



(11)

EP 3 257 957 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.12.2017 Bulletin 2017/51

(51) Int Cl.:
C22C 21/02 ^(2006.01) **B22F 3/17** ^(2006.01)
B22F 3/20 ^(2006.01) **B22F 3/24** ^(2006.01)
C22C 21/04 ^(2006.01)

(21) Application number: **17168677.7**

(22) Date of filing: **28.04.2017**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(30) Priority: **13.06.2016 JP 2016117232**

(54) **ALUMINUM ALLOY FORGING AND METHOD OF PRODUCING THE SAME**

(57) An aluminum alloy forging (20) is a forging of an aluminum alloy atomized powder containing Si: 10.0 mass% to 19.0 mass%, Mn: 3.0 mass% to 10.0 mass%, Cu: 0.5 mass% to 10.0 mass%, Mg: 0.2 mass% to 3.0 mass%, and the balance being Al and inevitable impurities. A cross-sectional structure of the forging (20) is con-

figured so as to include a θ -phase of CuAl_2 , and an average circle equivalent diameter of the θ -phase is 0.66 μm to 1.66 μm . The aluminum alloy forging (20) having such a structure is excellent in forgeability and high in temperature strength.

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Description**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention relates to an aluminum alloy forging excellent in strength at high temperature and a method of producing the aluminum alloy forging. More particularly, it relates to an aluminum alloy forging suitably used as a sliding member, such as, e.g., an engine piston of an internal combustion engine, which is required to have a large heat load, abrasion resistance, and seizure resistance, and a method of producing the aluminum alloy forging.

Description of Prior Art

[0002] Since an engine piston for an internal combustion engine is a member that slides at high temperature, it is required to have excellent abrasion resistance and sufficient high temperature strength, and further required to have excellent seizure resistance.

[0003] Further, as for automobile parts, it has become necessary to achieve weight saving and higher functionality in response to the recent demands for improvement in fuel economy in the automobile industry. Under the circumstances, as a sliding member for use as an automobile engine piston, etc., in place of conventional steel materials and cast iron materials, an aluminum alloy material which is light in weight has been attracting attention.

[0004] Among various aluminum alloys, eutectic or hypereutectic Al-Si alloys contain about 10 mass% or more of Si. This eutectic or hypereutectic Al-Si alloy is small in coefficient of thermal expansion and excellent in abrasion resistance, so it is used as a material for a sliding member, such as, e.g., an automobile engine piston.

[0005] However, since an Al-Si alloy containing a large amount of Si is produced by a casting method, there was a problem that the strength and toughness deteriorate since it was difficult to completely eliminate casting defects and primary crystal Si would be coarsely crystallized or segregated. Furthermore, this kind of Al-Si alloy is limited in the type of alloy elements and/or the additive amount, so there is a limit to further improve the performance with this Al-Si alloy.

[0006] Under such circumstances, attention is paid to an aluminum alloy powder material capable of being used even in high-temperature atmosphere. As the aluminum alloy powder, an aluminum alloy powder containing one or two heavy metals selected from the group consisting of Si: 15.0 to 25.0% by weight, Fe: 5.9 to 15.0% by weight, and Mn: 7.1 to 15.0% by weight, and the balance being Al and inevitable impurities, and having a size of a Si crystal grain of 15 μm or less is known (see Patent Document 1: Japanese Unexamined Laid-open Patent Publication No. S63-266005).

SUMMARY OF THE INVENTION**Problems to be Solved by the Invention**

[0007] In the meantime, in recent years, in order to improve a combustion efficiency and an output of an internal combustion engine, a combustion temperature of the internal combustion engine is raised. Along with this, for example, a sliding member, such as an engine piston for an automobile, is also required to have sufficiently high strength in a higher temperature range than in the past, but the technique described in the aforementioned patent document 1 could not meet such a demand.

[0008] The present invention was made in view of such a technical background, and aims to provide an aluminum alloy forging excellent in forgeability, such as easy to forging deformation and no occurrence of cracking, and also high in high temperature strength, and also to provide a method of producing such an aluminum alloy forging.

Means for Solving the Problem

[0009] In order to attain the aforementioned objects, the present invention provides the following means.

[1] An aluminum alloy forging made of an aluminum alloy atomized powder forging containing: Si: 10.0 mass% to 19.0 mass%; Mn: 3.0 mass% to 10.0 mass%; Cu: 0.5 mass% to 10.0 mass%; Mg: 0.2 mass% to 3.0 mass%; and the balance being Al and inevitable impurities,

characterized in that a cross-sectional structure of the forging includes a θ -phase of CuAl_2 , and an average circle equivalent diameter of the θ -phase is in a range of 0.66 μm to 1.66 μm .

[2] The aluminum alloy forging as recited in the aforementioned Item [1], wherein the forging contains an Al-Mn-Si based intermetallic compound, and an average circle equivalent diameter of the Al-Mn-Si based intermetallic compound in the cross-sectional structure of the forging is in a range of 0.04 μm to 0.24 μm .

[3] The aluminum alloy forging as recited in the aforementioned Item [1] or [2], wherein the aluminum alloy forging further contains 0.01 mass% to 5.0 mass% of each of one or more elements selected from the group consisting of Ti, Zr, V, W, Cr, Co, Mo, Ta, Hf, and Nb.

[4] A method of producing an aluminum alloy forging, the production method comprising:

a powdering step of powdering a molten metal of an aluminum alloy by rapidly solidifying the molten metal by an atomizing method to obtain an aluminum alloy powder, the aluminum alloy containing Si: 10.0 mass% to 19.0 mass%, Mn: 3.0 mass% to 10.0 mass%, Cu: 0.5 mass% to 10.0 mass%, Mg: 0.2 mass% to 3.0 mass%, and the balance being Al and inevitable impurities;

a forming step of compression molding the aluminum alloy powder to obtain a green compact;

an extrusion step of hot extruding the green compact to obtain an extruded material; and

a forging step of hot forging the extruded material to obtain a forging in which a cross-sectional structure of the forging includes a θ -phase of CuAl_2 and an average circle equivalent diameter of the θ -phase is in a range of 0.66 μm to 1.66 μm .

[5] The method of producing an aluminum alloy forging as recited in the aforementioned Item [4], wherein the forging contains an Al-Mn-Si based intermetallic compound, and an average circle equivalent diameter of the Al-Mn-Si based intermetallic compound is in a range of 0.04 μm to 0.24 μm in a forging cross-sectional structure of the forging.

[6] The method of producing an aluminum alloy forging as recited in the aforementioned Item [4] or [5], wherein the molten metal of the aluminum alloy further contains 0.01 mass% to 5.0 mass% of each of one or more elements selected from a group consisting of Ti, Zr, V, W, Cr, Co, Mo, Ta, Hf, and Nb.

Effects of Invention

[0010] According to the aforementioned invention [1], an aluminum alloy forging excellent in forgeability, such as easy to forging deformation and no occurrence of cracking, and high in temperature strength is provided. Therefore, this forging is suitable as, for example, a sliding member for an automobile engine piston, etc.

[0011] According to the aforementioned invention [2], an aluminum alloy forging higher in high temperature strength is provided.

[0012] According to the aforementioned invention [3], an aluminum alloy forging further increased in high temperature strength is provided.

[0013] According to the aforementioned invention [4], it is possible to produce an aluminum alloy forging excellent in forgeability, such as easy to forge deformation and no occurrence of cracking, and large in high temperature strength. Therefore, the obtained forging is suitable as, for example, a sliding member for an automobile engine piston.

[0014] According to the aforementioned invention [5], an aluminum alloy forging higher in high temperature strength can be manufactured.

[0015] According to the aforementioned invention [6], an aluminum alloy forging further increased in high temperature strength can be manufactured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a perspective view showing an example of an extruded material before being subjected to forging.

Fig. 2 is a perspective view showing an example of a forging according to the present invention.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0017] An aluminum alloy forging is a forging of an aluminum alloy atomized powder containing: Si: 10.0 mass% to 19.0 mass%, Mn: 3.0 mass% to 10.0 mass%, Cu: 0.5 mass% to 10.0 mass%, Mg: 0.2 mass% to 3.0 mass%, and the balance being Al (aluminum) and inevitable impurities. A cross-sectional structure of the forging is configured so as to include a θ -phase of CuAl_2 , and an average circle equivalent diameter of the θ -phase is 0.66 μm to 1.66 μm .

[0018] The forging having the aforementioned configuration is an aluminum alloy atomized powder forging. Since an atomized powder is used, the aforementioned forging is fine and uniform in structure. Compared to an alloy obtained by the aforementioned casting method, characteristics, such as, e.g., abrasion resistance and low coefficient of thermal expansion, can be improved. Furthermore, in the forging having the aforementioned configuration, its cross-sectional structure includes a θ -phase of CuAl_2 and the average circle equivalent diameter of the θ -phase is in the range of 0.66 μm to 1.66 μm . For this reason, a forging excellent in forgeability, such as easy to forge deformation and no occurrence

of cracking, and large in high temperature strength can be obtained.

[0019] When the average circle equivalent diameter of the θ -phase is smaller than $0.66\ \mu\text{m}$, larger high temperature strength cannot be obtained. Also, when the average circle equivalent diameter of the θ -phase is larger than $1.66\ \mu\text{m}$, the dispersion hardening ability decreases, which results in, for example, insufficient strength (high temperature strength) in the operating temperature range of a sliding member. In particular, the average circle equivalent diameter of the θ -phase is preferably $0.86\ \mu\text{m}$ to $1.46\ \mu\text{m}$.

[0020] The aluminum alloy forging is preferably configured such that it has an Al-Mn-Si based intermetallic compound and the average circle equivalent diameter of the Al-Mn-Si based intermetallic compound is in the range of $0.04\ \mu\text{m}$ to $0.24\ \mu\text{m}$ in the cross-sectional structure of the forging. When the average circle equivalent diameter is less than $0.04\ \mu\text{m}$, large high temperature strength cannot be obtained. Also, when the average circle equivalent diameter of the θ -phase is larger than $0.24\ \mu\text{m}$, the dispersion hardening ability decreases, which results in, for example, insufficient strength (high temperature strength) in the operating temperature range of a sliding member.

[0021] The circle equivalent diameter of the θ -phase is a value obtained by converting as a diameter of a circle having the same area as the area of the θ -phase (CuAl_2) in the SEM photograph (image), and the circle equivalent diameter of the Al-Mn-Si based intermetallic compound is a value converted as a diameter of a circle having the same area as the area of the Al-Mn-Si based intermetallic compound in the SEM photograph (image).

[0022] Next, the method of producing an aluminum alloy forging according to the present invention will be described. An aluminum molten metal containing Si: 10.0 mass% to 19.0 mass%, Mn: 3.0 mass% to 10.0 mass%, Cu: 0.5 mass% to 10.0 mass%, Mg: 0.2 mass% to 3.0 mass%, and the balance being Al and inevitable impurities is rapidly solidified by an atomizing method into a powder to obtain an aluminum alloy powder (Powdering Step).

[0023] The molten aluminum alloy having the aforementioned specific composition is prepared by a normal dissolution method. The obtained molten aluminum alloy is powdered by an atomizing method. The atomizing method is a method in which fine droplets of the molten aluminum alloy are misted and sprayed by a flow of gas, such as a nitrogen gas, from a spray nozzle to rapidly solidify the fine droplets to obtain a fine aluminum alloy powder. The cooling rate is preferably from 10^3 to $10^5\ ^\circ\text{C}/\text{sec}$. It is preferable to obtain an aluminum alloy powder of $30\ \mu\text{m}$ to $70\ \mu\text{m}$. It is preferable to classify the obtained aluminum alloy powder using a sieve. Among other things, it is more preferable to obtain an aluminum alloy powder of $150\ \mu\text{m}$ or less.

[0024] Next, the aluminum alloy powder obtained in the powdering step is compression molded to obtain a green compact (Compression Molding Step). For example, the aluminum alloy powder heated to 250°C to 300°C is filled in a metal mold heated to 230°C to 270°C and compression molded into a predetermined shape to obtain a green compact. Although the pressure of the compression molding is not particularly limited, it is usually preferable that the pressure be set at $0.5\ \text{ton}/\text{cm}^2$ to $3.0\ \text{ton}/\text{cm}^2$. Further, it is preferable to prepare a green compact having a relative density of 60% to 90%. Although the shape of the green compact is not particularly limited, it is preferable to form into a cylindrical shape or a disc-shape, considering the extrusion step which will be described below.

[0025] The green compact obtained in the Compression Molding Step is hot extruded to obtain an extruded material (Extrusion Step). The green compact is subjected to mechanical processing such as facing as necessary, and then subjected to a degassing treatment, heating, and an extrusion step. The heating temperature of the green compact before extrusion is preferably set to 300°C to 450°C . In extrusion, for example, the green compact is inserted into an extrusion container, pressurized by an extrusion ram, and extruded from an extrusion die into, for example, a round bar shape. At this time, it is preferable that the extrusion container be previously heated to 300°C to 400°C . By performing the hot extrusion as mentioned above, plastic deformation of the green compact progresses, and an extruded body in which the aluminum alloy powders (particles) are bonded and integrated is obtained. In the extrusion, the extrusion pressure is preferably set to $10\ \text{MPa}$ to $25\ \text{MPa}$.

[0026] Next, by hot forging the extruded material obtained in the extrusion step, it is possible to obtain a forging in which the cross-sectional structure includes a θ -phase of CuAl_2 and the average circle equivalent diameter of the θ -phase is $0.66\ \mu\text{m}$ to $1.66\ \mu\text{m}$ (Forging Step). As an example, after cutting a round bar shaped extruded material into a predetermined length as necessary, hot forging is performed. In this hot forging, it is preferable to adopt hermetically forging or semi-closed type forging so that the forged material (forging) is formed into a shape close to a product shape (for example, an engine piston shape). However, depending on the shape of the product (forging), the hot forging may be free forging. The temperature of the hot forging is preferably set to 300°C to 450°C .

[0027] The forged material may be subjected to cutting, surface polishing, etc., to obtain a product (forging) such as a sliding member for an automobile engine piston, etc., but the following heat treatment may be performed.

[0028] The forged material is subjected to a solution treatment. This solution treatment is a treatment to dissolve Cu, Mg, etc., in a supersaturated state, and the heating temperature of the solution treatment is preferably 480°C to 500°C .

[0029] After the solution treatment, a quenching treatment is performed by water quenching, etc., to obtain a supersaturated solid solution in which Cu, Mg, etc., are solid-dissolved so as to exceed the solid solubility limit at room temperature. The quenching temperature is preferably 0°C to 50°C .

[0030] After the quenching treatment, an aging treatment is performed. By this aging treatment, intermetallic com-

pounds containing Cu, Mg, etc., can be finely precipitated, which can improve the strength and abrasion resistance of the forging. The aging treatment is preferably performed at a temperature of 180°C to 280°C for 1 hour to 4 hours.

[0031] By subjecting the forging after the aging treatment to machining such as, e.g., cutting and surface polishing, etc., a product (forging), such as a sliding member exemplified by an engine piston for an automobile, can be obtained.

[0032] Hereinafter, the composition of the aluminum alloy in the forging and the method of producing the forging according to the present invention will be described below. The aluminum alloy is an aluminum alloy containing Si: 10.0 mass% to 19.0 mass%, Mn: 3.0 mass% to 10.0 mass%, Cu: 0.5 mass% to 10.0 mass%, Mg: 0.2 mass% to 3.0 mass%, the balance being Al and inevitable impurities.

[0033] The Si content in the aluminum alloy is set so as to fall within the range of 10.0 mass% to 19.0 mass%. When the Si content rate is less than 10.0 mass%, the amount of Si crystallized material decreases, resulting in decrease in abrasion resistance and strength. When the Si content rate exceeds 19.0 mass%, coarse primary crystal Si crystallizes to cause decrease in strength, causing embrittlement of the material, which results in deteriorated forgeability. In particular, the Si content rate in the aluminum alloy is preferably 12 mass% to 16 mass%, which can assuredly achieve both high temperature strength and excellent forgeability.

[0034] The Mn content in the aluminum alloy is set so as to fall within the range of 3.0 mass% to 10.0 mass%. When the Mn content is less than 3.0 mass%, dispersion strengthening by the Al-Mn-Si based intermetallic compound cannot be obtained sufficiently. Further, when the Mn content exceeds 10.0 mass%, the abrasion resistance is rather lowered, and the material tends to become brittle in the molded product. Among other things, the Mn content in the aluminum alloy is preferably in the range of 6.0 mass% to 8.0 mass%.

[0035] The Cu content in the aluminum alloy is set so as to fall within the range of 0.5 mass% to 10.0 mass%. Cu is an essential element for improving room temperature strength and high temperature strength. When the Cu content rate is less than 0.5 mass%, the solid solution amount decreases and the effect of improving the strength decreases, and the strength improvement effect due to the dispersion strengthening by the crystallized CuAl_2 phase is small. When the Cu content rate exceeds 10.0 mass%, the extrusion processability decreases and the θ -phase (CuAl_2) coarsely precipitates or crystallizes at the grain boundary, possibly reducing the elongation at break.

[0036] The Mg content in the aluminum alloy is set so as to fall within the range of 0.2 mass% to 3.0 mass%. Like Cu, Mg is an essential element for improving room temperature strength and high temperature strength. When the Mg content rate is less than 0.2 mass%, the effect of improving the strength is less. Further, when the Mg content rate exceeds 3.0 mass%, the extrusion processability deteriorates.

[0037] In the forging and the method of producing the forging according to the present invention, the aluminum alloy may be configured to contain 0.01 mass% to 5.0 mass% of each of one or more elements selected from the group consisting of Ti, Zr, V, W, Cr, Co, Mo, Ta, Hf, and Nb. In this case, an aluminum alloy forging further increased in high temperature strength is obtained.

Examples

[0038] Next, specific examples of the present invention will be described, but the present invention is not particularly limited to those of these examples.

<Example 1>

[0039] After heating the aluminum alloy containing Si: 15.8 mass%, Mn: 6.83 mass%, Cu: 3.14 mass%, Mg: 1.11 mass%, the balance being Al and inevitable impurities to obtain a molten aluminum alloy at 1,000°C, the molten aluminum alloy was atomized with gas and rapidly solidified into a powder, classified with a 100 mesh sieve. Thus, an aluminum alloy powder passed through a 100 mesh sieve was obtained.

[0040] Next, the obtained aluminum alloy powder was preheated to a temperature of 280°C, the preheated aluminum alloy powder was filled in a mold heated at the same temperature of 280°C, and compression molded at a pressure of 1.5 ton/cm². Thus, a columnar green compact (compact) having a diameter of 210 mm and a length of 250 mm was obtained. Next, the green compact obtained was faced by a lathe to a diameter of 203 mm to obtain a green compact billet.

[0041] Next, the obtained billet was heated to 350°C, and this heated billet was inserted into an extrusion container maintained at 350°C and having an inner diameter of 210 mm, and extruded at an extrusion rate of 7.8 by an indirect extrusion method with a die having an inner diameter of 75 mm. Thus, an extruded material 10 was obtained. After cutting the obtained extruded material into a length of 30 mm, it was heated to 450°C and subjected to hot free forging to obtain an aluminum alloy forging 20 having a diameter of 107.5 mm and a length of 15 mm. Note that Fig. 1 shows an extruded material 10 before forging, and Fig. 2 shows a forging 20 after forging.

<Comparative Example 1>

[0042] As an aluminum alloy for forming a molten aluminum alloy, using an aluminum alloy containing Si: 15.6 mass%, Mn: 6.72 mass%, Cu: 3.09 mass%, Mg: 1.06 mass%, and the balance being Al and inevitable impurities, an aluminum alloy forging was obtained in the same manner as in Example 1 except that the temperature of molten aluminum alloy was 900°C and a sieve of 170 mesh was used as a sieve.

<Comparative Example 2>

[0043] As an aluminum alloy for forming a molten aluminum alloy, using an aluminum alloy containing Si: 15.6 mass%, Mn: 6.78 mass%, Cu: 3.12 mass%, Mg: 1.11 mass%, and the balance being Al and inevitable impurities, an aluminum alloy forging was obtained in the same manner as in Example 1 except that the temperature of molten aluminum alloy was 1,100°C.

<Comparative Example 3>

[0044] As an aluminum alloy for forming a molten aluminum alloy, using an aluminum alloy containing Si: 15.6 mass%, Mn: 6.78 mass%, Cu: 3.12 mass%, Mg: 1.11 mass%, and the balance being Al and inevitable impurities, an aluminum alloy forging was obtained in the same manner as in Example 1 except that the temperature of molten aluminum alloy was 1,100°C and a sieve of 50 mesh was used as a sieve.

<Comparative Example 4>

[0045] As an aluminum alloy for forming a molten aluminum alloy, using an aluminum alloy containing Si: 15.6 mass%, Mn: 6.72 mass%, Cu: 3.09 mass%, Mg: 1.06 mass%, and the balance being Al and inevitable impurities, an aluminum alloy forging was obtained in the same manner as in Example 1 except that the temperature of molten aluminum alloy was 900°C.

[Table 1]

			Ex. 1	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4
Alloy composition	Si (mass%)		15.8	15.6	15.6	15.6	15.6
	Mn (mass%)		6.83	6.72	6.78	6.78	6.72
	Cu (mass%)		3.14	3.09	3.12	3.12	3.09
	Mn (mass%)		1.11	1.06	1.11	1.11	1.06
Molten alloy temperature (°C)			1,000	900	1,100	1100	900
Sieve size used (mesh)			100	170	100	50	100
Structure	Average circle equivalent diameter (μm)	θ-phase (CuAl ₂)	1.16	1.85	0.58	1.79	0.49
		Al-Mn-Si based compound	0.13	0.30	0.02	0.02	0.29
Tensile strength (MPa) at 300°C / Evaluation			160/◎	146/×	153/Δ	153/Δ	150/Δ

[0046] With respect to each of the aluminum alloy forgings obtained as described above, evaluation was conducted based on the following evaluation method. The results are shown in Table 1.

<High temperature tensile strength evaluation method>

[0047] The obtained forging was heated to 490°C and held for 3 hours and then quenched in water at 20°C. Thereafter, as an aging treatment, it was heated at 220°C for 1 hour to obtain a T7 treated product. The T7 treated product was processed into a tensile test piece having a gauge distance of 20 mm and a parallel portion diameter of 4 mm, and the high temperature tensile strength (tensile strength at 300°C) was measured by performing a high temperature tensile test of the tensile test piece. In the high-temperature tensile test, the high temperature tensile test piece was held at 300°C for 100 hours and then tested at 300°C. The evaluation was made based on the following criteria. In Example 1,

the tensile strength at 300°C was 160 MPa, and it was evaluated as ◎ (large high temperature tensile strength was obtained).

(Judgment criteria)

[0048]

"◎": Tensile strength at 300°C was 160 MPa or more

"○": Tensile strength at 300°C was 155 MPa or more and less than 160 MPa

"△": Tensile strength at 300°C was 150 MPa or more and less than 155 MPa

"X": Tensile strength at 300°C is less than 150 MPa

<Method of evaluating Structure evaluation of forging>

[0049] The obtained forging was heated to 490°C and held for 3 hours and then quenched in water at 20°C. Thereafter, as an aging treatment, it was heated at 220°C for 1 hour to obtain a T7 treated product. A structure observation sample having a size of 10 mm × 10 mm × 10 mm was cut out from the T7 treated product. The obtained structure observation sample was filled with resin, then subjected to mirror polishing by physical polishing and observed with a FE-SEM (Field Emission Scanning Electron Microscope; JEOL JSM-7000F) on the cross-section perpendicular to the upset direction (reflected electron image was observed). The image analysis of the obtained reflected electron image (×10k) was performed. The object of the image analysis is a θ-phase (CuAl₂ phase) and an Al-Mn-Si based intermetallic compound. For any objects, the circle equivalent diameters of arbitrary three fields of view (three places) in the electron microscope image were respectively calculated, and the average value was calculated to obtain an "average circle equivalent diameter". That is, the average circle equivalent diameter of the θ-phase (CuAl₂ phase) and the average circle equivalent diameter of Al-Mn-Si based intermetallic compound were obtained (see Table 1).

[0050] As is apparent from Table 1, the aluminum alloy forging of Example 1 according to the present invention was high in high temperature tensile strength (tensile strength at 300°C).

[0051] On the other hand, in the aluminum alloy forging of Comparative Examples 1 to 4 which deviated from the specified range of the present invention, the high temperature tensile strength (tensile strength at 300°C) was insufficient.

Industrial Applicability

[0052] The aluminum alloy forging according to the present invention and the aluminum alloy forging produced by the production method of the present invention are excellent in forgeability and excellent in strength at high temperature. Therefore, it is suitable as a sliding member for an automobile engine piston, etc., but it is not particularly limited to such use.

[0053] The present application claims priority to Japanese Patent Application No. 2016-117232 filed on June 13, 2016, the entire disclosure of which is incorporated herein by reference in its entirety.

[0054] It should be understood that the terms and expressions used herein are used for explanation of embodiments and the present invention is not limited to them. The present invention allows various modifications falling within the claimed scope of the present invention as long as it does not deviate from the gist of the invention.

Reference Sign List

[0055]

10 extruded material

20 aluminum alloy forging

Claims

1. An aluminum alloy forging made of an aluminum alloy atomized powder forging containing:

Si: 10.0 mass% to 19.0 mass%;

Mn: 3.0 mass% to 10.0 mass%;

Cu: 0.5 mass% to 10.0 mass%;

Mg: 0.2 mass% to 3.0 mass%; and

the balance being Al and inevitable impurities,

characterized in that a cross-sectional structure of the forging includes a θ -phase of CuAl_2 , and an average circle equivalent diameter of the θ -phase is in a range of 0.66 μm to 1.66 μm .

2. The aluminum alloy forging as recited in claim 1,
wherein the forging contains an Al-Mn-Si based intermetallic compound, and an average circle equivalent diameter of the Al-Mn-Si based intermetallic compound in the cross-sectional structure of the forging is in a range of 0.04 μm to 0.24 μm .
3. The aluminum alloy forging as recited in claim 1 or 2,
wherein the aluminum alloy forging further contains 0.01 mass% to 5.0 mass% of each of one or more elements selected from the group consisting of Ti, Zr, V, W, Cr, Co, Mo, Ta, Hf, and Nb.
4. A method of producing an aluminum alloy forging, the production method comprising:

a powdering step of powdering a molten metal of an aluminum alloy by rapidly solidifying the molten metal by an atomizing method to obtain an aluminum alloy powder, the aluminum alloy containing Si: 10.0 mass% to 19.0 mass%, Mn:

3.0 mass% to 10.0 mass%, Cu: 0.5 mass% to 10.0 mass%, Mg: 0.2 mass% to 3.0 mass%, and the balance being Al and inevitable impurities;

a forming step of compression molding the aluminum alloy powder to obtain a green compact;
an extrusion step of hot extruding the green compact to obtain an extruded material; and
a forging step of hot forging the extruded material to obtain a forging in which a cross-sectional structure of the forging includes a θ -phase of CuAl_2 and an average circle equivalent diameter of the θ -phase is in a range of 0.66 μm to 1.66 μm .
5. The method of producing an aluminum alloy forging as recited in claim 4,
wherein the forging contains an Al-Mn-Si based intermetallic compound, and an average circle equivalent diameter of the Al-Mn-Si based intermetallic compound is in a range of 0.04 μm to 0.24 μm in a forging cross-sectional structure.
6. The method of producing an aluminum alloy forging as recited in claim 4 or 5,
wherein the molten metal of the aluminum alloy further contains 0.01 mass% to 5.0 mass% of each of one or more elements selected from a group consisting of Ti, Zr, V, W, Cr, Co, Mo, Ta, Hf, and Nb.

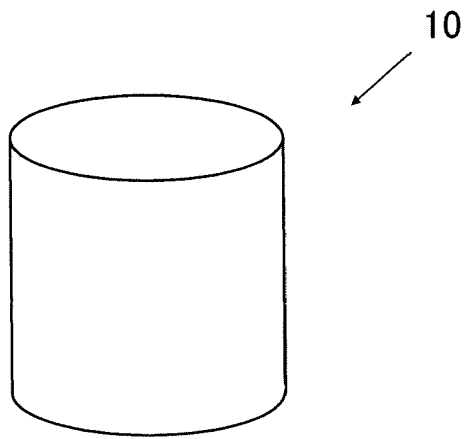


Fig. 1

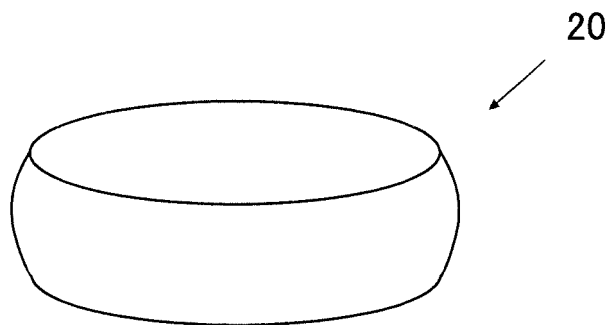


Fig. 2



EUROPEAN SEARCH REPORT

Application Number
EP 17 16 8677

5

10

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
E	EP 3 170 594 A1 (SHOWA DENKO KK [JP]) 24 May 2017 (2017-05-24) * paragraphs [0001], [0003], [0013], [0017] - [0019], [0043], [0046], [0051], [0053] - [0064]; table 1 *	1-6	INV. C22C21/02 B22F3/17 B22F3/20 B22F3/24 C22C21/04
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Place of search Munich		Date of completion of the search 6 October 2017	Examiner Brown, Andrew
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