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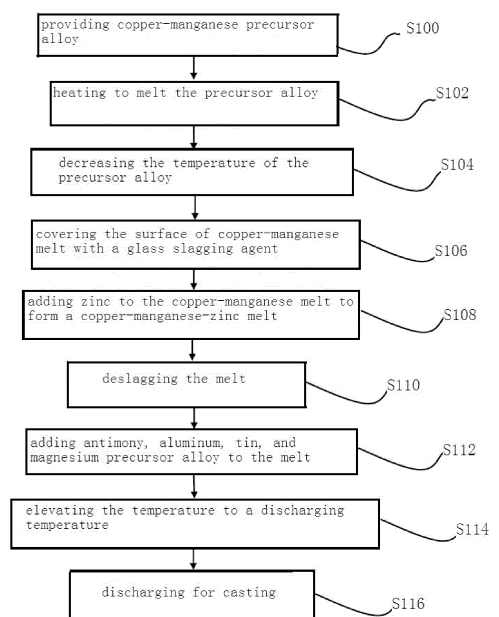
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(54) **LEAD-FREE BISMUTH-FREE SILICONE-FREE BRASS**

(57) The invention relates to a lead-free bismuth-free silicon-free brass alloy, comprising: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium, one or more element selected from the group consisting of 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus, 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron, and a balance of zinc. The brass alloy of the invention does not adopt lead, thus avoiding lead pollution. Besides, neither bismuth nor silicon is adopted, thus enabling the brass alloy to have an improved cutting performance.

Figure 1



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DescriptionFIELD OF INVENTION

[0001] The invention relates to an environmentally friendly brass alloy, and particularly to a free cutting and dezincification resistant brass alloy.

BACKGROUND OF INVENTION

[0002] Generally, the brass for processing is added with metallic zinc by a percentage of 38-42%. In order to make it easy to process brass, brass usually contains 2-3% lead to enhance strength and processability. Lead-containing brass has excellent moldability (making it easy to fabricate products of various shapes), cutting performance, and abrasion resistance, so that it is widely applied to mechanical part with various shapes, accounts for a large proportion in the copper industry, and is well known as one of the most important basic material in the world. However, during the production or use of lead-containing brass, lead tends to dissolve in the solid or gas state. Medical studies have shown that lead can bring about substantial damage to the human hematopoietic and nervous systems, especially children's kidneys and other organs. Many countries in the world take the pollution and hazard caused by lead very seriously. The National Sanitation Foundation (NSF) sets a tolerance of lead element of 0.25% or less. Organizations like the Restriction of Hazardous Substances Directive (RoHS) of European Union successively stipulate, restrict and prohibit the usage of brass with a high lead content.

[0003] Furthermore, when the zinc content in brass exceeds 20 wt%, the corrosion phenomenon of dezincification is prone to occur. Especially when brass is exposed to the chloride rich environment, e.g. marine environment, the occurrence of corrosion phenomenon of dezincification may be accelerated. Dezincification may severely destroy the structure of brass alloy, so that the surface strength of brass products is reduced and the brass tube even perforates. This greatly reduces the lifetime of brass products and causes problems in application.

[0004] Therefore, there is a need to provide an alloy formula for solving the above problems, which can replace the brass with a high lead content, is dezincification corrosion resistant, and further has excellent casting performance, forgeability, cutting performance, corrosion resistance and mechanical properties.

SUMMARY OF INVENTION

[0005] As known in the prior art, silicon may appear in the alloy metallographic structure as γ phase (sometimes as κ phase). In this case, silicon may replace the function of lead in the alloy to an extent, and improve cutting performance of the alloy. Cutting performance of the alloy increases with the content of silicon. However, silicon has a high melting point and a low specific gravity and is prone to be oxidized. As a result, after silicon monomer is added into the furnace in the alloy melting process, silicon floats on the surface of alloy. When the alloy is melt, silicon will be oxidized into silicon oxides or other oxides, making it difficult to produce silicon-containing copper alloy. In case silicon is added in the form of Cu-Si alloy, the economic cost is increased.

[0006] Bismuth can be added to replace lead for forming cutting breakpoints in the alloy structure to improve cutting performance. However, thermal cracking is prone to occur during forging in case of a high bismuth content, which is not conducive for producing.

[0007] Thus, it is an object of the invention to provide a brass alloy which exhibits excellent performance like tensile strength, elongation rate, dezincification resistance and cutting performance, which is suitable for cutting processed products that require high strength and wear resistance, and which is suitable for constituent materials for forged products and cast products. The brass alloy of the invention can securely replace the alloy copper with a high lead content, and can completely meet the demands about restrictions on lead-containing products in the development of human society.

[0008] To achieve the above object, the inventors have proposed the following lead-free bismuth-free silicon-free brass alloy.

[0009] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 1) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony and 0.1-0.5 wt% magnesium, and a balance of zinc.

[0010] In the inventive product 1, lead, silicon, and bismuth is absent, the content of copper is controlled at 60-65 wt%, and a small quantity of antimony and magnesium is added to form intermetallic compounds with copper, so that cutting performance of the alloy is improved and dezincification resistance of the alloy is simultaneously improved. In other words, in the inventive product 1, the cutting performance is improved by adding antimony and magnesium to form γ phase. The metallographic structure of the alloy mainly comprises α phase, β phase, γ phase, and soft and brittle intermetallic compounds which are distributed in grain boundaries or grains. Copper and zinc make main constituents of the brass alloy. By adding antimony and magnesium, not only the cutting performance of the alloy is improved, but

also the dezincification resistance is improved.

[0011] When the content of antimony is lower than 0.01 wt%, and the content of magnesium is lower than 0.1 wt%, the resulting alloy has a cutting performance which is not acceptable in the industrial production. The cutting performance of the alloy will increase with the content of antimony and magnesium. However, when the content antimony in the alloy is 0.15 wt% and the content of magnesium is 0.5 wt%, improvement in the cutting performance of the alloy reaches the saturated state.

[0012] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 2) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium, and further comprises, by the total weight of the brass alloy, 0.05-0.3 wt% phosphorus and/or 0.05-0.5 wt% manganese, and a balance of zinc.

[0013] As compared with the inventive product 1, the inventive product 2 is further added with 0.05-0.3 wt% phosphorus and/or 0.05-0.5 wt% manganese by the total weight of the brass alloy. Although phosphorus can't form γ phase, phosphorus has a function of facilitating a good distribution of γ phase for antimony and magnesium, thus increasing cutting performance of the alloy. Meanwhile, in case phosphorus is added, γ phase will disperse crystal grains of the primary α phase, thus increasing casting performance and corrosion resistance of the alloy. When the content of copper, antimony, and magnesium is 60-65 wt%, 0.01-0.15 wt%, and 0.1-0.5 wt%, respectively, and the content of phosphorus is lower than 0.05 wt%, phosphorus can not play its role effectively. While when the content of phosphorus is higher than 0.3 wt%, casting performance and corrosion resistance of the alloy will be degraded. Adding manganese helps to improve dezincification resistance and cast flowability of the alloy. When the content of manganese is lower than 0.05 wt%, manganese can not play its role effectively. While when the content of manganese is 0.5 wt%, manganese can play its role to the saturation value.

[0014] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 3) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium, and further comprises, by the total weight of the brass alloy, 0.05-0.5 wt% manganese, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus and/or 0.001-0.01 wt% boron, and a balance of zinc.

[0015] As compared with the inventive product 1, the inventive product 3 is further added with 0.05-0.5 wt% manganese, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus and/or 0.001-0.01 wt% boron by the total weight of the brass alloy.

[0016] Adding tin into the alloy also intends to form γ phase, thus increasing cutting performance of the alloy. Besides, adding tin obviously increases strength, plasticity, and corrosion resistance the alloy. However, since adding tin may increase cost, aluminum is added along with tin. As a result, not only cutting performance of the alloy can be improved, but also strength, wear resistance, cast flowability, and high temperature oxidation resistance of the alloy can be increased. In order to make a better use of the above effects, the content of tin and aluminum is 0.05-0.5 wt% and 0.1-0.7 wt%, respectively. Meanwhile, the alloy is further added with trace boron so as to increase corrosion resistance of the alloy. By adding boron, it is possible to better suppress alloy dezincification, increase the mechanical strength, and simultaneously alter defect structure of cuprous oxide film on the surface of copper alloy, thus forming a cuprous oxide film which is more uniform, dense, and stain resistant. When the content of boron is lower than 0.001 wt%, boron can't play its role as mentioned above. While when the content of boron is higher than 0.01 wt%, the above performance can't be further increased. Thus, the optimum content of boron is 0.001-0.01 wt%. The content of phosphorus and manganese has the same interval as that of the inventive product 2, and this is based on the same reason as that of the inventive product 2. Whether antimony, magnesium, aluminum, tin, phosphorus, manganese and/or boron should be added depends on the requirement for cutting performance of various products.

[0017] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 4) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium, and further comprises, by the total weight of the brass alloy, 0.05-0.5 wt% manganese, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus and/or 0.001-0.01 wt% boron, and a balance of zinc, wherein the total content of manganese, aluminum, tin, phosphorus and/or boron is not larger than 2 wt% of the total weight of the brass alloy.

[0018] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 5) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium, and further comprises, by the total weight of the brass alloy, 0.05-0.5 wt% manganese, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus and/or 0.001-0.01 wt% boron, and a balance of zinc, wherein the total content of manganese, aluminum, tin, phosphorus and/or boron is 0.2-2 wt% of the total weight of the brass alloy.

[0019] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 6) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium, and further comprises, by the total weight of the brass alloy, 0.05-0.5 wt% manganese, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus and/or 0.001-0.01 wt% boron, and a balance of zinc and unavoidable impurities, wherein the unavoidable impurities comprise: by the total weight of the brass alloy, 0.25 wt% or

less nickel, 0.15 wt% or less chrome and/or 0.25 wt% or less iron.

[0020] As compared with the inventive product 3, the inventive product 6 further comprises some unavoidable impurities, i.e., mechanical impurities of nickel, chrome and/or iron.

[0021] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 7) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.05-0.5 wt% tin, and two or more elements selected from the group consisting of, by the total weight of the brass alloy, 0.1-0.7 wt% aluminum, 0.05-0.3 wt% phosphorus and 0.05-0.5 wt% manganese, and a balance of zinc.

[0022] In case that neither antimony nor magnesium is present, adding 0.05-0.5 wt% tin of the total weight of the alloy can still meet the needs for cutting performance in the industrial production. The content of tin to be added has the same interval as that of the inventive product 3, and this is based on the same reason as that of the inventive product 3. Whether aluminum, phosphorus, and manganese should be added depends on the requirement for cutting performance of various products. The content to be added has the same interval as that of the inventive product 3, and this is based on the same reason as that of the inventive product 3.

[0023] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 8) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.05-0.5 wt% tin, and two or more elements selected from the group consisting of, by the total weight of the brass alloy, 0.1-0.7 wt% aluminum, 0.05-0.3 wt% phosphorus, and 0.05-0.5 wt% manganese, and further comprises, by the total weight of the brass alloy, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium and/or 0.001-0.01 wt% boron, and a balance of zinc.

[0024] Whether antimony, magnesium, aluminum, tin, phosphorus, manganese and/or boron should be added depends on the requirement for cutting performance of various products. The content to be added has the same interval as that of the inventive product 3, and this is based on the same reason as that of the inventive product 3.

[0025] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 9) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.05-0.5 wt% tin, and two or more elements selected from the group consisting of, by the total weight of the brass alloy, 0.1-0.7 wt% aluminum, 0.05-0.3 wt% phosphorus and 0.05-0.5 wt% manganese, and further comprises, by the total weight of the brass alloy, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium and/or 0.001-0.01 wt% boron, and a balance of zinc and unavoidable impurities, wherein the unavoidable impurities comprise: 0.25 wt% or less nickel, 0.15 wt% or less chrome and/or 0.25 wt% or less iron by the total weight of the brass alloy.

[0026] As compared with the inventive product 8, the inventive product 9 further comprises some unavoidable impurities, i.e., mechanical impurities of nickel, chrome and/or iron.

[0027] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 10) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony and 0.1-0.5 wt% magnesium, and one or more element selected from the group consisting of, by the total weight of the brass alloy, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus, 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron, and a balance of zinc.

[0028] Whether aluminum, tin, phosphorus, manganese and/or boron should be added depends on the requirement for cutting performance of various produc. The content to be added has the same interval as that of the inventive product 3, and this is based on the same reason as that of the inventive product 3.

[0029] A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 11) comprises: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony and 0.1-0.5 wt% magnesium, and one or more element selected from the group consisting of, by the total weight of the brass alloy, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus, 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron, and a balance of zinc and unavoidable impurities, wherein the unavoidable impurities comprise: 0.25 wt% or less nickel, 0.15 wt% or less chrome and/or 0.25 wt% or less iron by the total weight of the brass alloy.

[0030] As compared with the inventive product 10, the inventive product 11 further comprises some unavoidable impurities, i.e., mechanical impurities of nickel, chrome and/or iron.

[0031] The invention further provides a method for fabricating brass alloy. By taking an example of the inventive product 3 as an example, the method comprises the steps of:

- 1) providing copper and manganese and heating to 1000-1050 °C to form a copper-manganese alloy melt;
- 2) decreasing the temperature of the copper-manganese alloy melt to 950-1000 °C;
- 3) covering the surface of copper-manganese alloy melt with a glass slagging agent;
- 4) adding zinc to the copper-manganese alloy melt to form a copper-manganese-zinc melt;
- 5) deslagging the copper-manganese-zinc melt, and adding antimony, aluminum, tin, magnesium to the brass alloy melt to form a metal melt;
- 6) elevating the temperature of the metal melt to 1000-1050 °C, and adding boron copper alloy, phosphorus copper alloy to form a lead-free bismuth-free silicon-free brass alloy melt;
- 7) discharging the brass alloy melt for casting to form the brass alloy.

[0032] Preferably, in the above fabricating method, a copper-manganese alloy is provided as the precursor of copper and manganese elements.

[0033] Preferably, in the above fabricating method, the melting furnace is a high-frequency melting furnace, and the high-frequency melting furnace is provided with a furnace lining of graphite crucible.

[0034] The high-frequency melting furnace has the features of a large melting rate, a large temperature elevating rate, cleanness without pollution, and the ability of self-stirring (i.e., under the action of magnetic field lines) during melting.

[0035] In the invention, the lead-free bismuth-free silicon-free brass alloy is formed by adding various constituents in respective ratio, and then subjecting them to a process in a high-frequency melting furnace. The resulting brass alloy has a mechanical processability which is comparable with that of the existing lead-containing brass, has an excellent tensile strength, elongation rate, and dezincification resistance, and is lead-free. As a result, the brass alloy is suitable for replacing the existing lead-containing brass alloy and for producing parts like faucet and sanitary ware.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Fig. 1 is a flow chart illustrating a method for fabricating an example of the inventive product 3.

DETAILED DESCRIPTION

[0037] The technical solutions of the invention will be described expressly by referring to embodiments thereof.

[0038] It is not intended to limit the scope of the invention to the described exemplary embodiments. The modifications and alterations to features of the invention as described herein, as well as other applications of the concept of the invention (which will occur to the skilled in the art, upon reading the present disclosure) still fall within the scope of the invention.

[0039] In the invention, the wording "or more", "or less" in the expression for describing values indicates that the expression comprises the relevant values.

[0040] The dezincification corrosion resistant performance measurement, as used herein, is performed according to AS-2345-2006 specification in the cast state, in which 12.8 g copper chloride is added into 1000C.C deionized water, and the object to be measured is placed in the resulting solution for 24 hr to measure a dezincification depth. ⊙ indicates a dezincification depth of less than 100 μm; ○ indicates a dezincification depth between 100 μm and 200 μm; and indicates a dezincification depth larger than 200 μm.

[0041] The cutting performance measurement, as used herein, is performed in the cast state, in which the same cutting tool is adopted with the same cutting speed and feed amount. The cutting speed is 25 m/min (meter per minute), the feed amount is 0.2 mm/r (millimeter per number of cutting edge), the cutting depth is 0.5 mm, the measurement rod has a diameter of 20 mm, and C36000 alloy is taken as a reference. The relative cutting rate is derived by measuring the cutting resistance.

[0042] The relative cutting rate = cutting resistance of C36000 alloy/cutting resistance of the sample.

[0043] ⊙ indicates a relative cutting rate larger than 85%; and ○ indicates a relative cutting rate larger than 70%.

[0044] Both the tensile strength measurement and the elongation rate measurement, as used herein, are performed in the cast state at room temperature as an elongation measurement. The elongation rate refers to a ratio between the total deformation of gauge section after elongation ΔL and the initial gauge length L of the sample in percentage: $\delta = \Delta L / L \times 100\%$. The reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0045] According to measurement, the proportions for constituents of C36000 alloy are listed as follow, in the unit of weight percentage (wt%):

Material No.	copper (Cu)	zinc (Zn)	bismuth (Bi)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	lead (Pb)	iron (Fe)
C36000 alloy	60.53	36.26	0	0	0	0	0.12	2.97	0.12

[0046] Fig. 1 is a flow chart illustrating a method for fabricating an example of the inventive product 3, which comprises the steps of:

Step S100: providing copper and manganese. In this step, a copper-manganese alloy can be provided as the precursor of copper and manganese elements.

Step S102: heating the copper-manganese precursor alloy to 1000-1050 °C to form a copper-manganese alloy melt. In this step, the copper-manganese alloy can be added into the high-frequency melting furnace, and heated to melt

in the melting furnace. The temperature can be elevated to 1000-1050 °C, and even up to 1100 °C, for 5-10 minutes, so that the copper-manganese alloy is melt into a copper-manganese alloy melt. With these actions, it is possible to prevent the melt copper manganese from absorbing a lot of external gases (due to a too high temperature), which may otherwise result in cracking in the molded alloy.

Step S104: decreasing the temperature of the copper-manganese alloy melt to 950-1000 °C. In this step, when the temperature in the melting furnace is elevated to 1000-1050 °C for a duration of 5-10 minutes, the power supply of the high-frequency melting furnace is turned off, so that the temperature in the melting furnace is reduced to 950-1000 °C, while the copper-manganese alloy melt is maintained in the melt state.

Step S106: covering the surface of copper-manganese alloy melt with a glass slagging agent. In this step, the surface of copper-manganese alloy melt is covered with the glass slagging agent at 950-1000 °C. This step can effectively prevent the melt from contacting the air, and prevent zinc to be added in the next step from boiling and evaporating due to melting at a high temperature of 950-1000 °C.

Step S108: adding zinc to the copper-manganese alloy melt to form a copper-manganese-zinc melt. In this step, zinc is added to the melting furnace, and is immersed into the copper-manganese alloy melt, so that zinc is sufficiently melt in the copper-manganese alloy melt to form a copper-manganese-zinc melt.

Step S110: deslagging the copper-manganese-zinc melt. In this step, the copper-manganese-zinc melt can be stirred and mixed under the action high-frequency induction, and then the slagging agent can be removed. Then, the copper-manganese-zinc melt is deslagged with a deslagging agent.

Step S112: adding antimony, aluminum, tin, and magnesium to the copper-manganese-zinc melt to form a metal melt. In this step, copper antimony precursor alloy, copper aluminum precursor alloy, copper tin precursor alloy, and copper magnesium alloy can be added to the copper-manganese-zinc melt.

Step S114: elevating the temperature of the metal melt to 1000-1050 °C, and adding copper boron alloy and phosphorus copper alloy to form a lead-free bismuth-free silicon-free brass alloy melt.

Step S116: discharging the brass alloy melt for casting to form the brass alloy. In this step, the brass alloy melt is stirred evenly, the discharging temperature is controlled at 1000-1050 °C, and finally the brass alloy melt is discharged to casting a lead-free bismuth-free silicon-free brass alloy which exhibits good processability, dezincification resistance, and mechanical performance.

Embodiment 1

[0047] Table 1-1 lists inventive products 1 with 5 different constituents which are fabricated with the above process, which are respectively numbered as 1001-1005, each constituent being in the unit of weight percentage (wt%).

Table 1-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)
1001	62.605	36.839	0.254	0.010
1002	64.355	34.819	0.402	0.022
1003	65.000	34.198	0.100	0.150
1004	60.000	39.373	0.122	0.103
1005	61.005	38.040	0.500	0.143

[0048] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0049] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
1001	348	12	⊙	○
1002	367	11	⊙	⊙
1003	275	21	○	⊙

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(continued)

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
1004	281	13	○	○
1005	328	15	○	⊙
C36000 alloy	394	9	✕	⊙

Embodiment 2

[0050] Table 2-1 lists inventive products 2 with 5 different constituents which are fabricated with the above process, which are respectively numbered as 2001-2005, each constituent being in the unit of weight percentage (wt%).

Table 2-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	phosphorus (P)
2001	60.000	39.044	0.352	0.012	----	0.300
2002	64.501	34.340	0.403	0.010	0.302	0.152
2003	63.522	35.226	0.500	0.150	0.050	----
2004	65.000	34.144	0.220	0.132	0.252	0.050
2005	61.522	37.173	0.100	0.051	0.500	0.252

[0051] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0052] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
2001	368	12	⊙	⊙
2002	367	11	⊙	⊙
2003	335	21	⊙	⊙
2004	381	13	⊙	⊙
2005	308	15	⊙	○
C36000 alloy	394	9	✕	⊙

Embodiment 3

[0053] Table 3-1 lists inventive products 3 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 3001-3008, each constituent being in the unit of weight percentage (wt%).

Table 3-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	aluminum (Al)	tin (Sn)	manganese (Mn)	phosphorus (P)	boron (B)
3001	63.502	35.309	0.103	0.018	0.500	0.052	0.050	0.173	0.001
3002	60.000	37.758	0.500	0.047	0.522	0.500	0.051	0.252	-----
3003	65.221	33.233	0.487	0.010	0.622	0.050	0.032	0.050	0.010
3004	63.523	34.577	0.273	0.095	0.303	0.351	0.067	0.300	0.008
3005	63.210	34.673	0.100	0.032	0.700	-----	0.500	0.178	0.004
3006	65.000	33.244	0.211	0.150	0.352	0.235	0.253	-----	0.003
3007	60.351	38.339	0.195	0.111	-----	0.111	0.488	0.203	-----
3008	60.132	38.716	0.107	0.100	0.100	-----	0.231	0.210	0.002

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[0054] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0055] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
3001	368	12	⊙	⊙
3002	357	11	⊙	⊙
3003	335	13	⊙	⊙
3004	381	11	⊙	⊙
3005	388	10	⊙	⊙
3006	363	11	⊙	⊙
3007	323	15	⊙	○
3008	319	17	○	⊙
C36000 alloy	394	9	✕	⊙

Embodiment 4

[0056] Table 4-1 lists inventive products 4 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 4001-4008, each constituent being in the unit of weight percentage (wt%).

Table 4-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus(P)	boron (B)
4001	61.833	37.142	0.302	0.011	0.050	0.155	0.050	0.155	----
4002	62.501	36.327	0.253	0.015	----	0.200	0.355	0.050	0.008
4003	60.000	38.425	0.271	0.122	0.053	0.100	0.500	0.179	0.010
4004	65.000	32.643	0.500	0.010	0.253	0.534	0.454	0.300	0.005
4005	63.550	34.411	0.233	0.045	0.500	0.653	0.300	----	0.006
4006	60.221	37.902	0.244	0.150	----	0.700	----	0.222	0.009
4007	62.324	35.999	0.135	0.135	0.488	----	0.183	0.214	----
4008	64.049	34.511	0.100	0.052	0.325	0.454	0.143	0.063	0.001

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[0057] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0058] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
4001	368	12	⊙	⊙
4002	327	11	⊙	⊙
4003	335	21	⊙	⊙
4004	381	13	⊙	⊙
4005	388	10	⊙	⊙
4006	377	13	⊙	⊙
4007	301	10	⊙	⊙
4008	391	9	⊙	⊙
C36000 alloy	394	9	×	⊙

Embodiment 5

[0059] Table 5-1 lists inventive products 5 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 5001-5008, each constituent being in the unit of weight percentage (wt%).

Table 5-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)	boron (B)
5001	61.800	37.014	0.231	0.023	0.054	0.100	0.500	0.066	0.010
5002	62.472	36.526	0.207	0.010	0.108	----	0.325	0.052	----
5003	60.000	38.549	0.100	0.113	0.500	----	0.486	0.050	----
5004	62.731	36.021	0.137	0.141	0.192	0.118	0.050	0.194	0.005
5005	62.498	35.400	0.273	0.150	----	0.700	0.416	----	0.001
5006	64.032	34.578	0.186	0.013	0.067	0.328	0.377	0.104	0.004
5007	65.000	33.937	0.262	0.109	0.050	---	0.337	0.103	----
5008	64.855	32.526	0.500	0.072	0.452	0.676	----	0.300	0.008

[0060] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0061] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
5001	368	12	⊙	⊙
5002	297	11	⊙	⊙
5003	335	21	⊙	⊙

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(continued)

No.	TENSILE STRENGTH (N/ mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
5004	371	13	⊙	⊙
5005	328	15	⊙	⊙
5006	358	13	⊙	⊙
5007	383	12	⊙	⊙
5008	385	10	⊙	⊙
C36000 alloy	394	9	✕	⊙

Embodiment 6

[0062] Table 6-1 lists inventive products 6 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 6001-6008, each constituent being in the unit of weight percentage (wt%).

Table 6-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)	boron (B)	nickel (Ni)	chrome (Cr)	iron (Fe)
6001	61.030	37.482	0.332	0.133	-----	0.132	0.500	0.080	0.008	-----	-----	0.003
6002	64.501	33.966	0.227	0.120	0.500	-----	0.076	0.050	0.009	-----	0.144	0.007
6003	63.000	35.380	0.150	0.010	0.321	0.100	0.400	0.222	0.001	0.005	0.098	0.023
6004	62.231	36.218	0.100	0.032	-----	0.602	-----	0.300	0.010	-----	0.007	-----
6005	62.875	34.945	0.432	0.088	0.431	0.540	0.050	-----	0.007	0.021	-----	0.011
6006	65.000	33.696	0.378	0.117	0.311	-----	0.087	0.077	-----	0.009	0.112	0.013
6007	63.740	33.472	0.436	0.150	0.101	0.700	0.342	0.093	0.005	0.250	0.150	-----
6008	60.000	37.735	0.500	0.093	0.050	0.687	-----	0.103	0.009	0.007	-----	0.250

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[0063] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0064] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
6001	355	13	⊙	⊙
6002	398	10	⊙	⊙
6003	391	11	⊙	⊙
6004	337	13	⊙	⊙
6005	322	16	⊙	⊙
6006	383	13	⊙	⊙
6007	337	12	⊙	⊙
6008	301	17	⊙	⊙
C36000 alloy	394	9	×	⊙

Embodiment 7

[0065] Table 7-1 lists inventive products 7 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 7001-7008, each constituent being in the unit of weight percentage (wt%).

Table 7-1

No.	copper (Cu)	zinc (Zn)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)
7001	62.000	37.596	0.050	0.207	0.050	0.095
7002	63.431	35.903	0.223	0.332	0.109	----
7003	61.118	38.160	0.217	0.100	0.403	----
7004	60.000	39.525	----	0.157	0.233	0.083
7005	63.043	35.974	0.431	----	0.500	0.050
7006	65.000	33.620	0.500	0.541	0.337	----
7007	62.043	36.929	0.087	0.432	0.207	0.300
7008	64.754	33.867	0.093	0.700	0.331	0.253

[0066] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0067] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
7001	311	12	⊙	⊙
7002	352	11	⊙	⊙
7003	365	21	⊙	⊙

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(continued)

No.	TENSILE STRENGTH (N/ mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
7004	334	13	⊙	⊙
7005	295	11	○	⊙
7006	293	10	○	⊙
7007	354	12	⊙	⊙
7008	389	10	⊙	⊙
C36000 alloy	394	9	✕	⊙

Embodiment 8

[0068] Table 8-1 lists inventive products 8 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 8001-8008, each constituent being in the unit of weight percentage (wt%).

Table 8-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)	boron (B)
8001	63.120	35.186	0.450	0.150	0.055	0.350	0.050	0.087	---
8002	60.000	39.184	0.100	----	0.105	0.231	0.377	----	0.001
8003	61.157	37.521	0.243	0.050	0.374	0.100	0.094	0.050	0.009
8004	62.300	36.508	----	0.010	----	0.493	0.178	0.211	0.008
8005	62.138	35.691	0.500	0.130	0.109	0.700	0.203	0.300	0.007
8006	65.000	33.526	0.337	----	0.500	0.337	0.095	0.198	0.005
8007	63.433	34.703	0.295	0.075	0.089	0.205	0.500	0.188	0.010
8008	63.064	35.416	0.250	0.053	0.050	----	0.498	0.067	----

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[0069] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0070] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
8001	374	12	⊙	⊙
8002	299	24	○	⊙
8003	310	19	⊙	⊙
8004	311	13	⊙	⊙
8005	399	15	⊙	⊙
8006	384	10	⊙	⊙
8007	367	11	⊙	⊙
8008	353	14	⊙	⊙
C36000 alloy	394	9	✕	⊙

Embodiment 9

[0071] Table 9-1 lists inventive products 9 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 9001-9008, each constituent being in the unit of weight percentage (wt%).

Table 9-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)	boron (B)	nickel (Ni)	chrome (Cr)	iron (Fe)
9001	60.321	38.107	0.453	0.078	---	0.293	0.085	0.056	---	---	---	0.007
9002	61.050	37.387	0.100	0.150	0.067	---	0.050	0.143	0.009	0.250	0.112	0.132
9003	62.223	36.093	0.118	0.053	0.500	0.100	0.055	---	0.001	0.148	0.008	0.201
9004	62.350	36.702	0.119	---	0.109	0.105	0.155	0.050	0.010	---	0.150	0.250
9005	65.000	32.675	0.500	0.010	0.237	0.700	0.207	0.287	0.007	0.087	---	---
9006	64.487	33.545	0.373	0.092	0.498	0.583	0.211	---	0.005	---	0.006	---
9007	60.000	38.051	---	0.147	---	0.473	0.500	0.300	0.004	0.009	0.103	0.113
9008	63.185	35.314	0.208	0.118	0.050	0.373	0.321	0.217	----	0.007	0.001	0.006

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[0072] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0073] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
9001	310	12	⊙	⊙
9002	318	11	⊙	⊙
9003	320	21	⊙	⊙
9004	341	13	⊙	⊙
9005	387	15	⊙	⊙
9006	379	13	⊙	⊙
9007	311	12	⊙	⊙
9008	386	10	⊙	⊙
C36000 alloy	394	9	✕	⊙

Embodiment 10

[0074] Table 10-1 lists inventive products 10 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 10001-10008, each constituent being in the unit of weight percentage (wt%).

Table 10-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)	boron (B)
10001	61.099	38.035	0.454	0.054	0.056				
10002	62.413	36.677	0.500	0.010	0.050		0.050		0.008
10003	60.073	39.148	0.198	0.076		0.203			
10004	60.000	38.183	0.231	0.075	0.432	0.100	0.310	0.067	
10005	60.043	37.982	0.100	0.150	0.500	0.507	0.106	0.050	0.010
10006	63.661	34.510	0.307	0.100	0.108	0.700		0.203	0.009
10007	65.000	33.440	0.273	0.054	0.310	0.432	0.088		0.001
10008	64.398	33.251	0.203	0.073	0.298	0.670	0.500	0.300	0.005

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[0075] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0076] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
10001	301	22	⊙	⊙
10002	323	11	⊙	⊙
10003	300	20	⊙	⊙
10004	311	13	⊙	⊙
10005	320	10	⊙	⊙
10006	379	13	⊙	⊙
10007	387	12	⊙	⊙
10008	396	10	⊙	⊙
C36000 alloy	394	9	✕	⊙

Embodiment 11

[0077] Table 11-1 lists inventive products 11 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 11001-11008, each constituent being in the unit of weight percentage (wt%).

Table 11-1

No.	copper (Cu)	zinc (Zn)	magnesium (Mg)	antimony (Sb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)	boron (B)	nickel (Ni)	chrome (Cr)	iron (Fe)
11001	61.113	38.185	0.105	0.130	---	---	0.079	0.067	---	---	---	0.021
11002	60.002	38.030	0.100	0.111	0.057	0.700	0.204	0.050	---	0.085	0.111	0.250
11003	60.000	39.013	0.213	0.105	0.050	---	---	0.134	0.001	0.250	---	0.034
11004	64.322	33.670	0.322	0.010	0.107	0.455	0.500	0.233	0.007	---	0.084	---
11005	65.000	33.355	0.206	0.059	---	0.100	0.344	---	0.010	0.101	0.015	0.210
11006	63.122	34.726	0.500	0.031	0.500	0.104	0.050	0.300	0.009	0.044	0.009	0.005
11007	62.397	35.662	0.493	0.044	0.432	0.233	---	---	0.005	0.197	0.030	0.007
11008	64.920	32.869	0.405	0.150	0.210	0.653	0.133	0.095	0.008	0.007	---	---

[0078] Measurements about cutting performance, dezincification corrosion resistant performance, tensile strength, and elongation rate are performed on alloys with the above constituents in the cast state at room temperature, and the reference sample is a lead-containing brass with the same state and specification, i.e., C36000 alloy.

[0079] Results of the measurements about tensile strength, elongation rate, cutting performance, and dezincification corrosion resistant performance are listed as follow:

No.	TENSILE STRENGTH (N/mm ²)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
11001	317	13	⊙	⊙
11002	320	12	⊙	⊙
11003	305	18	⊙	⊙
11004	374	13	⊙	⊙
11005	378	15	⊙	⊙
11006	381	13	⊙	⊙
11007	369	12	⊙	⊙
11008	391	10	⊙	⊙
C36000 alloy	394	9	×	⊙

[0080] As can be seen, the lead-free bismuth-free silicon-free brass alloy of the invention can be formed by adding various constituents in respective ratio, and then subjecting them to a process in a high-frequency melting furnace. The resulting brass alloy has a mechanical processability which is comparable with that of the existing lead-containing brass, has an excellent tensile strength, elongation rate, and dezincification resistance, and is lead-free. As a result, the brass alloy is suitable for replacing the existing lead-containing brass alloy and for producing parts like faucet and sanitary ware.

[0081] Although the invention has been described with respect to embodiments there of, these embodiments do not intend to limit the invention. The ordinary skilled in the art can made modifications and changes to the invention without departing from the spirit and scope of the invention. Thus, the protection of the invention is defined by the appended claims.

Claims

1. A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance, **characterized by** comprising: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium, and a balance of zinc.
2. The brass alloy of claim 1, **characterized by** further comprising: 0.05-0.3 wt% phosphorus and/or 0.05-0.5 wt% manganese by the total weight of the brass alloy.
3. The brass alloy of claim 1, **characterized by** further comprising: 0.05-0.5 wt% manganese, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus and/or 0.001-0.01 wt% boron by the total weight of the brass alloy.
4. The brass alloy of claim 3, **characterized in that** a total content of manganese, aluminum, tin, phosphorus and/or boron is not larger than 2 wt% of the total weight of the brass alloy.
5. The brass alloy of claim 4, **characterized in that** a total content of manganese, aluminum, tin, phosphorus and/or boron is not less than 0.2 wt% of the total weight of the brass alloy.
6. The brass alloy of claim 3, **characterized by** further comprising: unavoidable impurities which comprise, by the total weight of the brass alloy, 0.25 wt% or less nickel, 0.15 wt% or less chrome and/or 0.25 wt% or less iron.
7. A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance, **characterized by** comprising: by the total weight of the brass alloy, 60-65 wt% copper, 0.05-0.5 wt% tin, and two or more elements selected from the group consisting of 0.1-0.7 wt% aluminum, 0.05-0.3 wt% phosphorus and 0.05-0.5 wt% manganese by the total

weight of the brass alloy, and a balance of zinc.

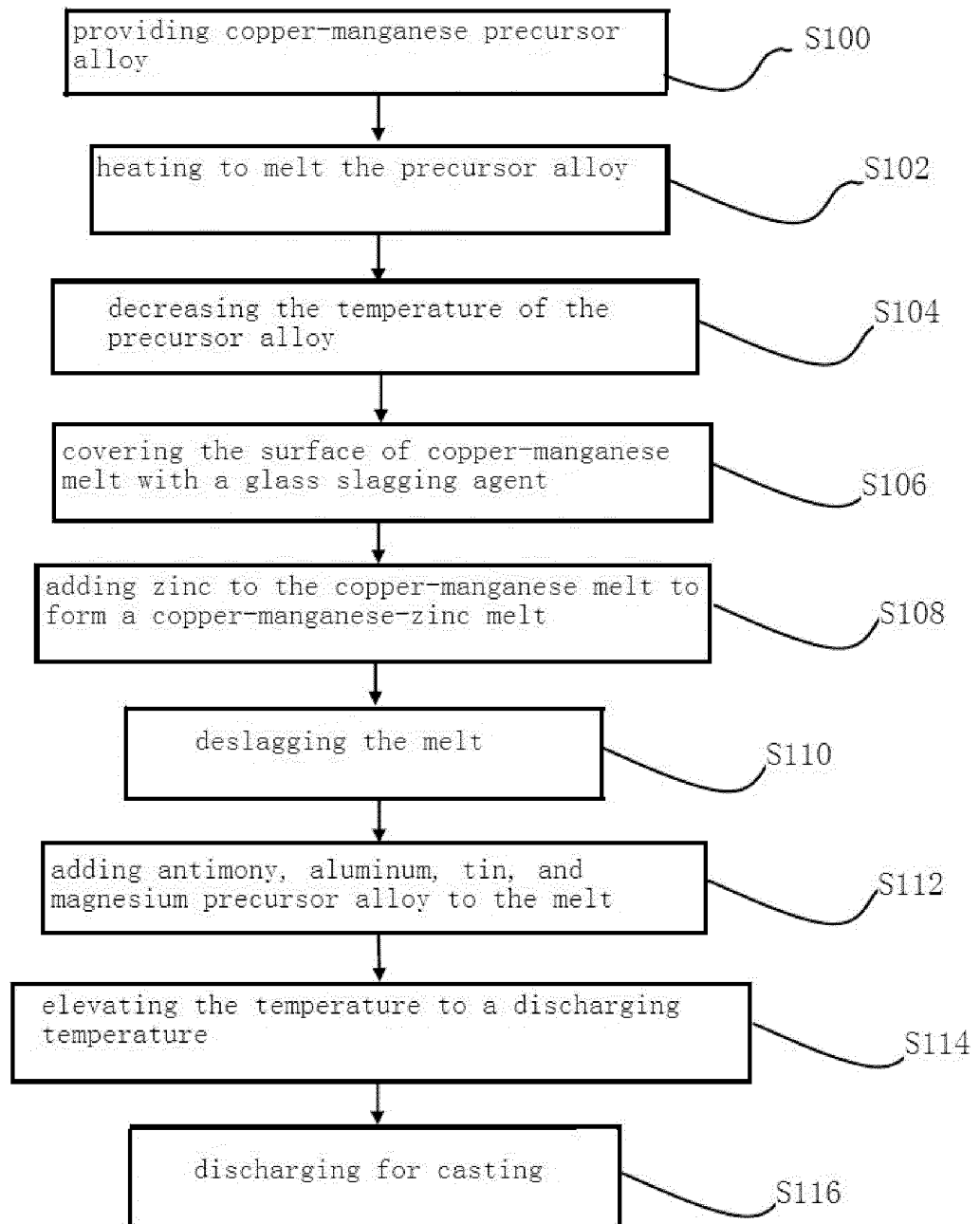
8. The brass alloy of claim 7, **characterized by** further comprising: 0.01-0.15 wt% antimony, 0.1-0.5 wt% magnesium and/or 0.001-0.01 wt% boron by the total weight of the brass alloy.

9. The brass alloy of claim 8, **characterized by** further comprising: unavoidable impurities which comprise, by the total weight of the brass alloy, 0.25 wt% or less nickel, 0.15 wt% or less chrome and/or 0.25 wt% or less iron.

10. A lead-free bismuth-free silicon-free brass alloy with excellent cutting performance, **characterized by** comprising: by the total weight of the brass alloy, 60-65 wt% copper, 0.01-0.15 wt% antimony and 0.1-0.5 wt% magnesium, and one or more element selected from the group consisting of 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus, 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron by the total weight of the brass alloy, and a balance of zinc.

11. The brass alloy of claim 10, **characterized by** further comprising: unavoidable impurities which comprise, by the total weight of the brass alloy, 0.25 wt% or less nickel, 0.15 wt% or less chrome and/or 0.25 wt% or less iron.

Figure 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2014/074942

A. CLASSIFICATION OF SUBJECT MATTER

C22C 9/04 (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)

IPC: C22C 9/-

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

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

CNPAT, CNKI, WPI, EPODOC, WANFANG: cut+, machin+, Sb, antimony, stibium, Mg, Magnesium, Sn, tin, stannum, Mn, Manganese, Manganous, Manganum, Mangan, Al, Aluminium, Aluminum, P, phosphorus

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101423905 A (ZHEJIANG HAILIANG CO., LTD. et al.), 06 May 2009 (06.05.2009), claims 1, 2, and 4-8	1-6, 10, 11
Y	CN 101423905 A (ZHEJIANG HAILIANG CO., LTD. et al.), 06 May 2009 (06.05.2009), claims 1, 2, and 4-8	8, 9
X	TW 201100564 A (CHAN WEN COPPER INDUSTRY CO., LTD.), 01 January 2011 (01.01.2011), claims 2 and 5	7
Y	TW 201100564 A (CHAN WEN COPPER INDUSTRY CO., LTD.), 01 January 2011 (01.01.2011), claims 2 and 5	8, 9
A	CN 101298643 A (CHINALCO LUOYANG COPPER CO., LTD.), 05 November 2008 (05.11.2008), the whole document	1-11
A	CN 103205597 A (MODERN ISLAND CO., LTD.), 17 July 2013 (17.07.2013), the whole document	1-11

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

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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5	Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
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	TW 201100564 A	01 January 2011	None	
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