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(54) **STEEL ALLOY FOR USE IN WATER SUPPLY MEMBER**

(57) It is an object of the present invention to obtain a copper alloy for use in a member for water works which inhibits leaching of Pb and exhibits suitable mechanical properties and castability, while restraining the amount of usage of Bi but securing the recyclability. The alloy of the present invention contains 0.5% by mass or less of Ni; 12% by mass or more and 21 % by mass or less of

Zn; 1.5% by mass or more and 4.5% by mass or less of Sn, a total content of Zn and Sn being 23.5% by mass or less; 0.005% by mass or more and 0.15% by mass or less of P; 0.05% by mass or more and 0.30% by mass or less of Pb; less than 0.2% by mass of Bi; and the balance, wherein the balance is Cu and unavoidable impurities.

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a material for use in a member for water works, which is made of a copper alloy and in which the level of lead leaching is not more than a stipulated value.

BACKGROUND ART

10 **[0002]** A cast bronze metal (JIS H5120 CAC406), which has been conventionally used for parts in materials and equipment for water works and in feed water supply systems, is excellent in castability, corrosion resistance, machinability, and/or water pressure resistance and used for parts in materials and equipment for water works and in feed water supply systems, and the like in various fields. This cast bronze metal (CAC406) contains from 4.0 to 6.0% by weight of lead so as to have the high machinability, and has characteristics of easy workability. However, this lead contained has a property to leach into the tap water in contact with the same, which fails to satisfy recent leaching lead amount regulations. Thus, in order to reduce the amount of toxic lead leaching, a copper alloy containing a reduced content of lead, or a lead-free copper alloy which contains no lead have been examined.

15 **[0003]** For example, Patent Document 1 as mentioned below discloses a brass alloy having an adjusted composition containing from 8 to 40% by mass of Zn, 0.0005 to 0.04% by mass of Zr, 0.01 to 0.25% by mass of P, at least one or more kinds of 0.005 to 0.45% by mass of Pb, 0.005 to 0.45% by mass of Bi, 0.03 to 0.45% by mass of Se, and 0.01 to 0.45% by mass of Te, and the balance of Cu and unavoidable impurities. This brass alloy is an alloy in which solid metals and liquid metals mixed in a semi-solid state are solidified, and in the course of its solidification, granular a primary crystals are crystallized or an a solid phase exists. Further, it is disclosed that as conditions of other elements, one or more kinds of 2 to 5% by mass of Si, 0.05 to 6% by mass of Sn, and 0.05 to 3.5% by mass of Al may be contained and in particular, Zr with the coexistence with P is effective in the size reduction in a semi-solid state.

20 **[0004]** Moreover, Patent Document 2 as mentioned below discloses a copper alloy for use in a member for water works, the copper alloy containing: less than 0.5% by mass of Ni in a limited manner; less than the detection limit of Pb; 0.2% by mass or more and 0.9% by mass or less of Bi; 12.0% by mass or more and 20.0% by mass or less of Zn; 1.5% by mass or more and 4.5% by mass or less of Sn; and 0.005% by mass or more and 0.1% by mass or less of P; in which a total content of Zn and Sn is 21.5% by mass or less, and the balance being unavoidable impurities and Cu. Further, it is proposed that 0.0003 to 0.006% by mass of B is additionally contained.

PRIOR ART DOCUMENT

35 PATENT DOCUMENT

[0005]

40 Patent Document 1: Japanese Patent No. 5116976

Patent Document 2: Japanese Patent No. 5406405

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

45 **[0006]** Conventionally, as copper alloys containing reduced toxic Pb, a copper alloy containing Bi and Si substituting Pb has been used to prevent a reduction in properties, such as the machinability and the water pressure resistance. On the other hand, in machine components unrelated to lead leaching other than members for water works, and the like, a cast bronze metal containing lead is often used. In cases in which such copper alloys are produced on the same line, if a cast bronze metal containing lead is melted and cast after a lead-free copper alloy containing Bi and Si, Bi and Si of the lead-free copper alloy produced before remain in a melting furnace and are mixed into a cast bronze metal to be produced. In a cast bronze metal product into which these elements are unintentionally mixed, product defects may increase and mechanical properties may be greatly reduced, and thus elements, such as Bi and Si, are desirably used as little as possible for convenience of the production site.

55 **[0007]** In addition, the alloy of Patent Document 1 has a problem in that in a range in which the Zn content is high, the dezincification corrosion is prone to occur, and has a property in which in a range in which the Pb content is high, the lead leaching level fails to be satisfied. Moreover, since Bi is contained, there has been a recycle problem as described above. Further, if in a range in which the Zn content is high and the Sn content is low, Zr is contained, the improvement

in properties is effectively made during a casting process having a small temperature range of solidification, such as that of solidification from a semi-solid state, whereas if in a range in which the Zn content is low and the Sn content is high, Zr is contained and in a process of casting a metal, which is not in a semi-solid state but completely liquid, in a mold, a temperature range to solidification is large so that a compound of Zr may be generated and shrinkage cavities may be facilitated to reduce mechanical properties.

[0008] Moreover, in the alloy of Patent Document 2, since Bi is contained, there has been a recycle problem as described above.

[0009] Accordingly, an object of the present invention is to provide a copper alloy for use in a member for water works, which has suitable mechanical properties and castability, while not only inhibiting lead leaching but also maintaining the recyclability.

MEANS FOR SOLVING THE PROBLEMS

[0010] The present invention has solved the above mentioned problems by a copper alloy for use in a member for water works, the copper alloy consisting of: 0.5% by mass or less of Ni; 12% by mass or more and 21% by mass or less of Zn; 1.4% by mass or more and 4.5% by mass or less of Sn, a total content of Zn and Sn being 23.5% by mass or less; 0.005% by mass or more and 0.15% by mass or less of P; 0.05% by mass or more and 0.30% by mass or less of Pb; less than 0.2% by mass of Bi; and the balance, wherein the balance is Cu and unavoidable impurities.

[0011] Bi is limited to be less than 0.2% by mass so as to be capable of being used even when mixed with another alloy in recycling. Meanwhile, even when Bi is less than 0.2% by mass as described above, if Pb is 0.30% by mass or less, effects of improving properties, such as the machinability, due to addition of Pb can be exhibited, while leaching lead amount regulations are satisfied. Further, values of Zn and Sn are adjusted together so as to be such a blending as to be capable of exhibiting sufficient mechanical properties without using Bi which has a large influence in recycling.

[0012] Moreover, Ni is 0.5% by mass or less so as to be capable of inhibiting an occurrence of shrinkage cavities.

[0013] Further, this copper alloy may contain in a limited manner an element which may be mixed therein as another unavoidable impurity. Note that its total amount is required to fall within such a range as not to inhibit effects of the present invention, and is preferably less than 1.0% by mass and the content of each of such element is preferably less than 0.5% by mass.

EFFECTS OF THE INVENTION

[0014] According to the present invention, it is possible to obtain a copper alloy which is also excellent in recyclability and has good mechanical properties by limiting the content of Pb and not containing Bi so as to be capable of producing a member for water works in which safety is further secured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a schematic view of type A defined in JISH 5120 for obtaining a sample used in a tensile test evaluation method in Examples.

FIG. 2 is a schematic view of a type 4 test specimen defined in JISZ 2241 used in a tensile test evaluation method in Examples.

FIG. 3 is a structural view illustrating a structure of an erosion-corrosion test.

FIGS. 4(a) and 4(b) are views illustrating a spiral-shaped test mold used in a flowability test in Examples.

FIG. 5 is a structural view of a step-shaped mold used in a shrinkage cavity test in Examples.

FIG. 6 shows photographs illustrating the results of a liquid penetrant testing in Examples.

MODE FOR CARRYING OUT THE INVENTION

[0016] The present invention will now be described in detail.

[0017] The present invention relates to a copper alloy for use in a member for water works, which contains Pb in a limited manner and is blended without containing Bi.

[0018] In the above mentioned copper alloy, a Zn content is required to be 12% by mass or more, and preferably 13% by mass or more. The Zn content of less than 12% by mass results in producing curled machining chips so as to reduce the machinability. Meanwhile, the Zn content is required to be 21% by mass or less, and is preferably 20% by mass or less and more preferably 18% by mass or less. Too high a Zn content results in not only a reduction in mechanical properties but also an increase of zinc residue so as to complicate the casting.

5 [0019] In the above mentioned copper alloy, a Sn content is required to be 1.4% by mass or more, and preferably 2.0% by mass or more. The Sn content of less than 1.4% by mass results in producing curled machining chips so as to reduce the machinability, similarly to effects of Zn. Moreover, an oxide film which protects a surface of a member for water works is removed by the water stream so that the resistance to erosion-corrosion in which the corrosion of the alloy progresses becomes insufficient. Meanwhile, the Sn content is required to be 4.5% by mass or less, and is preferably 4.3% by mass or less and more preferably 3.0% by mass or less. This is because too high a Sn content results in a reduced elongation and/or an occurrence of shrinkage cavities during the sand casting.

10 [0020] In the above mentioned copper alloy, a total content of Zn and Sn is required to be 23.5% by mass or less, and preferably 21.0% by mass or less. If an amount of Zn solid-solubilized in Cu is too high, the solid solubility of Sn is reduced to result in an increased concentration of Sn in the residual liquid phase during the solidification, and as a result, the crystallization of β -phase due to peritectic reaction is more likely to occur. Eventually, $\alpha+\delta$ phases, composed of α -phases scattered in hard δ -phases ($\text{Cu}_{31}\text{Sn}_8$), are generated between dendrites, resulting in a reduction in the tensile strength. Further, the presence of Bi dispersed in the vicinity of the $\alpha+\delta$ phases, during the generation thereof, leads to a synergistic reduction in the mechanical properties of the alloy. In addition, when the casting is carried out under the conditions of low solidification rate, such as when producing a thick wall casting or sand casting, there is a potential risk that the resulting casting may develop casting defects during the final solidification, such as a defect referred to as "tin sweat", a state where Sn exudes from the surface of the alloy as if it is sweating, or shrinkage cavity defects. If the total content of Zn and Sn exceeds 23.5% by mass, a reduction in mechanical properties and an occurrence of casting defects will be unignorable.

20 [0021] In the above mentioned copper alloy, a P content is required to be 0.005% by mass or more, and preferably 0.01% by mass or more. Since P produces a deoxidizing effect, too low a P content reduces the deoxidizing effect during the casting, resulting not only in an increased occurrence of gas defects, but also in a decreased flowability of molten metal due to oxidation of the molten metal. On the other hand, the P content is required to be 0.15% by mass or less, and preferably 0.05% by mass or less. If the P content is too high, P reacts with water in the mold to increase the occurrence of gas defects and shrinkage cavity defects in the resulting casting, and the mechanical properties thereof are also reduced. On the other hand, since the above mentioned copper alloy contains a high amount of Zn, gas absorption is reduced due to the degassing effect of Zn. This allows for production of a casting with little casting defects, even if the P content is low as compared to a representative bronze alloy, JIS H5120 CAC406.

25 [0022] In the above mentioned copper alloy, a Pb content is required to be 0.05% by mass or more, and preferably 0.07% by mass or more. This is because while Pb is contained slightly so as to greatly improve the machinability, the Pb content of less than 0.05% by mass results in its effects insufficient. On the other hand, the Pb content is required to be 0.30% by mass or less, and preferably 0.20% by mass or less. Pb is an element whose leaching should be prevented as much as possible, and if the Pb content exceeds 0.30% by mass, it will be difficult to satisfy a leaching reference value in a leaching test.

30 [0023] In the above mentioned copper alloy, a Ni content is required to be 0.5% by mass or less. Ni may not be contained but produces effects exhibiting stable mechanical properties, and, at the same time, produces effects of inhibiting an occurrence of shrinkage cavities, which facilitates production of a decent casting. On the other hand, if the Ni content exceeds 0.5% by mass, the machinability is prone to be reduced.

35 [0024] The above mentioned copper alloy may contain another impurities as the balance, in addition to Cu, within such a range as not to inhibit effects of the present invention. Note that the content is preferably restricted to such an extent as to be contained as unavoidable impurities which are unavoidably contained in view of problems of raw materials and problems during production. A total amount of the elements which constitute the unavoidable impurities is preferably less than 1.0% by mass, and more preferably less than 0.5% by mass. This is because, if too much unexpected elements are incorporated in the alloy, even if the above mentioned elements are contained within the above mentioned ranges, there is a potential risk that the physical properties of the alloy may be deteriorated. Further, a content of each element is preferably less than 0.4% by mass.

40 [0025] Among the elements which constitute above mentioned unavoidable impurities, a content of Bi is preferably less than 0.2% by mass, more preferably less than 0.1% by mass, and still more preferably less than the detection limit. Since Bi is not solid-solubilized in Cu, but dispersed, a higher Bi content is more prone to cause a reduction in the strength, such as the tensile strength. Further, such dispersed Bi leads to a tendency to easily cause an occurrence of shrinkage cavities during the sand casting. Further, too high a Bi content results in an occurrence of various demerits, such as a reduction in mechanical properties caused by mixture of Bi into an alloy to be recycled in recycling a member for water works produced using the above mentioned copper alloy so that the member for water works is required to be collected separately.

45 [0026] Among the elements that constitute the unavoidable impurities which the above mentioned copper alloy may contain, a content of Si is preferably less than 0.01% by mass, and more preferably less than 0.005% by mass. Too high a Si content results in facilitation of shrinkage cavities so that a decent casting fails to be produced.

50 [0027] Among the elements that constitute the unavoidable impurities which the above mentioned copper alloy may

contain, a content of Al is preferably less than 0.01% by mass, and more preferably less than 0.005% by mass. Similarly to Si, too high an Al content results in facilitation of shrinkage cavities so that a decent casting fails to be produced.

[0028] Among the elements that constitute the unavoidable impurities which the above mentioned copper alloy may contain, a content of Sb is preferably less than 0.05% by mass, more preferably less than 0.03% by mass, and still more preferably less than the detection limit. Since Sb tends to form Cu-Sn-Sb-based intermetallic compounds, which tend to reduce the toughness of the alloy, there is a risk that the mechanical properties of the alloy may be reduced.

[0029] Among the elements that constitute the unavoidable impurities which the above mentioned copper alloy may contain, a content of Zr is preferably less than 0.01% by mass, more preferably less than 0.0005% by mass, and still more preferably less than the detection limit. Containing Zr results in degradation of mechanical properties and facilitation of shrinkage cavities so that a decent casting fails to be produced.

[0030] Among the elements that constitute the unavoidable impurities which the above mentioned copper alloy may contain, the content of each of the unavoidable impurities is preferably less than 0.4% by mass, more preferably less than 0.2% by mass, and still more preferably less than the detection limit. Examples of such impurities include Fe, Mn, Cr, Mg, Ti, Te, Se, Cd, etc. Among those in particular, the content of Se and Cd, which are known to be toxic, is each desirably less than 0.1 % by mass, and more preferably less than the detection limit.

[0031] Note that, the values of the content of the elements as described in the present invention denote the values of the content of elements in the resulting casting or forging, not the content thereof in the raw materials.

[0032] The balance of the above mentioned copper alloy is Cu. The copper alloy according to the present invention can be produced by a common method for producing a copper alloy. When producing a member for water works using the thus obtained copper alloy, a common casting method (such as sand casting) can be used. For example, a member for water works can be prepared by a method in which an alloy is melted using an oil furnace, gas furnace, or high frequency induction melting furnace, and then cast using molds in various shapes.

EXAMPLES

[0033] Examples in which the copper alloy of the present invention was actually produced will now be described. Firstly, the testing methods for copper alloy will be described.

<Mechanical Properties Test>

[0034] A sample prepared by being cast into a shape of type A sample defined in JISH 5120 was processed into a type 4 test specimen defined in JISZ 2241. Specific shapes are each indicated in FIGS. 1 and 2. Among those, a type A test specimen in FIG. 1 is a hatched portion in the figure, and the unit of the size is mm. Moreover, a diameter d_0 is 14 ± 0.5 mm, an original gauge length of the test specimen L_0 is 50 mm, a length of a parallel portion L_c is 60 mm or more, and a radius of a shoulder portion R is 15 mm or more.

[0035] With respect to this test specimen, the tensile strength and elongation were then measured in accordance with JIS Z2241. The mechanical properties of each of the test specimens were evaluated based on the thus obtained values.

- The tensile strength was evaluated as follows: 195 MPa or more was evaluated as "°"; and less than 195 MPa was evaluated as "x".
- The elongation was evaluated as follows: 15% or more was evaluated as "°"; and less than 15% was evaluated as "x".

[0036] Note that, these threshold values are reference values for JIS H5120 CAC406 generally used in a member for water works.

<Erosion-corrosion test>

[0037] A sample prepared by casting in a metal mold having a size of 20 mm diameter \times 120 mm (length) was processed to have a cylindrical shape having a size of 16 mm diameter, as illustrated in FIG. 3, so as to be a test specimen 12, a nozzle 11 having a diameter of 1.6 mm is provided at a position spaced apart from this test specimen 12 by 0.4 mm, 1% CuCl₂ solution 13 was made to flow from the nozzle 11 toward the sample at the flow rate of 0.4 L/min in the normal flow direction for 5 hours, and the weight loss (abrasion amount) and the maximum depth of the sample before and after the test were measured.

- The abrasion amount was evaluated as follows: less than 150 mg was evaluated as "° "; 150 mg or more and less than 200 mg was evaluated as "Δ"; and 200 mg or more was evaluated as "x".
- The maximum depth was evaluated as follows: less than 100 μm was evaluated as "° "; 100 μm or more and less than 150 μm was evaluated as "Δ"; and 150 μm or more was evaluated as "x".

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<Machinability Test and Drilling Test>

[0038] For each of the alloys, the drilling test using a drilling machine was carried out. The drilling test was carried out using each of the samples formed by machining to cylindrical samples having a size of 18 mm diameter×20 mm (height), and using a drilling machine, times required to drill a hole having a 5 mm depth from a deep part of the cylinder were measured under the drilling conditions as indicated in Table 1. Times with the results of less than 6 seconds were evaluated as "o"; times with the results of 6 seconds or more and less than 7 seconds were evaluated as "Δ"; and times with results of 7 seconds or more were evaluated as "x".

[Table 1]

Item	Material	Conditions
Cutting tool (SDD0600 manufactured by Mitsubishi Corporation)	Material	High-speed steel
	Cutting diameter	Diameter: 6 mm
	Total length	102 mm
	Flute length	70 mm
	Point angle	118°
Load	25 kg	
Rotational speed	960 rpm	
Drilling depth	5 mm	

<Test for Flowability>

[0039] Each of the copper alloys of Examples and Comparative Examples was heated and melted, and then cast using a spiral-shaped test mold as illustrated in FIGS. 4(a) and 4(b), to obtain a spiral-shaped test specimen. Since each of the alloys varying in its Zn content has a different temperature at which solidification starts, it is impossible to evaluate the proper flowability of molten metal for each of the alloys, using the same pouring temperature. Therefore, the temperature at which the solidification starts was measured for each of the alloys, by thermal analysis method, and then the casting was carried out at a temperature of +110° C above the measured temperature. Then, the flow length of the spiral-shaped portion of the thus cast spiral-shaped test specimen was measured. Flow lengths with the results of 300 mm or more were evaluated as "o"; flow lengths with the results of 280 mm or more and less than 300 mm were evaluated as "Δ"; and flow lengths with results of less than 280 mm were evaluated as "x".

<Test for Casting Defects>

<Liquid Penetrant Testing Using Step-Shaped Sample>

[0040] For each of the alloys, liquid penetrant testing was performed using a step-shaped sample, and evaluation of casting defects was performed. "-" in the Table denotes that the evaluation was not carried out. Specifically the testing was carried out as follows. A step-shaped CO₂ mold as illustrated in FIG. 5 was prepared (casting temperature at 1120°C), which was provided with three stepped portions with varying wall thicknesses of 10, 20 and 30 mm, so that the feeding effect was reduced and the resulting casting was more likely to develop casting defects, and the thus obtained casting was cut in half in the middle, and the liquid penetrant testing was carried out in accordance with JIS Z2343 so that occurrences of casting defects and minute gaps in this liquid penetrant testing were examined. Those in which no defect indications such as defects of shrinkage cavities and gas defects were observed in a portion having a thickness of 10 and 20 mm were evaluated as "o"; those in which some defect indications were not observed in the portion having a thickness of 10 mm but observed in the portion having a thickness of 20 mm were evaluated as "Δ"; and those in which some defect indications were observed in the portions having a thickness of 10 and 20 mm were evaluated as "x". A portion having a thickness of 30 mm was not evaluated.

<Production Method>

[0041] Materials containing each of the elements were mixed, and melted in a high frequency induction melting furnace, followed by casting using a CO₂ mold to produce samples each having the composition as indicated in Table 2. Note

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that all the values of the content of the elements are expressed in % by mass and are values measured after the production. Further, a conventionally used bronze material containing lead, JIS H5120 CAC406, was used as Comparative Example 12, which was used for the comparison of physical properties. Its content is also indicated in the Table. The following tests were carried out for each of the resulting copper alloys. Note that "-" in the Table denotes to be less than the detection limit. Note that, the content of each of B, Bi, Sb, Al, Si, and Fe was less than the detection limit, in each of Examples and Comparative Examples except Comparative Example 11. The overall evaluation was carried out according to the following standards: those having "o" evaluation in all the tests performed were defined as "o"; those having at least one "o" evaluation in any of the tests were defined as "Δ"; and those having as least one "x" evaluation in any of the tests were defined as "x".

[Table 2]

	Cu	Zn	Sn	Zn+Sn	P	Pb	Ni	Bi	Overall Evaluation
	Balance	12~21	1.4~4.5	≤23.5	0.005~0.15	0.05~0.30	≤0.5	<0.2	
Comparative example 1	Balance	10.70	2.41	13.11	0.025	0.21	-	-	×
Example 1	Balance	12.00	2.52	14.52	0.026	0.22	-	-	○
Example 2	Balance	14.89	2.47	17.36	0.025	0.22	-	-	○
Example 3	Balance	18.05	2.53	20.58	0.024	0.21	-	-	○
Example 4	Balance	20.75	2.41	23.16	0.026	0.21	-	-	Δ
Comparative Example 2	Balance	14.95	0.99	15.94	0.023	0.21	-	-	×
Examples 5	Balance	14.95	1.43	16.38	0.022	0.21	-	-	Δ
Example 2	Balance	14.89	2.47	17.36	0.025	0.22	-	-	○
Example 6	Balance	17.58	4.39	21.97	0,024	0.21	-	-	○
Example 7	Balance	14.91	4.50	19.41	0.025	0.22	-	-	Δ
Comparative Example 3	Balance	14.71	4.92	9.68	0.023	0.22	-	-	×
Example 5	Balance	14.95	1.43	16.38	0.022	0.21	-	-	○
Example 3	Balance	18.05	2.53	20.58	0.024	0.21	-	-	○
Example 4	Balance	20.75	2.41	23.16	0.026	0.21	-	-	Δ
Comparative Example 4	Balance	19.79	4.51	24.30	0.027	0.20	-	-	×
Comparative Example 5	Balance	14.74	2.26	17.00	0.004	0.21	-	-	×
Example 8	Balance	14.87	2,27	17.14	0.007	0.21	-	-	Δ
Example 2	Balance	14.89	2.47	17.36	0.025	0.22	-	-	○
Example 9	Balance	15.03	2.30	17.33	0.058	0.21	-	-	Δ
Example 10	Balance	16,09	2.41	17.50	0.130	-	-	-	Δ
Comparative Example 6	Balance	14.83	2.30	17.13	0.192	0.22	-	-	×
Comparative Example 7	Balance	15.01	2.36	17.37	0.032	0.03	-	-	×
Example 11	Balance	15.10	2,38	17.48	0.029	0.06	-	-	Δ
Example 2	Balance	14,89	2.47	17.36	0.025	0.22	-	-	○
Example 12	Balance	15.19	2.47	17.66	0.029	0.27	-	-	○

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(continued)

	Cu	Zn	Sn	Zn+Sn	P	Pb	Ni	Bi	Overall Evaluation
5	Balance	12~2 1	1.4~ 4.5	≤23.5	0.005~ 0.15	0.05~ 0.30	≤0.5	<0.2	
	Comparative Example 8	15.18	2.39	17.57	0.029	0.32	-	-	Pb leaching ×
10	Example 2	14.89	2.47	17.36	0.025	0.22	-	-	○
	Example 13	15.32	2.38	17.70	0.028	0.21	0.11	-	△
	Example 14	14.36	2.41	16.77	0.023	0.21	0.31	-	△
	Example 15	14.27	2.35	16.62	0.018	0.21	0.50	-	△
15	Comparative Example 9	14.93	2.25	17.18	0.026	0.20	0.67	-	×
	Comparative Example 10	14.62	2.52	17.14	0.025	0.21	1.00	-	×
20	Comparative Example 11	15,35	2.26	17.61	0.028	0.20	-	0.3	×
	Comparative Example 12	5.14	5.78	10.92	0.021	5.38	0.15	-	Pb leaching ×

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[Table 3]

	Mechanical Properties		Machinability	Flowability		Casting Defects		Erosion-Corrosion Properties		Overall Evaluation
	Tensile strength 195 MPa or more	Elongation 15% or more		Drilling test Δ less than 6 seconds Δ 6 seconds or F more and less than 7 seconds \times 7 seconds or more	Flowability evaluation	Flow length (mm)	Defects evaluation	Defects type	Maximum depth Δ less than 100 μm or more and less than 150 μm \times 150 μm or more	
Comparative Example 1	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 1	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 2	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 3	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 4	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Comparative Example 2	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 5	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 2	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 6	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 7	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Comparative Example 3	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 5	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 3	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 4	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Comparative Example 4	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Comparative Example 5	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Example 8	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ

(continued)

	Mechanical Properties		Machinability	Flowability		Casting Defects		Erosion-Corrosion Properties		Overall Evaluation
	Tensile strength 195 MPa or more	Elongation 15% or more		Flowability evaluation	Flow length (mm)	Defects evaluation	Defects type	Maximum depth ○ less than 100µm △ 100µm or more and less than 150µm × 150µm or more	Abrasion amount ○ less than 150mg △ 150mg or more and less than 200mg × 200mg or more	
Example 2	○ 246	○ 44.0	○ 5.64	○	○ 318	○	-	○ 73	○ 104	○
Example 9	○ 235	○ 41.0	△ 6.82	○	○ 358	○	-	-	-	△
Example 10	-	-	-	○	○ 394	△	Shrinkage cavities	-	-	△
Comparative Example 6	○ 263	○ 52.0	○ 5.92	×	○ 258	×	Shrinkage cavities	-	-	×
Comparative Example 7	○ 235	○ 43.0	×	-	-	-	-	-	-	×
Example 11	○ 249	○ 59.0	△ 6.25	-	-	-	-	-	-	△
Example 2	○ 246	○ 44.0	○ 5.64	○	○ 318	○	-	○ 73	○ 104	○
Example 12	○ 244	○ 49.0	○ 5.15	-	-	-	-	-	-	○
Comparative Example 8	○ 229	○ 42.0	○ 4.83	-	-	-	-	-	-	Pb leaching ×
Example 2	○ 246	○ 44.0	○ 5.64	○	○ 318	○	-	○ 73	○ 104	○
Example 13	○ 242	○ 59.0	△ 6.70	-	-	-	-	-	-	△
Example 14	-	-	△ 6.48	-	-	-	-	-	-	△
Example 15	-	-	△ 6.74	-	-	-	-	-	-	△
Comparative Example 9	○ 250	○ 50.0	×	-	-	-	-	-	-	×
Comparative Example 10	-	-	×	-	-	-	-	-	-	×

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(continued)

	Mechanical Properties		Machinability	Flowability		Casting Defects		Erosion-Corrosion Properties		Overall Evaluation
	Tensile strength 195 MPa or more	Elongation 15% or more		Flowability evaluation	Flow length (mm)	Defects evaluation	Defects type	Maximum depth ○ less than 100µm Δ 100µm or more and less than 150µm × 150µm or more	Abrasion amount ○ less than 150mg Δ 150mg or more and less than 200mg × 200mg or more	
Comparative Example 11	× 180	○ 22.0	○ 4.12	-	-	-	-	-	-	×
Compare Example 12	○ 250	○ 33.2	-	Δ 298	○	-	-	-	-	Pb leaching ×

5 [0042] First, CAC406 of Comparative Example 12 will be described. CAC406 has mechanical properties, such as a tensile strength of 195 MPa or more and an elongation of 15% or more, which are values defined in JIS. Moreover, since CAC406 contains 5.38% by mass of Pb, good results were obtained in the drilling test. Further, the flow length measured in the test for flowability of molten metal was 298 mm, which was evaluated as "Δ". On the other hand, since from 4 to 6% by mass of Pb is contained, Comparative Example 12 has a problem in lead leaching.

10 [0043] Firstly, Comparative Example 1 and Examples 1 to 4 were prepared to have a varying Zn content, with the contents of elements other than Zn being as close to each other as possible. These were arranged in the first group in Table 2 and Table 3 in ascending order of Zn content. With respect to the mechanical properties, each showed values exceeding the tensile strength of 195 MPa and the elongation of 15%, whereas in Comparative Example 1 in which Zn is less than 12% by mass, the time required for machining was too long. On the other hand, in Example 4 in which Zn is nearly 21% by mass which is the upper limit, it was found that the machinability tended to be reduced.

15 [0044] Next, with Example 2 as a reference, Comparative Example 2, Examples 5, 6, and 7, and Comparative Example 3 were prepared to have a varying Sn content, with the contents of elements other than Sn being as close to each other as possible. These were arranged in the second group in Table 2 and Table 3 in ascending order of the Sn content. In Example 5 in which the Sn content is 1.43% by mass which is close to the lower limit value, the erosion-corrosion resistance had a tendency to be slightly reduced, and in Comparative Example 2 in which the Sn content is 0.99% by mass, the erosion-corrosion resistance remarkably lacked. On the other hand, in Example 7 in which Zn is 4.5% by mass, the machinability had a tendency to be reduced, and in Comparative Example 3 in which the Sn content is 4.92% by mass which exceeds 4.5% by mass, a problem in elongation and machinability occurred.

20 [0045] Next, Examples 5, 3, and 4 were arranged in ascending order of the total content of Zn+Sn in Table 2, and Comparative Example 4 in which the content of Zn+Sn further exceeds as compared to those and exceeds 23.5% by mass was prepared, and those were arranged in the third group in Table 2 and Table 3 in ascending order of the total content of Zn+Sn. In Comparative Example 4, both the tensile strength and the elongation were greatly reduced.

25 [0046] Next, with Example 2 as a reference, Comparative Example 5, Examples 8 and 9, and Comparative Example 6 were prepared to have a varying P content, with the contents of elements other than P being as close to each other as possible. These were arranged in the fourth group in Table 2 and Table 3 in ascending order of the P content. In each of Comparative Example 5 in which the P content is less than 0.005% by mass and Comparative Example 6 in which the P content exceeds 0.15% by mass, there consequently occurred a problem in flowability. Further, the results for the liquid penetrant testing are indicated in FIG. 6. In Comparative Example 6 in which the P content exceeds 0.15% by mass, there entirely occurred shrinkage cavities. Note that in the photograph, the portions having a thickness of 30 mm were not estimated and parts in which red and fine spots are generated in a thinner portion were examined. In Examples other than Comparative Example 6, at the portions having a thickness of 20 mm or less, no spots were found, which provided good results.

30 [0047] Next, with Example 2 as a reference, Comparative Example 7, Examples 10, Example 11, and Comparative Example 8 were prepared to have a varying Pb content, with the contents of elements other than Pb being as close to each other as possible. These were arranged in the fifth group in Table 2 and Table 3 in ascending order of the Pb content. In Comparative Example 7 in which the Pb content is 0.03% by mass which is less than 0.05% by mass, there consequently occurred a problem in machinability.

35 [0048] Further, with compositions similar to that of Example 2, Examples 13, 14, and 15 and Comparative Examples 9 and 10 were prepared to contain Ni. None of those had a problem in mechanical properties. However, in Comparative Examples 9 and 10 in which the Ni content exceeds 0.5% by mass, there occurred a problem in machinability.

40 [0049] Still further, with a composition similar to that of Example 2, Comparative Example 11 was prepared to contain 0.3% by mass of Bi. The tensile strength was greatly reduced so that there occurred a problem in mechanical properties. Moreover, this content exhibited a problem in view of recyclability.

45 Claims

50 1. A copper alloy for use in a member for water works, the copper alloy consisting of: 0.5% by mass or less of Ni; 12% by mass or more and 21% by mass or less of Zn; 1.4% by mass or more and 4.5% by mass or less of Sn, a total content of Zn and Sn being 23.5% by mass or less; 0.005% by mass or more and 0.15% by mass or less of P; 0.05% by mass or more and 0.30% by mass or less of Pb; less than 0.2% by mass of Bi; and the balance, wherein the balance is Cu and unavoidable impurities.

FIG. 1

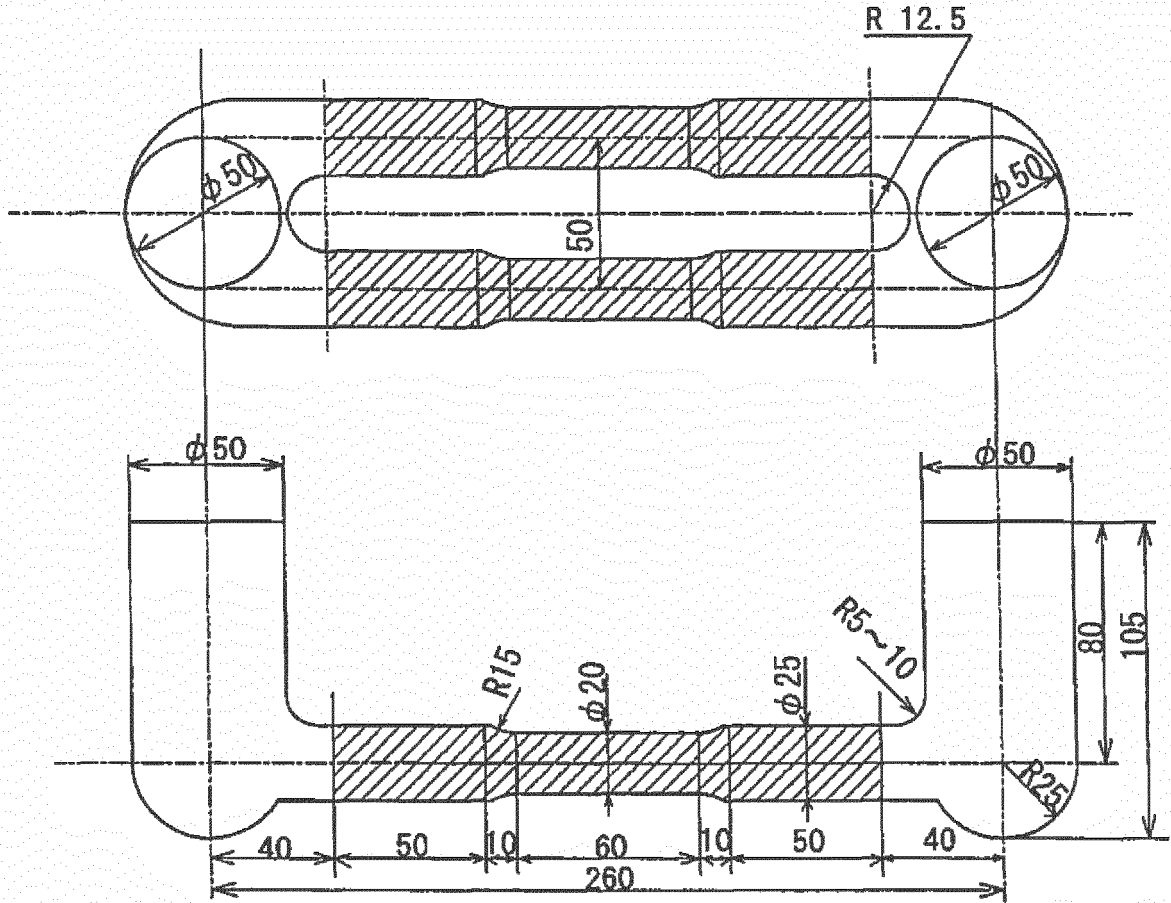


FIG. 2

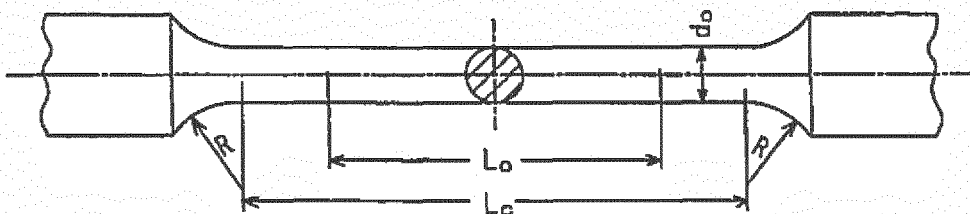


FIG. 3

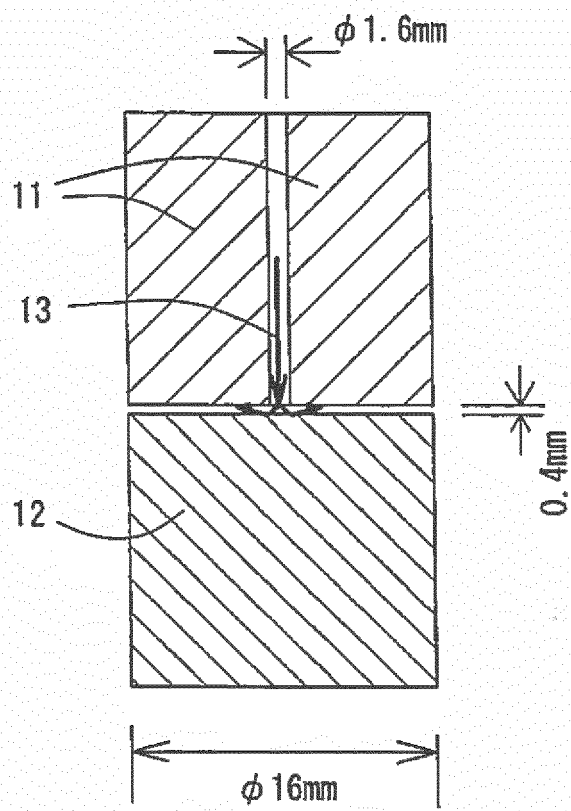


FIG. 5

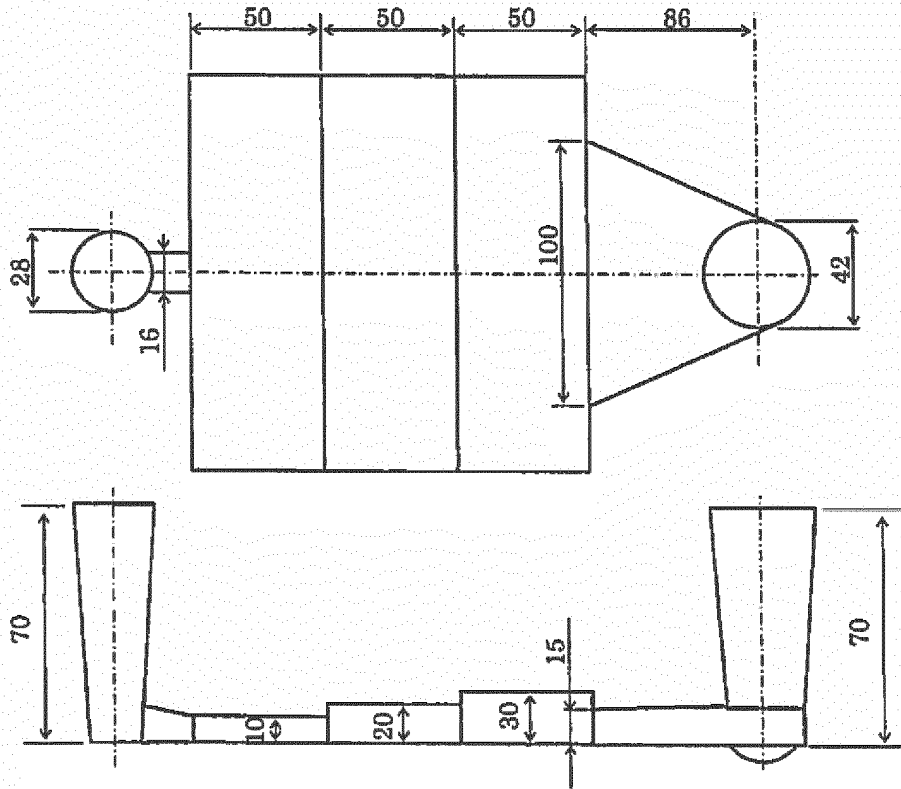
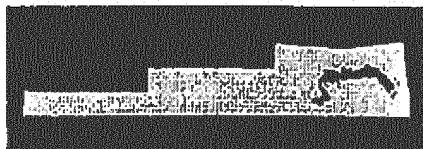
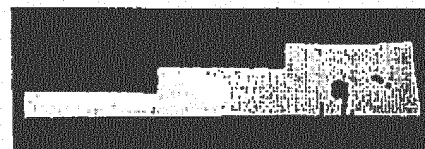


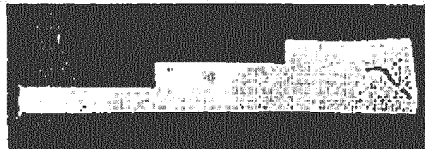
FIG. 6



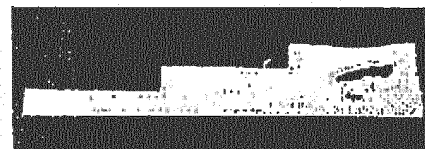
Example 2 P = 0.025 mass%



Comparative Example 5 P = 0.004 mass%



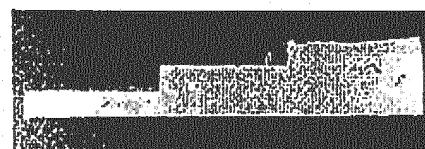
Example 8 P = 0.007 mass%



Comparative Example 9 P = 0.058 mass%



Example 10 P = 0.130 mass%



Comparative Example 6 P = 0.192 mass%

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/060141

A. CLASSIFICATION OF SUBJECT MATTER

C22C9/04(2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C9/00-9/10

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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

DWPI(Thomson Innovation)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-240517 A (Kurimoto Ltd.), 25 December 2014 (25.12.2014), claims 1, 2; table 2, example 13 & WO 2014/199530 A1	1
A	US 2012/0058005 A1 (Inho Song), 08 March 2012 (08.03.2012), table 2, test series 2-2, 2-3; claim 4 & WO 2011/066581 A1	1
A	JP 2001-64742 A (Chuetsu Metal Works Co., Ltd.), 13 March 2001 (13.03.2001), paragraph [0001]; table 1, No.7, 8, 11, 12, 16 (Family: none)	1

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

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"&" document member of the same patent family

Date of the actual completion of the international search

23 June 2015 (23.06.15)

Date of mailing of the international search report

30 June 2015 (30.06.15)

Name and mailing address of the ISA/
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Patent documents cited in the description

- JP 5116976 B [0005]
- JP 5406405 B [0005]