

DESCRIPTION

ALUMINUM ALLOY FOR CASTING AND ALUMINUM CAST THAT IS
PROVIDED BY USING AND CASTING IT

Field

5 [0001] The present invention relates to an aluminum alloy for casting and an aluminum cast that is provided by using and casting it.

Background

[0002] Patent Literature 1 (International Publication No.
10 2015/152133) discloses an Al-Si-Mg-based aluminum alloy for casting that is composed of 12.0 to 14.0% of Si, 1.5 to 4.0% of Mg, 0.10% or less of Mn, and a balance that is Al and an inevitable impurity/impurities, on a mass basis, and is excellent in a specific stiffness, a strength, and a
15 ductility thereof, and a casting member that is composed thereof.

Citation List

Patent Literature

[0003] Patent Literature 1: International Publication No.
20 2015/152133

Summary

Solution to Problem

[0004] An aspect of the present invention is an aluminum alloy for casting that includes 1.0 to 10.0 mass% of Ni,
25 8.01 to 18.0 mass% of Cu, and a balance that is Al and an inevitable impurity/impurities.

[0005] In such an aluminum alloy for casting, a content of Ni is 1.0 to 10.0 mass%, so that it is possible to crystallize a Ni-based intermetallic compound phase that is
30 an intermetallic compound phase with an elongated piece shape that originates from Ni, in an aluminum alloy, dispersedly. Hence, it is possible to improve a stiffness property of an aluminum alloy. Moreover, a content of Cu

is 8.01 to 18.0 mass%, so that it is possible to crystallize a Cu-based intermetallic compound phase that is an intermetallic compound phase that originates from Cu, in a net shape, around a Ni-based intermetallic compound phase.

5 Hence, a Ni-based intermetallic compound phase and a Cu-based intermetallic compound phase where crystallization areas thereof are different coexist, so that it is possible to further improve a stiffness property of an aluminum alloy. Furthermore, a Cu-based intermetallic compound
10 phase forms a network with a net shape around a Ni-based intermetallic compound phase, so that it is possible to improve a tensile strength of an aluminum alloy.

[0006] In an aluminum alloy for casting, it is preferable that a content of Ni is 3.0 to 10.0 mass%. A
15 lower limit of a content of Ni is 3.0 mass%, so that it is possible to crystallize a Ni-based intermetallic compound phase in an aluminum alloy more dispersedly. Hence, it is possible to further improve a stiffness property of an aluminum alloy.

20 [0007] In an aluminum alloy for casting, it is preferable that a content [Cu] of Cu and a content [Ni] of Ni satisfy a following condition (1)

$$10.0 \leq [\text{Cu}] + 0.87[\text{Ni}] \leq 23.5 \quad \dots (1).$$

[0008] It is preferable that an aluminum alloy for
25 casting further includes 5.0 to 20.0 mass% of Si. A content of Si is 5.0 to 20.0 mass%, so that it is possible to crystallize a Si phase in an aluminum alloy dispersedly. Hence, it is possible to improve a stiffness property of an aluminum alloy. Moreover, a content of Ni is 1.0 to 10.0
30 mass%, so that it is possible to crystallize a Ni-based intermetallic compound phase around a Si phase. Moreover, a content of Cu is 8.01 to 18.0 mass%, so that it is possible to crystallize a Cu-based intermetallic compound

phase, in a net shape, around a Si phase and a Ni-based intermetallic compound phase. Hence, a Si phase, a Ni-based intermetallic compound phase, and a Cu-based intermetallic compound phase where crystallization areas thereof are different coexist, so that it is possible to further improve a stiffness property of an aluminum alloy.

[0009] In an aluminum alloy for casting, it is preferable that a content of Si is 5.0 to 14.5 mass%. An upper limit of a content of Si is 14.5 mass%, so that coarsening of a Si phase in a solidification process for an aluminum alloy is reduced or prevented and embrittlement of such an aluminum alloy is readily reduced or prevented. Hence, a tensile strength of an aluminum alloy is readily improved.

[0010] In an aluminum alloy for casting, it is preferable that a content [Si] of Si, a content [Cu] of Cu, and a content [Ni] of Ni satisfy a following condition (2)

$$30.0 \leq [\text{Si}] + 0.94[\text{Cu}] + 2.02[\text{Ni}] \leq 42.5 \quad \dots (2).$$

[0011] It is preferable that an aluminum alloy for casting further includes 0.0001 to 0.1 mass% of P. A content of P is 0.0001 to 0.1 mass%, so that AlP (aluminum phosphide) that is produced in an aluminum alloy acts as a heterogeneous nucleus for a primary crystal of Si and hence it is possible to miniaturize such a primary crystal of Si.

Hence, a primary crystal of Si is readily crystallized in an aluminum alloy uniformly and dispersedly. Therefore, variations of a stiffness property and a tensile strength of an aluminum alloy are readily reduced or prevented.

[0012] It is preferable that an aluminum alloy for casting further includes 0.01 to 3.0 mass% of Mg. A content of Mg is 0.01 to 3.0 mass%, so that it is possible to precipitate an Mg-based intermetallic compound phase that is an intermetallic compound phase that originates

from Mg, by an aging process. Hence, it is possible to further improve a tensile strength of an aluminum alloy.

[0013] In an aluminum alloy for casting, it is preferable that a content of Cu is 9.0 to 15.5 mass%.

5 [0014] Another aspect of the present invention is an aluminum cast that is provided by using and casting an aluminum alloy for casting as described above. It is possible to provide an aluminum cast with a high stiffness property and an excellent tensile strength.

10 Brief Description of Drawings

[0015] FIG. 1 is a diagram that illustrates compositions, values of condition (1), values of condition (2), Young's moduli, and tensile strengths of practical examples and comparative examples of an aluminum alloy for casting
15 according to embodiments.

FIG. 2 is a diagram that illustrates a result of an observation on a texture of a test piece of an aluminum alloy for casting according to comparative example 1.

FIG. 3 is a diagram that illustrates a result of an observation on a texture of a test piece of an aluminum alloy for casting according to practical example 1.
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FIG. 4 is a diagram that illustrates a result of an observation on a texture of a test piece of an aluminum alloy for casting according to practical example 2.

25 FIG. 5 is a diagram that illustrates a result of an observation on a texture of a test piece of an aluminum alloy for casting according to practical example 3.

FIG. 6 is a diagram that illustrates a result of an observation on a texture of a test piece of an aluminum alloy for casting according to practical example 8.
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FIG. 7 is a diagram that illustrates a result of an observation on a texture of a test piece of an aluminum alloy for casting according to practical example 10.

FIG. 8 is a diagram that illustrates a result of an observation on a texture of a test piece of an aluminum alloy for casting according to comparative example 2.

Description of Embodiments

5 [0016] Hereinafter, embodiments of an aluminum alloy for casting and an aluminum cast that is provided by using and casting it as disclosed in the present application will be explained with reference to the accompanying drawings. Additionally, the present invention is not limited to
10 undermentioned embodiments and includes those specified in what is claimed.

[0017] <First Embodiment>

An aluminum alloy for casting according to a first embodiment includes 1.0 to 10.0 mass% of Ni, 8.01 to 18.0
15 mass% of Cu, and a balance that is Al and an inevitable impurity/impurities.

[0018] In the present embodiment, "casting" includes casting that is executed by various types of casting methods such as a sand mold casting method, a metallic mold
20 casting method, and a die-casting method. Furthermore, an "aluminum alloy" means an alloy that includes an aluminum phase as a main phase thereof. Therefore, an "aluminum alloy for casting" means an aluminum alloy that is casted by various types of casting methods such as a sand mold
25 casting method, a metallic mold casting method, and a die-casting method. A "mass%" of an element means a percentage of a mass of such an element in a mass of an aluminum alloy for casting. For example, a representation of "A to B mass% of an element" means that a mass% of an element is A%
30 or more and B% or less. A "balance" means a component(s) other than a listed element(s), among components that compose an aluminum alloy for casting. For example, a representation of "An aluminum alloy for casting that

includes . . . Ni, . . . Cu, and a balance that is Al and an inevitable impurity/impurities." means that components other than Ni and Cu, among components that compose an aluminum alloy for casting, are Al and an inevitable
5 impurity/impurities. The same also applies to undermentioned embodiments.

[0019] (Ni: Nickel)

An aluminum alloy for casting according to the first embodiment includes 1.0 to 10.0 mass% of Ni. In an
10 aluminum alloy for casting according to the present embodiment, a Ni-based intermetallic compound phase that is an intermetallic compound phase with an elongated piece shape that originates from Ni is dispersedly crystallized as, for example, a primary crystal, in an aluminum alloy.
15 A lower limit of a content of Ni is 1.0 mass%, so that it is possible to increase an amount of a produced Ni-based intermetallic compound phase. Hence, it is possible to improve a stiffness property of an aluminum alloy.
Furthermore, an upper limit of a content of Ni is 10.0
20 mass%, so that it is possible to reduce or prevent coarsening of a Ni-based intermetallic compound phase in a solidification process for an aluminum alloy. Hence, for example, a situation that cracking is developed along a Ni-based intermetallic compound phase with an elongated piece
25 shape is also readily prevented. Therefore, it is possible to reduce or prevent a decrease of a tensile strength of an aluminum alloy. The same also applies to undermentioned embodiments.

[0020] (Cu: Copper)

30 An aluminum alloy for casting according to the first embodiment includes 8.01 to 18.0 mass% of Cu. In an aluminum alloy for casting according to the present embodiment, a Cu-based intermetallic compound phase that is

an intermetallic compound phase that originates from Cu is crystallized in a net shape as, for example, a eutectic crystal with Al, around a Ni-based intermetallic compound phase. A lower limit of a content of Cu is 8.01 mass%, so that it is possible to increase an amount of a produced Cu-based intermetallic compound phase. Hence, it is possible to improve a stiffness property of an aluminum alloy.

Furthermore, an upper limit of a content of Cu is 18.0 mass%, so that it is possible to reduce or prevent an

excessive increase of a Cu-based intermetallic compound phase as a hard phase. Hence, it is possible to reduce or prevent embrittlement of an aluminum alloy. Therefore, it is possible to reduce or prevent a decrease of a tensile strength of an aluminum alloy. The same also applies to undermentioned embodiments.

[0021] (Al: Aluminum, Inevitable Impurity/Impurities)

A balance in an aluminum alloy for casting according to the first embodiment is Al and an inevitable impurity/impurities. For an inevitable impurity/impurities that is/are included in a balance, for example, an element(s) such as Zn (zinc), Fe (iron), Mn (manganese), Cr (chromium), Sn (tin), Pb (lead), V (vanadium), and/or Ti (titanium) is/are provided. It is preferable that a content(s) of an inevitable impurity/impurities is/are 7.5 mass% or less in total, and it is more preferable that it/they is/are 5.0 mass% or less in total, 4.0 mass% or less in total, or 3.0 mass% or less in total. The same also applies to undermentioned embodiments.

[0022] In an aluminum alloy for casting according to the present embodiment, a content of Ni is 1.0 to 10.0 mass%, so that it is possible to crystallize a Ni-based intermetallic compound phase in an aluminum alloy dispersedly. Hence, it is possible to improve a stiffness

property of an aluminum alloy. Moreover, a content of Cu is 8.01 to 18.0 mass%, so that it is possible to crystallize a Cu-based intermetallic compound phase in a net shape, around a Ni-based intermetallic compound phase.

5 Hence, a Ni-based intermetallic compound phase and a Cu-based intermetallic compound phase where crystallization areas thereof are different coexist, so that it is possible to further improve a stiffness property of an aluminum alloy. Furthermore, a Cu-based intermetallic compound
10 phase forms a network with a net shape around a Ni-based intermetallic compound phase, so that it is possible to improve a tensile strength of an aluminum alloy.

[0023] In an aluminum alloy for casting according to the present embodiment, it is preferable that a lower limit of
15 a content of Ni is 1.5 mass%, and it is more preferable that it is 2.0 mass%, 2.1 mass%, 3.0 mass%, 3.5 mass%, or 4.0 mass%. Furthermore, it is preferable that an upper limit of a content of Ni is 8.0 mass%, and it is more preferable that it is 7.0 mass%, 6.5 mass%, or 6.1 mass%.
20 A lower limit and an upper limit of a content of Ni are thus provided, so that both a stiffness property and a tensile strength of an aluminum alloy are readily improved. Alternatively, a situation that one of a stiffness property and a tensile strength thereof is extremely decreased is
25 reduced or prevented, so that both a stiffness property and a tensile strength thereof are readily developed with balance. In particular, a lower limit of a content of Ni is 3.0 mass%, so that it is possible to crystallize a Ni-based intermetallic compound phase in an aluminum alloy
30 more dispersedly. Hence, it is possible to further improve a stiffness property of an aluminum alloy. The same also applies to undermentioned embodiments.

[0024] In an aluminum alloy for casting according to the

present embodiment, it is preferable that a lower limit of a content of Cu is 8.2 mass%, and it is more preferable that it is 9.0 mass%, 9.5 mass%, 10.0 mass%, 10.1 mass%, 10.5 mass%, 11.0 mass%, 11.5 mass%, or 11.9 mass%.

5 Furthermore, it is preferable that an upper limit of a content of Cu is 17.5 mass%, and it is more preferable that it is 17.0 mass%, 16.5 mass%, 16.0 mass%, 15.5 mass%, 15.0 mass%, or 14.7 mass%. A lower limit and an upper limit of a content of Cu are thus provided, so that both a stiffness
10 property and a tensile strength of an aluminum alloy are readily improved. Alternatively, a situation that one of a stiffness property and a tensile strength thereof is extremely decreased is reduced or prevented, so that both a stiffness property and a tensile strength thereof are
15 readily developed with balance. The same also applies to undermentioned embodiments.

[0025] In an aluminum alloy for casting according to the present embodiment, formulation is executed in such a manner that a content [Cu] of Cu and a content [Ni] of Ni
20 satisfy a following condition (1)

$$10.0 \leq [\text{Cu}] + 0.87[\text{Ni}] \leq 23.5 \quad \dots (1).$$

[0026] In the present embodiment, condition (1) is satisfied, so that both a stiffness property and a tensile strength of an aluminum alloy are readily improved.
25 Alternatively, a situation that one of a stiffness property and a tensile strength thereof is extremely decreased is reduced or prevented, so that both a stiffness property and a tensile strength thereof are readily developed with balance. It is preferable that a lower limit of condition
30 (1) is 11.0, and it is more preferable that it is 12.0 or 13.0. Furthermore, it is preferable that an upper limit of condition (1) is 23.0, and it is more preferable that it is 22.5. The same also applies to an undermentioned

embodiments.

[0027] <Second Embodiment>

An aluminum alloy for casting according to a second embodiment includes 5.0 to 20.0 mass% of Si, 1.0 to 10.0 mass% of Ni, 8.01 to 18.0 mass% of Cu, and a balance that is Al and an inevitable impurity/impurities.

[0028] (Si: Silicon)

An aluminum alloy for casting according to the second embodiment includes 5.0 to 20.0 mass% of Si. In an aluminum alloy for casting according to the present embodiment, a Si phase is dispersedly crystallized as, for example, each of a primary crystal of Si and a eutectic crystal of Si with Al. A lower limit of a content of Si is 5.0 mass%, so that it is possible to increase an amount of a crystallized Si phase. Hence, it is possible to improve a stiffness property of an aluminum alloy. Furthermore, an upper limit of a content of Si is 20.0 mass%, so that it is possible to reduce or prevent coarsening of a Si phase in a solidification process for an aluminum alloy. Hence, it is possible to reduce or prevent embrittlement of an aluminum alloy. Therefore, it is possible to reduce or prevent a decrease of a tensile strength of an aluminum alloy. Moreover, an upper limit of a content of Si is 20.0 mass%, so that it is possible to reduce or prevent an increase of buoyancy that acts on a Si phase, in association with coarsening of such a Si phase. Hence, it is possible to reduce or prevent floating and/or separation of a Si phase in an aluminum alloy. Therefore, it is possible to reduce or prevent variations of a texture and a tensile strength of an aluminum alloy. The same also applies to undermentioned embodiments.

[0029] In an aluminum alloy for casting according to the present embodiment, a content of Si is 5.0 to 20.0 mass%,

so that it is possible to crystallize Si phases as a primary crystal and an eutectic crystal in an aluminum alloy dispersedly. Hence, it is possible to improve a stiffness property of an aluminum alloy. Moreover, a content of Ni is 1.0 to 10.0 mass%, so that it is possible to crystallize a Ni-based intermetallic compound phase around a Si phase. Moreover, a content of Cu is 8.01 to 18.0 mass%, so that it is possible to crystallize a Cu-based intermetallic compound phase in a net shape around a Si phase and a Ni-based intermetallic compound phase. Hence, a Si phase, a Ni-based intermetallic compound phase, and a Cu-based intermetallic compound phase where crystallization areas thereof are different coexist, so that it is possible to further improve a stiffness property of an aluminum alloy.

[0030] In an aluminum alloy for casting according to the present embodiment, it is preferable that a lower limit of a content of Si is 5.5 mass%, and it is more preferable that it is 5.6 mass%, 6.0 mass%, 6.5 mass%, 7.0 mass%, 7.5 mass%, 8.0 mass%, or 8.5 mass%. Furthermore, it is preferable that an upper limit of a content of Si is 18.0 mass%, and it is more preferable that it is 17.0 mass%, 16.5 mass%, 16.4 mass%, 16.0 mass%, 15.5 mass%, 15.0 mass%, 14.5 mass%, 14.0 mass%, 13.8 mass%, or 13.5 mass%. A lower limit and an upper limit of a content of Si are thus provided, so that both a stiffness property and a tensile strength of an aluminum alloy are readily improved. Alternatively, a situation that one of a stiffness property and a tensile strength thereof is extremely decreased is reduced or prevented, so that both a stiffness property and a tensile strength thereof are readily developed with balance. In particular, an upper limit of a content of Si is 14.5 mass%, so that coarsening of a Si phase in a

solidification process for an aluminum alloy is reduced or prevented and embrittlement of such an aluminum alloy is reduced or prevented more readily. Hence, a tensile strength of an aluminum alloy is readily improved. The same also applies to undermentioned embodiments.

[0031] In an aluminum alloy for casting according to the present embodiment, formulation is executed in such a manner that a content [Si] of Si, a content [Cu] of Cu, and a content [Ni] of Ni satisfy a following condition (2)

$$30.0 \leq [\text{Si}] + 0.94[\text{Cu}] + 2.02[\text{Ni}] \leq 42.5 \quad \dots (2).$$

[0032] In the present embodiment, condition (2) is satisfied, so that both a stiffness property and a tensile strength of an aluminum alloy are readily improved.

Alternatively, a situation that one of a stiffness property and a tensile strength thereof is extremely decreased is reduced or prevented, so that both a stiffness property and a tensile strength thereof are readily developed with balance. It is preferable that a lower limit of condition (2) is 30.5, and it is more preferable that it is 31.0 or 31.5. Furthermore, it is preferable that an upper limit of condition (2) is 42.0, and it is more preferable that it is 41.5. The same also applies to an undermentioned embodiments.

[0033] <Third Embodiment>

25 An aluminum alloy for casting according to a third embodiment includes 5.0 to 20.0 mass% of Si, 1.0 to 10.0 mass% of Ni, 8.01 to 18.0 mass% of Cu, 0.0001 to 0.1 mass% of P, and a balance that is Al and an inevitable impurity/impurities.

30 [0034] (P: Phosphorus)

An aluminum alloy for casting according to the third embodiment includes 0.0001 to 0.1 mass% of P. A lower limit of a content of P is 0.0001 mass%, so that it is

possible to improve an action that miniaturizes a primary crystal of Si. Hence, it is possible to crystallize a primary crystal of Si in an aluminum alloy uniformly and dispersedly. Furthermore, an upper limit of a content of P is 0.1 mass%, so that it is possible to reduce or prevent a decrease of fluidity of an aluminum alloy. Therefore, it is possible to improve a casting property of an aluminum alloy. The same also applies to an undermentioned embodiment.

10 [0035] In an aluminum alloy for casting according to the present embodiment, a content of P is 0.0001 to 0.1 mass%, so that AlP (aluminum phosphide) that is produced in an aluminum alloy acts as a heterogeneous nucleus for a primary crystal of Si and hence it is possible to
15 miniaturize such a primary crystal of Si. Hence, a primary crystal of Si is readily crystallized in an aluminum alloy uniformly and dispersedly. Therefore, variations of a stiffness property and a tensile strength of an aluminum alloy are readily reduced or prevented.

20 [0036] In an aluminum alloy for casting according to the present embodiment, it is preferable that a lower limit of a content of P is 0.0003 mass%, and it is more preferable that it is 0.0006 mass%. Furthermore, it is preferable that an upper limit of a content of P is 0.05 mass%, and it
25 is more preferable that it is 0.04 mass% or 0.03 mass%. A lower limit and an upper limit of a content of P are thus provided, so that variations of a stiffness property and a tensile strength of an aluminum alloy are readily reduced or prevented. The same also applies to an undermentioned
30 embodiment.

[0037] <Fourth Embodiment>

An aluminum alloy for casting according to a fourth embodiment includes 1.0 to 10.0 mass% of Ni, 8.01 to 18.0

mass% of Cu, 0.01 to 3.0 mass% of Mg, and a balance that is Al and an inevitable impurity/impurities.

[0038] (Mg: Magnesium)

An aluminum alloy for casting according to the fourth
5 embodiment includes 0.01 to 3.0 mass% of Mg. A lower limit
of a content of Mg is 0.01 mass%, so that it is possible to
improve an action that precipitates an Mg-based
intermetallic compound phase that is an intermetallic
compound phase that originates from Mg, by an aging process
10 for an aluminum alloy. Hence, it is possible to attain
precipitation strengthening for an aluminum alloy.
Furthermore, an upper limit of a content of Mg is 3.0 mass%,
so that it is possible to reduce or prevent an excessive
increase of an Mg-based intermetallic compound phase.
15 Hence, it is possible to reduce or prevent a decrease of
elongation of an aluminum alloy.

[0039] In an aluminum alloy for casting according to the
present embodiment, a content of Mg is 0.01 to 3.0 mass%,
so that it is possible to precipitate an Mg-based
20 intermetallic compound phase that is an intermetallic
compound phase that originates from Mg, by an aging process.
Hence, it is possible to further improve a tensile strength
of an aluminum alloy.

[0040] In an aluminum alloy for casting according to the
25 present embodiment, it is preferable that a lower limit of
a content of Mg is 0.05 mass%, and it is more preferable
that it is 0.1 mass%, 0.2 mass%, or 0.3 mass%. Furthermore,
it is preferable that an upper limit of a content of Mg is
2.0 mass%, and it is more preferable that it is 1.0 mass%,
30 0.8 mass%, or 0.6 mass%. A lower limit and an upper limit
of a content of Mg are thus provided, so that a tensile
strength of an aluminum alloy is readily improved.

[0041] It is preferable that an aluminum alloy for

casting according to the present embodiment further includes 5.0 to 20.0 mass% of Si. Furthermore, it is preferable that an aluminum alloy for casting according to the present embodiment further includes 0.0001 to 0.1 mass% of P.

[0042] As an aluminum alloy for casting according to an aforementioned embodiment is used, it is possible to provide an aluminum cast with a high stiffness property and an excellent tensile strength. Therefore, such an aluminum cast is preferable for a wide variety of applications that need a high stiffness property and a high tensile strength. For an example of an application of such an aluminum cast, a component(s), etc., of a machine tool, a robot, an automobile, etc., is/are provided.

[0043] <Practical Examples>

FIG. 1 illustrates compositions (mass%), values of condition (1), values of condition (2), Young's moduli (GPa), and tensile strengths (MPa) of practical examples and comparative examples of an aluminum alloy for casting according to aforementioned embodiments. The tensile strengths (MPa) are values that were measured in accordance with "JIS Z 2241 (Metallic Material Tensile Test Method)" for test pieces of aluminum alloys for casting according to the practical examples and the comparative examples. For the test pieces, No. 14A test pieces with a diameter of 6 mm and a parallel part length of 36 mm were used that were provided by casting in a metallic mold casting method. The Young's moduli are values that were obtained from a slope of a relationship between stress and strain within an elastic range in a tensile test. The strain is an average of measurement values of two uniaxial strain gauges that were oppositely applied on a surface of a parallel part of a test piece.

[0044] (Comparison between Practical Examples 1 to 10 and Comparative Example 1)

As illustrated in FIG. 1, contents of Cu in practical examples 1 to 10 were 8.01 mass% or more whereas a content of Cu in comparative example 1 was less than 8.01 mass%. Herein, Young's moduli in practical examples 1 to 10 were 95 to 108 GPa whereas a Young's modulus in comparative example 1 was 95 GPa. Hence, stiffness properties in practical examples 1 to 10 were improved by a maximum of about 14% relative to that in comparative example 1. Furthermore, tensile strengths in practical examples 1 to 10 were 170 to 261 MPa whereas a tensile strength in comparative example 1 was 160 MPa. Hence, tensile strengths in practical examples 1 to 10 were improved by a maximum of about 63% (a minimum of about 6%) relative to that in comparative example 1. Thus, it could be confirmed that it was possible to improve a stiffness property and a tensile strength of an aluminum alloy for casting as a lower limit of a content of Cu was 8.01 mass%.

[0045] (Comparison between Practical Examples 1 to 10 and Comparative Example 2)

As illustrated in FIG. 1, contents of Cu in practical examples 1 to 10 were 18.0 mass% or less whereas a content of Cu in comparative example 2 was more than 18.0 mass%. Herein, Young's moduli in practical examples 1 to 10 were 95 to 108 GPa whereas a Young's modulus in comparative example 2 was 104 GPa. Hence, a range of variation of stiffness properties in practical examples 1 to 10 relative to that in comparative example 2 falls within a range of 4 to 9%. Furthermore, tensile strengths in practical examples 1 to 10 were 170 to 261 MPa whereas a tensile strength in comparative example 2 was 119 MPa. Hence, tensile strengths in practical examples 1 to 10 were

improved by a maximum of about 120% (a minimum of about 43%) relative to that in comparative example 2. Thus, it could be confirmed that it was possible to reduce or prevent a variation of a stiffness property of an aluminum alloy for casting so as to develop such a stiffness property stably, and to improve a tensile strength thereof significantly as an upper limit of a content of Cu was 18.0 mass%.

[0046] (Comparison between Practical Examples 2 to 9 and Practical Example 1)

As illustrated in FIG. 1, contents of Cu in Practical Examples 2 to 9 were 9.0 mass% or more whereas a content of Cu in Practical Example 1 was less than 9.0 mass%. Herein, Young's moduli in Practical Examples 2 to 9 were 95 to 108 GPa whereas a Young's modulus in Practical Example 1 was 99 GPa. Hence, a range of variation of stiffness properties in Practical Examples 2 to 9 relative to that in Practical Example 1 falls within a range of 4 to 9%. Furthermore, tensile strengths in Practical Examples 2 to 9 were 181 to 261 MPa whereas a tensile strength in Practical Example 1 was 172 MPa. Hence, tensile strengths in Practical Examples 2 to 9 were improved by a maximum of about 52% (a minimum of about 5%) relative to that in Practical Example 1. Thus, it could be confirmed that it was possible to reduce or prevent a variation of a stiffness property of an aluminum alloy for casting so as to develop such a stiffness property stably, and to improve a tensile strength thereof as a lower limit of a content of Cu was 9.0 mass%.

[0047] (Comparison between Practical Examples 2 to 9 and Practical Example 10)

As illustrated in FIG. 1, contents of Cu in Practical Examples 2 to 9 were 15.5 mass% or less whereas a content

of Cu in Practical Example 10 was more than 15.5 mass%.
Herein, Young's moduli in Practical Examples 2 to 9 were 95 to 108 GPa whereas a Young's modulus in Practical Example 10 was 104 GPa. Hence, a range of variation of stiffness properties in Practical Examples 2 to 9 relative to that in Practical Example 10 falls within a range of 4 to 9%. Furthermore, tensile strengths in Practical Examples 2 to 9 were 181 to 261 MPa whereas a tensile strength in Practical Example 10 was 170 MPa. Hence, tensile strengths in Practical Examples 2 to 9 were improved by a maximum of about 54% (a minimum of about 6%) relative to that in Practical Example 10. Thus, it could be confirmed that it was possible to reduce or prevent a variation of a stiffness property of an aluminum alloy for casting so as to develop such a stiffness property stably, and to improve a tensile strength thereof as an upper limit of a content of Cu was 15.5 mass%.

[0048] (Textures of Aluminum alloys for casting)

FIG. 2 to FIG. 8 illustrate results of observations on textures of test pieces of aluminum alloys for casting. FIG. 2, FIG. 3, FIG. 4, FIG. 5, FIG. 6, FIG. 7, and FIG. 8 are diagrams that illustrate results of observations on a micro-textures, by a scanning electron microscope (SEM), in comparative example 1, practical example 1, practical example 2, practical example 3, practical example 8, practical example 10, and comparative example 2, respectively.

[0049] As illustrated in FIG. 1, a content of Cu in comparative example 1 was 4.7 mass%. As illustrated in FIG. 2, in comparative example 1, a Cu-based intermetallic compound phase 30 with a thin needle shape was sparsely crystallized around a Si phase 10 and a Ni-based intermetallic compound phase 20 that were crystallized in

an aluminum alloy. Furthermore, in comparative example 1, a lot of parts where a Cu-based intermetallic compound phase 30 was not crystallized were present in the aluminum alloy, and even in a part where a Cu-based intermetallic compound phase 30 was crystallized, adjacent Cu-based intermetallic compound phases 30 were discontinuously distributed therein in a state where they were mutually separated. As a result, as illustrated in FIG. 1, it was difficult to improve a tensile strength of an aluminum alloy for casting in comparative example 1.

[0050] As illustrated in FIG. 1, a content of Cu in practical example 1 was 8.2 mass%, a content of Cu in practical example 2 was 10.1 mass%, a content of Cu in practical example 3 was 11.9 mass%, a content of Cu in practical example 8 was 15.0 mass%, and a content of Cu in practical example 10 was 17.0 mass%. As illustrated in FIG. 3 to FIG. 7, in practical examples 1, 2, 3, 8, and 10, a Cu-based intermetallic compound phase 30 was substantially evenly crystallized across a substantially whole area of an aluminum alloy. Furthermore, in practical examples 1, 2, 3, 8, and 10, adjacent Cu-based intermetallic compound phases 30 were continuously distributed therein in a state where they were mutually linked, and a network with a net shape was formed among some of Cu-based intermetallic compound phases 30. As a result, as illustrated in FIG. 1, in practical examples 1, 2, 3, 8, and 10, it was possible to improve a tensile strength of an aluminum alloy for casting. Moreover, as illustrated in FIG. 4 to FIG. 6, in practical examples 2, 3, and 8, a Cu-based intermetallic compound phase 30 that composed a net, per se, was grown thickly, and a network with a net shape extended so as to be distributed across a substantially whole area of an aluminum alloy. As a result, as illustrated in FIG. 1, it

was possible to further improve a tensile strength of an aluminum alloy for casting in practical examples 2, 3, and 8.

[0051] As illustrated in FIG. 1, a content of Cu in comparative example 2 was 18.5 mass%. As illustrated in FIG. 8, in comparative example 2, a Cu-based intermetallic compound phase 30 that composed a net, per se, was coarsened so as to have a granular shape (a block shape), and a network with a net shape was divided and/or broken. As a result, as illustrated in FIG. 1, in comparative example 1, it was difficult to improve a tensile strength of an aluminum alloy for casting.

[0052] Thus, as a result of observations on textures of test pieces of aluminum alloys for casting, it could be confirmed that it was possible to provide a Si phase 10, a Ni-based intermetallic compound phase 20, and a Cu-based intermetallic compound phase 30 where crystallization areas thereof were different so as to coexist therein.

Furthermore, it could be confirmed that it was possible to crystalize a Cu-based intermetallic compound phase 30 in a net shape continuously around a Si phase 10 and a Ni-based intermetallic compound phase 20 as a content of Cu was 8.01 to 18.0 mass%. Moreover, it could be confirmed that it was possible to form a network with a net shape that was provided by a Cu-based intermetallic compound phase 30, across a substantially whole area of an aluminum alloy as a content of Cu was 9.0 to 15.5 mass%. As a result, as illustrated in FIG. 1, in practical examples 1 to 10, it was possible to improve a stiffness property of an aluminum alloy for casting or develop such a stiffness property with a small range of variation stably, and further, it was possible to improve a tensile strength thereof, relative to comparative examples 1 and 2.

Reference Signs List

[0053] 10 Si phase

20 Ni-based intermetallic compound phase

30 Cu-based intermetallic compound phase

CLAIMS

1. An aluminum alloy for casting that consists of 3.0 to 10.0 mass% of Ni, 8.01 to 18.0 mass% of Cu, 5.0 to 20.0 mass% of Si, 0.01 to 3.0 mass% of Mg, and a balance that is Al and an inevitable impurity/impurities.

2. The aluminum alloy for casting according to claim 1, wherein a content [Cu] of Cu and a content [Ni] of Ni satisfy a following condition (1)

$$10.0 \leq [\text{Cu}] + 0.87[\text{Ni}] \leq 23.5 \quad \dots (1).$$

3. The aluminum alloy for casting according to claim 1 or 2, wherein a content of Si is 5.0 to 14.5 mass%.

4. The aluminum alloy for casting according to any one of claims 1 to 3, wherein a content [Si] of Si, a content [Cu] of Cu, and a content [Ni] of Ni satisfy a following condition (2)

$$30.0 \leq [\text{Si}] + 0.94[\text{Cu}] + 2.02[\text{Ni}] \leq 42.5 \quad \dots (2).$$

5. An aluminum alloy for casting that consists of 3.0 to 10.0 mass% of Ni, 8.01 to 18.0 mass% of Cu, 5.0 to 20.0 mass% of Si, 0.01 to 3.0 mass% of Mg, 0.0001 to 0.1 mass% of P, and a balance that is Al and an inevitable impurity/impurities.

6. The aluminum alloy for casting according to any one of claims 1 to 5, wherein a content of Cu is 9.0 to 15.5 mass%.

7. An aluminum cast that is provided by using and casting the aluminum alloy for casting according to any one of claims 1 to 6.