SWING ARM FOR ACTUATING MAGNETIC HEAD AND CASTING MOLD FOR THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a swing arm for actuating magnetic head mounted on a hard disc drive (HDD) of a computer and a casting mold for casting the same.

2. Description of the Related Art

In general, in a hard disk drive, as shown in Fig. 7, a plurality of magnetic discs 1 are arranged at a constant interval along a rotary axis C_1, and are integrally drivingly rotated by a spindle motor (not shown). On the other hand, a sleeve-shaped body 3a of a swing arm 3 is pivoted about a pivot 2 having a rotary axis C_2 in parallel with the above-described rotary axis C_1. A plurality of suspensions 4 on which magnetic heads (not shown) are to be mounted are supported to a plurality (for example, three) of plate blades 3b provided in a multi-stage around a body 3a of the swing arm 3. The swing arm 3 is angularly moved about the rotary axis C_2 by the magnetic excitation of a voice coil motor (not shown) disposed inside and outside an arm piece 3c extending in the opposite direction of the above-described blades 3b from the periphery of the body 3a of the swing arm 3. Thus, the above-described magnetic heads may move to a desired position of the magnetic discs 1.

By the way, in such a kind of a hard disc drive, in order to cope with the recent demand of the miniaturization of computers and enhancement in performances, there is a tendency that a smaller diameter magnetic disc 1 is used and a larger number of magnetic discs are to be arranged at higher density with smaller intervals therebetween. In accordance with this requirement, the number of the blades 3b provided in the

swing arm 3 is increased more and more and its thickness is reduced more and more.

However, the conventional swing arm 3 has been manufactured by cutting as a material an aluminum alloy extruded material (generally, JIS A6061S-T6) having substantially the same cross-section as an contour of the swing arm and applying a predetermined cutting work to a blank obtained through the cut. In this case, for example, when a swing arm having a large number of extremely thin blades 3b with a thickness of about 0.9 mm is to be produced, not only would a distortion or be likely to occur in the blades but also the degradation in dimensional precision would not be avoidable. If the working operation is to be effected while suppressing these disadvantages, there are serious problems in that it takes a long period of time for the work, the cost of the extruded material as the material is increased, and the manufacturing cost of the swing arm is considerably increased.

Incidentally, in some cases, the above-described swing arm 3 is manufactured by a die-casting method that is superior in mass-production. However, as the thickness of the blades 3b to be obtained is thinner, the spread of the molten material to the casting space would be insufficient. In addition, it is difficult to exhaust gas from the casting space, resulting in casting defaults-shaped a void of material, a blow hole or the-shaped. For this reason, in the case where the swing arm is produced through the die-casting, there is a limit to the thickness of about 1.05 mm as the thickness of the blades 3b. The conventional method suffers from a disadvantage that it is impossible to satisfactorily cope with the issues of miniaturization of the above-described hard disc drive and the high density tendency (highly stored memory capacity).

SUMMARY OF THE INVENTION

In order to solve the above-noted defects inherent in the conventional cases, an object of the present invention is to provide a swing arm that is made by die-cast with high quality and has thinner blades than those of the conventional cases, and a cast mold for casting the swing arm.

The swing arm for actuating magnetic disc according to the present invention is made of aluminum alloy die-cast material, and it is characterized in that a thickness of blades is less than 1.05 mm, preferably in the range of 0.85 to 0.95 mm.

In the case where the number of the blades is six in the swing arm used in an HDD, on the design, the thickness of the blades is about 0.90 mm. The present invention provides as a die-cast product the swing arm having such an extremely thin blade. The above-described preferable range of 0.85 to 0.95 mm is a value that is centered about the thickness of 0.90 mm including an allowance of +0.05 mm and -0.05 mm.

According to the present invention, it is possible to use any kind of material for the above-described aluminum alloy. It is preferable to use an Al-Si based alloy that is good in casting property and high in mechanical strength, for example, JIS ADC10, AD C12 or the-shaped.

On the other hand, in a casting mold for casting the swing arm, a cross-sectional area of an overflow gate provided at a terminal of a blade casting space is set to be greater than a cross-sectional area of a runner gate provided in a body casting space and a volume of a molten material storage portion connected to the overflow gate is set to enable to receive the overflow of a greater weight of the molten material than a weight

of a product portion.

In general, a cross-sectional area of the overflow gate of the die-cast mold is set in the range of 50 to 70% of the cross-sectional area of the runner gate, and at the same time, the overflow weight is set so as not to exceed the product portion weight. However, as described above, the cross-sectional area of the overflow gate and the volume of the overflow molten material portion are set to be greater than those in the conventional case. Not only can the molten material flow be smoother to the blade casting space but also gas removal may be attained smoothly to thereby thin the blades as much as possible.

However, if the cross-sectional area of the overflow gate and the overflow weight are set to be too large, the pressure of the molten material is reduced and the cast concentration would be likely to occur. Accordingly, it is preferred that the cross-sectional area of the overflow gate and the overflow weight are suppressed below the upper limit of 150% of the runner gate cross-sectional area and the product portion weight.

In the casting mold according to the present invention, the above-described overflow molten material storage portion may be in communication with the chill vent in communication with the evacuation means. Accordingly, it is possible to perform well the molten material flow and the gas removal.

Also, a heating circuit for causing thermal medium to flow may be provided around the body casting space and the blade casting space. With the flow of the thermal flow to the heating circuit, the temperature drop of the molten material is suppressed, and the molten material flow and the gas removal may be further smoothly performed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a plan view illustrating the shape of a swing arm for actuating a magnetic head according to the present invention;

Fig. 2 is a side view illustrating a cross-sectional portion of the shape of a swing arm according to the present invention;

Fig. 3 is a cross-sectional view showing an entire structure of a casting mold for casting the swing arm;

Fig. 4 is a cross-sectional view showing an enlarged main portion of the casting mold;

Fig. 5 is a plan view showing a partly cross-sectional structure of a movable type that constitutes the casting mold;

Fig. 6 is a cross-sectional view showing an arrangement of a movable core that constitutes the casting mold; and

Fig. 7 is a schematic diagram illustrating a structure of a hard disk drive including a swing arm.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will now be described with reference to the accompanying drawings.

Figs. 1 and 2 shows a swing arm for actuating a magnetic head in accordance with the present invention. The swing arm 10 has the same basic construction as that shown in Fig. 7 and is composed of a sleeve-shaped body 11 pivoted about a pivot 2 (Fig. 7) having a rotary axis C_2, a plurality (for example, five) of plate blades 12 arranged in a multistage about the body 11, and a fork-shaped arm piece 13 extending to the opposite direction from the periphery of the above-described body 11 to the above-described blades 12. A suspension 4 (Fig. 7) on which the magnetic head (not shown) is to be mounted is supported to each blade 12. A voice coil motor (not

shown) is disposed inside and outside of the arm piece 13. The swing arm 10 is angularly moved about the rotary axis C_2 by the magnetic excitation of the above-described voice coil motor and the above-described magnetic head may move to a desired position of the magnetic disc 1 (Fig. 7) drivingly rotated by a spindle (not shown). Incidentally, an inward flange 14 for coupling with a pivot (not shown) is provided in the interior of the body 11. Also, a triangular through hole 15 for reducing the weight is provided in the central portion of each blade 12.

In the embodiment, the swing arm 10 is set so that a thickness t_1 of each blade 12 is about 0.9 mm, a gap p between the adjacent blades 12 is about 2.7 mm and a thickness t_2 of the arm piece 13 is about 2.3 mm, respectively. The swing arm as a whole is made of die-cast product of Al-Si based alloy such as JIS ADC10, ADC12 or the like. However, integration portions (extra material) 16 that connect the respective blades 12 are present in the region surrounded by dotted lines in Fig. 2 if any process is not applied to the integration portions. In the swing arm 10, the integration portions 16 are removed by cutting work to thereby provide a final product.

The thus produced swing arm 10 partially needs the cutting work of the integration portions 16 on the tip end side of each blade 12. However, since the product is superior in mass production as a whole and almost all the parts may be used without any process after the die-casting, in comparison with the conventional case where the extruded material is used as a basic material, it is possible to considerably reduce the manufacturing cost and the material cost, which is very advantageous in cost.

Incidentally, organic substance or the-shaped

sticks onto the surface of the cast product. Since an outgas would be generated in use due to this organic substance, during the production, for example, it is preferable to apply a non-electrolyte nickel or the-shaped to the surface to cover the surface with a coating.

Figs. 3 to 6 show a casting mold 20 according to the present invention for casting the above-described swing arm 10. In Figs. 3 to 6, reference numeral 21 denotes a fixed die into which a fixed core 22 is disposed, and reference numeral 23 denotes a movable die into which a movable core 24 is inserted. The movable die 23 is supported on a movable die base 25 through a spacer 26, integrally moved back and forth with the movable base 25 by a driving means (not shown), and in the casting operation, keeps the mold closing condition in contact with the fixed die 21 as shown in Fig. 3. In Fig. 3, PL designates a parting line between the above-described fixed die and movable die 23. In the above-described mold clamping condition, a casting space 27 to be described in more detail later (indicated by solid portions in Fig. 3), a runner 28, a runner gate 29 and the like are formed on the PL. Also, a sprue bush 30 is internally provided to the fixed die 21 and a branch 31 is internally provided in the movable die 23, respectively. In the above-described mold clamping condition, a molten material inlet portion 32 is formed between the sprue bush 30 and the branch 31. A plunger sleeve 33 through which a plunger (not shown) is slidingly moved is connected to the sprue bush 30. The advance of the above-described plunger causes the molten material within the plunger sleeve 33 to pour into the casting space 27 through the molten material inlet portion 32, the runner 28 and the runner gate 29.

In the embodiment, a first fixed core 34 for forming

the sleeve-shaped body 11 of the above-described swing arm 10 (Figs. 1 and 2) is provided in the movable die 23. The proximal end portion of the fixed core 34 is supported to the above-described movable base 25 and the upper end portion thereof extends into the above-described casting space 27 through the movable die 23 and the movable core 24. On the other hand, as shown in Fig. 4, a cylindrical projection 35 which projects into the casting space 27 is provided in the fixed core 22. The tip end of the above-described first fixed core 34 is in abutment with the end face of the projection 35 in the mold clamping condition. A body casting space 27a (see Figs. 4 and 5) for forming the sleeve-shaped body 11 of the above-described swing arm is defined around the fixed core 35. Thus, the above-described gate 29 is opened to the casting space 27a and the molten material that has passed through the above-described molten material inlet portion 32 and the runner 28 is first introduced into the body casting space 27a.

Second fixed cores 36A and 36B are disposed for forming through holes 15 to be provided in the respective blades 12 of the above-described swing arm 10 in both of the fixed die 21 and the movable die 23. The proximal end portions of the second fixed cores 36A and 36B are fixed to the back surfaces of the fixed die 21 and the movable die 23 and extend to the above-described casting space 27 through the dies 21 and 23 and the cores 22 and 24 to which the end portions thereof correspond, respectively. Then, the respective end faces of the second fixed cores 36A and 36B are caused to face each other at an intermediate position (on a parting line PL) of the casting space 27 under the mold clamping condition (Fig. 4).

On the contrary, movable cores 37A and 37B for forming the respective blades 12 of the above-described swing

arm 10 are arranged slidably in the movable die 23 (Fig. 6). As shown in Figs. 4 and 5, the movable cores 37A and 37B have a multiplicity (four in this case) of ribs 38 at the tip end portions. In casting, the tip ends of the respective ribs 38 are made to abut directly or indirectly through the above-described fixed cores 36A and 36B so that the blade casting spaces 27b for forming the respective blades 12 of the swing arm 10 are defined around the second fixed cores 36A and 36B.

Here, as best shown in Fig. 6, slant holes 39 are formed in the respective movable cores 37A and 37B, and slant pins 40 arranged in the fixed die 21 are inserted into the slant holes 39 in response to the mold clamping operation. These slant holes 39 and slant pins 40 are provided to slant in a direction away from the casting space 27 toward the movable die 23 from the fixed die 21. Accordingly, in accordance with the increase of the insertion depth of the slant pins 40 to the slant hole 39, i.e., in accordance with the clamping operation, the respective movable cores 37A and 37B are driven in a direction in which they are closer to each other, and upon the completion of the clamping operation, the ribs 38 of the respective ends are brought into abutment with each other within the casting space 27. On the other hand, one end of an operating rod 42 extending from the interior to the exterior of the mold through a guide sleeve 41 provided fixedly to the movable die 23 is coupled to a rear end of each movable core 37A, 37B. Under the unclamping condition, each movable core 37A, 37B is biased in a direction away from each other by a spring 42' wound around the operating rod 42 and positioned at the retracted end. Incidentally, a positioning block 43 for positioning each movable core 37A, 37B in abutment with the shoulder surface on the rear portion of each movable core 37A, 37B upon the completion of the clamping

operation is fixed to the fixed die 21. Also, a recess portion 44 for escaping the tip end of the slant pins 40 passed through the above-described slant hole 39 is formed in the movable die 23.

A portion corresponding to the casting space of the integration portion 16 for forming the tip end portions of the blades 12 of the above-described swing arm 10 integrally with each other is cut in each of the above-described movable cores 37A and 37B so that the tip end portion of the blade casting space 27b is formed as the a communication region 45. An overflow gate 46 in communication with the communication region 45 and a communication passage 47 in communication with an overflow first molten storage portion 51 between the fixed core 22 and the movable core 24 are provided in the respective alignment portions of the respective movable cores 37A and 37B.

Arm piece casting spaces 27c and 27c for forming the fork-shaped arm pieces 13 of the above-described swing arm 10 are formed between the fixed core 22 and the movable core 24 (Figs. 4 and 5). Second molten material storage portions 52 and 52 for the overflow are in communication with the casting spaces 27c and 27c through the second overflow gates 53. (Fig. 5).

A chill vent 54 is interposed between the fixed die 21 and the movable die 23 (Fig. 3). A flow path 55 in communication with the first molten material storage portion 51 is provided in the interior of the chill vent 54. An evacuation means 56 disposed outside of the mold is connected to this flow path 55 through a pipe 57. Also, flow paths (heating circuits) 58 and 59 for circulation of thermal medium are formed in the interiors of the fixed core 22 and the movable core 24, respectively (Fig. 3). These heating circuit 58 and 59 are provided so as to surround the peripheries of the body casting space 27a,

the blade casting spaces 27b and the arm piece casting spaces 27c and are supplied with the thermal medium from the heating means provided outside the mold.

Incidentally, each extruder member is arranged in the movable die 23. However, here, only a sleeve-shaped extruder member 60 (Fig. 4) around the first fixed core 34 is shown and the other members are omitted.

Thus, the first overflow gate 46 in communication with the communication region 45 at the tip end side of the above-described blade casting space 27b is set so that its cross-sectional area is greater than a cross-sectional area of the runner gate 29. Also, the overflow first molten material storage portion 51 has a volume so that it may receive the overflow having a weight that is more than the weight of the product portion filled in the casting space 27.

The die casting by the casting mold 20 thus constructed will now be described.

In casting, after the movable die 23 is closed to the fixed die 21, a predetermined amount of molten material is fed into the plunger sleeve 33 and the plunger (not shown) is advanced. Then, the molten material within the plunger sleeve 33 is fed at a predetermined pressure from the molten material inlet portion 32 formed between the tip end of the sprue bush 30 and the branch 31 through the runner 28 and the runner gate 29 to the body casting space 27a. The molten material filled in this body casting space 27a fills the casting space 27a, and thereafter flows into the blade casting spaces 27b and the arm piece casting spaces 27c to fill these spaces 27b and 27c. Thereafter, the molten material flows into the first and second molten material storage portions 51 and 52 from the first and second overflow gates 46 and 53 and solidifies intact.

Then, after the solidification, when the movable

die 23 is unclamped from the fixed die 21, the movable cores 37A and 37B are retracted from the casting position by the slant pins 40. The ribs 38 at the tip ends thereof are removed from the product portion. Thereafter, the product portion and the overflow portion are removed from the movable die 5 together by the operation of the extruder members (not shown). Thus, one casting cycle is completed. Incidentally, the product portion is cut away from the overflow portion in another process. However, in this stage, since the tip end side of each blade 12 is formed integrally with the integration portion 16, this integration portion 16 is cut away by cutting work to thereby complete the production of the swing arm 10.

However, as described above, the first overflow gate 46 in communication with the blade casting space 27b is set so that its cross-sectional area S_1 is greater than the cross-sectional area S_0 of the runner gate 29 and the overflow first molten metal storage portion 51 has a volume so that the overflow weight W_1 of the molten material to flow into the storage portion is greater than the product portion weight W_0 of the material to be filled into the casting space 27. Accordingly, the molten material that flows into the blade casting space 27b flows smoothly through the casting space 27b and flows to the overflow molten material portion 51 to thereby make good the material flow and to smoothly remove the gas. As a result, in spite of the fact that the thickness t_1 of the material is about 0.9 mm, there is no fault such as void or blow hole in the blades 12. The obtained swing arm 10 is provided as a high quality die-cast product as a whole.

In the embodiment, in particular, since the overflow first molten material storage portion 51 is formed in communication with the chill vent 54 in communication with the evacuation means 56, the molten material flow

and the gas removal may be further smoothly attained.

Also, since the heating circuits 58 and 59 for flowing the thermal medium are provided around the body casting space 27a, the blade casting spaces 27b and the arm piece casting spaces 27c and the thermal medium is caused to flow therethrough, the temperature drop of the molten material is considerably suppressed, and the molten material flow and the gas removal may be further smoothly attained.

Experimental Example

The following experiment was conducted for the above-described embodiment of the present invention. In the casting mold 20, the runner gate 29 was of a size with a width w_0=11 mm (Fig. 5) and a height h_0=1.0 mm (Fig. 4). Its cross-sectional area S_0 (W_0xh_0) was set at 11 mm^2. On the other hand, the first overflow gate 46 was of a size with a width w_1=1.0 mm (Fig. 5) and a height h_1=12 mm (Fig. 4). Its cross-sectional area S_1 (w_1xh_1) was 12 mm^2. In this case, a ratio (S_1/S_0) of the cross-sectional area S_1 of the first overflow gate 46 to the cross-sectional area S_0 of the runner gate 29 was about 109% and was rather large in comparison with the conventional ratio of 50 to 70%.

Also, the overflow weight W_1 of the molten material introduced into the first molten material storage portion 51 was set at 12g and the amount of the molten material filled in the casting space 27, i.e., the weight W_0 of the product portion was set at 11g, respectively. In this case, the ratio (W_1/W_0) of the overflow weight W_1 to the product portion weight W_0 was about 109% and was rather high in comparison with the conventional ratio of less than 100%.

Then, after the above-described casting mold 20 was closed, the oil kept at a temperature in the range of 250 to 300°C was circulated in the above-described heating

circuits 58 and 59, and at the same time, the evacuation means 56 was operated to provide the flow path 55 within the chill vent 54 with a negative pressure. Under this condition, the molten material of Al-Si alloy of JIS ADC12 molten in a furnace was fed to the plunger sleeve 33. The molten material was filled in the casting space 27 within the casting mold 20 under the condition of the maximum injection pressure of 11.8 MPa by the sliding movement of the plunger. Furthermore, the molten material was filled into the first and second molten material storage portions 51 and 52 and was solidified intact. Then, after the unclamping operation, the product portion and the overflow portion were removed from the mold together. In another process, the integration portion 16 (Fig. 2) of the tip end of each blade 12 was cut away by the cutting work. The swing arm 10 (Figs. 1 and 2) having the blades 12 with a thickness t_1=0.9 mm was obtained.

Then, the outer appearance of the swing arm 10 thus completed was observed, and at the same time, the inspection of the surface damage was conducted by a magnetic probe method. Furthermore, an X-ray inspection was conducted to inspect the internal quality. As a result, there was no casting fault such as a void, a blow hole, or an unusual concentration in the swing arm 10 including the blades 12 as a whole. It was confirmed that the swing arm 12 that satisfies the quality requirement might be obtained.

As described above, with the swing arm for actuating the magnetic head according to the present invention, it is possible to provide a die-cast product having blades that are thinner than the conventional blades with a high quality. It is possible to attain the remarkable cost reduction in comparison with the conventional case using the extruding material as a raw material.

Also, in the casting mold in accordance with the present invention, it is possible to form the extremely thin blades only with a simple countermeasure to expand the overflow gate and the overflow molten material storage portions beyond the conventional case. Accordingly, in a factory where the swing arm was produced in a conventional manner through the die-casting, it is possible to use the casting faculty as it is by slightly changing the design of the mold, which leads to a tremendous advantage.

WHAT IS CLAIMED IS:

1. A casting mold for casting a swing arm for actuating a magnetic head in which a plurality of plate blades for supporting magnetic heads are provided around a sleeve-shaped member pivoted about a pivot in a multiplicity of stages, the swing arm being die-cast of aluminum alloy and a thickness of the blades being less than 1.05 mm, wherein a cross-sectional area of an overflow gate provided at a terminal of a blade casting space is set to be greater than a cross-sectional area of a runner gate provided in a body casting space and a volume of a molten material storage portion connected to the overflow gate is set to receive the overflow of a greater weight of the molten material than a weight of a product portion.

2. The casting mold for casting the swing arm according to claim 1, wherein the overflow molten material storage portion is in communication with a chill vent in communication with an evacuation means.

3. The casting mold for casting the swing arm according to claim 1 or 2, wherein a heating circuit for causing thermal medium to flow is provided in around the body casting space and the blade casting space.