

METHOD FOR MANUFACTURING ARTICLE HAVING THIN PLATE STRUCTURE AND
INTERMEDIATE PRODUCT THEREOF

5 TECHNICAL FIELD

The present invention relates to a forging method for manufacturing an article and in particular, to a forging method for manufacturing an article having a thin plate structure and an intermediate product made by the method.

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BACKGROUND

Articles with thin plate structure are used in many mechanical and electronic devices. For example in hard disk drives, parts such as damper plate, actuator arm and base plate have thin plate structure and as the shapes are relatively more complicated, these parts are typically made by die casting process. Die-casted parts are, however, porous in nature and with high roughness in its surface. Due to the porousness which may lead to acid seeping out after plating, die-casted parts are not suitable for EN plating (Electroless nickel plating) but instead to undergo electrical plating.

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Forging has been conventionally used to make parts which have a relatively more dense structure and with higher strength and better surface quality compared to die-casted parts. However after failure of many attempts made, conventional forging process has been considered unsuitable for manufacturing articles with thin plate structure such as the damper plate, actuator arm or base plate used in hard disk drives, due to the complicated shape of such parts, the tight structural and/or dimensional tolerance requirements for such parts which exceed the capability of conventional forging process. As a result, such parts are presently still made by die casting process in spite of unsatisfactory performance.

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SUMMARY OF THE INVENTION

According to one aspect, embodiments of the present invention provide an improved forging method for manufacturing an article which has a thinner body and a thicker body. A blank of a plastically deformable material, e.g. an aluminum bar is placed between an upper die and a lower die. The upper die is moved towards the lower die to press the blank, causing the blank to become plastically deformed. The deformed blank flows into an impression and a gutter formed in the upper die and lower die. An intermediate product is formed in which, the blank material forms the thinner body, the thicker body and a flash. The thinner body is formed in a shallow trench of the impression, the thicker body is formed in a deeper trench of the impression, and the flash is formed in the gutter surrounding the shallow trench and the deeper trench. The intermediate product is then extracted from the dies and the flash is trimmed to form the article.

The flash includes a first flash portion closer to the thicker body and a second flash portion away from the thicker body. The first flash portion has a first flash thickness and the second flash portion has a second flash thickness. The first flash thickness is greater than the second flash thickness. In the process of forming the intermediate product, a first gutter area of the upper die and the lower die corresponding to the first flash portion allows more material to flow through than a second gutter area of the upper die and the lower die which corresponds to the second flash portion, and a third gutter area of the upper die and the lower die which corresponds to the third flash portion. In this way, the blocking effect to material flow caused by materials filled in the deeper trench is compromised and compensated and accordingly, material flow at shallow trench is evenly distributed. Applying a method according to the embodiments of the present invention, a hard disk damper plate can be manufactured by forging in which, the main thin plate body portion has an even thickness to satisfy the thickness requirements for use in a hard disk drive.

Other aspects and advantages of the present invention will become apparent from the following detailed description, illustrating by way of example the inventive concept of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present invention will be described in detail with reference to the accompanying drawings, in which:

Figs. 1A and 1B are perspective views showing blanks for manufacturing a hard disk damper plate;

5 Fig. 2 is a perspective view showing a lower die for manufacturing a hard disk damper plate from the blank shown in Fig. 1A or 1B;

Fig. 3 is a perspective view showing an intermediate product made by a method according to one embodiment of the present invention;

10 Fig. 4 is a partial cross sectional view of Fig. 3 along A-A;

Fig. 5 is a partial cross sectional view of Fig. 3 along B-B;

15 Fig. 6 is a perspective view showing a finished article made from the intermediate product of Fig. 3;

Fig. 7 is a perspective view showing an intermediate product according to one embodiment of the present invention;

20 Fig. 8 is a perspective view showing an intermediate product according to another embodiment of the present invention;

Fig. 9 is a flow chart showing a method of manufacturing an article according to an embodiment of the present invention.

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Fig. 10 is a perspective view showing a sectional material for preparation of blanks for forming thin plate article according to a further embodiment of the present invention.

30 Fig. 11 is a perspective view showing forming of blanks from the sectional material of Fig. 10.

Fig. 12 is a flow chart showing a method of manufacturing an article according to an embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

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A method for manufacturing an article by forging process is provided. In the present embodiment, the article is a hard disk damper plate having a thin plate structure. Figs. 1A and 1B show

blank 10a, 10b of a plastically deformable material e.g. an aluminum bar, used to produce the hard disk damper plate. The blank may be bent from a straight aluminum bar with various types of cross section, for instance one having a round cross section as shown in Fig. 1A, or a rectangular cross section as shown in Fig. 1B. The bent aluminum bar 10a or 10b is heated up to a temperature suitable for hot forging, and placed and pressed between an upper die and a lower die. The upper die and lower die have a complementary structure, shape and dimension and therefore only the lower die 22 is shown in Fig. 2 for illustration.

Lower die 22 includes an impression formed of a shallow trench 220 and three deeper trenches 222, 224 and 226 connected to shallow trench 220. A gutter 228 is formed surrounding shallow trench 220 and deeper trenches 222, 224 and 226. When being pressed between the upper and lower dies, blank 10 is plastically deformed with the material flows and fills in shallow trench 220, deeper trenches 222, 224 and 226 as well as gutter 228. When the pressing process is completed, blank 10 is formed into an intermediate product 20 of an integral structure, as shown in Fig. 3. The blank material filled in shallow trench 220 forms a thin plate body 210. The blank material filled in deeper trenches 222, 224 and 226 form pads 212, 214 and 216, and the blank material filled in gutter 228 forms a flash 218. The thin plate body illustrated in the present embodiment refers to a body structure having a thickness ranging from about 1.3 mm to 3.6 mm, and with a thickness/width ratio ranging from about 0.1 to 0.7.

Further referring to Figs. 4 and 5, flash 218 includes a first flash portion 2181, a second flash portion 2182 and a third flash portion 2183. First flash portion 2181 and second flash portion 2182 are located at a same side of plate body 210 as pad 212, and third flash portion 2183 is located at an opposite side of main body 210 with respect to pad 212. First flash portion 2181 is closer to pad 212 than second flash portion 2182 and third flash portion 2183. First flash portion 2181 has a first flash thickness 2181a greater than a second flash thickness 2182a of second flash portion 2182. First flash thickness 2181a is also greater than the third flash thickness 2183a of third flash portion 2183.

To form flash 218 with the above-described structure and dimensions, the upper die and lower die are provided with corresponding gutter structure and dimensions as illustrated in Fig. 2. As shown, gutter 228 has a first gutter area 2281 closer to deeper trench 222, a second gutter area 2282 away from deeper trench 222, and a third gutter area 2283 located at an opposite side of shallow trench 220 with respect to deeper trench 222. First gutter area 2281 has a depth greater than that of the second gutter area 2282 and third gutter area 2283.

During the process of pressing blank 10a or 10b to form intermediate product 20, first gutter area 2281 allows more material to flow through to form first flash portion 2181 than second gutter area

2282 and third gutter area 2283. In this way, the blocking effect to material flow caused by the materials filled in deeper trench 222 is compromised and compensated by the deeper first gutter area 2281 and accordingly, material flow at shallow trench 220 is evenly distributed. Upon completion of the pressing process, an intermediate product 20 is obtained in which, the thicknesses of flash 218 at first flash portion 2181 is different from that at second flash portion 2182 and third flash portion 2183. As a result, a plate body 210 is obtained with an even thickness 210a throughout the whole area.

In the present embodiment, intermediate product 20 is to form a damper plate 20' for hard disk drive, after flash 218 is trimmed off, as shown in Fig. 6. An intermediate product 30 is manufactured by a method of the present invention to form a damper plate, as shown in Fig. 7. Intermediate product 30 is partially ring-shaped having a first end 30a, a second end 30b and a middle portion 30c between first end 30a and second end 30b. A first pad 312, a second pad 314 and a third pad 316 are formed spaced apart from each other, to serve as screw mount support. First pad 312 is formed adjacent to first end 30a, second pad 314 is formed adjacent to second end 30b and third pad 316 is formed at middle portion 30c and closer to first pad 312 but away from second pad 314. A first middle flash portion 3181 between first and third pads 312, 316 is thicker than a second middle flash portion 3182 between second and third pads 314, 316. By configuring the flash thickness in this manner, first middle flash portion 3181 and second middle flash portion 3182 assist in better material flow control during the pressing process and as a result, the main body 310 can be formed with even thickness.

In an alternative embodiment as shown in Fig. 8, and intermediate product 40 for a hard disk damper plate may be formed with first, second and third pads 412, 414 and 416 having different shape, dimension and mass. For instance, first pad 412 may have a mass greater than second pad 414. In this embodiment, a first flash portion 4181 closer to first pad 412 is thicker than a second flash portion 4182 closer to second pad 414. By configuring the flash thickness in this manner, first flash portion 4181 and second flash portion 4182 assist in better material flow control during the pressing process and as a result, the main body 410 can be formed with even thickness.

According to a method provided by the present embodiment, a hard disk damper plate is formed by an improved hot -forging process, the damper plate has a main body with thickness tolerance meeting the structural and dimensional requirements for use in hard disk drives.

A damper plate formed with the plate body complies with the dimensional tolerance requirements, and also has the advantage in that, the plate body may also serve as a clamping portion and positional/dimensional reference for machining the pads. The pads machined on this basis will also possess necessary dimensional and positioning accuracy for use as screw support to mount the damper

plate to a hard disk base plate. After the pads are machined to the desired shape/dimension, the surface of the thinner body and the thicker body may be treated with electroless nickel plating.

Fig. 9 is a flow chart showing a method 900 of manufacturing an article according to an embodiment of the present invention. At step 902, a blank is heated up to a temperature suitable for hot forging. At step 904, the blank is placed between an upper die and a lower die. At step 906, the upper die is moved towards the lower die to press the blank, and cause the blank to plastically deform and to fill in an impression and a gutter formed in the upper die and lower die. An intermediate product is formed in which, the blank material forms the thinner body, the thicker body and a flash. The thinner body is formed in a shallow trench of the impression, the thicker body is formed in a deeper trench of the impression, and the flash is formed in the gutter. An intermediate product is formed in which, the blank material forms the thinner body, the thicker body and the flash. The thinner body is formed in a shallow trench of the impression, the thicker body is formed in a deeper trench of the impression, and the flash is formed in the gutter. The flash has a first flash portion closer to the thicker body and a second flash portion away from the thicker body. The first flash portion has a first flash thickness which is thicker than a second flash thickness of the second flash portion. By controlling the thickness of the flash at different portions, the thinner body is obtained with an even thickness. At step 908, the flash is trimmed off to form the article.

In a further embodiment as shown in Figs. 10 and 11, a sectional material 1000 is pre-made, by extrusion for instance, for forming a thin plate article e.g. a hard disk damper plate. Sectional material 1000 has thinner portions 1010 with thickness slightly greater than main body 210 (Fig. 6) of the hard disk damper plate. The thickness difference between thinner portion 1010 and main body 210 is within the range of plastic deformation of the sectional material 1010 when being pressed by cold forging, i.e. without the heating process. Similarly, thicker portions 1012, 1014 and 1016 each has a thickness the same or slightly greater than that of the pads 212, 214 and 216. As shown in Fig. 11, blanks 1020 are formed by stamping the sectional material 1000, each blank 1020 has a contour dimension slightly greater than the final dimension of the hard disk damper plate. The blank 1020 can then be further pressed by the molding process similar to that illustrated hereinabove, to form the hard disk damper plate.

Fig. 12 is a flow chart showing a method 1200 of manufacturing an article according to an embodiment of the present invention. At step 1202, a blank is provided, for instance, by stamping a sectional material. The sectional material is shaped and dimensioned suitable for being plastically deformed by cold-forging to form the required thin plate part i.e., without heating. At step 1204, the blank is placed between an upper die and a lower die. At step 1206, the upper die is moved towards the

lower die to press the blank, and cause the blank to plastically deform and to fill in an impression and a gutter formed in the upper die and lower die. An intermediate product is formed in which, the blank material forms the thinner body, the thicker body and a flash. The thinner body is formed in a shallow trench of the impression, the thicker body is formed in a deeper trench of the impression, and the flash is formed in the gutter. An intermediate product is formed in which, the blank material forms the thinner body, the thicker body and the flash. The thinner body is formed in a shallow trench of the impression, the thicker body is formed in a deeper trench of the impression, and the flash is formed in the gutter. The flash has a first flash portion closer to the thicker body and a second flash portion away from the thicker body. The first flash portion has a first flash thickness which is thicker than a second flash thickness of the second flash portion. By controlling the thickness of the flash at different portions, the thinner body is obtained with an even thickness. At step 1208, the flash is trimmed off to form the article.

Although embodiments of the present invention have been illustrated in conjunction with the accompanying drawings and described in the foregoing detailed description, it should be appreciated that the present invention is not limited to the embodiments disclosed. Therefore, the present invention should be understood to be capable of numerous rearrangements, modifications, alternatives and substitutions without departing from the spirit of the invention as set forth and recited by the following claims.

CLAIMS

1. A method for manufacturing an article having a thinner body and a thicker body, the method comprising:
 - 5 providing a blank;
 - placing the blank between an upper die and a lower die, the upper and lower dies include an impression and a gutter surrounding the impression;
 - moving the upper die towards the lower die to press the blank therebetween, wherein the blank is plastically deformed to fill in the impression and the gutter to form the thinner
 - 10 body, the thicker body and a flash, wherein the thinner body and the thicker body are formed in the impression, and the flash is formed in the gutter, and
 - trimming the flash,
 - wherein the flash includes a first flash portion closer to the thicker body and a second flash portion away from the thicker body, the first flash portion has a first flash thickness
 - 15 and the second flash portion has a second flash thickness, and
 - wherein the first flash thickness is greater than the second flash thickness.
2. The method of claim 1, wherein the article is a hard disk damper plate, the thinner body is a main body of the hard disk damper plate and the thicker body is one or more pads for
- 20 mounting the hard disk damper plate to a hard disk base.
3. The method of claim 2, wherein the hard disk damper plate is partially ring-shaped having a first end, a second end and a middle portion between the first end and the second end, the thicker portion including a first pad adjacent to the first end, a second pad adjacent to the
- 25 second end, and a third pad formed at middle portion at a position closer to the first pad than the second pad, wherein a thickness of a first middle flash portion between the first and second pads is greater than a thickness of a second middle flash portion between the second and third pads.
- 30 4. The method of claim 2, wherein the thicker portion includes a first pad and a second pad spaced apart from each other, the first pad having a mass greater than the second pad, wherein a thickness of a first flash portion closer to the first pad is greater than a thickness of a second flash portion closer to the second pad.
- 35 5. The method of claim 1 further comprising, after trimming the flash, clamping the main body and machining the pads.

6. The method of claim 5 further comprising, after machining the pads, treating a surface of the thinner body and the thicker body with electroless nickel plating.
- 5 7. The method of claim 1, wherein providing the blank includes preparing a sectional material, and stamping the sectional material to form the blank.
8. An intermediate product comprising:
 - a thinner body;
 - a thicker body formed integral to the thinner portion;
 - 10 a flash formed integral to and surrounding the thinner body and the thicker body;
 - wherein the flash including a first flash portion closer to the thicker body and a second flash portion away from the thicker body, the first flash portion having a first flash thickness and the second flash portion having a second flash thickness, and
 - wherein the first flash thickness is greater than the second flash thickness.
- 15 9. The intermediate product of claim 8, wherein the thinner body has a first end, a second end and a middle portion between the first end and the second end, the thicker body includes a first pad adjacent to the first end, a second pad adjacent to the second end, and a third pad formed at middle portion at a position closer to the first pad than the second pad, wherein the thickness of
- 20 a first middle flash portion between the first and second pads is greater than the thickness of a second middle flash portion between the second and third pads.
10. The intermediate product of claim 8, wherein the thicker body includes a first pad and a second pad spaced apart from each other, the first pad having a mass greater than the second pad,
- 25 wherein a thickness of a first flash portion closer to the first pad is greater than a thickness of a second flash portion closer to the second pad.