of aluminum or an aluminum alloy used for a magnetic disk substrate for computer. The blank has a thickness within a range of from 0.4 to 2.5 mm, depending upon the material and the diameter of the magnetic disk substrate.

The blank 1 is formed by a known stamping process, and has a convex side 2 and a concave side 2. As shown in Fig. 1, a plurality of blanks 1 are piled with a convex side 2 thereof in contact with another convex side 2 and a concave side 3 thereof in contact with another concave side 3. Fig. 1 shows a case where the blanks are piled one by one alternately in a sequence of a back, a face, a back and then a face. As shown in Fig. 2, a block 4a comprising a plurality of piled blanks as shown in Fig. 1 is placed on a lower stool 10 having a flat surface 10a. Then, an intermediate stool 9a (spacer) having flat upper and lower surfaces is placed on this block 4a, and then, another block 4b comprising a plurality of similarly piled blanks is placed on the intermediate stool 9a. Furthermore, blocks 4c and 4d and intermediate stools 9c

and 9d are alternately piled, and an upper stool 8 having a flat surface 8 is placed on the final block 4e. A prescribed pressing force is applied onto the surface of the blank 1 via a spring 11 which is made of a heat resistant elastic material by means of a screw stock 12 fixed to the lower stool 10 and a nut 13 screw-engaging with the screw stock 12. The thus formed assembly is charged into an annealing furnace (not shown), and pressure-annealed at a prescribed temperature for a prescribed period of time, for example, at a temperature of over 300°C, or preferably, at a temperature within a range of from 350 to 360°C for a sufficient period of time, for example, from 5 to 6 hours.

In the foregoing embodiment, the number of blanks in a block and the pressing force are appropriately selected, depending upon the material of the blank, thickness or diameter thereof. While a case with five blocks has been described in this embodiment, the present invention is not limited to this, but the number of blocks is appropriately selected, as in the case of the number of blanks and the pressing force, depending upon the material of the blank, thickness or diameter thereof. The stool is made of aluminum or an aluminum alloy and must have a flatness at least higher than the flatness of the blank after straightening. The spring 11 must be heat-resistant,

keeping elasticity at an annealing/holding temperature within, for example, a range of from 350 to 360°C, and should be made of a material such as an alloy tool steel or a heat-resistant spring steel. The shape thereof is not limited to a helical shape, but it may be any other shape.

By piling the blanks 1, with a convex side 2 in contact with another convex side 2 and a concave side 3 in contact with another concave side 3, and applying pressure-annealing, the pressing force required for straightening the blanks 1 is reduced, leading to an easy straightening, and an excellent flatness is available, with reduced damage or wear of jigs used for straightening and a longer service life of the jigs.

In addition, pressing by the utilization of an elastic force of the heat-resistant spring 11 absorbs the difference in expansion and contraction caused by temperature between the blanks 1 and the tightening jigs during annealing in the annealing furnace, thus permitting application of a constant pressing force during annealing, resulting in a stable straightening.

Fig. 3 is a descriptive view illustrating another embodiment of lamination of the annular metallic sheets shown in Fig. 1. According to this embodiment, a plurality of blanks which are piled annular metallic

sheets are placed between stools having flat surfaces. Upon annealing the plurality of blanks while pressing them, a plurality of, for example, five blanks 1 piled with a convex side 2 in contact with a concave side 3 are considered as a unit, and units are piled with a concave side 7 of the unit 5a in contact with a concave side 7 of the unit 5b, and with a convex side 6 of the unit 5b in contact with a convex side 6 of the unit 5c. In this manner, units are piled by bringing into contact concave sides 7 with concave sides 7 of the units 5c to 5f, and convex sides 6 with convex sides 6. In other words, a plurality of blanks 1 are piled by bringing into contact the sides of the same direction of strain, and units are piled with the convex sides in contact with the convex sides and with the concave sides 7 in contact with the concave sides 7.

This manner of piling with convex sides in contact with convex sides and concave sides in contact with concave sides of units and pressure-annealing the units as in this embodiment gives a larger pressing force than in the manner of bringing a convex side into contact with a convex side, and a concave side, with a concave side one by one as shown in Fig. 1. It permits however more effective straightening of many blanks under a smaller pressing force, with a better flatness, than in the

conventional method bringing a convex side into contact with a concave side.

Now, an example showing the effect of straightening by the method of straightening annular metallic sheets of the present invention and a comparative example showing the effect of straightening by the conventional method for comparison will be described.

EXAMPLE

Thirty blanks each comprising 4.5 wt.% Mg, 0.06 wt.% Cu and the balance Al and incidental impurities having an outside diameter of 95 mm, an inside diameter of 25 mm and a thickness of 0.8 mm were piled, as shown in Fig. 1, by bringing a convex side into contact with a convex side and a concave side, with a concave side of the blank one by one, into a block. Five such blocks were inserted between a lower stool, an intermediate stool (spacer) and an upper stool in a five-layer lamination. This resulted in 150 blanks in total. The spacer in this case had a diameter of 110 mm and a thickness of 20 mm, and was made of S55C. A nut was tightened and vertical pressing was applied. The tightening torque at the moment when gaps between piled blanks were eliminated was measured with a torque wrench to determine a tightening pressure: this gave a result of 200 kgf/cm². When a tightening pressure of 100

kgf/cm² was additionally applied, the blanks showed a surface pressure of 2 kgf/cm². Three sets of such blanks were provided, and an annealing treatment was applied at an annealing/holding temperature of 350°C for a holding time of five hours.

Flatness of the 420 straightened blanks (excluding the first blanks in contact with the steels) was measured by counting fringes by means of a known optical interference fringe gauge. A concentric fringe pattern on the blank is the ideal one, and in this case, one fringe corresponds to 1 μ m. For the blanks before annealing, the foregoing gauge showed unmeasurable result because of range over. The results included an average value $\bar{x}$ = 4.8 μ m and a standard deviation σ = 0.54 μ m.

COMPARATIVE EXAMPLE

For comparison purposes, 30 blanks obtained in the same process as that of the blanks used in the Example were piled by bringing a convex side into contact with a concave side, and the piled blanks were placed between stools similar to those used in the Example into five-layer lamination. Thus three sets of 150 blanks in total were prepared. Further, a tightening nut was tightened, and a vertical pressure was applied. At the moment when gaps between the piled blanks were eliminated, the

pressing force was measured with a torque wrench. A pressing force of 800 kgf/cm² resulted. In addition, a tightening pressure of 100 kgf/cm² was added. This gave a blank surface pressure of 6 kgf/cm². Three sets of such blanks were prepared, and an annealing treatment was applied at an annealing/holding temperature of 350°C for a holding time of five hours.

Measurement of the flatness of 420 blanks excluding the first ones in contact with the stools, in the same manner as in the Example, by means of a flatness measuring gauge gave results including an average value $\bar{x} = 7.2 \mu\text{m}$ and a standard deviation $\sigma = 0.73 \mu\text{m}$.

These results of measurement of flatness suggest that the blanks in the Example are largely improved in terms of flatness over the blanks in the Comparative example, with smaller variations. Further, the pressing force for pressure-straightening the blanks was reduced to a third that in the Comparative Example.

The present invention has been described in detail by means of the Examples shown in the drawings. The present invention is not however limited to these Examples, but it is needless to mention that diverse and various variations are possible by making various modifications without deviating from the spirit of the present invention.

According to the present invention, it is possible to

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obtain annular metallic sheets easily straightened with a small pressing force and excellent in flatness.



WHAT IS CLAIMED IS:

1. A method of straightening annular metallic sheets, comprising the steps of putting a plurality of annular metallic sheets to be straightened each having a convex and a concave sides one on top of the other; sandwiching said annular metallic sheets between stools having flat surfaces; and annealing said plurality of annular metallic sheets via said stools while applying a pressure; wherein at least part of said plurality of annular metallic sheets are piled by bringing a convex side into contact with another convex side and a concave side, with another concave side, and the thus piled sheets are annealed while applying a pressure.

2. The method according to claim 1, wherein said plurality of annular metallic sheets are piled by bringing a convex side into contact with another convex side and a concave side, with another concave side one by one.

3. The method according to claim 1, wherein said plurality of annular metallic sheets are piled by bringing a convex side into contact with another convex side and a concave side, with another concave side to form a unit, and bringing a convex side of said unit into contact with a convex side of another unit and a concave side of said



unit, with another concave side of another unit.

4. The method according to claim 1, wherein said application of a pressure is accomplished by the utilization of an elastic force of a heat resistant elastic material.

5. A method of straightening annular metallic sheets, comprising the steps of:

forming a block by putting a plurality of annular metallic sheets to be straightened each having a convex and a concave sides one on top of the other so that, for at least part of the annular metallic sheets, a convex side is in contact with another convex side and a concave side, with another concave side;

sandwiching said block between stools having flat surfaces, and piling a plurality of such assemblies;

vertically applying a pressure to the piled blocks of the annular metallic sheets; and

annealing said blocks of the annular metallic sheets under pressure.

6. The method according to claim 5, wherein a block is formed by putting said plurality of annular metallic sheets by bringing a convex side into contact with another



convex side and a concave side, with another concave side one by one.

7. The method according to claim 5, wherein said plurality of annular metallic sheets are piled by bringing a convex side into contact with another convex side and a concave side, with another concave side to form a unit, and bringing a convex side of said unit into contact with a convex side of another unit and a concave side of said unit, with a concave side of another unit.

8. The method according to claim 5, wherein said application of a pressure is accomplished by means of a tightening jigs fixed to said stools and heat resistant elastic spring built in said jigs.