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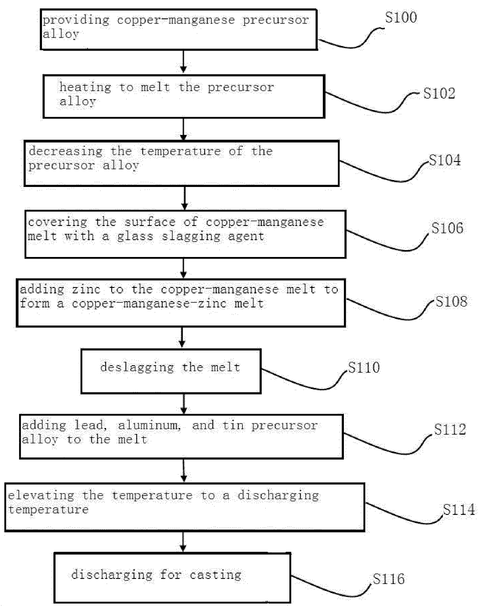
(54) LOW-LEAD BISMUTH-FREE SILICONE-FREE BRASS

(57) The invention relates to a low-lead bismuth-free silicon-free brass alloy with excellent cutting performance, comprising, by the total weight of the brass alloy, 60-65 wt% copper, 0.1-0.25 wt% lead, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, one or more element selected from the group consisting of 0.05-0.3 wt% phosphorus, 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron, and a balance of zinc.

Figure 1



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Description

FIELD OF INVENTION

[0001] The invention relates to a low-lead brass alloy, and particularly to a brass alloy which is both free cutting and resistant to dezincification.

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.

SU MMARY 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 low-lead bismuth-free silicon-free brass alloys.

[0009] A low-lead 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, 0.1-0.25 wt% lead, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, and a balance of zinc.

[0010] In the inventive product 1, the content of lead is reduced to 0.1-0.25 wt%, the content of copper is controlled at 60-65 wt%, and a small quantity of aluminum and tin is added to improve cutting performance of the alloy. 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.

[0011] Adding tin into the alloy can form γ phase, thus increasing cutting performance of the alloy. In addition, the addition of tin obviously increases strength, plasticity, and corrosion resistance of 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.

[0012] A low-lead 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, 0.1-0.25 wt% lead, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, and further comprises 0.05-0.5 wt% manganese and/or 0.05-0.3 wt% phosphorus, 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. Although phosphorus can't form γ phase, phosphorus has a function of facilitating a good distribution of γ phase, 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 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 will be affected adversely. Adding manganese helps to improve dezincification resistance and cast flowability. 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 low-lead 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, 0.1-0.25 wt% lead, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, and further comprises one or more element selected from the group consisting of 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.

[0015] As compared with the inventive product 2, the inventive product 3 is further added with trace boron, so as to better suppress alloy dezincification, increase the mechanical strength, and 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.

[0016] A low-lead 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, 0.1-0.25 wt% lead, 0.1-0.7 wt% aluminum, 0.05-0.5 wt% tin, 0.05-0.3 wt% phosphorus, and further comprises 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron, and a balance of zinc.

[0017] The effects of lead, aluminum, tin, phosphorus, manganese and boron elements in the brass alloy have been discussed above. By adding these elements into the brass alloy simultaneously, it is possible to further increase mechanical performance of alloy so as to meet needs for products with strict requirements.

[0018] A low-lead 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, 0.1-0.25 wt% lead, 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 further comprises 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.

[0019] As compared with the inventive product 4, the inventive product 5 further comprises some unavoidable impurities, i.e., mechanical impurities of nickel, chrome and/or iron.

[0020] A low-lead 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, 0.1-0.25 wt% lead, 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, wherein a total content of aluminum, tin, phosphorus, manganese and boron is not larger than 2 wt% of the total weight of the brass alloy.

[0021] A low-lead 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, 0.1-0.25 wt% lead, 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, wherein a total content of aluminum, tin, phosphorus, manganese and boron is 0.2-2 wt% of the total weight of the brass alloy.

[0022] A low-lead 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, 0.1-0.25 wt% lead, 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, 0.05-0.5 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.

[0023] Whether 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.

[0024] A low-lead 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, 0.1-0.25 wt% lead, 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, 0.05-0.5 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 further comprises 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.

[0025] 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.

[0026] A low-lead 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, 0.1-0.25 wt% lead, 0.05-0.5 wt% tin and 0.05-0.3 wt% phosphorus, and a balance of zinc.

[0027] The content of phosphorus in the inventive product 10 has the same interval and effect as that in the inventive product 2. Although phosphorus can't form γ phase, phosphorus has a function of facilitating a good distribution of γ phase. 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. Thus, even if there is no aluminum, the needs for cutting performance can still be met in the usual production situation.

[0028] A low-lead 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, 0.1-0.25 wt% lead, 0.05-0.5 wt% tin and 0.05-0.3 wt% phosphorus, and further comprises two or more elements selected from the group consisting of 0.1-0.7 wt% aluminum, 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.

[0029] Whether aluminum, 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.

[0030] A low-lead bismuth-free silicon-free brass alloy with excellent cutting performance (hereinafter referred to as the inventive product 12) comprises, by the total weight of the brass alloy, 60-65 wt% copper, 0.1-0.25 wt% lead, 0.05-0.5 wt% tin and 0.05-0.3 wt% phosphorus, two or more elements selected from the group consisting of 0.1-0.7 wt% aluminum, 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron by the total weight of the brass alloy, and further comprises 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, and a balance of zinc.

[0031] As compared with the inventive product 11, the inventive product 12 further comprises some unavoidable impurities, i.e., mechanical impurities of nickel, chrome and/or iron.

[0032] The invention further provides a method for fabricating brass alloy. By taking 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 lead, aluminum, tin 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 low-lead bismuth-free silicon-free brass alloy melt; and
7) discharging the brass alloy melt for casting to form the brass alloy.

[0033] Preferably, in the above fabricating method, a copper-manganese alloy is provided as the precursor of copper and manganese elements.

[0034] 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.

[0035] 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.

[0036] In the invention, the low-lead 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 has a low content of lead. 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

[0037] Fig. 1 is a flow chart illustrating a method for fabricating the inventive product 3.

DETAILED DESCRIPTION

[0038] The technical solutions of the invention will be described expressly by referring to embodiments thereof.

[0039] 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.

[0040] In the invention, the wording "or more", "or less" in the expression for describing values indicates that the expression comprises the relevant values.

[0041] 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 X indicates a dezincification depth larger than 200 μm.

[0042] 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 alloyis taken as a reference. The relative cutting rate is derived by measuring the cutting resistance.

[0043] The relative cutting rate = cutting resistance of C36000 alloy/cutting resistance of the sample.

[0044] ◎ indicates a relative cutting rate larger than 85%; and ○ indicates a relative cutting rate larger than 70%.

[0045] 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.

[0046] According to measurement, the proportions for constituents of C36000 alloyare 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

[0047] Fig. 1 is a flow chart illustrating a method for fabricating 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 durationi 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 lead, aluminum, and tin to the copper-manganese-zinc melt to form a metal melt. In this step, copper lead precursor alloy, copper aluminum precursor alloy, and copper tin precursor 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 low-lead 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 low-lead bismuth-free silicon-free brass alloy which exhibits good processability, dezincification resistance, and mechanical performance.

Embodiment 1

[0048]

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)	lead (Pb)	aluminum (Al)	tin (Sn)
1001	63.633	35.559	0.235	0.231	0.340
1002	64.365	34.183	0.250	0.700	0.500
1003	62.345	36.943	0.110	0.300	0.300
1004	65.000	34.424	0.100	0.424	0.050
1005	60.000	39.445	0.108	0.100	0.345

[0049] 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.

[0050] 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	366	23	◎	◎
1002	387	21	◎	◎
1003	325	27	◎	◎
1004	387	25	◎	◎
1005	295	35	○	◎
C36000 alloy	394	9	×	◎

Embodiment 2

[0051] 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)	lead (Pb)	aluminum (Al)	tin (Sn)	manganese (Mn)	phosphorus (P)
2001	60.000	39.137	0.144	0.312	0.055	0.050	0.300
2002	64.307	34.305	0.214	0.700	0.320	----	0.152
2003	62.221	37.467	0.250	0.521	0.089	0.500	0.050
2004	65.000	32.662	0.213	0.685	0.500	0.432	----
2005	61.331	37.922	0.100	0.100	0.050	0.443	0.252

[0052] 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.

[0053] 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	338	23	◎	◎
2002	307	19	◎	◎
2003	375	31	○	◎
2004	381	29	◎	◎
2005	308	17	○	◎
C36000 alloy	394	9	×	◎

Embodiment 3

[0054] 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)	lead (Pb)	aluminum (Al)	tin (Sn)	manganese (Mn)	phosphorus (P)	boron (B)
3001	62.400	36.395	0.220	0.542	0.152	----	0.288	0.001
3002	60.000	39.245	0.100	0.163	0.406	0.075	----	0.009
3003	64.221	34.422	0.122	0.344	0.500	0.332	0.050	0.007
3004	63.443	35.250	0.203	0.700	0.351	0.050	----	0.001
3005	63.766	34.967	0.200	0.698	0.081	----	0.286	----
3006	64.250	35.061	0.152	0.100	0.130	----	0.300	0.005
3007	60.355	38.534	0.250	0.311	0.050	0.488	----	0.010
3008	65.000	34.110	0.100	0.211	0.077	0.500	----	----

[0055] 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.

[0056] 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	348	19	◎	◎
3002	359	17	◎	◎
3003	385	15	◎	◎
3004	379	26	◎	◎
3005	389	18	◎	◎
3006	392	27	◎	◎
3007	311	39	◎	◎
3008	303	30	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 4

[0057] 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)	lead (Pb)	aluminum (Al)	tin (Sn)	manganese (Mn)	phosphorus (P)	boron (B)
4001	61.306	37.387	0.205	0.650	0.050	0.093	0.300	0.007
4002	61.560	37.539	0.100	0.165	0.413	0.170	0.050	0.001
4003	63.750	35.015	0.193	0.371	0.500	0.057	0.107	0.005
4004	62.105	36.704	0.211	0.502	0.333	0.050	0.083	0.010
4005	65.000	33.232	0.202	0.700	0.085	0.487	0.286	0.006
4006	62.950	35.663	0.188	0.304	0.132	0.498	0.260	0.003
4007	60.000	38.802	0.250	0.387	0.111	0.138	0.300	0.010
4008	61.432	37.539	0.135	0.100	0.050	0.500	0.234	0.008

[0058] 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.

[0059] 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	302	29	◎	◎
4002	319	19	◎	◎
4003	383	23	◎	◎
4004	344	26	◎	◎
4005	389	27	◎	◎
4006	332	37	◎	◎
4007	311	39	◎	◎

(continued)

No.	TENSILE STRENGTH (N/ mm^2)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
4008	303	20	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 5

[0060] 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)	lead (Pb)	manganese (Mn)	alumin um (Al)	tin (Sn)	phosphorus (P)	boron (B)	nickel (Ni)	chrome (Cr)	iron (Fe)
5001	61.783	37.673	0.100	0.067	0.155	0.050	0.105	0.002	---	0.065	---
5002	62.344	36.864	0.187	0.056	0.267	0.063	0.050	0.001	0.010	0.150	0.008
5003	65.000	33.638	0.250	0.500	0.100	0.172	0.211	0.010	0.007	0.097	0.015
5004	62.271	36.191	0.147	0.324	0.156	0.500	0.300	0.007	0.104	---	---
5005	64.033	34.003	0.195	0.211	0.545	0.433	0.240	0.005	---	0.085	0.250
5006	63.078	34.939	0.179	0.085	0.700	0.408	0.177	0.001	0.250	0.073	0.110
5007	63.730	34.926	0.188	0.050	0.398	0.383	0.285	0.006	---	0.034	---
5008	60.000	38.865	0.158	0.075	0.400	0.217	0.102	0.008	0.062	0.008	0.105

[0061] 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.

[0062] 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	312	19	◎	◎
5002	319	21	◎	◎
5003	390	30	◎	◎
5004	334	17	◎	◎
5005	389	18	◎	◎
5006	337	25	◎	◎
5007	321	19	◎	◎
5008	301	21	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 6

[0063] 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)	lead (Pb)	manganese (Mn)	aluminum (Al)	tin (Sn)	phosphorus (P)	boron (B)
6001	62.311	37.687	0.103	0.105	0.100	0.050	0.211	0.009
6002	60.000	39.824	0.117	0.057	0.322	0.121	0.300	0.010
6003	62.052	37.195	0.201	0.050	0.203	0.234	0.055	0.008
6004	62.261	36.613	0.250	0.213	0.104	0.500	0.050	0.007
6005	64.075	34.316	0.207	0.304	0.556	0.432	0.103	0.005
6006	63.011	35.151	0.184	0.500	0.607	0.331	0.213	0.001
6007	65.000	33.371	0.197	0.443	0.700	0.087	0.198	0.002
6008	60.079	39.028	0.100	0.116	0.433	0.102	0.137	0.003

[0064] 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.

[0065] 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	344	30	◎	◎
6002	313	31	◎	◎
6003	340	27	◎	◎

(continued)

No.	TENSILE STRENGTH (N/ mm^2)	ELONGATION RATE (%)	DEZINCIFICATION LAYER	RELATIVE CUTTING RATE
6004	399	17	◎	◎
6005	351	21	◎	◎
6006	339	23	◎	◎
6007	355	19	◎	◎
6008	307	21	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 7

[0066] 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)	lead (Pb)	manganes e (Mn)	aluminum (Al)	tin (Sn)	phosphoru s (P)	boron (B)
7001	60.231	38.981	0.100	0.341	0.112	0.103	0.122	0.008
7002	61.054	38.264	0.196	0.117	0.231	0.076	0.050	0.010
7003	62.013	36.904	0.133	0.500	0.100	0.050	0.292	0.006
7004	62.613	35.805	0.100	0.493	0.540	0.143	0.300	0.004
7005	65.000	33.525	0.211	0.050	0.631	0.500	0.076	0.005
7006	63.011	35.287	0.250	0.210	0.700	0.410	0.123	0.007
7007	60.000	38.747	0.201	0.077	0.487	0.377	0.100	0.009
7008	61.123	37.779	0.197	0.192	0.391	0.218	0.097	0.001

[0067] 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.

[0068] 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 (%)	DEZINCIFICA TION LAYER	RELATIVE CUTTING RATE
7001	327	23	◎	◎
7002	332	17	◎	◎
7003	341	18	◎	◎
7004	354	31	◎	◎
7005	397	37	◎	◎
7006	393	39	◎	◎
7007	300	28	◎	◎
7008	301	27	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 8

[0069] 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)	lead (Pb)	manganes e (Mn)	aluminum (Al)	tin (Sn)	phosphoru s(P)	boron (B)
8001	60.000	39.615	0.105	0.052	0.123	---	0.102	0.001
8002	62.031	37.395	0.197	0.121	0.100	0.102	0.050	----
8003	62.178	36.995	0.250	0.455	---	0.112	---	0.008
8004	65.000	33.839	0.100	0.500	0.341	0.050	0.158	0.010
8005	64.175	35.328	0.211	---	---	---	0.277	0.007
8006	64.097	34.142	0.233	0.314	0.407	0.500	0.300	0.005
8007	63.050	35.487	0.102	0.218	0.518	0.411	0.212	---
8008	61.071	38.101	0.112	0050	0.700	---	---	0.009

[0070] 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.

[0071] 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 (%)	DEZINCIFICA TION LAYER	RELATIVE CUTTING RATE
8001	302	23	◎	◎
8002	311	27	◎	◎
8003	345	32	◎	◎
8004	342	24	◎	◎
8005	367	37	◎	◎
8006	366	29	◎	◎
8007	339	31	◎	◎
8008	307	27	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 9

[0072] 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)	lead (Pb)	mangan ese (Mn)	alumin um (Al)	tin (Sn)	phosph orus (P)	boron (B)	nickel (Ni)	chrome (Cr)	iron (Fe)
9001	61.058	38.409	0.112	---	---	0.098	0.073	----	---	---	0.250
9002	62.025	36.933	0.109	0.102	0.500	0.050	0.050	0.010	0.009	0.113	0.099
9003	60.000	39.554	0.100	0.050	---	---	---	0.007	0.215	---	0.074
9004	61.256	36.743	0.207	0.321	0.700	0.134	0.231	0.008	0.250	0.150	---
9005	65.000	34.019	0.198	0.076	0.100	---	0.300	----	0.125	0.078	0.104
9006	63.056	34.935	0.222	0.500	0.214	0.500	0.289	0.001	0.123	0.043	0.117
9007	63.340	35.447	0.250	---	0.566	---	0.250	0.004	0.143	---	---
9008	60.870	37.906	0.234	---	0.452	0.430	---	----	---	0.108	---

[0073] 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.

[0074] 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 (%)	DEZINCIFICA TION LAYER	RELATIVE CUTTING RATE
9001	317	27	◎	◎
9002	324	19	◎	◎
9003	303	17	◎	◎
9004	378	36	◎	◎
9005	389	17	◎	◎
9006	332	37	◎	◎
9007	391	39	◎	◎
9008	303	21	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 10

[0075] Table 10-1 lists inventive products 1 with 5 different constituents which are fabricated with the above process0, which are respectively numbered as 10001-10005, each constituent being in the unit of weight percentage (wt%).

Table 10-1

No.	copper (Cu)	zinc (Zn)	lead (Pb)	tin (Sn)	phosphorus (P)
10001	60.000	39.740	0.113	0.089	0.056
10002	62.345	37.272	0.100	0.050	0.231
10003	65.000	33.964	0.234	0.500	0.300
10004	61.983	37.366	0.247	0.324	0.078
10005	64.037	35.552	0.250	0.109	0.050

[0076] 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.

[0077] 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 (%)	DEZINCIFICA TION LAYER	RELATIVE CUTTING RATE
10001	300	29	◎	◎
10002	337	19	◎	◎
10003	389	33	◎	◎
10004	364	26	◎	◎
10005	379	27	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 11

[0078] 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)	lead (Pb)	manganes e (Mn)	aluminum (Al)	tin (Sn)	phosphoru s(P)	boron (B)
11001	63.521	36.133	0.119	0.098	----	0.067	0.050	0.010
11002	62.143	37.196	0.234	0.050	0.198	0.054	0.123	-----
11003	60.000	39.228	0.235	0.178	0.100	0.103	0.150	0.006
11004	63.015	35.844	0.200	----	0.655	0.050	0.231	0.003
11005	65.000	33.061	0.250	0.500	0.543	0.343	0.300	0.001
11006	61.197	37.214	0.179	0.377	0.433	0.500	0.098	-----
11007	61.132	37.588	0.150	0.236	0.231	0.476	0.178	0.007
11008	62.273	36.599	0.100	----	0.700	0.214	0.104	0.008

[0079] 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.

[0080] 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 (%)	DEZINCIFICA TION LAYER	RELATIVE CUTTING RATE
11001	361	23	◎	◎
11002	354	33	◎	◎
11003	317	39	◎	◎
11004	336	36	◎	◎
11005	401	41	◎	◎
11006	321	26	◎	◎
11007	300	23	◎	◎
11008	341	21	◎	◎
C36000 alloy	394	9	×	◎

Embodiment 12

[0081] Table 12-1 lists inventive products 12 with 8 different constituents which are fabricated with the above process, which are respectively numbered as 12001-12008, each constituent being in the unit of weight percentage (wt%).

Table 2-1

No.	copper (Cu)	zinc (Zn)	lead (Pb)	mangan ese (Mn)	alumin um (Al)	tin (Sn)	phosph orus (P)	boron (B)	nickel (Ni)	chrome (Cr)	iron (Fe)
12001	61.148	38.358	0.250	0.098	---	0.088	0.050	0.005	----	----	0.003
12002	62.434	36.989	0.123	0.050	0.102	0.103	0.076	0.001	0.122	----	----
12003	60.000	39.131	0.108	---	0.234	0.231	0.136	0.010	----	0.150	----
12004	60.166	38.272	0.197	0.232	---	0.455	0.220	0.007	0.250	0.098	0.103
12005	60.000	37.850	0.100	0.341	0.452	0.500	0.300	----	0.207	----	0.250
12006	62.126	36.129	0.102	0.500	0.100	0.341	0.276	0.006	0.198	0.109	0.113
12007	65.000	33.876	0.113	----	0.673	0.122	0.087	0.009	0.113	0.007	----
12008	61.430	37.130	0.150	0.476	0.700	0.050	0.059	----	----	0.004	0.001

[0082] 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.

[0083] 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 (%)	DEZINCIFICA TION LAYER	RELATIVE CUTTING RATE
12001	312	29	◎	◎
12002	317	19	◎	◎
12003	303	13	◎	◎
12004	314	16	◎	◎
12005	309	17	◎	◎
12006	332	28	◎	◎
12007	391	29	◎	◎
12008	311	21	◎	◎
C36000 alloy	394	9	×	◎

[0084] 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 has a low content of lead. 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.

[0085] Although the invention has been described with respect to embodiments thereof, 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 low-lead 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, 0.1-0.25 wt% lead, 0.1-0.7 wt% aluminum and 0.05-0.5 wt% tin, and a balance of zinc.

2. The brass alloy of claim 1, **characterized by** further comprising 0.05-0.5 wt% manganese and/or 0.05-0.3 wt% phosphorus by the total weight of the brass alloy.

3. The brass alloy of claim 1, **characterized by** further comprising one or more element selected from the group consisting of 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.

4. The brass alloy of claim 1, **characterized by** further comprising 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.

5. The brass alloy of claim 4, **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.

6. The brass alloy of claim 4, **characterized in that** a total content of manganese, aluminum, tin, phosphorus and boron is not larger than 2 wt% of the total weight of the brass alloy.

7. The brass alloy of claim 6, **characterized in that** the total content of manganese, aluminum, tin, phosphorus and

boron is not less than 0.1 wt% of the total weight of the brass alloy.

8. A low-lead 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, 0.1-0.25 wt% lead, two or more elements 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.

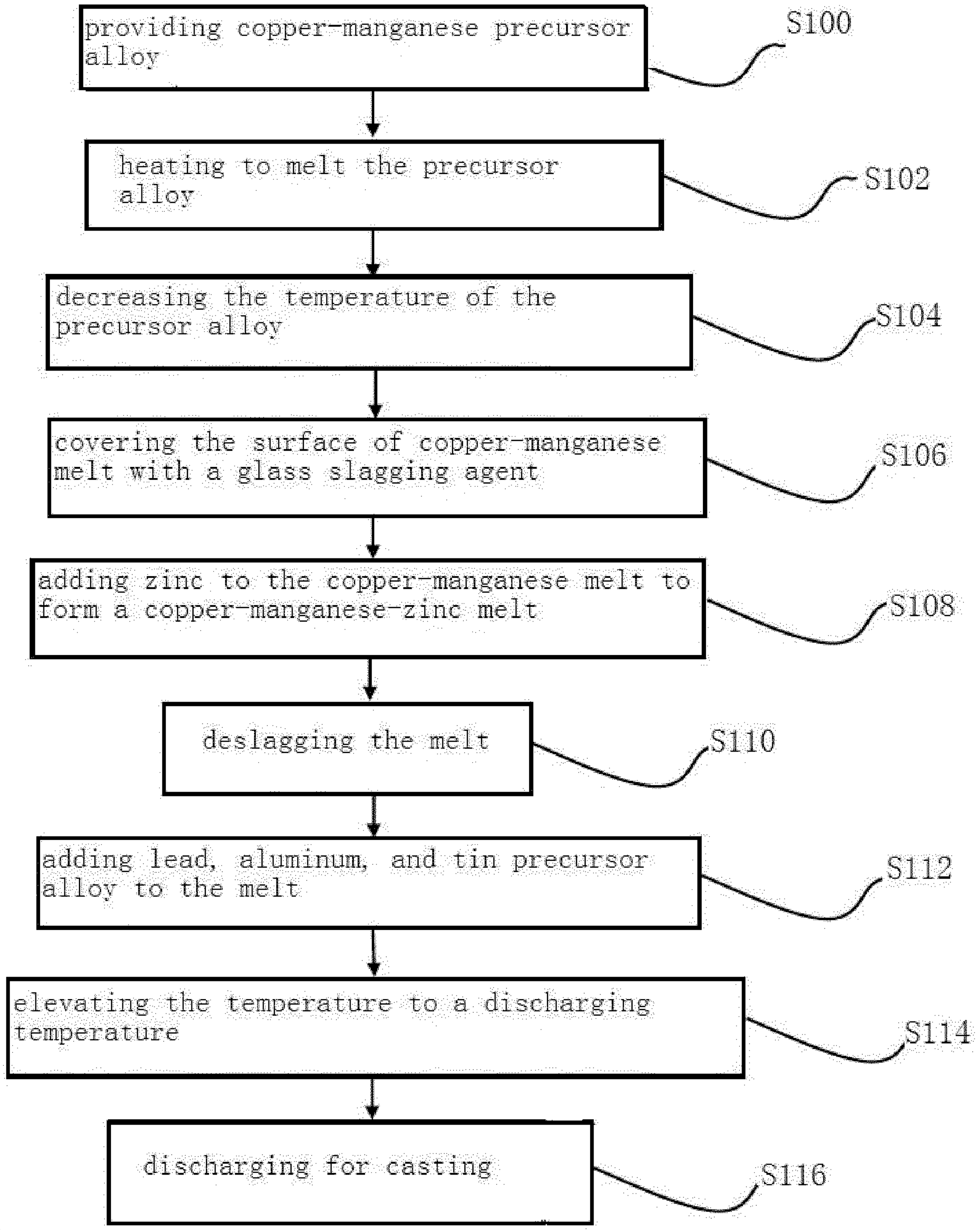
9. The brass alloy of claim 8, **characterized by** further comprising: unavoidable impurities which comprise, by the total weight of the brass alloy, 0.25 wt% or less nickel, 0.15 wt% or less chrome and/or 0.25 wt% or less iron.

10. A low-lead bismuth-free silicon-free brass alloy with excellent cutting performance, **characterized by** comprising: 60-65 wt% copper, 0.1-0.25 wt% lead, 0.05-0.5 wt% tin and 0.05-0.3 wt% phosphorus by the total weight of the brass alloy, and a balance of zinc.

11. The brass alloy of claim 10, **characterized by** further comprising two or more elements selected from the group consisting of 0.1-0.7 wt% aluminum, 0.05-0.5 wt% manganese and 0.001-0.01 wt% boron by the total weight of the brass alloy.

12. The brass alloy of claim 11, **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


providing copper-manganese precursor alloy
S100
heating to melt the precursor alloy
S102
decreasing the temperature of the precursor alloy
S104
covering the surface of copper-manganese melt with a glass slagging agent
S106
adding zinc to the copper-manganese melt to form a copper-manganese-zinc melt
S108
deslagging the melt
S110
adding lead, aluminum, and tin precursor alloy to the melt
S112
elevating the temperature to a discharging temperature
S114
discharging for casting
S116

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/074938

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: copper alloy, copper base alloy, Al, Sn, P, Pb, B, lead, aluminium, copper, aluminum, tin, phosphor, phosphorous, brass, boron

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 1461815 A (SAN-ETSU METALS CO., LTD.), 17 December 2003 (17.12.2003), claims 1 and 9	1-12
Y	CN 1557981 A (NINGBO POWERWAY GROUP CO., LTD.), 29 December 2004 (29.12.2004), description, page 3, paragraphs 1-3, and page 4, paragraph 6	1-12
A	CN 101440445 A (XIAMEN LOTA INTERNATIONAL CO., LTD.), 27 May 2009 (27.05.2009), abstract	1-12
A	US 5137685 A (OLIN CORP.), 11 August 1992 (11.08.1992), abstract	1-12
A	JP 2000239765 A (JOETSU MATERIAL KK), 05 September 2000 (05.09.2000), abstract	1-12

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

* Special categories of cited documents:

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 September 2014 (10.09.2014)	**30 September 2014 (30.09.2014)**

Name and mailing address of the ISA/CN:	Authorized officer
State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	**WANG, Jing** Telephone No.: (86-10) **82245714**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/074938

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