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(54) MG-AL-CA-BASED MASTER ALLOY FOR MG ALLOYS, AND A PRODUCTION METHOD THEREFOR

MG-AL-CA-BASIERTE MASTERLEGIERUNG FÜR MG-LEGIERUNGEN UND HERSTELLUNGSVERFAHREN DAFÜR

ALLIAGE MAÎTRE À BASE DE MG-AL-CA POUR DES ALLIAGES DE MG, ET PROCÉDÉ DE PRODUCTION DE CELUI-CI

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- **MIHRIBAN O. PEKGULERYUZ ET AL.: ’Creep Resistant Magnesium Diecasting Alloys Based on Alkaline Earth Elements’ MATERIALS TRANSACTIONS vol. 42, no. 7, 2001, pages 1258 - 1267, XP055127116**

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Description

TECHNICAL FIELD

[0001] The present invention relates to an Mg-Al-Ca based master alloy for Mg alloys and a production method therefor.

BACKGROUND ART

[0002] Mg alloys have a density of approximately 1.8 g/cm^3, which is a minimum of density levels of various alloys that are commercially available up to now, and demonstrate high specific strength and modulus of elasticity. In particular, Mg alloys are excellent in view of absorbing capability of vibrations or impacts, electrical and thermal conductivity, processibility, fatigue strength at high temperature, impact property, and so on. Specifically, Mg alloys have various advantageous properties complying with requirements for weight reduction in various fields including transportation equipment such as automobiles, airplanes, or the like, equipment for defense industry, general machinery, and so on.

[0003] One of the most favorable advantages of Mg alloys is lightness in weight. Currently commercially available Mg alloys have a specific weight in a range of 1.79 to 1.81, which is approximately 35% or greater lighter than Al alloys, and demonstrate excellent mechanical properties. That is to say, whereas Mg alloys are similar to Al or steel in view of the modulus of elasticity and density, they demonstrate a noticeably reducing effect of weight, compared to Al alloys or plastic material.

[0004] Since the Mg alloy is melted at a relatively low temperature in a range of 650 to 680°C, although there is a slight difference in the melting temperature according to the kind of allying element used, a small amount of energy is consumed in recycling the Mg alloy. In particular, the Mg alloy can be recycled only with a quarter of the energy required for producing an Mg alloy ingot for the first time, thereby demonstrating a very high energy saving effect. The Mg alloy recovered from the field production process may be melted to be recycled, followed by removing impurities and reducing components, and the recycled Mg alloy can be reused in substantially the same state as a new Mg alloy. In addition, Mg alloys are at least twice longer than Al alloys in view of the life of molds, and are higher than Al alloys in view of manufacturability. Consequently, the production cost required by each unitary part can be reduced.

[0005] If a group of elements are added at once in the manufacture of an alloy, they may not be properly mixed. Thus, in order to add alloying elements to be used in uniform amounts, it is often the case that an alloy containing large amounts of elements to be added is separately prepared as a flux, and small pieces of the flux are added to a molten metal used as a parent material of a desired alloy to then be diluted. Here, the alloy containing large amounts of elements to be added is referred to as a master alloy. The master alloy is also called an intermediate alloy.

[0006] Al has the most advantageous effect when it is used as an alloying element of Mg. The addition of Al increases the strength and hardness of Mg alloys, improves flowability during casting and increases a solidifying range, thereby improving castability. When Al is added in an amount of 6 wt% or less, it may turn into solid-solution in an Mg base. On the other hand, when Al is added in an amount of greater than 6 wt%, it may be precipitated and cured by heat treatment. In general, in most commercially available alloys, the content of Al is 10 wt% or less, in which Al alloys have excellent physical properties in view of strength and elongation. However, when Al reacts with Mg, an $Mg_{17}Al_{12}$ phase may be formed, thereby lowering crepe resistance at high temperature.

[0007] Ca considerably improves high temperature strength and crepe resistance of Mg-Al based Mg alloys. The addition of a trace amount (<0.5%) of Ca to an Al containing Mg alloy forms an Al_2Ca intermetallic compound, which is stable at high temperature, during solidification, thereby increasing the strength and heat resistance. In addition, it is also known that Ca is an effective element in preventing alloys from being oxidized during casting or heat treatment. Further, Ca may serve to make crystalline particles into microstructures. However, Ca may reduce flowability of a molten metal, thereby deteriorating castability, facilitates hot tearing, and increasing viscosity with respect to a mold during die casting, thereby ultimately lowering the manufacturability. If Ca is added in an amount of 0.3 wt% or greater, cracks may be generated during welding.

[0008] When the conventional Ca alloying element is directly input into Mg or Mg alloy for manufacturing Mg Alloy, solid-solution of Ca in the Mg alloy occurs in a certain amount, so that the conventional Ca alloying element turns into solid-solution in the Mg alloy base, rather than forming a phase in the Mg ally base. In addition, when the conventional Ca alloying element is added to an Mg molten metal, which is highly brittle, the yield with the addition of Ca is not high, but an oxide derived from Ca may be generated. For example, when Ca is added in an amount of 1.3 wt% or greater (0.8 wt% in a non-equilibrium state), dissolution of Ca in the Mg base is not further performed, and an intermetallic compound is formed. Typical examples of the intermetallic compound affecting physical properties of Mg or other alloying elements include Al_2Ca.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

[0009] In order to overcome the above-mentioned shortcomings, the present invention provides a novel Mg-Al-Ca based master alloy for Mg alloys, which is different from alloying elements added for alloying to Mg or an Mg alloy or a conventional master alloy, and a production method therefor. The Mg alloy produced using the master alloy according to the present invention demonstrates excellent physical properties, compared to conventional Mg alloys. In the present invention, while the Ca:Al composition ratio is maintained at 4.3:5.7, Mag is contained in an amount of 65% of the entire weight of the master alloy, based on percentage per weight.

[0010] The objects of the present invention are not limited to the above-described objects and other objects not described above may be understood by those of ordinary skill in the art from the following description of the preferred embodiments.

TECHNICAL SOLUTION(S)

[0011] According to an aspect of the invention, there is provided an Mg-Al-Ca based master alloy for Mg alloys, wherein while the Ca:Al composition ratio is maintained at 4.3: 5.7, Mg may be contained in an amount of 65% of the entire weight of the master alloy, based on percentage by weight.

[0012] According to an aspect of the invention, there is provided a production method of an Mg-Al-Ca based master alloy for Mg alloys, the production method including preparing components of a master alloy by selecting a composition of claim 1, sequentially melting Mg, Al and Ca, completely melting the components by applying an adequate amount of heat, and solidifying the molten metal.

[0013] The solidifying of the molten metal may include rapidly cooling the molten metal.

[0014] In the melting, Mg may first be melted, Al may then be melted, and Ca may finally be melted.

[0015] In the melting, Al may first be melted, Mg may then be melted, and Ca may finally be melted.

[0016] In the melting, Mg and Al may be melted together and Ca may then be melted.

[0017] In the melting, Mg and Ca may be melted together and Al may then be melted.

[0018] The production method comprises the steps of: preparing components of a master

ADVANTAGEOUS EFFECTS

[0019] As described above, the master alloy according to the present invention is used in producing Mg alloys having excellent physical properties by controlling components of alloying elements added to produce commercially available Mg alloys within composition ranges to cause Al_2Ca phase formation. That is to say, the Al_2Ca phase formed from the master alloy is maintained in the final Mg alloy, thereby making the Mg alloy have a microstructure and increasing yield strength and the tensile strength of the Mg alloy. In addition, formation of a β-$Mg_{17}Al_{12}$ phase that is thermally unstable is suppressed, and casting defects can be greatly reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The objects, features and advantages of the present invention will be more apparent from the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 is a calculated phase diagram of Al-Ca binary alloys;
FIG. 2 is a calculated phase diagram of Mg-Al binary alloys;
FIG. 3 is a calculated phase diagram of Mg-Ca binary alloys;
FIG. 4 is a graph illustrating composition ranges (region 1) according to an embodiment of the present invention on a liquid projection view of an Mg-Al-Ca ternary phase diagram indicated by weight ratios; and
FIG. 5 is a graph illustrating composition ranges (region 2) according to another embodiment of the present invention on a liquid projection view of an Mg-Al-Ca ternary phase diagram indicated by weight ratios.

BEST MODE FOR CARRYING OUT THE INVENTION

[0021] Preferred embodiments of the present invention will be described below in more detail with reference to the accompanying drawings. In every possible case, like reference numerals are used for referring to the same or similar elements in the description and drawings. Moreover, detailed descriptions related to well-known functions or configurations will be ruled out in order not to unnecessarily obscure subject matters of the present invention.

[0022] The present invention provides an Mg-Al-Ca based master alloy, which is different from the conventional alloying element or conventional master alloy added to Mg or an Mg alloy for alloying, and a production method therefor, in an attempt to develop Mg alloys having better physical properties than conventional Mg alloy using the master alloy according to the present invention.

[0023] When the conventional Ca alloying element is directly input into Mg or Mg alloy for manufacturing Mg Alloy, solid-solution of Ca in the Mg alloy occurs in a certain amount, so that the conventional Ca alloying element turns into solid-solution in the Mg alloy base, rather than forming a phase in the Mg ally base. In addition, when the conventional Ca alloying element is added to an Mg molten metal, which is highly brittle, the yield with the addition of Ca is not high, but an oxide derived from Ca may be generated. For example, when Ca is added in an amount of 1.3 wt% or greater (0.8 wt% in a non-equilibrium state), dissolution of Ca in the Mg base is not further performed, and an intermetallic compound is formed. Typical examples of the intermetallic compound affecting physical properties of Mg or other alloying elements include Al_2Ca.

[0024] In the present invention, the inputting of the alloying element using the master alloy is achieved by inputting comprises inputting an Mg-Al-Ca master alloy prepared to cause Al_2Ca phase formation to Mg or an Mg alloy. As the result, the obtained Mg alloy has better physical properties than the conventional Mg alloy obtained by adding alloying elements of the same composition. Here, in order to obtain a desired composition, Ca or Al may further be added in addition to the master alloy.

[0025] FIG. 1 is a calculated phase diagram of Al-Ca binary alloy.

[0026] It can be confirmed that intermetallic compounds are formed in various composition ranges. Examples of the intermetallic compound may include Al_4Ca, Al_2Ca, $Al_{14}Ca_{13}$ and Al_3Ca_8. Specifically, Al_2Ca has a considerably high melting point. It is understood that Al_2Ca, observed in the present invention for the purpose of improving physical properties, is an intermetallic compound having a high melting point. A method of calculating and obtaining a phase diagram is generally known in the related art. In particular, a commercially available program, such as a CALPHAD method, may also be used in calculating and obtaining the phase diagram.

[0027] FIG. 2 is a calculated phase diagram of Mg-Al binary alloys. As shown in FIG. 2, there is high solid solubility of either Mg or Al with respect to each opponent element. While Mg and Al are mixed together and melted, melting points thereof are lowered.

[0028] FIG. 3 is a calculated phase diagram of Mg-Ca binary alloys. Mg_2Ca exists as an intermetallic compound between the Mg-Ca binary alloys. The melting point of Mg_2Ca is positioned between melting points between pure Mg and pure Ca. That is to say, the melting point of Mg_2Ca is higher than the melting point of pure Mg and lower than the melting point of pure Ca.

[0029] FIGS. 4 and 5 are liquid projection views of Mg-Al-Ca ternary phase diagrams indicated by weight ratios. Composition ranges of the master alloy developed according to the present invention and exemplary embodiments thereof are illustrated in FIGS. 4 and 5. In the ternary phase diagram, vertexes of a triangle indicates points at which fractions of components Mg, Ca and Al are 100%, respectively, and sides of the triangle indicate binary system of two components on each of the sides.

[0030] As shown in FIGS. 4 and 5, as the temperature is lowered, Al_2Ca is present in the wider composition range. By contrast, as temperature is lowered, Al_4Ca, $Al_{14}Ca_{13}$, Mg_2Ca and Al_3Ca_8 are present in narrower composition ranges. In all of the figures (FIGS. 1 to 5), the temperatures can be calculated in terms of degrees in Celsius (°C) by simply subtracting 273 from temperature values indicated in terms of degrees in Kelvin (K).

[0031] The Mg-Al-Ca based master alloy for Mg alloys produced in the present invention maintains a Ca:Al composition ratio at between 7:3 and 1:9, based on percentages by weight.

[0032] As shown in FIG. 4, the line of the Ca:Al composition ratio being 7:3 is maintained along the line ①, and the line of the Ca:Al composition ratio being 1:9 is maintained along the line ②. In the present invention, what is meant by the expression "the Ca:Al composition ratio is maintained at between 7:3 and 1:9, based on percentages by weight" is that the ranges of components of the master alloy are established below the line 1 and above the line ②.

[0033] In addition, according to the present invent, while the Ca:Al composition ratio is maintained at between 7:3 and 1:9, based on percentages by weight, Mg is further added in an amount of up to 85% of the entire weight of the master alloy, based on percentage by weight, which is established above line ③.

In the present invention, the compositions for the master alloy are determined in a region established by the lines ①, ② and ③, indicated by a region 1. That is to say, the master alloy is produced within the composition range of the region 1 established by the lines ①, ② and ③.

[0034] More preferably, the Ca:Al composition ratio is maintained at between 6:4 and 2:8, which are composition ranges formed by lines ④, ⑤ and ③, as shown in FIG. 5. That is to say, in the case where the Ca:Al composition ratio is maintained at between 6:4 and 2:8, the compositions for the master alloy are determined in a region established by the lines ④, ⑤ and ③.

[0035] In the Ca:Al composition ratio, 6:4 is more preferred than 7:3 for the reason below. That is to say, when the composition range is shifted toward Al_2Ca from the region established by Mg_2Ca, $Al_{14}Ca_{13}$ and Al_2Ca, Al_2Ca formation is more securely guaranteed. That is to say, since the 7:3 composition ratio exists around boundary lines between Mg_2Ca, $Al_{14}Ca_{13}$ and Al_2Ca, there are also possibilities of forming Mg_2Ca and $Al_{14}Ca_{13}$, rather than Al_2Ca. However, the 6:4 composition ratio can make Al_2Ca formation more securely confirmed.

[0036] In the Ca:Al composition ratio, 2:8 is more preferred than 1:9 for the reason below. That is to say, when the composition range is shifted toward Al_2Ca from the region established by Al_2Ca and Al_4Ca, Al_2Ca formation is more securely guaranteed. That is to say, since the 1:9 composition ratio exists around a boundary line between Al_2Ca and Al_4Ca, there is also possibility of forming Al_4Ca, rather than Al_2Ca. However, the 2:8 composition ratio can make Al_2Ca formation more securely confirmed.

[0037] In addition, a feature of the present invention lies in that the content of Al is contained in an amount of 15% or greater of the entire weight of the Mg-Al-Ca based master alloy, based on percentage by weight. If the content of Al is less than 15%, an amount of Al_2Ca formed is reduced. In this case, the effect of Al_2Ca as a master alloy may become insignificant.

[0038] A production method of an Mg-Al-Ca based master alloy for Mg alloys according to an embodiment of the present invention includes preparing components of a master alloy by selecting a composition in which, while a Ca:Al composition ratio is maintained at between 7:3 and 1:9, based on percentages by weight in the alloy, there is a balance of Mg in an amount of up to 85% of the entire weight of the master alloy, based on percentage by weight, sequentially melting Mg, Al and Ca, completely melting the components by applying an adequate amount of heat, and solidifying the molten metal. Preferably, in the solidifying of the molten metal, the molten metal may be rapidly cooled. Here, the rapidly cooling refers to forced cooling, which is faster than natural solidifying in a general casting process. The forced cooling includes water cooling (including brine quenching) or rapid cooling by blowing air quenching.

[0039] Here, the composition selected for producing the Mg-Al-Ca based master alloy is determined in the range of the region 1 shown in FIG. 4. The reason of the foregoing is briefly described. That is to say, the alloy components are completely melted by raising the temperature over the liquid phase line of the corresponding composition of the region 1, and the molten metal is then rapidly cooled, thereby maximally producing Al_2Ca as desired in the master alloy of the present invention.

[0040] More preferably, the Ca:Al composition ratio may be maintained at between 6:4 and 2:8, based on percentage by weight. The composition selected for producing the Mg-Al-Ca based master alloy is determined in the range of the region 2 shown in FIG. 5, established by the lines ④, ⑤ and ③. As described above, in the Ca:Al composition ratio, 6:4 is more preferred than 7:3 because when the composition range is shifted toward Al_2Ca from the region established by Mg_2Ca, $Al_{14}Ca_{13}$ and Al_2Ca, Al_2Ca formation is more securely guaranteed. That is to say, since the 7:3 composition ratio exists around boundary lines between Mg_2Ca, $Al_{14}Ca_{13}$ and Al_2Ca, there are also possibilities of forming Mg_2Ca and $Al_{14}Ca_{13}$, rather than Al_2Ca. However, the 6:4 composition ratio can make Al_2Ca formation more securely confirmed.

[0041] In the Ca:Al composition ratio, 2:8 is more preferred than 1:9 for the reason below. That is to say, when the composition range is shifted toward Al_2Ca from the region established by Al_2Ca and Al_4Ca, Al_2Ca formation is more securely guaranteed. That is to say, since the 1:9 composition ratio exists around a boundary line between Al_2Ca and Al_4Ca, there is also possibility of forming Al_4Ca, rather than Al_2Ca. However, the 2:8 composition ratio can make Al_2Ca formation more securely confirmed.

[0042] More preferably, while the Ca:Al composition ratio is maintained at 4.3: 5.7, Mg is contained in an amount of 65% of the entire weight of the master alloy, based on percentage by weight. When the Ca:Al composition ratio is 4.3 : 5.7 by wt%, maximum Al_2Ca phase formation can be expected by maintaining a molar ratio of Ca:Al at 1:2. As confirmed from FIG. 5 (Al_2Ca line), when Mg is contained in an amount of 65% or less, Al_2Ca phase formation can be more securely guaranteed.

[0043] As shown in FIG. 5, on the Al_2Ca line, Al and Ca maintain the Al_2Ca composition ratio. An ideal amount of Al_2Ca can be formed by adding Mg while maintaining the composition ratio on the Al_2Ca line. In this case, Mg is more preferably added in an amount of up to 65% of the entire weight of the master alloy, based on percentage by weight.

Melting methods of various components

[0044] Various components for forming the Mg-Al-Ca based master alloy according to the present invention are prepared, and Mg, Al and Ca are sequentially melted one by one. For example, Mg is melted by applying an adequate amount of heat, Al is then melted, and Ca is finally melted.

[0045] Here, the melting may also be performed from Mg to Al and to Ca, Al to Ca and to Mg, or Ca to Mg and to Al in that order. As shown in FIGS. 1, 2 and 3, when an intermetallic compound is generated during melting, the molten metal can only be formed by applying a much larger amount of heat due to a high melting point of the generated intermetallic compound, which is disadvantageous. Therefore, when the respective components are melted, it is not desirable to form Al_2Ca from the beginning by melting Al and Ca together. Therefore, the melting in the order of Al-Ca-Mg or Ca- Al-Mg is the most undesirable method.

[0046] Unlike the melting order stated above, Mg and Al may be melted together, or Ca and Mg may be melted together, and the rest alloying element (Ca or Al) may then be melted. As described above, in order to prevent the Al_2Ca intermetallic compound from being immediately formed before forming the master alloy, it is least desirable to melt Al and Ca at the same time. As confirmed from FIGS. 1, 2 and 3, with regard to cases of Al and Mg, and Ca and Mg, except for a case of Al and Ca, when two metals are melted at the same time, the melting point is lowered, compared to a case when a pure metal is melted. Of course, with regard to a case of a Ca-Mg binary system, when two metals are melted at the same time, compared to the case when pure Ca or Mg is melted, the melting point decreased in a certain composition range and increased after passing an eutectic point. However, it can also be confirmed that a temperature at which the intermetallic compound of Mg_2Ca is formed is lower than the melting temperature of Ca.

[0047] Here, three components Mg, Al and Ca may also be melted at the same time. When the three components Mg, Al and Ca are put into a crucible and an adequate amount of heat for melting is applied in a protection gas atmosphere, they are melted in the crucible, thereby forming a molten metal for forming the Mg-Al-Ca based master alloy. In a case where ignition occurs due to the Mg or Ca composition, melting may be performed in the protection gas atmosphere.

Melting Temperature in Producing Master Alloy

[0048] In the present invention, the melting temperature for forming the molten metal is as high as a temperature in which a solid phase metal is sufficiently melted to then exist a perfect liquid phase. However, considering that the temperature of the molten metal may be lowered with addition of sequentially input components, it is necessary to maintain the molten metal to be in a temperature range having a sufficient margin. In metallography, it is generally often the case that the melting point is lowered according to the progress of alloying.

[0049] If the melting temperature is excessively raised, evaporation of a liquid metal may occur, and Mg or Ca may be readily evaporated in view of its characteristic, resulting in a loss of the amount of the molten metal, thereby adversely affecting final physical properties due to ignited oxides.

[0050] In order to form the molten metal of the master alloy, the molten metal is preferably stirred. The stirring may be performed by generating an electric field by providing an apparatus for applying an electromagnetic field around a furnace containing the molten metal, thereby inducing convection of the molten metal. Alternatively, the molten metal may be mechanically stirred from the outside.

[0051] In Table 1 below, after producing the master alloy with the compositions in the composition ranges of the region 1 or 2, Al_2Ca formation in the master alloy was confirmed. In order to allow Al_2Ca in a liquid phase to exist in a solid phase, casting is preferably performed on the molten metal by rapid cooling. The rapid cooling is performed because it cannot be confirmed into which phase the liquid phase Al_2Ca is converted as the result of cooling. That is to say, the rapid cooling is performed for the purpose of maintaining Al_2Ca in the liquid phase at high temperature to be present as much as possible even in a solid phase at room temperature.

[0052] FIG. 4 shows compositions a to j listed in Table 1 below.

Table 1

Composition	Mg wt%	Al wt%	Ca wt%	Al_2Ca formation
a	10	30	60	Confirmed
b	10	50	40	Confirmed
c	20	45	35	Confirmed
d	30	35	35	Confirmed
e	30	60	10	Confirmed
f	40	24	36	Confirmed
g	40	40	20	Confirmed
h	50	18	32	Confirmed
i	60	18	22	Confirmed
j	70	20	10	Confirmed

[0053] The components of the respective alloys shown in Table 1 were melted at sufficiently high temperatures according to the melting method of the present invention. In Table 1, the presence of Al_2Ca was confirmed by X-ray diffraction. Here, the content of Al_2Ca was not measured.

[0054] Table 2 shows yield strengths of final Mg alloys obtained by inputting the master alloy produced by the present invention to Mg or Mg alloys according to composition ratios.

[0055] Table 3 shows measuring results of yield strengths of Mg alloys of Comparative Examples having the same composition ratios with those of Examples of the present invention by directly adding Al and/or Ca to the final Mg alloys, instead of adding the master alloy produced by the present invention.

[0056] Numbers for identifying the respective examples shown in Table 2 correspond to those for identifying the respective comparative examples shown in Table 3. When Mg alloys are produced using the master alloy with Al_2Ca formed in the present invention, they exhibited higher yield strengths than general Mg alloys having the same composition ratios.

[0057] The reason of the foregoing is presumably caused by a large amount of Al_2Ca as the intermetallic compound contained in the master alloy finally produced by the present invention. Accordingly, physical properties of the Mg alloys are improved.

In addition, it was confirmed that the Mg alloy was microstructured with the addition of the master alloy produced by the present invention. Further, it was confirmed that Mg_2Ca or $(Mg, Al)_2Ca$ phases in addition to Al_2Ca were distributed in the Mg alloy base.

Table 2

Example	Composition Ratio (wt%)	Yield Strength [MPa]
1	Mg-4Al-0.5Ca	127
2	Mg-5Al-0.5Ca	139
3	Mg-6Al-0.5Ca	151
4	Mg-4Al-1.0Ca	135
5	Mg-5Al-1.0Ca	149
6	Mg-6Al-1.0Ca	158

[0058] It is noted that the composition ratios listed in Tables 2 and 3 indicate compositions of the final Mg alloys produced using the master alloy according to the present invention.

Table 3

Comparative Example	Composition Ratio (wt%)	Yield Strength [MPa]
1	Mg-4Al-0.5Ca	109
2	Mg-5Al-0.5Ca	115
3	Mg-6Al-0.5Ca	126
4	Mg-4Al-1.0Ca	112
5	Mg-5Al-1.0Ca	128
6	Mg-6Al-1.0Ca	135

[0059] Table 4 below shows comparison results of Ca yields when Mg-5Al-2Ca is produced by adding 10Mg-50Al-40Ca as the inventive master alloy to Mg, by wt%, and directly adding Ca as an alloying element to Mg or an Mg alloy.

[0060] Additionally, when necessary, Al is further added to adjust the final composition to Mg-5Al-2Ca. Here, the yield means a percentile obtained by dividing the amount of finally alloyed Ca in the Mg alloy by a total input amount of Ca.

[0061] As confirmed from Table 4 below, when Ca was added as an alloying element through the master alloy, the recovery rate of Ca was higher than that in a case when Ca is directly added as the alloying element. The reason of the forgoing is that alloying may not be performed well when Ca is directly added.

Table 4

	Composition Ratio (wt%)	Yield with addition of Ca
Example	Addition of 10Mg-50Al-40Ca master alloy	95%
Comparative Example	Direct addition of Ca	72%

[0062] As described above, it can be confirmed that the Mg alloy is microstructured with the addition of the master alloy produced by the present invention with the addition of the master alloy and Mg_2Ca, Al_2Ca or $(Mg, Al)_2Ca$ phases are uniformly distributed in the Mg alloy. In addition, In addition, formation of a β-$Mg_{17}Al_{12}$ phase that is thermally unstable can be suppressed, and casting defects can be greatly reduced. As the result, the yield strengths of the Mg alloys were increased and the tensile strengths of the Mg alloys were also increased.

[0063] The Mg-Al-Ca based master alloy produced according to the present invention may be added as an alloying means to one selected from the group consisting of pure Mg, Mg alloys and equivalents thereof. In addition, usable examples of the Mg alloy may include AZ91D, AM20, AM30, AM50, AM60, AZ31, AS41, AS31, AS21X, AE42, AE44, AX51, AX52, AJ50X, AJ52X, AJ62X, MRI153, MRI230, AM-HP2, Mg-Al, Mg-Al-Re, Mg-Al-Sn, Mg-Zn-Sn, Mg-Si, and Mg-Zn-Y, but aspects of the present invention are not limited thereto. Any Mg alloy that is generally used in industries may be used.

Claims

1. An Mg-Al-Ca based master alloy for Mg alloys, wherein while the Ca:Al composition ratio is maintained at 4.3: 5.7, Mg is contained in an amount of 65% of the entire weight of the master alloy, based on percentage by weight.

2. A production method of an Mg-Al-Ca based master alloy for Mg alloys, the production method comprising:

   preparing components of a master alloy by selecting a composition of claim 1; melting Mg, Al and Ca;
   and
   solidifying the molten metal.

3. The production method of claim 2, wherein the solidifying of the molten metal comprises rapidly cooling the molten metal.

4. The production method of claim 2 or 3, wherein in the melting, Mg is first melted, Al is then melted, and Ca is finally melted.

5. The production method of claim 2 or 3, wherein in the melting, Al is first melted, Mg is then melted, and Ca is finally melted.

6. The production method of claim 2 or 3, wherein in the melting, Mg and Al are melted together and Ca is then melted.

7. The production method of claim 2 or 3, wherein in the melting, Mg and Ca are melted together and Al is then melted.

Patentansprüche

1. Eine Mg-Al-Ca-basierte Masterlegierung für Mg-Legierungen, wobei, während das Ca : Al-Zusammensetzungsverhältnis bei 4,3: 5,7 gehalten wird, Mg in einer Menge von 65% des Gesamtgewichts der Vorlegierung basierend auf Gewichtsprozent enthalten ist.

2. Herstellungsverfahren für eine Mg-Al-Ca-basierte Masterlegierung für Mg-Legierungen, wobei das Herstellungsverfahren umfasst:

   Herstellen von Komponenten einer Masterlegierung durch Auswählen einer Zusammensetzung nach Anspruch 1;
   Schmelzen von Mg, Al und Ca;
   und
   Verfestigen des geschmolzenen Metalls.

3. Herstellungsverfahren nach Anspruch 2, wobei das Verfestigen des geschmolzenen Metalls rasches Abkühlen des geschmolzenen Metalls umfasst.

4. Herstellungsverfahren nach Anspruch 2 oder 3, wobei beim Schmelzen zunächst Mg geschmolzen wird, Al dann geschmolzen und schließlich Ca geschmolzen wird.

5. Herstellungsverfahren nach Anspruch 2 oder 3, wobei beim Schmelzen Al zuerst geschmolzen wird, dann wird Mg geschmolzen und Ca schließlich geschmolzen.

6. Herstellungsverfahren nach Anspruch 2 oder 3, wobei beim Schmelzen Mg und Al zusammen geschmolzen werden und dann Ca geschmolzen wird.

7. Herstellungsverfahren nach Anspruch 2 oder 3, wobei beim Schmelzen Mg und Ca zusammen geschmolzen werden und Al dann geschmolzen wird.

Revendications

1. Alliage mère à base de Mg-Al-Ca pour alliages Mg, dans lequel quand le rapport de composition Ca:Al est maintenu à 4,3:5,7, le Mg est contenu en une quantité de 65 % du poids total de l'alliage mère, sur une base en pourcentage en poids.

2. Procédé de production d'un alliage mère à base de Mg-Al-Ca pour alliages Mg, le procédé de production comprenant :

   la préparation des composants d'un alliage mère par sélection d'une composition selon la revendication 1 ;
   la fusion du Mg, Al et Ca ; et
   la solidification du métal fondu.

3. Procédé de production selon la revendication 2, dans lequel la solidification du métal fondu comprend le refroidissement rapide du métal fondu.

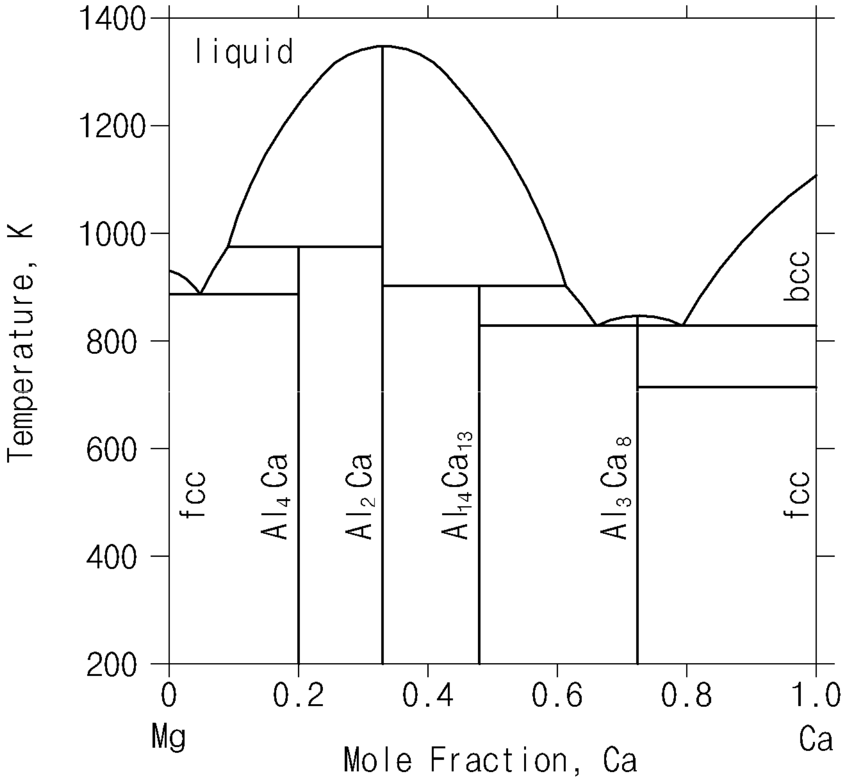
4. Procédé de production selon la revendication 2 ou 3, dans lequel lors de la fusion, le Mg est porté à fusion en premier, l'Al est ensuite porté à fusion, et pour finir le Ca est porté à fusion.

5. Procédé de production selon la revendication 2 ou 3, dans lequel lors de la fusion, l'Al est porté à fusion en premier, le Mg est ensuite porté à fusion, et pour finir le Ca est porté à fusion.

6. Procédé de production selon la revendication 2 ou 3, dans lequel lors de la fusion, le Mg et l'Al sont portés à fusion ensemble et le Ca est ensuite porté à fusion.

7. Procédé de production selon la revendication 2 ou 3, dans lequel lors de la fusion, le Mg et le Ca sont portés à fusion ensemble et l'Al est ensuite porté à fusion.

Fig. 1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fcc
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Al$_{14}$Ca$_{13}$
Al$_3$Ca$_8$
fcc
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1200
1000
800
600
400
200
Temperature, K
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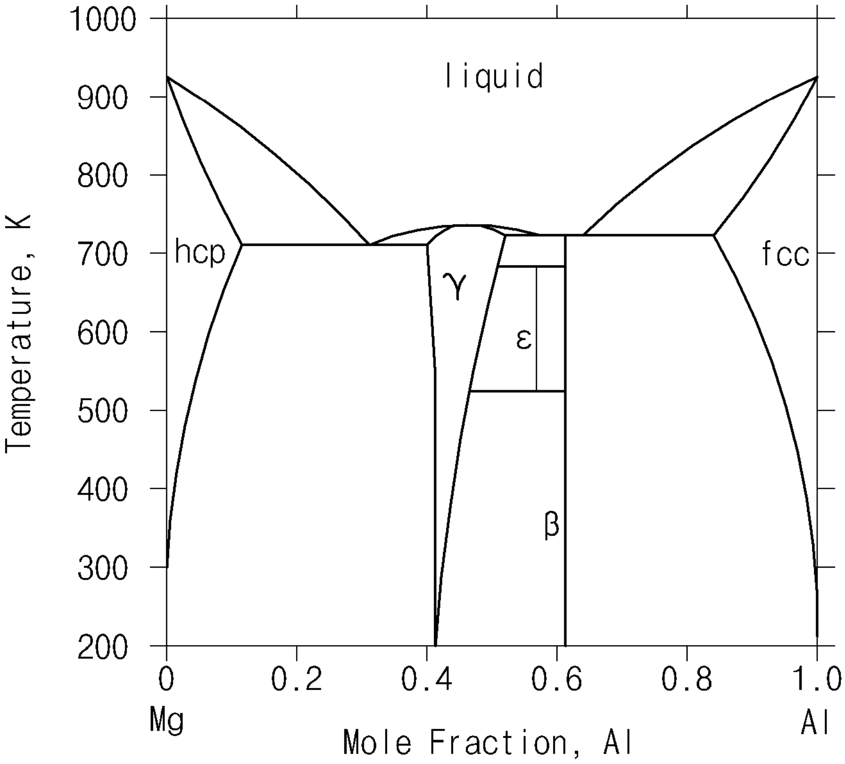
0.4
0.6
0.8
1.0
Mg
Ca
Mole Fraction, Ca

Fig. 2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Temperature, K
liquid
hcp
fcc
γ
ε
β
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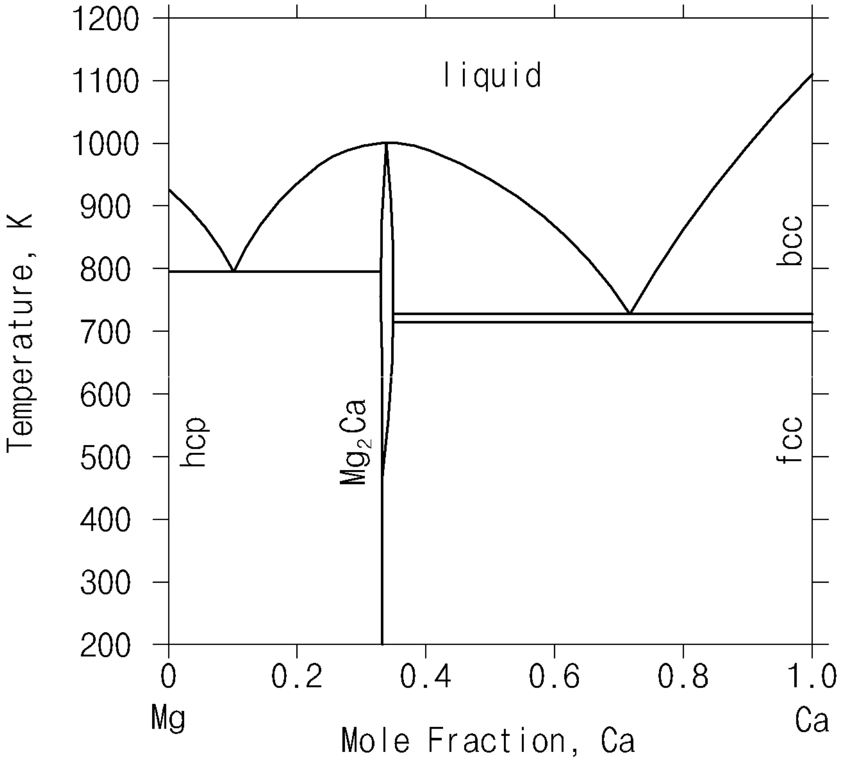
0.6
0.8
1.0
Mg
Al
Mole Fraction, Al

Fig. 3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Temperature, K
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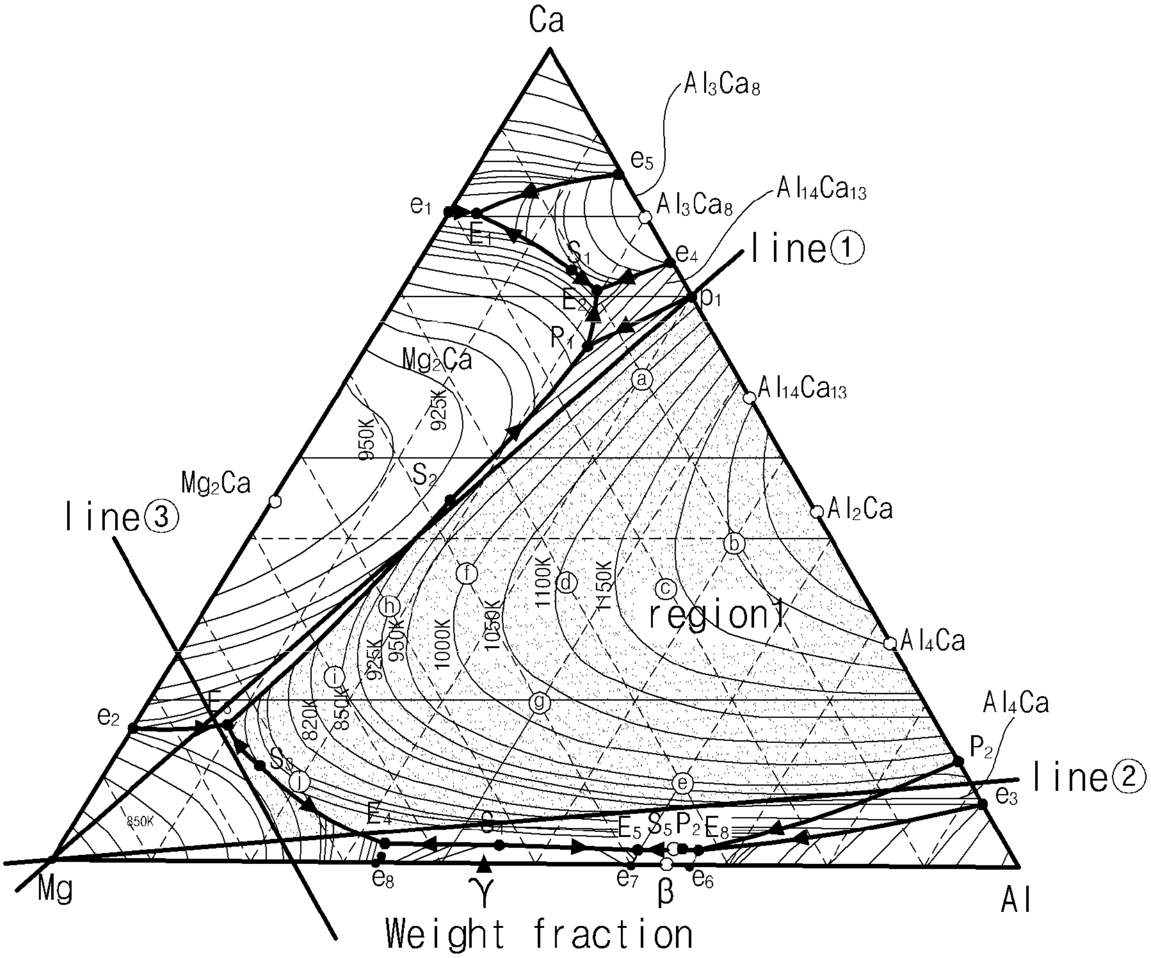
0.4
0.6
0.8
1.0
Mg
Ca
Mole Fraction, Ca

Fig. 4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E1
S1
e4
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E2
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P1
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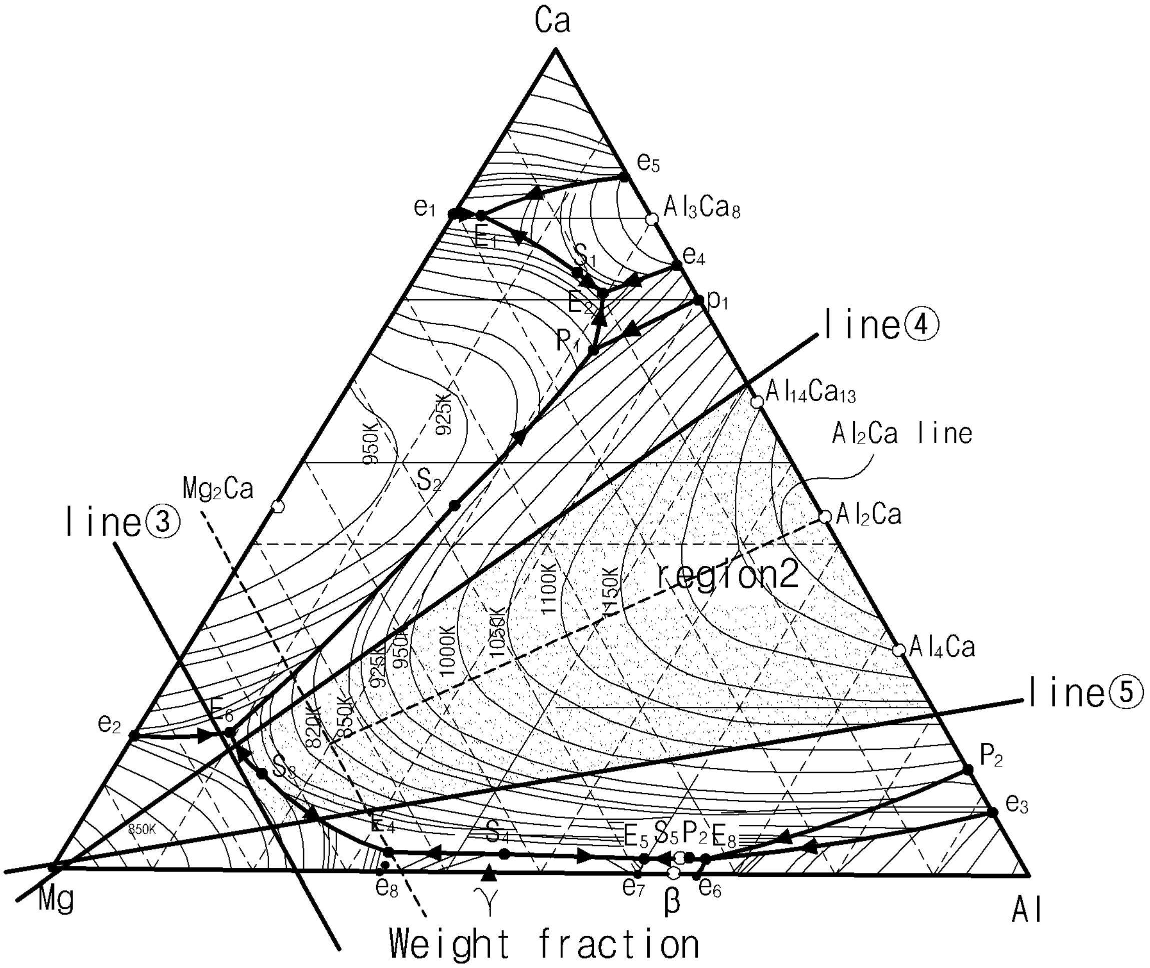
Al14Ca13
925K
950K
S2
Mg2Ca
Al2Ca
line③
b
f
d
1100K
1150K
c
h
region1
950K
1000K
1050K
Al4Ca
925K
i
820K
850K
g
Al4Ca
e2
E
P2
S3
j
line②
e
e3
850K
E4
C4
E5
S5
P2
E8
Mg
e8
γ
e7
β
e6
Al
Weight fraction

Fig. 5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e1
Al3Ca8
E1
S1
e4
E2
p1
P1
line④
Al14Ca13
Al2Ca line
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950K
S2
Mg2Ca
Al2Ca
line③
region2
1100K
1150K
1050K
1000K
950K
925K
Al4Ca
850K
820K
line⑤
e2
E6
S3
P2
e3
850K
E4
S4
E5
S5
P2
E8
Mg
e8
γ
e7
β
e6
Al
Weight fraction