(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 134 460 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.02.2023 Bulletin 2023/07

(21) Application number: **22165622.6**

(22) Date of filing: **30.03.2022**

(51) International Patent Classification (IPC):
C22C 21/08 *(1974.07)* ***C22F 1/05*** *(1985.01)*

(52) Cooperative Patent Classification (CPC):
C22C 21/08; C22F 1/05

(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:
KH MA MD TN

(30) Priority: **12.08.2021 CN 202110926730**

(71) Applicants:
- **Shanghai XPT Technology Limited**
  Shanghai City, Shanghai 200000 (CN)
- **Nonferrous Metallic of Hebei New Lizhong Group Co., Ltd.**
  Baoding, Hebei Province 071000 (CN)

(72) Inventors:
- **ZHANG, Ling**
  Shanghai City, 200000 (CN)
- **WANG, Zhiming**
  Shanghai City, 200000 (CN)
- **QIN, Ge**
  Shanghai City, 200000 (CN)
- **MA, Hongjiang**
  Shanghai City, 200000 (CN)
- **HAN, Li**
  Shanghai City, 200000 (CN)
- **LIU, Yongchang**
  Shanghai City, 200000 (CN)
- **GE, Sujing**
  Shanghai City, 200000 (CN)
- **SUN, Fangfang**
  Shanghai City, 200000 (CN)
- **YANG, Haijun**
  Shanghai City, 200000 (CN)

(74) Representative: **Vossius & Partner**
Patentanwälte Rechtsanwälte mbB
Siebertstraße 3
81675 München (DE)

(54) ALUMINUM ALLOY WITH PREFERRED MECHANICAL PROPERTY AND PREFERRED ELECTRICAL AND THERMAL CONDUCTIVITY AND RELATED MANUFACTURING METHOD

(57) Aluminum alloy with preferred mechanical property and preferred electrical and thermal conductivity is provided by a manufacturing method. The aluminum alloy consists of Si about 0.33~0.37wt%, Mg about 0.45~0.55wt%, and Fe about 0.07~0.15wt%, and the rest weight of the aluminum alloy is Al. A ratio of Mg to a different between Al and one third Fe is ranged between 1.45-1.75.

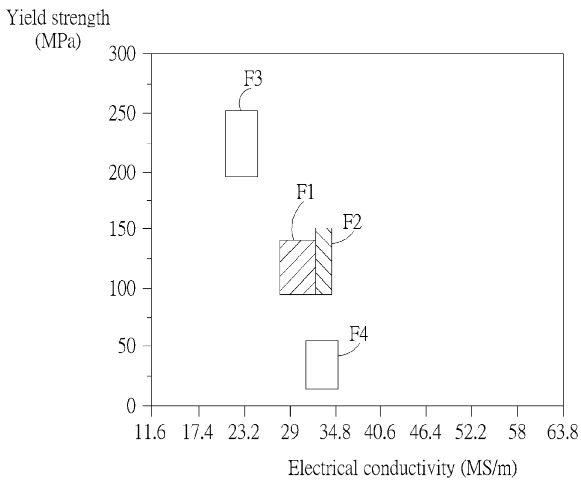

FIG. 3

EP 4 134 460 A1

Description

Background of the Invention

1. Field of the Invention

[0001] The disclosure relates to an aluminum alloy and a related manufacturing method, and more particularly, to an aluminum alloy with preferred mechanical property and preferred electrical and thermal conductivity and a related manufacturing method.

2. Description of the Prior Art

[0002] Aluminum has properties of electrical conductivity and thermal conductivity next only to silver, copper, and gold among metals. Compared with silver, copper and gold, aluminum has advantages of abundant resources, low mining cost, and the preferred electrical conductivity and thermal conductivity per unit weight, and is suitable for manufacturing a lightweight workpiece. Further, aluminum and aluminum alloys can be applied to manufacturing process, forming process and joining process via means to casting, rolling, extruding, forging, drawing, riveting and welding procedures. The aluminum and aluminum alloys can have not only the preferred properties of thermal conductivity, electrical conductivity and non-magnetism, but also the certain mechanical and processing performance for meeting the applicably industrial design requirement. Thus, there are a large number of standards for conductive aluminum alloys, and new conductive aluminum alloys still have been invented. It is difficult to balance high electrical conductivity and high yield strength for the conventional aluminum alloy, which means that the conventional aluminum alloy with the high electrical conductivity has the lower yield strength, and the conventional aluminum alloy with the high yield strength has the lower electrical conductivity. The new electric vehicle industry in Europe and the United States may mix rare earth elements into the aluminum alloy for improving the electrical conductivity and the yield strength, but has drawbacks of expensive cost and manufacturing difficulty.

Summary of the Invention

[0003] The disclosure provides an aluminum alloy with preferred mechanical property and preferred electrical and thermal conductivity and a related manufacturing method for solving above drawbacks.

[0004] According to the claimed disclosure, an aluminum alloy with preferred mechanical property and preferred electrical and thermal conductivity includes Si from 0.33 to 0.37 wt%, Mg from 0.45 to 0.55 wt%, Fe from 0.07 to 0.15 wt%. The rest weight of the aluminum alloy is made of Al. A ratio of Mg to a different between Si and one third Fe is ranged between 1.45 and 1.75.

[0005] According to the claimed disclosure, the aluminum alloy further includes Ga smaller than or equal to 0.03wt%, Zn smaller than or equal to 0.03wt%, Mn smaller than or equal to 0.01wt%, Ti smaller than or equal to 0.01wt%, Na smaller than or equal to 0.001wt%, Li smaller than or equal to 0.0002wt%, a total of Mn, V and Cr smaller than or equal to 0.015wt%, and other elements smaller than or equal to 0.01wt%. The total of above-mentioned elements is smaller than or equal to 0.1wt%.

[0006] According to the claimed disclosure, electrical conductivity of the aluminum alloy is greater than or equal to 34 mS/m, thermal conductivity of the aluminum alloy is greater than or equal to 220 W/m.K, yield strength of the aluminum alloy is greater than or equal to 80 MPa, an elongation rate of the aluminum alloy is greater than or equal to 10%, and hardness of the aluminum alloy is greater than or equal to 40 HBS.

[0007] According to the claimed disclosure, a manufacturing method of the aluminum alloy with preferred mechanical property and preferred electrical and thermal conductivity includes melting Al and Si, wherein a weight ratio of A1 to Si is preset, melting Mg with a preset weight into combination of Al and Si, and mixing and preserving heat of combination of Mg, Al and Si for centrifugal casting execution or high temperature casting execution so as to acquire the aluminum alloy.

[0008] According to the claimed disclosure, the manufacturing method further includes melting the combination of Al and Si with the preset weight ratio at 740-770 degrees Celsius, detecting and setting Si in a range of 0.33 to 0.37wt% and Fe in a range of 0.07 to 0.15 wt%, detecting and setting Mg in a range of 0.45 to 0.55wt%, and detecting and setting a ratio of Mg to a different between Si and one third Fe being ranged between 1.45 and 1.75.

[0009] In the disclosure, variations of the mechanical property, the electrical conductivity and the thermal conductivity of the aluminum alloy depend on alloy composition, metallographic structure and alloy cleanness of alloy material. The alloy material has more crystallographic defect, lattice distortion and dislocation resistance are increased accordingly to enhance alloy strength; however, the alloy material may have more structure defects in response to the increased crystallographic defect, and the alloy cleanness being decreased may result in high electron scattering rate, so as to accordingly decrease the electrical conductivity and the thermal conductivity of the alloy material. Thus, the disclosure achieves comprehensive balance between the mechanical property, the electrical conductivity and the thermal conductivity through element composition design and defect control, so as to meet performance requirement of the motor rotor or other applications.

[0010] These and other objectives of the disclosure will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

Brief Description of the Drawings

[0011]

FIG. 1 is a diagram of an assembling component made by an aluminum alloy according to an embodiment of the disclosure.

FIG. 2 is a flow chart of an aluminum alloy manufacturing method according to the embodiment of the disclosure.

FIG. 3 is a performance diagram of the aluminum alloy according to the embodiment of the disclosure.

Detailed Description

[0012] Please refer to FIG. 1. FIG. 1 is a diagram of an assembling component 10 made by an aluminum alloy according to an embodiment of the disclosure. The assembling component 10 can be a motor rotor, which include a rotor ring 12, rotor guiders 14 and a rotor axle 16. The rotor ring 12 and the rotor guider 14 can be made by the aluminum alloy of the disclosure, and therefore the aluminum alloy can provide superior performance in mechanical property and electrical and thermal conductivity. It should be mentioned that the aluminum alloy of the disclosure can be used to manufacture the motor rotor and any other type of mechanical workpiece. Any mechanical workpiece of needing the preferred mechanical property and the preferred electrical and thermal conductivity belongs to a scope of the aluminum alloy in the disclosure, and a detailed description is omitted herein for simplicity.

[0013] Al (aluminum element) has the preferred electrical and thermal conductivity. The disclosure discloses a manufacturing method of manufacturing the aluminum alloy with the preferred mechanical property, preferred electrical conductivity and preferred thermal conductivity, and the aluminum alloy can be applied for an electric vehicle and any other industry. The aluminum alloy is described herein by a weight percent (wt%) of the total elements within the alloy. The aluminum alloy of the disclosure can include Si about 0.33~0.37wt%, Mg about 0.45~0.55wt%, and Fe about 0.07~0.15wt%; and the rest weight of the aluminum alloy is made of Al. In addition, Si and Mg can be transformed into Mg_2Si, and Mg_2Si can be mixed with Al to generate lattice distortion, so as to further increase mechanical property of the aluminum alloy.

[0014] If the aluminum alloy has excess Si element, the electrical conductivity and the mechanical property of the aluminum alloy are decreased accordingly; if Mg in the aluminum alloy is excess, Mg and Al can be transformed into Al_3Mg_2 and the electrical conductivity of the aluminum alloy is decreased accordingly; if Mg_2Si in the aluminum alloy is excess, the electrical conductivity of the aluminum alloy is decreased due to eutectic phase. Thus, the quantity of Si and Mg is strictly constrained to accurately control the preferred electrical conductivity, the preferred thermal conductivity, and the preferred mechanical property of the aluminum alloy. Besides, Al material in crude metal may include Fe, and the quantity of Fe is further constrained to accurately control the quantity and the ratio of Si to Mg.

[0015] In the disclosure, Al, Si and Fe can be transformed into AlFeSi in solidifying process of the aluminum alloy, and the rest of Si can be transformed with Mg to generate Mg_2Si, and then the rest of Mg can be transformed into Al_3Mg_2. Therefore, the aluminum alloy and the manufacturing method of the disclosure can accurately set a ratio of Mg to a different between Si and one third Fe conforming to a specific range, which means the quantity of Mg, Si and Fe is decided by Formula 1, so as to effectively avoid the aluminum alloy from having the excess Si element and Al_3Mg_2.

$$1.45 \leq \frac{\mathrm{Mg}}{\mathrm{Si} - \mathrm{Fe} \times 1/3} \leq 1.75 \qquad \text{Formula 1}$$

[0016] Moreover, the electrical conductivity and the mechanical property of the aluminum alloy may be decreased due to existence of Mn, Ti, Cr, V and other impure elements, so the quantity of the impure elements should be strictly constrained; that is to say, the aluminum alloy may inevitably have oxidized inclusion and porosity drawbacks in melting and casting process due to a mutual effect upon necessary elements and unnecessary elements. A conductive area of the aluminum alloy is decreased due to an electron scattering function resulted from the foresaid drawbacks, which decrease the electrical conductivity and the mechanical property of the aluminum alloy further, so that the quantity and percentage of the impure elements in the aluminum alloy are strictly constrained.

[0017] The necessary elements of the aluminum alloy in the disclosure preferably can include Si about 0.33~0.37wt%, Mg about 0.45~0.55wt%, Fe about 0.07~0.15wt%, and the rest weight of the aluminum alloy is made of Al; the quantity of Mg, Si and Fe can conform to Formula 1. The impure elements of the aluminum alloy can include Ga equal to or smaller than 0.03wt%, Zn equal to or smaller than 0.03wt%, Mn equal to or smaller than 0.01wt%, Ti equal to or smaller than 0.01wt%, Na equal to or smaller than 0.001wt%, Li equal to or smaller than 0.0002wt%, a total of Mn, V and Cr equal to or smaller than 0.015wt%, and other elements equal to or smaller than 0.01wt%; a total percent of foresaid elements in the aluminum alloy can be equal to or smaller than 0.1wt%.

[0018] Please refer to FIG. 2. FIG. 2 is a flow chart of an aluminum alloy manufacturing method according to the embodiment of the disclosure. The aluminum alloy manufacturing method illustrated in FIG. 2 can be suitable for the aluminum alloy and the assembling component 10 shown in FIG. 1. The aluminum alloy manufacturing method can execute step S100 to melt metal aluminum and crystalline silicon inside a container at 740-770 degrees Celsius; step S100 can preset a weight ratio of Al to Si. Then, step S102 can be executed to detect and adjust the aluminum alloy inside the container including Si about 0.33 to 0.37wt% and Fe about 0.07~0.15wt%, and further confirm other impure elements conforming to the above-mentioned condition.

[0019] Then, step S104 and step S106 can be executed to mix non-polluted salt scouring agent into the container for deslagger execution, and melt Mg with a preset weight into the container. Content of the scouring agent and the related deslagger execution can depend on a design demand, and a detailed description is omitted herein for simplicity. The quantity of Mg melted in step S106 can conform to the preset weight, and further conform to the foresaid ratio of Mg to the different between Si and one third Fe, which means Formula 1. In the meantime, step S108 can be optionally executed to detect and set the aluminum alloy including Mg about 0.45~0.55wt%, and the ratio of Mg to the different between Si and one third Fe ranged between 1.45 and 1.75.

[0020] Then, step S110 can be executed to aerate inert gas into the container for degassing execution. The inert gas may be nitrogen gas, argon gas or other applicable gas, which depends on the design demand. In the disclosure, porosity degree of the aluminum alloy after the degassing execution can conform to Level 2 or higher level of Metallographic of cast aluminum alloys (JB/T7946.3) published as machinery industry standard (People's Republic of China, RPC), or decompression solidification density of the aluminum alloy in a decompression condition can be greater than 2.67 g/cm^3, or a ratio of a difference between atmospheric solidification density and the decompression solidification density to the atmospheric solidification density in an atmospheric condition can be smaller than 1.5, or hydrogen content of molten aluminum of the aluminum alloy can be smaller than 0.2 ml/100gAl and liquid permeability of the aluminum alloy can be greater than or equal to 500 g/min. Final, step S112 can be executed to mixing and preserving heat of the aluminum alloy in a liquid state for centrifugal casting execution or high temperature casting execution, so as to form the ingot, the stick or any other type by the aluminum alloy, such as the motor rotor of the assembling component 10.

[0021] After step S112, if the cast ingot and/or the cast stick is melted for reproduction, the liquid aluminum alloy still has to conform to the foresaid quantity of Si, Mg and Fe, and the foresaid ratio of Mg to the different between Si and one third Fe, and a cooling rate of the aluminum alloy in casting execution can be ranged between 1~100 Celsius degrees per second, so that the aluminum alloy can provide the preferred mechanical property, the preferred electrical conductivity and the preferred thermal conductivity. As if the motor rotor of the assembling component 10 is cast via step S112, a temperature of the motor rotor in hot installation process can be set as 200~350 degrees Celsius, and a thermal insulation period of the motor rotor in the hot installation process can be set between 15~60 minutes. Therefore, the aluminum alloy manufactured by the manufacturing method of the disclosure can have the electrical conductivity greater than or equal to 34 mS/m, and further have the thermal conductivity greater than or equal to 220 W/m.K, and further have the yield strength greater than or equal to 80 MPa, and further have the elongation rate greater than or equal to 10%, and further have the hardness greater than or equal to 40 HBS.

[0022] Table 1 discloses several sampling examples of the motor rotor of the assembling component 10, which conforms to the foresaid element quantity and ratio, and further discloses testing results of the electrical conductivity, the thermal conductivity, the mechanical property, metallographic analysis and grain-size analysis of each sampling example. The aluminum alloy made by the manufacturing method of the disclosure can have advantages of the preferred mechanical property, the preferred electrical conductivity and the preferred thermal conductivity. Density equivalent disclosed in Table 1 can be interpreted as the foresaid ratio of the difference between the atmospheric solidification density and the decompression solidification density to the atmospheric solidification density in the atmospheric condition.

Item		Example 1	Example 2	Example 3	Example 4
Alloy composition	Mg (wt%)	0.453	0.552	0.545	0.461
	Si (wt%)	0.334	0.365	0.371	0.363
	Fe (wt%)	0.074	0.146	0.081	0.135
	Mg/(Si-1/3Fe)	1.46	1.74	1.58	1.45
	Ga (wt%)	0.015	0.027	0.019	0.023
	Zn (wt%)	0.018	0.024	0.009	0.012
	Mn (wt%)	0.009	0.002	0.003	0.003
	Mn+V+Cr (wt%)	0.014	0.010	0.008	0.010
	Ti (wt%)	0.005	0.009	0.008	0.008
	Na (wt%)	0.0002	0.0005	0.0009	0.0003
	Li (wt%)	0.0001	0.0002	0.0001	0.0001
	other elements (wt%)	≤0.01	≤0.01	≤0.01	≤0.01
	Total of impure elements (wt%)	≤0.1	≤0.1	≤0.1	≤0.1
	Al	the rest	the rest	the rest	the rest
Gas content	Porosity degree	——	Level 1	Level 2	——
	Decompression solidification density (g/cm^3)	2.672	——	——	2.681
	Density equivalent(%)	——	——	——	——
	Hydrogen content(ml/100g)	——	——	——	——
Slag content	Liquid permeability (g/min)	536	——	552	520
Mechanical property	Yield strength (MPa)	86	102	93	89
	Elongation rate (%)	21.3	17.8	18.5	19.6
	Hardness (HB)	42.6	46.7	45.3	44.8
Electrical conductivity (MS/m)		35.2	34.2	34.6	34.5
Thermal conductivity		227	221	223	223

(W/(m.K))				

Item		Example 5	Example 6	Example 7	Example 8	Example 9
Alloy composition	Mg (wt%)	0.543	0.457	0.539	0.459	0.511
	Si (wt%)	0.342	0.338	0.336	0.359	0342
	Fe (wt%)	0.095	0.139	0.082	0.125	0.117
	Mg/(Si-1/3Fe)	1.75	1.57	1.75	1.45	1.69
	Ga (wt%)	0.014	0.026	0.018	0.023	0.021
	Zn (wt%)	0.019	0.009	0.013	0.027	0.025
	Mn (wt%)	0.004	0.003	0.003	0.002	0.003
	Mn+V+Cr (wt%)	0.012	0.009	0.008	0.007	0.007
	Ti (wt%)	0.007	0.005	0.008	0.006	0.007
	Na (wt%)	0.0006	0.0004	0.0008	0.0005	0.0005
	Li (wt%)	0.0002	0.0002	0.0001	0.0001	0.0001
	other elements (wt%)	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01
	Total of impure elements (wt%)	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1
	Al	the rest	the rest	the rest	the rest	the rest
Gas content	Porosity degree	——	——	——	——	——
	Decompression solidification density (g/cm^3)	——	——	——	——	2.682
	Density equivalent(%)	0.9	——	——	1.4	——
	Hydrogen content(ml/100g)	——	0.18	0.14	——	——
Slag content	Liquid permeability (g/min)	——	——	——	——	518
Mechanical property	Yield strength (MPa)	95	93	99	88	96
	Elongation rate (%)	18.8	19.2	17.5	18.0	19.5
	Hardness (HB)	43.5	43.1	44.0	44.6	45.9
Electrical conductivity (MS/m)		34.8	34.6	34.5	34.7	34.9
Thermal conductivity (W/(m.K))		222	225	221	223	224

Table 1

[0023] Please refer to FIG. 3. FIG. 3 is a performance diagram of the aluminum alloy according to the embodiment of the disclosure. As shown in FIG. 3, a marking frame F3 can represent the conventional aluminum alloy with high yield strength and low electrical conductivity, such as A356-T6 and A356 + 0.5Cu-T6; a marking frame F4 can represent the conventional aluminum alloy with high electrical conductivity and low yield strength, such as A199.7(99.7wt% Al) and A199.5(99.5wt%Al); a marking frame F1 can represent the aluminum alloy including Ni in the range of 4.3 to 6wt%, which has high manufacturing cost and medium yield strength and medium electrical conductivity, is disclosed in WO 2020/028730; a marking frame F2 can represent the aluminum alloy of the disclosure, which has the yield strength and the electrical conductivity better than the aluminum alloy of the frame F1.

[0024] In conclusion, variation of the mechanical property, the electrical conductivity and the thermal conductivity of the aluminum alloy depend on alloy composition, metallographic structure and alloy cleanness of alloy material. The alloy material has more crystallographic defects, lattice distortion and dislocation resistance are increased accordingly to enhance alloy strength; however, the alloy material may have more structure defect in response to the increased crystallographic defect, and the alloy cleanness being decreased may result in high electron scattering rate, so as to accordingly decrease the electrical conductivity and the thermal conductivity of the alloy material. Thus, the disclosure achieves comprehensive balance between the mechanical property, the electrical conductivity and the thermal conductivity through element composition design and defect control, so as to meet performance requirement of the motor rotor or other applications.

[0025] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the disclosure. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

Claims

1. An aluminum alloy with preferred mechanical property and preferred electrical and thermal conductivity, comprising:

Si from 0.33 to 0.37wt%;
Mg from 0.45 to 0.55wt%;
Fe from 0.07 to 0.15 wt%; and
Al, wherein the rest weight of the aluminum alloy is made of Al.

2. The aluminum alloy of claim 1, wherein a ratio of Mg to a different between Si and one third Fe is ranged between 1.45 and 1.75.

3. The aluminum alloy of claim 1 or 2, further comprising:

Ga smaller than or equal to 0.03wt%;
Zn smaller than or equal to 0.03wt%;
Mn smaller than or equal to 0.01wt%;
Ti smaller than or equal to 0.01wt%;
Na smaller than or equal to 0.001wt%;
Li smaller than or equal to 0.0002wt%;
a total of Mn, V and Cr smaller than or equal to 0.015wt%; and
other elements smaller than or equal to 0.01wt%;
wherein a total of above-mentioned elements is smaller than or equal to 0.1wt%.

4. The aluminum alloy of claim 1, 2, or 3, wherein electrical conductivity of the aluminum alloy is greater than or equal to 34 mS/m, thermal conductivity of the aluminum alloy is greater than or equal to 220 W/m.K, yield strength of the aluminum alloy is greater than or equal to 80 MPa, an elongation rate of the aluminum alloy is greater than or equal to 10%, and hardness of the aluminum alloy is greater than or equal to 40 HBS.

5. A manufacturing method of an aluminum alloy with preferred mechanical property and preferred electrical and thermal conductivity, preferably the aluminum alloy according to any one of claims 1 to 4, the method comprising:

melting Al and Si, wherein a weight ratio of Al to Si is preset;
melting Mg with a preset weight into combination of Al and Si; and
mixing and preserving heat of combination of Mg, Al and Si for centrifugal casting execution or high temperature casting execution so as to acquire the aluminum alloy.

6. The manufacturing method of claim 5, further comprising:
melting the combination of Al and Si with the preset weight ratio at 740-770 degrees Celsius.

7. The manufacturing method of claim 5, or 6, further comprising:
detecting and setting Si in a range of 0.33 to 0.37wt% and Fe in a range of 0.07 to 0.15 wt%.

8. The manufacturing method of claim 5, 6, or 7, further comprising:

detecting and setting Mg in a range of 0.45 to 0.55wt%; and
detecting and setting a ratio of Mg to a different between Si and one third Fe being ranged between 1.45 and 1.75.

9. The manufacturing method of any one of claims 5 to 8, further comprising:

mixing salt scouring agent into the foresaid combination for deslagger execution; and
aerating inert gas into the foresaid combination for degassing execution.

10. The manufacturing method of claim 9, wherein porosity degree of the aluminum alloy after the degassing execution conforms to Level 2 or higher level of Metallograph of cast aluminum alloys (JB/T7946.3) published as machinery industry standard (People's Republic of China, RPC), or decompression solidification density of the aluminum alloy in a decompression condition is greater than 2.67 g/cm^3, or a ratio of a difference between atmospheric solidification density and the decompression solidification density to the atmospheric solidification density in an atmospheric condition is smaller than 1.5, or hydrogen content of molten aluminum of the aluminum alloy is smaller than 0.2 ml/100gAl and liquid permeability of the aluminum alloy is greater than or equal to 500 g/min.

11. The manufacturing method of any one of claims 5 to 10, further comprising:
setting a cooling rate of the aluminum alloy in casting execution ranged between 1~100 Celsius degrees per second.

12. The manufacturing method of any one of claims 5 to 11, further comprising:

forming a motor rotor by the aluminum alloy; and
setting a temperature of the motor rotor at 200~350 degrees Celsius in hot installation process, and a thermal insulation period in the hot installation process being set between 15~60 minutes.

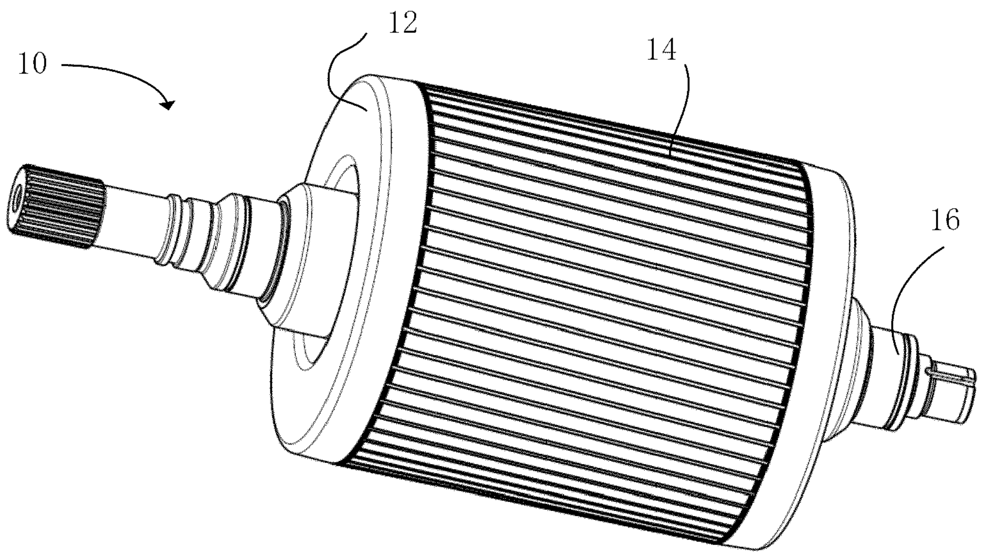

FIG. 1

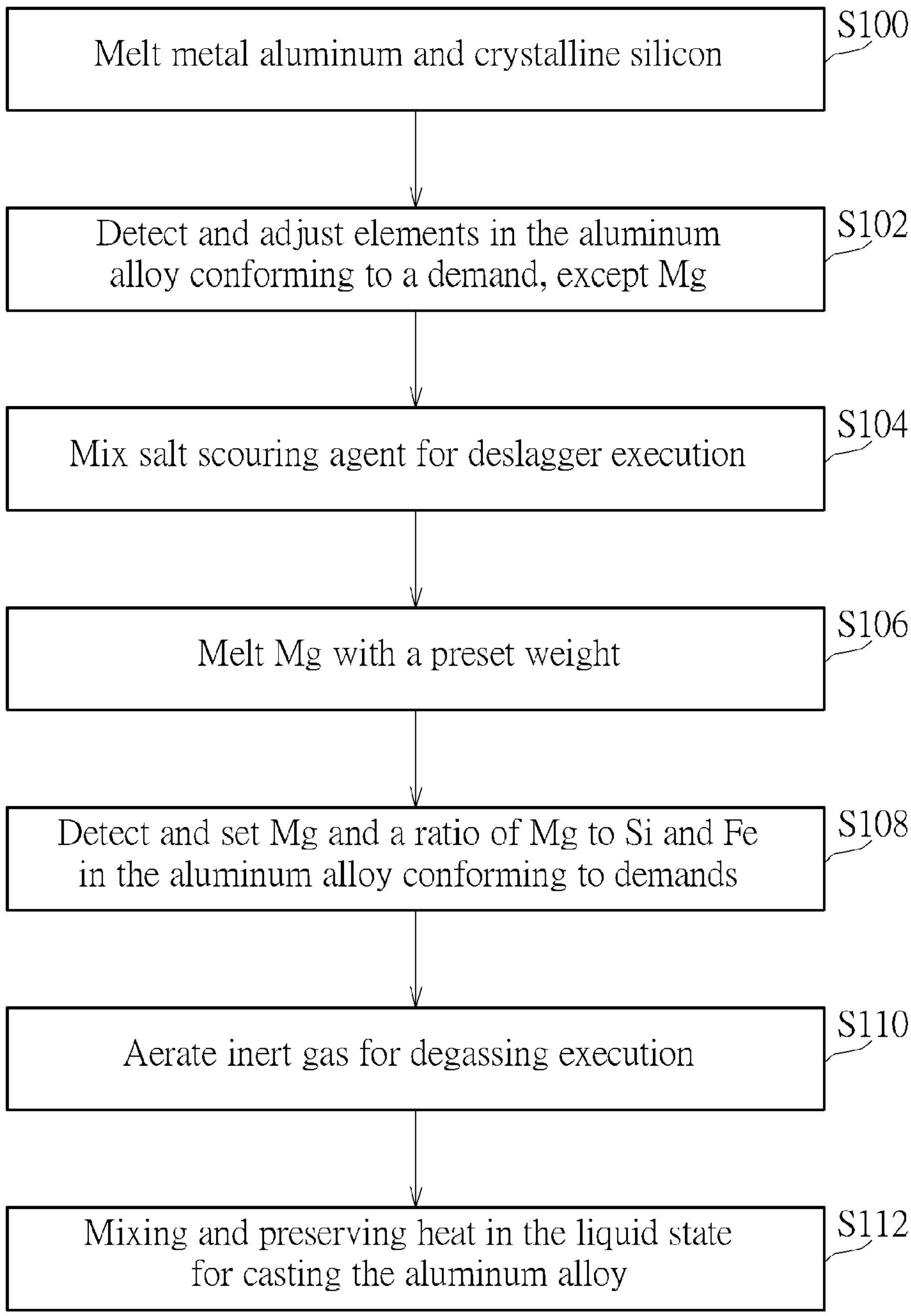
Melt metal aluminum and crystalline silicon
S100
Detect and adjust elements in the aluminum alloy conforming to a demand, except Mg
S102
Mix salt scouring agent for deslagger execution
S104
Melt Mg with a preset weight
S106
Detect and set Mg and a ratio of Mg to Si and Fe in the aluminum alloy conforming to demands
S108
Aerate inert gas for degassing execution
S110
Mixing and preserving heat in the liquid state for casting the aluminum alloy
S112

FIG. 2

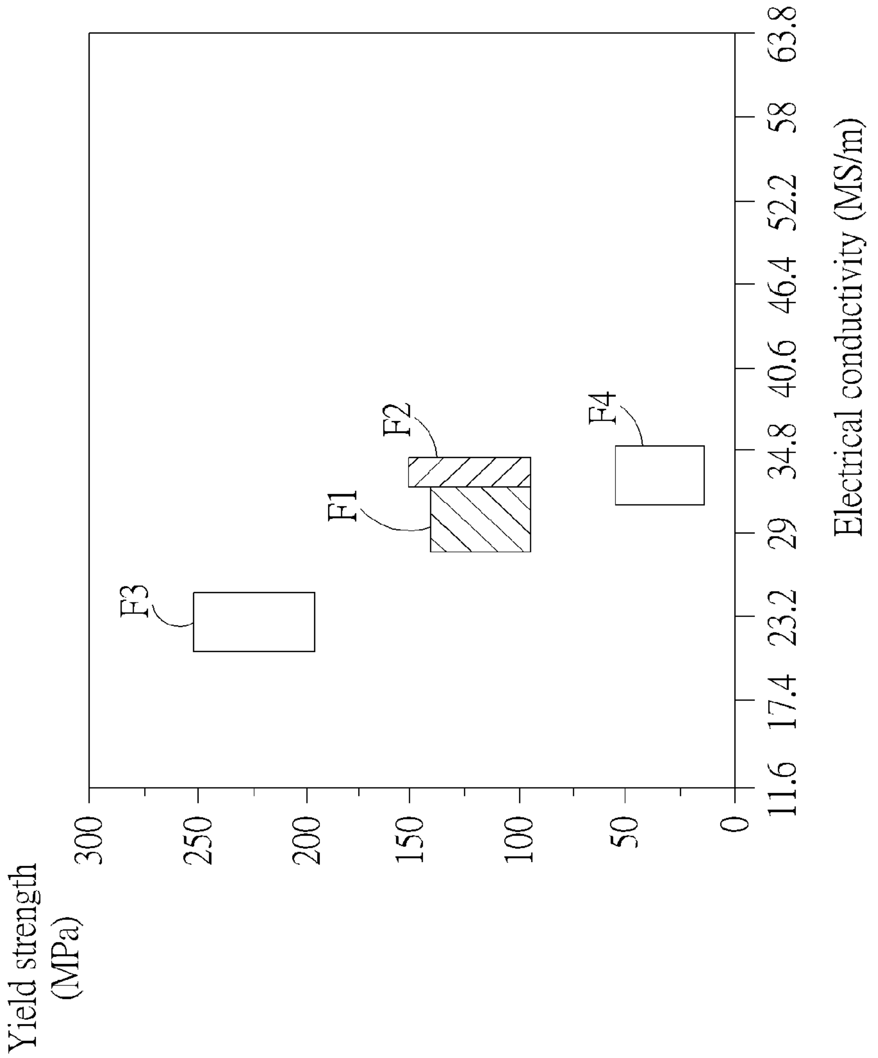
Yield strength
(MPa)
300
250
200
150
100
50
0
11.6
17.4
23.2
29
34.8
40.6
46.4
52.2
58
63.8
Electrical conductivity (MS/m)
F1
F2
F3
F4

FIG. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 16 5622

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 110 257 677 A (JIANGSU WETOWN ELECTRIC POWER TECH CO LTD) 20 September 2019 (2019-09-20) * paragraphs [0010], [0013], [0015]; examples 1, 2 * -----	1,2,4-11	INV. C22C21/08 C22F1/05
X	CN 110 343 884 B (JIANGSU WETOWN ELECTRIC POWER TECH CO LTD) 17 November 2020 (2020-11-17) * paragraphs [0023] - [0037], [0048]; examples 1, 2; table 1 * -----	1,2,4-12	
X	CN 112 695 233 A (NINGBO KENUO PRECISION INDUSTRY TECH CO LTD) 23 April 2021 (2021-04-23) * paragraphs [0030], [0034]; examples 1, 3 * -----	1-3	
X	CN 112 680 640 A (NINGBO KENUO PRECISION INDUSTRY TECH CO LTD) 20 April 2021 (2021-04-20) * paragraph [0030]; example 1 * -----	1-3	TECHNICAL FIELDS SEARCHED (IPC)
X	CN 101 660 883 A (DONGGUAN AODA ALUMINUM CO LTD) 3 March 2010 (2010-03-03) * pages 7-9 * -----	1,2,4-12	C22C C22F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	28 September 2022	Martinavicius, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 22 16 5622

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

28-09-2022

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
CN 110257677	A	20-09-2019	NONE	
CN 110343884	B	17-11-2020	NONE	
CN 112695233	A	23-04-2021	NONE	
CN 112680640	A	20-04-2021	NONE	
CN 101660883	A	03-03-2010	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2020028730 A **[0023]**