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(54) ALUMINUM ALLOY FOR DIE CASTING AND ALUMINUM-ALLOY DIE CAST OBTAINED THEREFROM

ALUMINIUMLEGIERUNG FÜR KOKILLENGUSS UND DARAUS HERGESTELLTE ALUMINIUMLEGIERUNGSKOKILLE

ALLIAGE D'ALUMINIUM POUR COULÉE SOUS PRESSION ET PIÈCE D'ALLIAGE D'ALUMINIUM MOULÉE SOUS PRESSION OBTENUE À PARTIR DUDIT ALLIAGE

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Description

Technical Field

[0001] The present invention relates to an aluminum alloy for die casting having improved yield strength and ductility, and an aluminum alloy die cast produced using the alloy.

Background Art

[0002] Aluminum alloys are lightweight and are excellent in moldability and mass productivity, and therefore are widely used as materials for components in various fields such as automobiles, industrial machines, aircrafts, and electrical home appliances.

[0003] For use in automobiles, many components using aluminum alloys are adopted for the purpose of reducing the weight of an automobile body. Meanwhile, with increase in the number of components for which use of aluminum alloys is considered, existing aluminum alloys cannot satisfy mechanical properties required of these components in some cases.

[0004] Under such circumstances, as a technology for solving the above problem, for example, Patent Literature 1 described below discloses an aluminum alloy for casting that contains: silicon by 5.0 to 11.0%; magnesium by 0.2 to 0.8%; chromium by 0.3 to 1.5%; and iron by not more than 1.2%, and that has a high elongation percentage, as a material suitable for components requiring high elongation, such as disc wheels of automobiles.

[0005] According to this technology, it is possible to provide an aluminum alloy for casting that has high elongation while containing iron as an impurity.

[0006] CN 102 676 887 B describes an aluminum alloy comprising the following components in percentage by weight: 5.5 - 11.0 percent of Si, 0.3 - 0.7 percent of Mg, 0.05 - 0.3 percent of Cu, 0.2 - 0.8 percent of Fe, 0.2 - 0.5 percent of Mn, 0.05 - 0.3 percent of Ti, 0.05 - 0.1 percent of Cr, 0.05 - 0.3 percent of V and the balance of Al and inevitable impurities.

Citation List

[Patent Literature]

[0007]

[PTL 1] Japanese Laid-Open Patent Publication No. S52-126609
[PTL 2] CN102 676 887 B

Summary of Invention

Technical Problem

[0008] However, in the above-described conventional technology, it is not certain whether the aluminum alloy is applicable to components requiring higher elongation and high yield strength, such as engine mounts, and it is difficult to say that the aluminum alloy has suitability for die casting that enables mass production of fine components such as engine mounts.

[0009] Thus, a main objective of the present invention is to provide: an aluminum alloy for die casting having castability equivalent to that of ADC12 that is an Al-Si-Cu based alloy for die casting specified by Japanese Industrial Standards JIS H5302 (hereinafter simply referred to as "ADC12"), and having high yield strength and high ductility; and an aluminum alloy die cast produced using the alloy.

Solution to Problem

[0010] A first aspect of the present invention is an aluminum alloy for die casting containing: Si by more than 6.00 wt% and less than 6.50 wt%; Mg by 0.10 to 0.50 wt%; Fe by more than 0 and not more than 0.30 wt%; Mn by 0.30 to 0.60 wt%; Cr by 0.20 to 0.30 wt%; and optionally Sb by 0.05 to 0.20 wt%, Ti by 0.05 to 0.30 wt%, B by 1 to 50 ppm and/or at least one selected from Na, Sr, and Ca by 30 to 200 ppm, with the remaining portion of the aluminum alloy being Al and unavoidable impurities.

[0011] In this aspect, Si is contained as a main component by more than 6.00 wt% and less than 6.50 wt% to minimize reduction in elongation while maintaining fluidity during die casting, and the content ratio of Fe, which significantly affects elongation of the alloy, is reduced to not more than 0.30 wt%, and further, Mn, which has an effect to improve anti-seizing characteristic and elongation of the alloy during die casting, is contained by 0.30 to 0.60 wt%. Therefore, it is possible to obtain an alloy having: suitability for die casting equivalent to that of ADC12; yield strength equivalent to that of ADC12; and elongation significantly higher than that of ADC12.

[0012] As described above, in the present invention, by simply containing the five types of elemental components at the predetermined ratio, an ingot of an aluminum alloy for die casting having not only excellent castability for die casting but also excellent mechanical properties, especially elongation (ductility) and yield strength, can be produced safely and easily.

[0013] With respect to the aluminum alloy for die casting according to the present invention, preferably, at least one selected from Na, Sr, and Ca is added by 30 to 200 ppm, or Sb is added by 0.05 to 0.20 wt%. By doing so, it is possible to reduce the size of particles of eutectic Si and further improve strength and toughness of the aluminum alloy.

[0014] In addition, adding Ti by 0.05 to 0.30 wt% or adding B by 1 to 50 ppm is also preferable. By doing so, crystal grains of the aluminum alloy can be miniaturized even when the amount of Si is particularly small or when a casting method having a low cooling rate is used. As a result, elongation of the aluminum alloy can be improved.

[0015] A second aspect of the present invention is an aluminum alloy die cast obtained through die-casting the aluminum alloy for die casting according to the first aspect.

[0016] Since the aluminum alloy die cast obtained through die-casting the aluminum alloy for die casting according to the present invention can be mass produced with satisfactory castability and is superior in yield strength and elongation, the aluminum alloy die cast is most suitable for structural components for automobiles, especially components such as engine mounts.

Advantageous Effects of Invention

[0017] According to the present invention, it is possible to provide: an aluminum alloy for die casting, having castability equivalent to that of ADC12 and high yield strength and high ductility; and an aluminum alloy die cast produced using the alloy.

Brief Description of the Drawings

[0018] FIG. 1 shows graphs representing the relationships between the amount of Mn in aluminum alloys for die casting according to Examples and Comparative Examples of the present invention, and mechanical properties of the alloys, in which FIG. 1(a) represents the relationship between the amount of Mn and elongations of the alloys, and FIG.1(b) represents the relationship between the amount of Mn and 0.2%-yield strengths of the alloys.

Description of Embodiments

[0019] In the following, an embodiment of the present invention will be described in detail with specific examples.

[0020] An aluminum alloy for die casting of the present invention (hereinafter, also simply referred to as "aluminum alloy") mainly contains: Si (silicon) by more than 6.00 wt% and less than 6.50 wt%; Mg (magnesium) by 0.10 to 0.50 wt%; Fe (iron) by >0 to 0.30 wt%; Mn (manganese) by 0.30 to 0.60 wt%; Cr (chromium) by 0.20 to 0.30 wt%; and optionally Sb by 0.05 to 0.20 wt%, Ti by 0.05 to 0.30 wt%, B by 1 to 50 ppm and/or at least one selected from Na, Sr, and Ca by 30 to 200 ppm with the remaining portion of the aluminum alloy being Al (aluminum) and unavoidable impurities. Hereinafter, the properties of each of the elements will be described.

[0021] Si (silicon) is an important element that contributes to improvement of fluidity, reduction in liquidus temperature, and the like when the aluminum alloy is molten, thereby to improve castability.

[0022] The content ratio of Si with respect to the whole weight of the aluminum alloy is within a range of more than 6.00 wt% and less than 6.50 wt% as described above. When the content ratio of Si is not more than 6.00 wt%, melting temperature and casting temperature of the aluminum alloy increase, and sufficient fluidity cannot be ensured during die casting since fluidity of the aluminum alloy reduces when the aluminum alloy is molten. On the other hand, when the content ratio of Si is more than 6.50 wt%, elongation of the obtained alloy is reduced although sufficient fluidity can be ensured during die casting.

[0023] Mg (magnesium) mainly exists as Mg_2Si or in a solid-solution state in an Al base material in the aluminum alloy, and is a component that provides 0.2%-yield strength and tensile strength to the aluminum alloy, but, when being contained by an excessive amount, has an adverse effect on castability and elongation of the alloy.

[0024] The content ratio of Mg with respect to the whole weight of the aluminum alloy is within a range of 0.10 to 0.50 wt% as described above. The presence of Mg within the above range can improve mechanical properties of the aluminum alloy such as yield strength and tensile strength, without greatly affecting castability and elongation of the alloy. When the blending ratio of Mg is more than 0.50 wt%, elongation of the alloy is reduced, which results in degraded quality of an aluminum alloy die cast produced by using the alloy.

[0025] Fe (iron) is known to have a seizing prevention effect during die casting. However, Fe causes crystallization of a needle like crystal in the form of Al-Si-Fe, significantly reduces elongation of the aluminum alloy, and, when being added in a large quantity, causes melting at a suitable temperature to be difficult.

[0026] The content ratio of Fe with respect to the whole weight of the aluminum alloy is >0 to 0.30 wt% as described above. When the content ratio of Fe is more than 0.30 wt%, elongation of the alloy is remarkably reduced although the seizing prevention effect is sufficient.

[0027] Mn (manganese) is used mainly for preventing seizing of the aluminum alloy and a mold during casting.

[0028] The blending ratio of Mn with respect to the whole weight of the aluminum alloy is within a range of 0.30 to 0.60 wt% as described above, and more preferably within a range of 0.40 to 0.60 wt%. When the blending ratio of Mn is less than 0.30 wt%, seizing will occur between the aluminum alloy and a mold during die casting. On the other hand, when the blending ratio of Mn is more than 0.60 wt%, elongation of the alloy is reduced although the problem of seizing does not occur during die casting.

[0029] In the aluminum alloy of the present invention, since the blending ratio of Mn up to 0.60 wt% is accepted with respect to the weight of the whole alloy as described above, an Al-Mn based scrap having high Mn content, as in the case with aluminum can recycled materials, can be used as a part of the raw material for the alloy.

[0030] Cr (chromium) mainly exists in a molten state when the aluminum alloy is molten, and when the aluminum alloy is solid, exists in a solid-solution state in an Al phase or in a crystallized state as an Al-Si-Cr phase or an Al-Si-Cr-Fe phase. Cr is used for preventing seizing of the aluminum alloy and a mold during die casting.

[0031] The blending ratio of Cr with respect to the whole weight of the aluminum alloy is within the range of 0.20 to 0.30 wt% as described above. When the blending ratio of Cr is less than 0.20 wt%, seizing will occur between the aluminum alloy and a mold during die casting. On the other hand, when the blending ratio of Cr is more than 0.30 wt%, elongation of the aluminum alloy is rapidly reduced although seizing during die casting is solved.

[0032] When the content ratios of Si, Mg, Fe, Mn, and Cr are adjusted in accordance with the content ratios described above, it is possible to obtain a base metal of an aluminum alloy for die casting having castability equivalent to that of ADC12, and having high yield strength and high ductility.

[0033] In the above-described aluminum alloy for die casting in an as-cast state, elongation (breaking elongation) thereof is preferably not less than 11%, and at the same time, 0.2%-yield strength thereof is preferably not less than 125 MPa. An aluminum alloy for die casting having such mechanical properties is particularly suitable as a die-cast material for engine mounts of automobiles.

[0034] In addition to the elemental components described above, at least one element selected from Na (sodium), Sr (strontium), Ca (calcium), and Sb (antimony) may be added as a modification material. By adding such a modification material, it is possible to reduce the size of eutectic Si particles, and further improve toughness and strength of the aluminum alloy.

[0035] The addition ratio of the modification material with respect to the whole weight of the aluminum alloy is preferably within a range of 30 to 200 ppm when the modification material is Na, Sr, and Ca, and within a range of 0.05 to 0.20 wt% when the modification material is Sb. When the addition ratio of the modification material is less than 30 ppm (0.05 wt% in the case with Sb), miniaturizing eutectic Si particles in the aluminum alloy becomes difficult, whereas when the addition ratio of the modification material is more than 200 ppm (0.20 wt% in the case with Sb), eutectic Si particles in the aluminum alloy are sufficiently miniaturized, and no further addition effect can be obtained even when the added amount is increased.

[0036] Furthermore, at least one of Ti (titanium) and B (boron) may be added instead of or together with the modification material. By adding at least one of Ti and B in such manner, crystal grains of the aluminum alloy are miniaturized, and elongation of the alloy can be improved. It should be noted that such an advantageous effect becomes significant when the amount of Si is particularly small or when a casting method having a low cooling rate is used.

[0037] The addition ratios of Ti and B with respect to the whole weight of the aluminum alloy are preferably within a range of 0.05 to 0.30 wt% and a range of 1 to 50 ppm, respectively. When the addition ratio of Ti is less than 0.05 wt% or the addition ratio of B is less than 1 ppm, miniaturizing the crystal grains in the aluminum alloy becomes difficult, whereas when the addition ratio of Ti is more than 0.30 wt% or the addition ratio of B is more than 50 ppm, the crystal grains in the aluminum alloy are sufficiently miniaturized, and no further addition effect can be obtained even when the added amount is increased.

[0038] When the aluminum alloy for die casting according to the present invention is to be produced, first, a raw material designed to contain, at the predetermined ratio described above, each of the elemental components of Al, Si, Mg, Fe, Mn, and Cr is prepared. Next, the raw material is placed in a melting furnace such as a sealed melting furnace or a melting furnace with a fore hearth to melt the raw material. The molten raw material, i.e., the molten metal of the aluminum alloy is subjected to refinement treatments such as a dehydrogenation treatment and an inclusion removal treatment, if necessary. Then, the refined molten metal is casted in a predetermined mold and solidified in order to form the molten metal of the aluminum alloy into an alloy base metal ingot or the like.

[0039] Furthermore, after producing the aluminum alloy die cast using the aluminum alloy for die casting according to the present invention, a solution treatment and an aging treatment, etc., are performed if necessary. By performing the solution treatment and the aging treatment on the aluminum alloy die cast in such manner, mechanical properties of the aluminum alloy cast can be improved.

Examples

[0040] In the following, the present invention will be described specifically by means of Examples, but the present invention is not limited to the Examples.

[0041] Mechanical properties (tensile strength, elongation, and 0.2%-yield strength) in predetermined Examples and Comparative Examples were measured by a method described below. Specifically, by using an ordinary die casting machine (DC135EL manufactured by Toshiba Machine Co., Ltd.) having a clamping force of 135 ton, die casting was performed at an injection speed of 1.0 m/s with a casting pressure of 60 MPa to produce a round bar test piece that is in compliance with ASTM (American Society for Testing and Material) standard. Then, tensile strength, elongation (breaking elongation), and 0.2%-yield strength were measured for the round bar test piece in an as-cast state by using a universal testing machine (AG-IS 100kN) manufactured by Shimadzu Corp.

[0042] A solid emission spectrophotometer (Thermo Scientific (registered trademark) ARL 4460) manufactured by Thermo Fisher Scientific Inc. was used for component analysis of the round bar test piece produced by die casting.

[0043] Further, in order to evaluate castability of each alloy, fluidity of the molten metal and presence/absence of seizing to a mold (anti-seizing characteristic) during the die casting were visually observed, and were evaluated in three grades of ○ (good), Δ (fair), × (poor).

[0044] Table 1 shows elemental compositions, mechanical properties, and suitabilities for die casting of aluminum alloys, which are the objects of the present invention, in Examples 1 and 2 and Comparative Examples 1 to 3. Comparative Example 1 corresponds to ADC12 that is widely used as an aluminum alloy for die casting.

[Table 1]

[0045]

Table 1-(1). Elemental compositions of Examples and Comparative Examples

	Elemental composition (wt%)					
	Cu	Si	Mg	Fe	Mn	Cr
Example 1	0.00	6.17	0.35	0.19	0.41	0.20
Example 2	0.01	6.24	0.36	0.19	0.60	0.20
Comparative Example 1	1.79	10.41	0.27	1.28	0.19	0.04
Comparative Example 2	0.01	6.24	0.34	0.19	0.01	0.20
Comparative Example 3	0.01	6.21	0.35	0.19	0.21	0.20

Table 1-(2). Physical property measurement results and castability evaluation results of Examples and Comparative Examples

	Physical property measurement result			Fluidity	Anti-seizing characteristic
	Tensile strength (MPa)	Elongation (%)	0.2%-yield strength (MPa)		
Example 1	274	11.9	126	○	○
Example 2	280	11.9	127	○	○
Comparative Example 1	313	2.4	155	○	○
Comparative Example 2	265	11.1	117	○	×
Comparative Example 3	273	11.4	123	○	Δ

[0046] According to Table 1, when Examples 1 and 2, which are alloys of the present invention, are compared with Comparative Example 1 corresponding to ADC12, it is found that elongations of the alloys of Examples 1 and 2 are significantly higher than that of Comparative Example 1 corresponding to ADC12 although both have equivalent castability (i.e., suitability for die casting).

[0047] Further, when Examples 1 and 2 are compared with Comparative Examples 2 and 3 in which only the content ratios of Mn are different from those of Examples 1 and 2, it is found from FIG. 1 and Table 1 that, with 0.3 wt% of Mn being a boundary, Examples 1 and 2 containing more than 0.3 wt% of Mn are able to effectively prevent seizing during die casting, and have improved elongations and 0.2%-yield strengths of the alloys.

Claims

1. An aluminum alloy for die casting consisting of: Si by more than 6.00 wt% and less than 6.50 wt%; Mg by 0.10 to 0.50 wt%; Fe by more than 0 and not more than 0.30 wt%; Mn by 0.30 to 0.60 wt%; Cr by 0.20 to 0.30 wt%; and optionally Sb by 0.05 to 0.20 wt%, Ti by 0.05 to 0.30 wt%, B by 1 to 50 ppm and/or at least one selected from Na, Sr, and Ca by 30 to 200 ppm, with the remaining portion of the aluminum alloy being Al and unavoidable impurities.

2. The aluminum alloy for die casting according to claim 1, including at least one selected from Na, Sr, and Ca by 30 to 200 ppm.

3. The aluminum alloy for die casting according to claim 1 or 2, including Sb by 0.05 to 0.20 wt%.

4. The aluminum alloy for die casting according to any one of claims 1 to 3, including Ti by 0.05 to 0.30 wt%.

5. The aluminum alloy for die casting according to any one of claims 1 to 4, including B by 1 to 50 ppm.

6. An aluminum alloy die cast obtained through die-casting the aluminum alloy for die casting according to any one of claims 1 to 5.

Patentansprüche

1. Aluminiumlegierung zum Druckgießen aufweisend: mehr als 6,00 Gew.% und weniger als 6,50 Gew.% Si; 0,10 bis 0,50 Gew.% Mg; mehr als 0 und höchstens 0,30 Gew.% Fe; 0,30 bis 0,60 Gew.% Mn; 0,20 bis 0,30 Gew.% Cr ; und optional 0,05 bis 0,20 Gew % Sb, 0,05 bis 0,30 Gew % Ti, 1 bis 50 ppm B und/oder 30 bis 200 ppm von zumindest einem ausgewählt aus Na, Sr, und Ca, wobei der Rest der Aluminiumlegierung Al und unvermeidbare Unreinheiten sind.

2. Aluminiumlegierung zum Druckgießen gemäß Anspruch 1, aufweisend 30 bis 200 ppm von zumindest einem ausgewählt aus Na, Sr, und Ca.

3. Aluminiumlegierung zum Druckgießen gemäß Anspruch 1 oder 2, aufweisend 0,05 bis 0,20 Gew % Sb.

4. Aluminiumlegierung zum Druckgießen gemäß einem der Ansprüche 1 bis 3, aufweisend 0,05 bis 0,30 Gew % Ti.

5. Aluminiumlegierung zum Druckgießen gemäß einem der Ansprüche 1 bis 4, aufweisend 1 bis 50 ppm B.

6. Aluminiumlegierungsdruckguss, der durch Druckgießen einer Aluminiumlegierung zum Druckgießen gemäß einem der Ansprüche 1 bis 5 erlangt ist.

Revendications

1. Alliage d'aluminium de coulée sous pression constitué : de Si selon une teneur supérieure ou égale à 6,00 % en poids et inférieure à 6,50 % en poids ; de Mg selon une teneur de 0,10 à 0,50 % en poids ; de Fe selon une teneur supérieure à 0 et inférieure ou égale à 0,30 % en poids ; de Mn selon une teneur de 0,30 à 0,60 % en poids ; de Cr selon une teneur de 0,5 à 0,30 % en poids ; et éventuellement de Sb selon une teneur de 0,05 à 0,20 % en poids, de Ti selon une teneur de 0,05 à 0,30 % en poids, de B selon une teneur de 1 à 50 ppm et/ou au moins un

élément sélectionné parmi le Na, le Sr et le Ca selon une teneur de 30 à 200 ppm, la partie restante de l'alliage d'aluminium étant de l'Al et des impuretés inévitables.

2. Alliage d'aluminium de coulée sous pression selon la revendication 1, comprenant au moins un élément sélectionné parmi le Na, le Sr et le Ca selon une teneur de 30 à 200 ppm.

3. Alliage d'aluminium de coulée sous pression selon la revendication 1 ou la revendication 2, comprenant du Sb selon une teneur de 0,05 à 0,20 % en poids.

4. Alliage d'aluminium de coulée sous pression selon l'une quelconque des revendications 1 à 3, comprenant du Ti selon une teneur de 0,05 à 0,30 % en poids.

5. Alliage d'aluminium de coulée sous pression selon l'une quelconque des revendications 1 à 4, comprenant du B selon une teneur de 1 à 50 ppm.

6. Alliage d'aluminium de coulée sous pression obtenu par coulée sous pression de l'alliage d'aluminium de coulée sous pression selon l'une quelconque des revendications 1 à 5.

FIG. 1

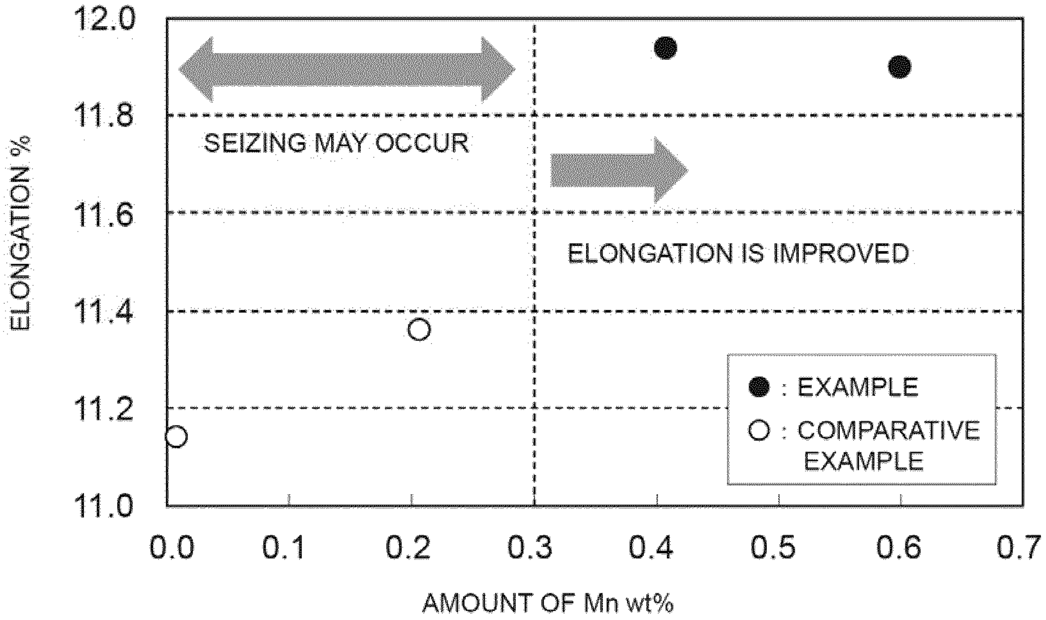

FIG. 1(a) RELATIONSHIP BETWEEN AMOUNT OF Mn AND ELONGATION OF ALLOY

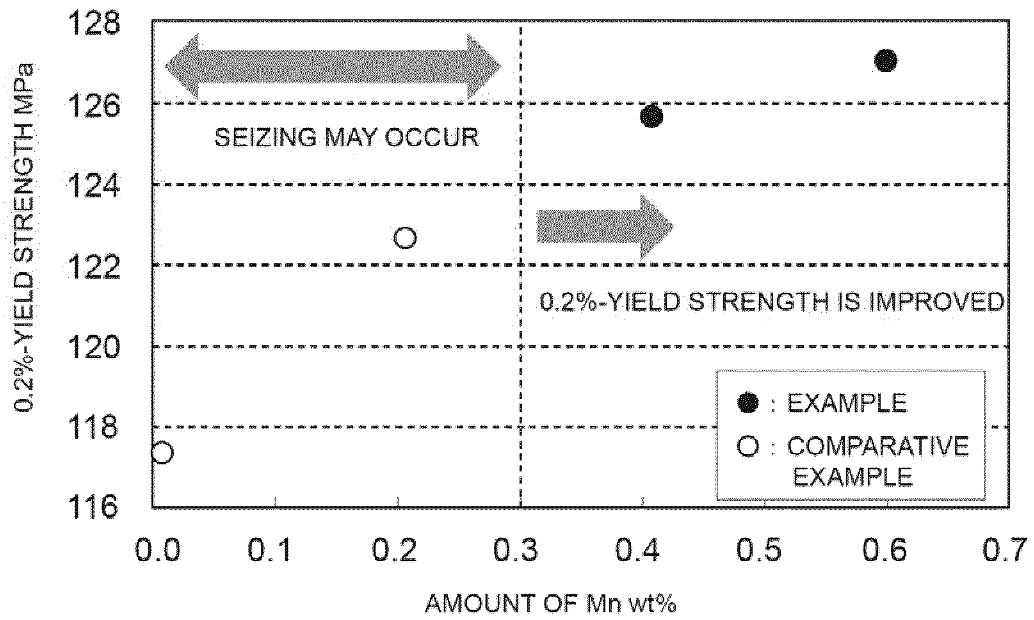

FIG. 1(b) RELATIONSHIP BETWEEN AMOUNT OF Mn AND 0.2%-YIELD STRENGTH OF ALLOY

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 102676887 B **[0006] [0007]**
- JP S52126609 B **[0007]**