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(54) **Beryllium-aluminium-based alloy**

(57) A Be-Al-based alloy suitably used for an actuator of a hard disk device is disclosed, which includes 30 to 95 wt% Be, and not more than 1.0 wt% Mg as a flowability improving element. The Be-Al-based alloy has an improved flowability which makes it possible to decrease extrusion pressure during extrusion stage, to extend the lifetime of the extrusion dies, and allow an inexpensive crucible material to be used.

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a Be-Al-based alloy which can be suitably used for an actuator of a hard disk device.

2. Description of the Related Art

[0002] Recently, in various application fields such as for actuator of hard disk device and the like, Be-Al-based alloy is considered to be a prominent material in view of light weight and high strength or high Young's modulus properties.

[0003] For manufacturing products from Be-Al-based alloy, it is customary to prepare ingot by vacuum casting and perform subsequent process steps such as extrusion, rolling, drawing, forging, and the like. As known in the art, Be-Al-based alloy has a composite structure in which beryllium-rich phase and aluminum-rich phase coexist.

[0004] When Be-Al-based alloy is subjected to extrusion process after vacuum casting, since the flowability of the material is poor, there have been noted problems that high extrusion pressure is needed, and that die abrasion is notable and lifetime is shortened. Further, when Be-Al-based alloy is formed into ingot by vacuum casting process, beryllia (BeO) porcelain is required for a crucible material, which is difficult to produce and is thus expensive. This is because if the crucible material of Be-Al-based alloy casting comprises relatively inexpensive alumina porcelain, alumina porcelain may be dissolved by the strong reductivity of Be according to the following reaction formula:

$$Al_2O_3 + 3Be(Liq) \rightarrow 2Al(Liq) + 3BeO,$$

with the result that the crucible may be eroded.

[0005] In order to eliminate the above-mentioned problems, there has been proposed a Be-Al alloy forming process in which Be powder and Al powder are mixed and compacted, and then sintered such that only Al powder is caused to melt. Such a process is disclosed, for example, in U.S. Patent No. 5,551,997. However, this type of forming process is still disadvantageous in that the final products are brittle due to insufficient bonding between Be and Al powders, that preparation of Be and Al powders separately from each other is not only time-consuming and costly, but also there is a risk of explosion during preparation of Al powder.

DISCLOSURE OF THE INVENTION

[0006] It is therefore a primary object of the present invention to eliminate the above-mentioned problems.

[0007] It is a more specific object of the invention to provide a Be-Al-based alloy having an improved flowability, thereby making it possible to decrease the extrusion pressure when manufacturing the products, to extend the lifetime of extrusion dies, and to allow an inexpensive crucible to be used.

[0008] According to the present invention, there is provided a Be-Al-based alloy having an excellent flowability, comprising 30 to 95 wt% Be, not more than 1.0 wt% Mg, and the balance which consists essentially of Al.

[0009] The Be-Al-based alloy according to the invention may further comprise at least one member selected from the group consisting of Si: 0.5 to 5.0 wt%, Ag: 0.2 to 5.0 wt% and Zr: 0.2 to 5.0 wt%, as an Al-rich phase strengthening element.

[0010] Also, the Be-Al-based alloy according to the invention may further comprise at least one member selected from the group consisting of Co: 0.05 to 5.0 wt%, Ni: 0.05 to 5.0 wt% and Cu: 0.2 to 5.0 wt%, as a Be-rich phase strengthening element.

[0011] Furthermore, the Be-Al-based alloy according to the invention may further comprise at least one member selected from the group consisting of Sr: 0.005 to 0.3 wt% and Sb: 0.005 to 0.3 wt%, as an extensibility improving element.

[0012] In the following, explanation will be made of the reasons for the above-mentioned numerical limitations for the respective elements in the composition of Be-Al-based alloy according to the invention.

<u>Be: 30 to 95 wt%</u>

[0013] Be is an element useful for improving the strength and hardness by forming eutectic structure with Al. When the Be content is less than 30 wt%, the desired improvement of strength and hardness cannot be sufficiently achieved. On the other hand, when the Be content exceeds 95 wt%, the formability is notably deteriorated. Therefore, according to the invention, Be is contained within the ranges of 30 to 95 wt%.

Mg: not more than 1.0 wt%

[0014] Mg is an important element for remarkably improving the flowability of Be-Al-based alloy. However, when the Mg content exceeds 1.0 wt%, Young's modulus of the alloy is notably decreased. Therefore, according to the invention, the Mg content is limited to be not more than 1.0 wt%. There is no particular lower limit of Mg contents, because the desired effect can be achieved even by addition of a small amount of Mg. Nevertheless, Mg contents is preferably not less than 0.05 wt% in order to obtain good flowability and adequately decrease the extrusion pressure during the extrusion stage.

Si: 0.5 to 5.0 wt %, Ag: 0.2 to 5.0 wt%, Zr: 0.2 to 5.0 wt%

[0015] Si, Ag and Zr effectively contribute to strengthen an Al-rich phase of the alloy. When these contents of these elements content are too small, the desired strengthening effect is difficult to achieve. On the other hand, when the contents of these elements are excessive, the density of the alloy becomes higher so that the essentially required properties of Be-Al-based alloy, such as the desired lightness, cannot be readily achieved. Therefore, these elements are contained by the above-mentioned respective ranges.

Co: 0.005 to 5.0 wt%. Ni: 0.05 to 5.0 wt%. Cu: 0.05 to 5.0 wt%

[0016] Co, Ni and Cu also effectively contribute to strengthen a Be-rich phase of the alloy. When the contents of these elements are too small, the desired strengthening effect is difficult to achieve. On the other hand, when the contents of these elements are excessive, the density of the alloy becomes higher so that the essentially required properties of Be-Al-based alloy, such as the desired lightness, cannot be readily achieved. Therefore, these elements are contained by the above-mentioned respective ranges.

Sr: 0.005 to 0.3 wt%. Sb: 0.005 to 0.3 wt%

[0017] Sr and Sb are respectively useful elements for improving the extensibility of the alloy. When the contents of these element are less than 0.005 wt%, the desired improvement cannot be sufficiently achieved. On the other hand, when the contents of these elements exceed 0.3 wt%, the cost of the alloy increases though the extensibility cannot be further improved anymore.

[0018] According to the invention, as described above, Mg in the range of not less than 1.0 wt% is added into the Be-Al-based alloy, so as to remarkably improve the flowability of the Be-Al-based alloy. As a result, the extrusion pressure during the extrusion stage can be remarkably decreased when products are manufactured.

[0019] Moreover, it is of course that a desired amount of Mg can be added into Be-Al-based metal when raw material is melted. However, when a magnesia (MgO) crucible is used for melting the raw material of Be-Al-based alloy, Mg can be automatically added from the crucible because Mg is dissolved from MgO contents of the crucible. In this instance, it is unnecessary, when melting the raw material, to add Mg which is easily oxidized and consumed, besides that an inexpensive magnesia crucible can be used which contributes to reduce the manufacturing cost.

[0020] Also, since the Mg amount of deoxidization from the magnesia crucible is not more than 1.0 wt%, the crucible is essentially free from erosion.

[0021] The present invention will be further described below with reference to specific examples.

Example 1

[0022] Be-Al-based ingots (size: 70 mm∅ ×250 mm) having compositions as shown in Table 1 were extruded from an extrusion die under the temperature condition of 490°C and the extrusion ratio of 10. The extrusion pressure, Young's modulus of the products and the dies lifetime are also shown in Table 1.

[0023] In this respect, the dies lifetime shown in Table 1 are indices compared with control alloys (lifetime index =1.0) having a compositional ratio of Be and Al which is essentially the same as the alloys according to the invention, indicating how lifetime of the dies are extended by the addition of Mg.

[0024] Also, the asterisks (*) in Table 1 indicate alloys which were made by magnesia (MgO) crucible in melting, and Mg was added from such crucible to the alloy.

Table 1

No.	composition (wt%)			Young's Modulus (kgf/mm^2)	extrusion pressure (kgf/cm^2)	lifetime of the die	note
	Be	Al	Mg				
1*	65.0	34.5	0.5	19000	4200	1.2	inventive example
2	65.0	34.0	1.0	18950	4050	1.3	inventive example
3	45.0	54.9	0.1	15850	2400	1.1	inventive example
4	45.0	54.5	0.5	15800	2340	1.2	inventive example
5*	45.0	54.0	1.0	15750	2300	1.2	inventive example
6	60.0	35.0	5.0	18500	3950	1.3	comparative example
7	63.0	35.0	2.0	18550	4000	1.2	comparative example
8	45.0	45.0	10.0	14400	2100	1.3	comparative example
9	45.0	50.0	5.0	15100	2150	1.3	comparative example
10	45.0	53.0	2.0	15200	2250	1.2	comparative example
11	65.0	35.0	0	19000	4500	1.0	control example
12	45.0	55.0	0	15900	2500	1.0	control example

* made by magnesia (MgO) porcelain

[0025] As can be clearly seen from Table 1, the Be-Al-based alloys containing a proper amount of Mg according to the present invention serve to effectively decrease the extrusion pressure without essentially decreasing Young's modulus. It can be also clearly seen that the addition of Mg contributes to extend the lifetime of the dies.

Example 2

[0026] Be-Al-based ingots having compositions as shown in Table 2 were extruded from the dies under the conditions which are same as those in Example 1. The extrusion pressure, Young's modulus of the products, and the lifetime of the dies are also shown in Table 2.

Table 2

No.	composition (wt%)				Young's Modulus (kgf/mm^2)	extrusion pressure (kgf/cm^2)	lifetime of the die	note
	Be	A1	Mg	others				
1*	65.0	34.0	0.5	Co: 0.5	19050	4250	1.2	inventive example
2	65.0	32.0	1.0	Ni: 1.0 Co: 1.0	19150	4250	1.2	inventive example
3	45.0	53.9	0.1	Cu: 1.0	15950	2300	1.2	inventive example
4	45.0	52.5	0.5	Si: 2.0	16000	2400	1.15	inventive example
5*	45.0	51.0	1.0	Ag: 3.0	16050	2400	1.15	inventive example
6	65.0	33.5	0.5	Zr: 1.0	19100	4200	1.15	inventive example
7	65.0	34.45	0.5	Sr: 0.05	19000	4150	1.2	inventive example
8	45.0	54.44	0.5	Sb: 0.01 Sr: 0.05	15800	4050	1.25	inventive example
9*	45.0	44.0	1.0	Co: 10.0	15000	2600	0.85	comparative example
10	45.0	44.0	1.0	Si: 10.0	15050	2650	0.85	comparative example
11*	65.0	24.5	0.5	Zr: 10.0	19300	4700	0.85	comparative example

* made by magnesia (MgO) porcelain

[0027] Similar to Example 1, the Be-Al-based alloys containing a proper amount of Mg according to the present invention serve to effectively decreased the extrusion pressure without essentially decreasing Young's modulus. It can be also clearly seen that the addition of Mg contributes to extend the lifetime of the dies.

[0028] It will be appreciated that the present invention provides a novel Be-Al-based alloy which advantageously improve the flowability of the materials after vacuum casting, and which makes it possible to improve the formability of materials and productivity. The present invention is also advantageous in that, when extrusion is applied as a forming step, the extrusion pressure can be decreased and a high extrusion ratio can be used while extending the lifetime of extrusion dies.

[0029] A Be-Al-based alloy suitably used for an actuator of a hard disk device is disclosed, which includes 30 to 95 wt% Be, and not more than 1.0 wt% Mg as a flowability improving element. The Be-Al-based alloy has an improved flowability which makes it possible to decrease extrusion pressure during extrusion stage, to extend the lifetime of the extrusion dies, and allow an inexpensive crucible material to be used.

Claims

1. A Be-Al-based alloy having an excellent flowability, comprising 30 to 95 wt% Be, not more than 1.0 wt% Mg, and the balance which consists essentially of Al.

2. A Be-Al-based alloy according to claim 1, further comprising at least one member selected from the group consisting of Si: 0.5 to 5.0 wt%, Ag: 0.2 to 5.0 wt% and Zr: 0.2 to 5.0 wt%.

3. A Be-Al-based alloy according to claim 1, further comprising at least one member selected from the group consisting of Co: 0.05 to 5.0 wt%, Ni: 0.05 to 5.0 wt% and Cu: 0.2 to 5.0 wt%.

4. A Be-Al-based alloy according to claim 1, further comprising at least one member selected from the group consisting of Sr: 0.005 to 0.3 wt% and Sb: 0.005 to 0.3 wt%.

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EUROPEAN SEARCH REPORT

Application Number
EP 98 12 3234

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	8 March 1999	Badcock, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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