(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 November 2017 (02.11.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/185321 A1

(51) International Patent Classification:
C22C 21/02 (2006.01)

(21) International Application Number:
PCT/CN2016/080629

(22) International Filing Date:
29 April 2016 (29.04.2016)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicants: **GM GLOBAL TECHNOLOGY OPERATIONS LLC** [US/US]; 300 Renaissance Center, Mail Code 482-c23-b21, Detroit, Michigan 48265-3000 (US). **SHANGHAI JIAO TONG UNIVERSITY** [CN/CN]; 800 Dongchuan Road, Shanghai 200240 (CN).

(72) Inventors: **HU, Bin**; 58 West Xiangjing Street, Shanghai 201800 (CN). **RIZZO, Michael C.**; 2659 New England Drive, Rochester Hills, Michigan 48309 (US). **PENG, Liming**; Department No. #7-201, No. 651 Xinzhu Road, Shanghai 201104 (CN). **DING, Wenjiang**; Qinzhou Road 567, Shanghai 200050 (CN).

(74) Agent: **CHINA PATENT AGENT (H.K.) LTD.**; 22/F., Great Eagle Center, 23 Harbour Road, Wanchai, Hong Kong (CN).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** DIE-CASTING ALUMINUM ALLOYS FOR THIN-WALL CASTING COMPONENTS

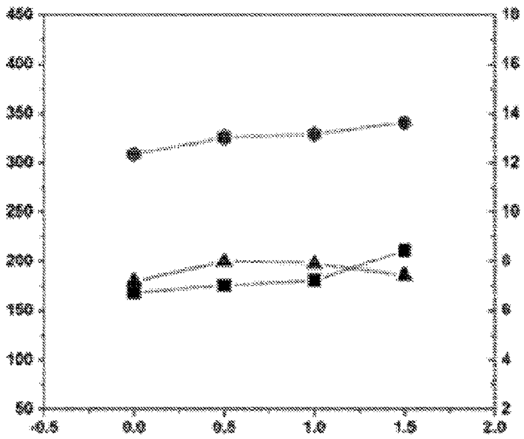

Fig. 1

(57) **Abstract:** An aluminum alloy composition is provided. The aluminum alloy composition includes silicon at a concentration of from greater than or equal to about 9.5% (wt. /wt.) to less than or equal to about 11.5% (wt. /wt.); manganese at a concentration of greater than or equal to about 0.5% by weight to less than or equal to about 0.8% by weight of the alloy composition; copper at a concentration of less than or equal to about 2% (wt. /wt.); and a balance of the alloy composition being aluminum. The aluminum alloy composition has a superior strength and ductility relative to traditional aluminum alloys.

WO 2017/185321 A1

DIE-CASTING ALUMINUM ALLOYS FOR THIN-WALL CASTING COMPONENTS

FIELD

[1] The present disclosure relates to alloy compositions for high strength and high ductility components made by casting.

BACKGROUND

[2] This section provides background information related to the present disclosure which is not necessarily prior art.

[3] Aluminum alloys are commonly used in manufacturing industries for die-casting components, such as, for example, engine blocks and transmission cases in the automobile industry. In particular, aluminum alloys (Al alloys) are often used to die-cast parts with thin walls that require high strength and high ductility and that are lightweight.

[4] A common Al alloy used in the automobile industry is known as A380. A380 has a silicon content of 7.5% (wt./wt.) to 9.5% (wt./wt.), an iron content of 0.6% (wt./wt.) to 1.3% (wt./wt.), a copper content of 3.0% (wt./wt.) to 4.0% (wt./wt.), a zinc content of 3.0% (wt./wt.), other components, and a balance being aluminum. However, A380 may require an additional heat treatment (T5) to improve strength. Accordingly, the development of new alloys that are strong and ductile, and do not require expensive heat treatments or manufacturing processes are desirable.

SUMMARY

[5] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[6] The present technology provides an alloy composition. The alloy composition comprises silicon at a concentration of from greater than or equal to about 9.5% by weight per total alloy composition weight to less than or equal to about 11.5% by weight/total alloy composition weight (or wt./wt.); manganese at a concentration of greater than or equal to about 0.5% (wt./wt.) to less than or equal to about 0.8% (wt./wt.); copper at a concentration of less than or equal to about 2% (wt./wt.); and a balance of the alloy composition being aluminum. The alloy composition has a higher strength and ductility relative to traditional alloys.

[7] The present technology also provides an alloy composition that comprises silicon at a concentration of from greater than or equal to about 9.5% by weight per total alloy composition weight (or wt./wt.) to less than or equal to about 11.5% (wt./wt.); copper at a concentration of greater than or equal to about 0.5% (wt./wt.) to less than or equal to about 1.5% (wt./wt.); manganese at a concentration of greater than or equal to about 0.5% (wt./wt.) to less than or equal to about 0.8% (wt./wt.); magnesium at a concentration of greater than or equal to about 0.1% (wt./wt.) to less than or equal to about 0.5% (wt./wt.); and a balance of the alloy composition being aluminum. The alloy composition may form, without any artificial heat treatment, a cast part in an as-cast condition that has a yield strength of from greater than or equal to about 150 MPa to less than or equal to about 210 MPa, an ultimate tensile strength of from greater than or equal to about 270 MPa to less than or equal to about 330 MPa, and a ductility (elongation) of from greater than or equal to about 5% to less than or equal to about 8%.

[8] Additionally, the present technology provides a method of manufacturing an automobile or vehicle part. The method includes die casting the vehicle part with an alloy composition. The alloy composition comprises silicon at a concentration of from greater than or equal to about 9.5% by weight per total alloy composition weight (or wt./wt.) to less than or equal to about 11.5% (wt./wt.); at last one element selected from the group consisting of copper at a concentration of greater than or equal to about 0.5% (wt./wt.) to less than or equal to about 1.5% (wt./wt.), magnesium at a concentration of greater than or equal to about 0.1% by weight to less than or equal to about 0.5% by weight of the alloy composition, and manganese at a concentration of greater than or equal to about 0.5% by weight to less than or equal to about 0.8% by weight of the alloy composition; and a balance of the alloy composition being aluminum. The die casting is either high-pressure die casting or low-pressure die casting. An as-cast vehicle part made by this method has a yield strength of from greater than or equal to about 150 MPa to less than or equal to about 210 MPa, an ultimate tensile strength of from greater than or equal to about 270 MPa to less than or equal to about 330 MPa, and a ductility (elongation) of from greater than or equal to about 5% to less than or equal to about 8%. Accordingly, a heat treatment after casting is not necessary.

[9] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[10] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[11] Fig. 1 is a graph that shows the effect of copper (Cu) content on tensile strength and ductility, wherein the left y-axis is tensile strength (MPa), the right y-axis is ductility (% elongation), and the x-axis is Cu content (% wt./wt.) and square points refer to yield strength, hexagonal points refer to ultimate tensile strength, and triangles refer to ductility.

[12] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[13] Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific compositions, components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

[14] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, elements, compositions, steps, integers, operations, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Although the open-ended term "comprising," is to be understood as a non-restrictive term used to describe and claim various embodiments set forth herein, in certain aspects, the term may alternatively be understood to instead be a more limiting and restrictive term, such as "consisting of" or "consisting essentially of." Thus, for any given embodiment reciting compositions, materials, components, elements, features, integers, operations, and/or process steps, the present disclosure also specifically includes embodiments consisting of, or consisting essentially of, such recited compositions, materials, components, elements, features, integers, operations, and/or process steps. In the case of "consisting of," the alternative embodiment excludes any additional compositions, materials, components, elements, features, integers, operations, and/or process steps, while in the case of "consisting essentially of," any additional compositions, materials, components, elements, features, integers, operations, and/or process steps that materially affect the basic and novel characteristics are excluded from such an embodiment, but any compositions, materials, components, elements, features, integers, operations, and/or process steps that do not materially affect the basic and novel characteristics can be included in the embodiment.

[15] Throughout this disclosure, the numerical values represent approximate measures or limits to ranges to encompass minor deviations from the given values and embodiments having about the value mentioned as well as those having exactly the value mentioned. All numerical values of parameters (e.g., of quantities or conditions) in this specification, including the appended claims, are to be understood as being modified in all instances by the term "about" whether or not "about" actually appears before the numerical value. "About" indicates that the stated numerical value allows some slight imprecision (with some approach to exactness in the value; approximately or reasonably close to the value; nearly). If the imprecision provided by "about" is not otherwise understood in the art with this ordinary meaning, then "about" as used herein indicates at least variations that may arise from ordinary methods of measuring and using such parameters.

[16] In addition, disclosure of ranges includes disclosure of all values and further divided ranges within the entire range, including endpoints and sub-ranges given for the ranges.

[17] As used herein, the terms “composition” and “material” are used interchangeably to refer broadly to a substance containing at least the preferred elements, but which may also comprise additional elements, substances or compounds, including impurities.

[18] Example embodiments will now be described more fully with reference to the accompanying drawings.

[19] The present technology pertains to improved aluminum alloys, which may be used in vehicle applications. The aluminum alloys include low-cost alloying elements and minimal impurities that result in high strength and high ductility thin-wall casting components or parts. Not only are the alloying elements low-cost, but the components or parts cast from the alloy do not require expensive heat treatments as with existing alloys, including A380, to achieve high strength and the desired stiffness and ductility requirements. Additionally, the high strength of the aluminum alloys enables significant mass reduction in completed components relative to conventional aluminum alloys, while meeting ductility requirements for the components.

[20] Aluminum alloys are widely used in vehicles, such as automobiles, motorcycles, boats, tractors, buses, mobile homes, campers, and tanks, and their utilization will continue alongside efforts to reduce vehicle mass and save space. The aluminum alloy according to the present technology results in components with reduced mass relative to components made with traditional alloys, while maintaining strength and ductility requirements. Therefore, relative to components made with traditional alloys, compact components can be made with the current aluminum alloys that have lower mass and take less space. Aluminum alloys are particularly suitable for use in components of an automobile or other vehicle (*e.g.*, motorcycles, boats), but may also be used in a variety of other industries and applications, including aerospace components, industrial equipment and machinery, farm equipment, heavy machinery, by way of non-limiting example. For example, aluminum alloys may be used to form die-cast vehicle or automotive components. Non-limiting examples include engine mount brackets, transmission mount brackets, shock towers, alternator brackets, air conditioner compressor brackets, cowl plates, and the like.

[21] The aluminum alloy provided by the present technology includes greater than or equal to about 9.5% by weight to less than or equal to about 11.5% by weight of the alloy composition (wt./wt.) silicon (Si). This increased Si content relative to traditional alloys, such as A380, provides an improved castability. As used herein, “castability” refers to an alloys ability to be cast without formation of defects, such as cracks, segregations, pores, or misruns. Moreover, the aluminum alloy can be used in high-pressure die casting or low-pressure die casting applications, without additional heat treatments or machining. Nonetheless, the aluminum alloy may be used in other casting applications that include much lower cooling rates relative to high-pressure die casting or low-pressure die casting, such as, for example, gravity casting, sand casting, and investment casting, with heat treatment.

[22] Additionally, the current aluminum alloy includes copper (Cu) at a concentration of less than or equal to about 2% (wt./wt.) or optionally less than or equal to about 1.5% (wt./wt.). In certain variations, the Cu concentration is greater than or equal to about 0.5% (wt. /wt.) to less than or equal to about 1.5% (wt./wt.). Having this low Cu concentration prevents or deters the formation of an Al_2Cu phase and does not negatively influence corrosion. Simultaneously, the addition of Cu increases yield strength. Fig. 1 is a graph that shows the effect of Cu content on tensile strength and ductility. In particular, the left y-axis is tensile strength (MPa), the right y-axis is ductility (% elongation), and the x-axis is Cu content (% wt./wt.). Square points refer to yield strength, hexagonal points refer to ultimate tensile strength, and triangles refer to ductility. As the graph shows, a copper concentration between 0 and about 1.5% (wt./wt.) provides results that are positive in regard to yield strength, ultimate tensile strength, and ductility.

[23] The aluminum alloy also includes a low iron (Fe) concentration of less than or equal to about 0.20% (wt. /wt.) or less than or equal to about 0.15% (wt./wt.). This low concentration of Fe results in less brittle Al-Si-Fe intermetallic phase relative to traditional alloys. The presence of an intermetallic phase generally decreases ductility.

Therefore, having a minimal amount of Fe contributes to the aluminum alloy's high ductility by preventing or minimizing the formation of a brittle intermetallic phase.

[24] In some alloys, Fe is included to decrease die soldering, wherein die soldering (also known as die sticking) occurs during casting when molten aluminum binds or welds to a die surface. Die soldering results in damage to the die and poor surface quality of a casting. Therefore, the decrease in Fe content relative to traditional alloys is offset by an increase in manganese (Mn) concentration, wherein manganese is an anti-die soldering element. Accordingly, the aluminum alloy also may include a Mn concentration of greater than nor equal to about 0.5% (wt./wt.) to less than or equal to about 0.8% (wt./wt.).

[25] An increased level of magnesium (Mg) is included in the present aluminum alloy relative to traditional alloys. In particular, Mg is included at a concentration of greater than or equal to about 0.10% (wt./wt.) to less than or equal to about 0.50% (wt./wt.). The Mg increases the strength of the aluminum and does not have a negative impact on ductility.

[26] A high phosphorous (P) content in Al-Si alloys results in a fibrous eutectic Si phase, which may have a negative impact on strength as well as ductility. Due to this effect, P may be considered an impurity. Consequently, strontium (Sr) is commonly added to Al-Si alloys to modify this phase. Using Sr as a modifier of eutectic Si phase has a tendency to increase the risk of hydrogen absorption into molten Al-Si alloys so as to increase the formation of pore-type defects in castings. However, a low P content in Al-Si alloys results in a finer morphology of particle-like eutectic Si phases associated with increased ductility without the addition of Sr. Therefore, the current aluminum alloy includes phosphorous at a concentration of less than or equal to about 0.003% (wt./wt.) to promote fine particle-like eutectic Si morphology and to improve ductility. Based on the foregoing, including Sr in the current aluminum alloy is optional. Accordingly, the aluminum alloy composition may optionally include Sr at a concentration of greater than or equal to 0.0% (wt./wt.) (or a positive concentration greater than 0.0% (wt./wt.)) to less than or equal to about 0.05% (wt./wt.).

[27] The present aluminum alloy also contains low levels of the impurities zinc (Zn) and tin (Sn) relative to traditional alloys. In particular, the Zn and Sn concentrations are individually less than or equal to about 0.01% (wt./wt.). The low Zn and Sn concentrations relative to traditional alloys provide increased ductility and improved machinability, which refers to the ease in which the alloy can be worked with a cutting tool. Similarly, the aluminum alloy includes a low titanium (Ti; another impurity) concentration of greater than or equal to about 0.05% (wt./wt.) to less than or equal to about 0.1% (wt./wt.).

[28] Although it is understood that the aluminum alloy may contain small concentrations of other impurities, the balance of the aluminum alloy is aluminum. Therefore, the aluminum concentration is greater than or equal to about 84% (wt./wt.) to less than or equal to about 90%.

[29] As described above, the current aluminum alloy contains Al, Si, Fe, Cu, Mn, Mg, Zn, Ti, P, Sn, and optionally Sr with varying concentrations.

[30] In various aspects, the current aluminum alloy comprises Al and Si and at least one or at least two elements selected from the group consisting of Fe, Cu, Mn, and

Mg. The current aluminum alloy may also comprise Zn, Ti, P, and/or Sn. The foregoing elements and their corresponding concentrations are provided in Table 1. Nonetheless, it is understood that the aluminum alloy may include trace amounts of impurities (other than the impurities described herein) that do not materially affect the strength, ductility, and stiffness of the aluminum alloy at a concentration of less than or equal to about 0.15% (wt./wt.).

Table 1. Component concentrations (% (wt./wt.)) of the aluminum alloy prepared in accordance with certain variations of the present disclosure.

Al	Si	Fe	Cu	Mn	Mg	Zn	Ti	P	Sn
Balance	9.5 - 11.5	≤ 0.20	0.5 - 1.5	0.50 - 0.60	0.10 -0.50	≤ 0.01	0.05 - 0.10	≤ 0.003	≤ 0.01

[31] In various embodiments, the current aluminum alloy composition comprises Al and Si and at least one or at least two elements selected from the group consisting of Cu, Mn, Mg, Fe, Zn, Ti, P, Sn, and Sr at the concentrations provided herein. In certain embodiments, the aluminum alloy composition comprises Al, Fe, Si, Cu, Mn, Fe, Mg, Zn, Ti, P, Sn, and optionally Sr at the concentrations provided herein.

[32] In some embodiments, the aluminum alloy consists essentially of the components described herein. In other words, the aluminum alloy can include Al, Si, Fe, Cu, Mn, Mg, Zn, Ti, P, Sn, and optionally Sr at the concentrations provided herein and other impurities that do not materially affect the strength, ductility, and stiffness of the aluminum alloy. In yet other embodiments, the aluminum alloy consists essential of Al and Si and at last one or at least two other elements selected from the group consisting of Fe, Cu, Mn, Mg, Zn, Ti, P, Sn, and Sr.

[33] In other embodiments, the aluminum alloy consists of the components described herein. In other words, the aluminum alloy can include Al, Si, Fe, Cu, Mn, Mg, Zn, Ti, P, Sn, and optionally Sr at the concentrations provided herein and no other impurities. In yet further embodiments, the aluminum alloy consists of Al and Si and at last one or at least two other elements selected from the group consisting of Fe, Cu, Mn, Mg, Zn, Ti, P, Sn, and Sr.

[34] In an as-cast condition, without heat treatment, the aluminum alloy provided herein has a yield strength (YS) of from greater than or equal to about 150 MPa, or from greater than or equal to about 150 MPa to less than or equal to about 210 MPa, such as a YS of about 150 MPa, 160 MPa, 170 MPa, 180 MPa, 190 MPa, 200 MPa, or 200 MPa. Moreover, in the as-cast condition without heat treatment, the aluminum alloy has an ultimate tensile strength (UTS) of greater than or equal to about 270 MPa, or from greater than or equal to about 270 MPa to less than or equal to about 330 MPa, such as a UTS of about 270 MPa, 280 MPa, 290 MPa, 300 MPa, 310 MPa, 320 MPa, or 330 MPa. Also, the aluminum alloy has a ductility (elongation) of greater than or equal to about 5% (elongation) to less than or equal to about 8% (elongation), such as a ductility of about 5% (elongation), about 6% (elongation), about 7% (elongation), or about 8% (elongation) in the as-cast condition without heat treatment.

[35] As described above, the current aluminum alloy enables the design of lighter weight components relative to traditional alloys. For example, the mass of a casting made from the current aluminum alloy is about 26% less than the mass of an equivalent casting composed of A380. Moreover, the casting made from the current aluminum alloy maintains all stiffness and strength requirements. Therefore, the current

aluminum alloy has improved strength and ductility relative to traditional alloys and maintains an acceptable stiffness.

[36] The current technology also provides a method of manufacturing a component, such as an automobile part. The method comprises die casting the component with an aluminum alloy described herein. The die casting is either high-pressure die casting or low-pressure die casting and optionally includes heat treating the component after casting and machining the casting. In some preferred embodiments, the method omits any heat treatment and/or machining after the die casting. The component can be, for example, an engine mount bracket, a transmission mount bracket, a shock tower, an alternator bracket, an air conditioner compressor bracket, or a cowl plate.

[37] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

CLAIMS

What is claimed is:

1. An alloy composition comprising:

silicon at a concentration of from greater than or equal to about 9.5% by weight to less than or equal to about 11.5% by weight of the alloy composition;

manganese at a concentration of greater than or equal to about 0.5% by weight to less than or equal to about 0.8% by weight of the alloy composition;

copper at a concentration of less than or equal to about 2% by weight of the alloy composition; and

a balance of the alloy composition being aluminum.

2. The alloy composition according to Claim 1, wherein the copper concentration is from greater than or equal to about 0.5% by weight to less than or equal to about 1.5% by weight of the alloy composition.

3. The alloy composition according to Claim 1, further comprising:

iron at a concentration of less than or equal to about 0.20% by weight of the alloy composition.

4. The alloy composition according to Claim 3, wherein the iron concentration is less than or equal to about 0.15% by weight of the alloy composition.

5. The alloy composition according to Claim 1, further comprising:

zinc at a concentration of less than or equal to about 0.01% by weight of the alloy composition.

6. The alloy composition according to Claim 1, further comprising: phosphorus at a concentration of less than or equal to about 0.003% by weight of the alloy composition.

7. The alloy composition according to Claim 1, further comprising:

tin at a concentration of less than or equal to about 0.01% by weight of the alloy composition.

8. The alloy composition according to Claim 1, wherein the alloy composition has a yield strength of from greater than or equal to about 150 MPa to less than or equal to about 210 MPa.

9. The alloy composition according to Claim 1, wherein the alloy composition has an ultimate tensile strength of from greater than or equal to about 270 MPa to less than or equal to about 330 MPa.

10. The alloy composition according to Claim 1, wherein the alloy composition has a ductility of from greater than or equal to about 5% (elongation) to less than or equal to about 8% (elongation).

11. An alloy composition comprising:

silicon at a concentration of from greater than or equal to about 9.5% by weight to less than or equal to about 11.5% by weight of the alloy composition;

copper at a concentration of greater than or equal to about 0.5% by weight to less than or equal to about 1.5% by weight of the alloy composition;

manganese at a concentration of greater than or equal to about 0.5% by weight to less than or equal to about 0.8% by weight of the alloy composition;

magnesium at a concentration of greater than or equal to about 0.1% by weight to less than or equal to about 0.5% by weight of the alloy composition; and

a balance of the alloy composition being aluminum,

wherein the alloy composition has a yield strength of from greater than or equal to about 150 MPa to less than or equal to about 210 MPa, and an ultimate tensile strength of from greater than or equal to about 270 MPa to less than or equal to about 330 MPa.

12. The alloy composition according to Claim 11, further comprising:

iron at a concentration of less than or equal to about 0.15% by weight of the alloy composition.

13. The alloy composition according to Claim 11, further comprising:

strontium at a positive concentration greater than 0.0% by weight to less than or equal to about 0.05% by weight of the alloy composition.

14. The alloy composition according to Claim 11, wherein the yield strength is about 150 MPa.

15. The alloy composition according to Claim 11, wherein the ultimate tensile strength is about 280 MPa.

16. The alloy composition according to Claim 11, wherein the alloy composition has a ductility of about 5% (elongation).

17. The alloy composition according to Claim 11, wherein the alloy composition does not require a heat treatment after casting.

18. An automotive component composed of the alloy composition according to Claim 11.

19. A method of manufacturing a vehicle part, the method comprising:

die casting the vehicle part with an alloy composition, wherein the alloy composition comprises:

silicon at a concentration of from greater than or equal to about 9.5% by weight to less than or equal to about 11.5% by weight of the alloy composition;

at least one element selected from the group consisting of copper at a concentration of greater than or equal to about 0.5% by weight to less than or equal to about 1.5% by weight of the alloy composition, magnesium at a concentration of greater than or equal to about 0.1% by weight to less than or equal to about 0.5% by weight of the alloy composition, and manganese at a concentration of greater than or equal to about 0.5% by weight to less than or equal to about 0.8% by weight of the alloy composition; and

a balance of the alloy composition being aluminum,

wherein the die casting is either high-pressure die casting or low-pressure die casting and the vehicle part formed via the die casting is not heat treated.

20. The method according to Claim 19, wherein the vehicle part is selected from the group consisting of an engine mount bracket, a transmission mount bracket, a shock tower, an alternator bracket, an air conditioner compressor bracket, a cowl plate, and combinations thereof.

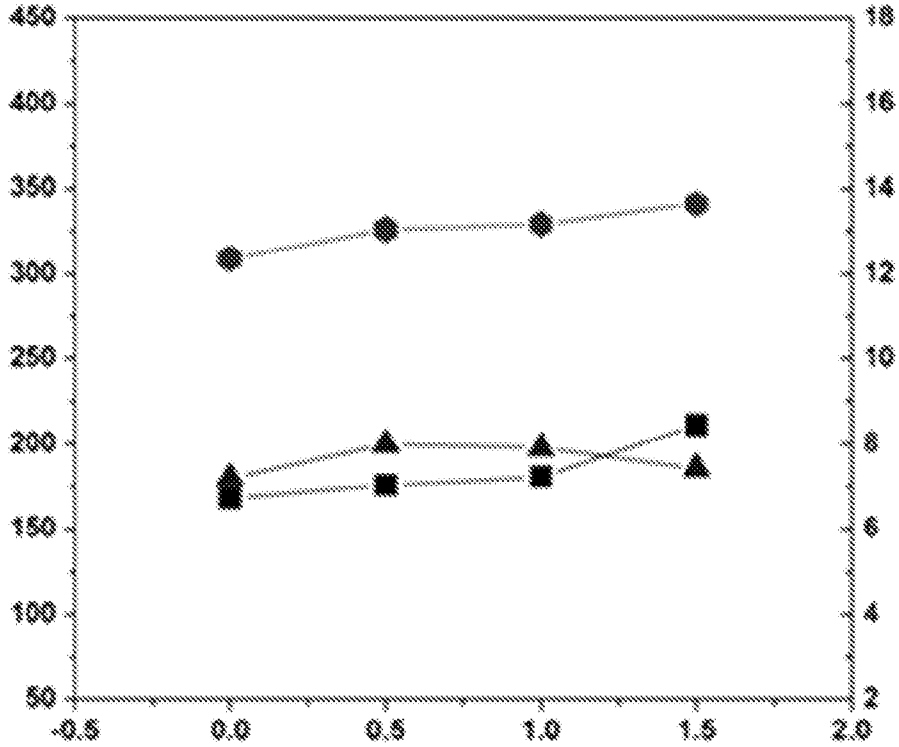
450
400
350
300
250
200
150
100
50
18
16
14
12
10
8
6
4
2
-0.5
0.0
0.5
1.0
1.5
2.0

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/080629

A. CLASSIFICATION OF SUBJECT MATTER

C22C 21/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,CNKI,DWPI,EPODOC,TWABS,ISI Web of Knowledge:alloy,al,aluminum,si,silicon,mn,manganese,cu,copper,mg, magnesium,vehicle,cast+,die,heat,engine,sr,strontium

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6364970 B1 (RHEINFELDEN ALUMINIUM GMBH) 02 April 2002 (2002-04-02) Column 1, line 23 - column 2, line 44 of the description	1-20
X	EP 0577062 A1 (SUMITOMO ELECTRIC INDUSTRIES) 05 January 1994 (1994-01-05) Page 3, line 30 - page 5, line 39 of the description	1-20
X	CN 104498781 A (GUIYANG GUANGHANG CASTING CO. LTD.) 08 April 2015 (2015-04-08) Paragraphs [0008]-[0025] of the description	1-20
X	CN 102703774 A (GUIYANG HUAFENG NONFERROUS CASTING CO. LT.) 03 October 2012 (2012-10-03) Paragraphs [0004]-[0008] of the description	1-20
X	CN 101709415 A (SUZHOU INST. NANO TECH. & NANO BIONICS) 19 May 2010 (2010-05-19) Paragraphs [0007]-[0021] of the description	1-20
X	US 4336076 A (KAWASAKI HEAVY IND. LTD.) 22 June 1982 (1982-06-22) Column 2, line 20 - column 5, line 14 of the description	1-20

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 December 2016	**22 December 2016**

Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 China	**TANG,Zhiyong**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)62413812**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 105039799 A (ZHANG，XIAOLONG) 11 November 2015 (2015-11-11) Paragraphs [0012]-[0025] of the description	1-20
X	DE 19524564 A1 (VAW ALUCAST GMBH) 02 January 1997 (1997-01-02) Claims 1-3	1-20
X	CN 105112740 A (CHEN，JUGEN) 02 December 2015 (2015-12-02) Paragraphs [0012]-[0025] of the description	1-20

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/080629

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	6364970	B1	02 April 2002	EP	0687742	A1	20 December 1995
				NO	952344	D0	14 June 1995
				JP	3255560	B2	12 February 2002
				ES	2109798	T3	16 January 1998
				AU	689872	B2	09 April 1998
				CA	2151884	C	13 March 2007
				NO	306867	B1	03 January 2000
				BR	9502816	A	16 January 1996
				CA	2151884	A1	17 December 1995
				NO	952344	A	15 December 1995
				EP	0687742	B1	10 September 1997
				DE	59500630	D1	16 October 1997
				ZA	9504057	B	19 January 1996
				JP	H0841575	A	13 February 1996
				ZA	9504057	A	19 January 1996
				AU	2011595	A	04 January 1996
				CH	689143	A5	30 October 1998
				AT	158025	T	15 September 1997
EP	0577062	A1	05 January 1994	DE	69326290	T2	27 January 2000
				EP	0577062	B1	08 September 1999
				US	5338168	A	16 August 1994
				DE	69326290	D1	14 October 1999
CN	104498781	A	08 April 2015	None			
CN	102703774	A	03 October 2012	None			
CN	101709415	A	19 May 2010	CN	101709415	B	11 January 2012
US	4336076	A	22 June 1982	JP	S53115407	A	07 October 1978
				JP	S579426	B2	22 February 1982
CN	105039799	A	11 November 2015	None			
DE	19524564	A1	02 January 1997	None			
CN	105112740	A	02 December 2015	None			