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(54) BRASS WITH IMPROVED DEZINCIFICATION RESISTANCE AND MACHINABILITY

MESSING MIT VERBESSERTEM ENTZINKUNGSWIDERSTAND UND VERBESSERTER BEARBEITBARKEIT

LAITON PRÉSENTANT UNE MEILLEURE RÉSISTANCE À LA DÉZINCIFICATION ET UNE MEILLEURE USINABILITÉ

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Description

TECHNICAL FIELD

[0001] The present invention concerns an essentially arsenic-free brass alloy with improved dezincification resistance, protection against intergranular grain boundary corrosion, and machinability.

BACKGROUND OF THE INVENTION

[0002] Brass is a material the basic components of which are copper (Cu) and zinc (Zn). By the addition of different alloying materials such as lead (Pb), iron (Fe), aluminium (Al), nickel (Ni), manganese (Mn), silicon (Si), the brass can be given unique properties, and there are many different brass alloys adapted to different types of processing and final products. Depending on composition and manufacture, the brass will consist of different so-called phases, which are microstructure components. The usual phases of brass are the α-phase, which is rich in copper and the β-phase, which is rich in zinc. Often, brass consists of a mixture of these two phases.

[0003] A solid solution having a uniform brass composition is formed when up to about 35 % by weight of zinc is added to copper. A further increase of the content of zinc gives a mixture of the original solid solution (the α-phase) and a new solid solution having a higher content of zinc (the β-phase). Brass containing between 35-45 % by weight of zinc consists of mixtures of these two phases and is called α-β-brass or duplex brass, the relationship between the α-phase to the β-phase depending primarily on the content of zinc. The presence of β-phase in α-β-brass gives a decreased cold ductility but a considerably increased susceptibility to hot working by extrusion or punching and casting without thermal cracks, also when lead is present. In addition, α-β-alloys have better mechanical properties and, since they contain a higher share of zinc, they are in certain cases more inexpensive than α-brass. However, α-β-brass alloys have a higher sensitivity to dezincification. Thereby, there is a need of producing α-β-brass alloys with dezincification resistance.

[0004] In certain environments, special alloys have to be used. Such an example is building services fittings in the form of mixer taps, valves, couplings, etc., when dezincification resistance is required. Dezincification is a type of corrosion where zinc selectively is attacked and leaves a porous copper structure. Dezincification resistant brass has a relatively high Cu content, above 60 %, and contains an inhibitor such arsenic (As), antimony (Sb), or phosphorus (P), which makes the α-phase of the brass resistant to dezincification. Since only the α-phase can be stabilized, it is important to minimize the content of β-phase by a higher content of copper. However, it has turned out that there remains β-phase even if arsenic and a high content of copper of above 60 % have been used. Thereby, there is a need of minimizing the β-phase of α-β-brass alloys (comprising ≥60 % by weight of Cu) in an alternative way.

[0005] It is known by US 3.963.526 that a brass alloy with 5-20 % of β-phase can be obtained by means of addition to the alloy of at least 0.02 % by weight of dezincification inhibiting alloying elements such as As, Sb, or P. The continuous network of β-phase naturally being present in the alloy may be broken up by the cast brass alloy being heat-treated at a temperature between 400-600 °C for a suitable period of time.

[0006] Brass alloys may in addition to dezincification be subjected to intergranular grain boundary corrosion, which is a form of corrosion taking place along the grain boundaries. The content of zinc is higher at the grain boundaries of brass alloys and intergranular grain boundary corrosion attacks just at the zinc present along the grain boundaries. Thereby, there is also a need of protecting brass alloys against intergranular grain boundary corrosion.

[0007] People are exposed most often to inorganic arsenic via drinking water and certain food, and to various organic arsenic compounds via, above all, fish and shellfish [1-3]. As seen globally, several million people use drinking water having such high arsenic content that there is risk of serious health effects. Worst hit are Bangladesh, India, Taiwan, as well as parts of South America and China [3]. Thereby, there is a need for lowering the contents of arsenic in drinking water by using as little arsenic as possible in alloys of brass that are in contact with drinking water.

[0008] The American Academy of Sciences has estimated the lifetime risk of cancer to 1-3 cases per 1000 individuals at a daily intake of 1 l of drinking water having arsenic contents at the threshold level of 10 μg/l, which exceeds the low-risk level (approx. one case per 100 000 exposed) that could be considered to be an acceptable risk of an individual environmental factor [3]. As with other carcinogenic substances, the risk of health effects decreases at decreased exposure. The threshold for arsenic in drinking water is 10 μg/l within the EU.

[0009] The threshold for arsenic in drinking water in Sweden, 10 μg/l, is based on the cancer risk [3]. Lifetime risk of the genesis of cancer, at a daily intake of arsenic corresponding to the threshold in drinking water (10-20 μg arsenic per day depending on age, climate and physical activity), has been estimated to 1-3 per 1 000 individuals (0.1-0.3 %). Thereby, it is desirable to limit the intake of arsenic as far as possible. This applies particularly to children, since experimental studies show that foetuses and small children are more sensible than adults.

[0010] In countries where lead is relatively common in the water work system, lead in drinking water has contributed to high exposure. Lead may damage the nervous system already at very low doses [3.4]. The immature nervous system is particularly sensitive. The lead content of blood may be set in relation to the health risk. At blood lead contents around

100 μg/l and higher, symptoms as degraded intellectual capacity, delayed development, and behaviour disorders have been possible to be demonstrated in children who have been exposed during the foetal stage and the infant ages. Thereby, there is a need for lowering the contents of lead in drinking water by using lower contents of lead in alloys of brass in contact with drinking water.

THE OBJECT OF THE INVENTION

[0011] The object of the present invention is to provide an essentially arsenic-free α-β-brass alloy.

[0012] The object is furthermore that the brass alloy has improved dezincification resistance than brass alloys with arsenic or solely arsenic.

[0013] The object is furthermore to provide a brass alloy having similar or better protection against intergranular grain boundary corrosion than brass alloys with arsenic or solely arsenic.

[0014] The object is furthermore that the lead content of the brass alloy should be ≤1.0 % by weight, preferably ≤0.10 % by weight of Pb.

[0015] The object is furthermore that the content of the β-phase is <5 %, preferably ≤1 %.

SUMMARY OF THE INVENTION

[0016] By the present invention, as it is seen in the independent claims, the above-mentioned objects are met. Suitable embodiments of the invention are defined in the dependent claims.

[0017] The invention concerns an essentially arsenic-free α-β-brass alloy with improved (i) dezincification resistance, (ii) machinability, and (iii) protection against intergranular grain boundary corrosion.

[0018] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises 62-68 % by weight of Cu, 0.02-1.00 % by weight of Pb, <0.02 % by weight of As, and/or 0.01-0.06 % by weight of P and/or 0.01-0.06 % by weight of Sb (antimony), and balance Zn. Said brass alloy is characterized in that it comprises <5 % of β-phase, preferably ≤1 %. Since only the α-phase can be stabilized, it is important to minimize the content of β-phase to <5 % of β-phase, preferably ≤1 %, with the purpose of counteracting dezincification and intergranular grain boundary corrosion.

[0019] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises 62-68 % by weight of Cu, 0.02-1.00 % by weight of Pb, <0.02 % by weight of As, and/or 0.01-0.06 % by weight of P and/or 0.01-0.06 % by weight of Sb, and balance Zn, the brass alloy being produced by means of a method comprising the steps of:

a. adding Sb and P to a base alloy in a furnace,
b. the smelt being poured into a mould,
c. the cast brass alloy being heat-treated at 500 °C to 550 °C for 1-2 h.

Since only the α-phase can be stabilized, it is important to minimize the content of β-phase with the purpose of counteracting dezincification and intergranular grain boundary corrosion. The heat treatment in combination with the inhibitor Sb lowers the amount of β-phase as well as that the alloying additive P lowers the cutting forces.

[0020] In this preferred embodiment, the essentially arsenic-free brass alloy has been characterized by the method of producing it (product-by-process) in combination with other determinations of the alloy since it is difficult to define the technical features of the alloy in another way, i.e., it is partly thanks to heat treatment that the alloy obtains improved (i) dezincification resistance and (ii) protection against intergranular grain boundary corrosion.

[0021] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises 63.0-64.0 % by weight of Cu, 0.02-1.00 % by weight of Pb, and/or 0.02-0.06 % by weight of P, 0.02-0.06 % by weight of Sb, and balance Zn. The somewhat higher amount of Pb gives a certain improved machinability.

[0022] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises 63.0-64.0 % by weight of Cu, 0.80-1.00 % by weight of Pb, 0.02-0.06 % by weight of P, 0.02-0.06 % by weight of Sb, and balance Zn. The somewhat higher amount of Pb gives a certain improved machinability.

[0023] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises also 0.07-0.12 % by weight of Fe and 0-0.05 % by weight or 0.45-0.70 % by weight of Al. The presence of Fe and Al in the brass alloy entails a certain increased hardness, strength, and tensile strength.

[0024] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises 63.5 % by weight of Cu, 35.0 % by weight of Zn, 0.9 % by weight of Pb, 0.10 % by weight of Fe, 0.50 % by weight of Al, 0.02-0.06 % by weight of P, 0.02-0.06 % by weight of Sb. Alloying additives such as Fe and Al improve strength, hardness, and tensile strength. The content of P and Sb of 0.02-0.06 % by weight each gives protection against dezincification and intergranular grain boundary corrosion.

[0025] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises 63.5 % by weight of Cu, 35.0 % by weight of Zn, 0.9 % by weight of Pb, 0.10 % by weight of Fe, 0.50 % by weight of Al, 0.03 % by weight

of P, and 0.03 % by weight of Sb. The content of P and Sb of 0.03 % by weight each gives better protection against dezincification and intergranular grain boundary corrosion and approx. 10 % lower cutting forces.

[0026] According to a preferred embodiment, the essentially arsenic-free brass alloy comprises 0-0.200 % by weight of Ni, 0-0.100 % by weight of Mn, 0-0.02 % by weight of Si, 0-0.002 % by weight of As and/or 0.0004-0.0006 % by weight of B (boron), preferably 0.0005 % by weight of B. Nickel improves corrosion resistance, hardness, and tensile strength without significant effect on ductility, which gives improved properties at elevated temperatures. The presence of Mn entails a certain increased hardness, strength, and tensile strength. Si increases the strength, workability, and the resistance to wear. The content of As and B is acceptable contents of inevitable impurities in the alloy.

[0027] According to a preferred embodiment, the brass alloy comprises 62-68 % by weight of Cu, 0.02-1.00 % by weight of Pb, 0.01 % by weight of As, 0.02 % by weight of Sb, and balance Zn.

[0028] According to a preferred embodiment, the brass alloy comprises 62-68 % by weight of Cu, 0.02-1.00 % by weight of Pb, 0.01 % by weight of As, 0.02 % by weight of Sb, 0.015 % by weight of P, and balance Zn.

[0029] According to a preferred embodiment, the essentially arsenic-free brass alloy according to the present application is produced by the steps of:

a. adding Sb and P to a base alloy in a furnace,
b. the smelt being poured into a mould,
c. the cast brass alloy being heat-treated at 500 °C to 550 °C for 1-2 h.

The heat treatment in combination with the inhibitors Sb and/or As lowers the amount of β-phase as well as that the alloying additive P lowers the cutting forces.

[0030] According to a preferred embodiment, the essentially arsenic-free brass alloy is produced by heat treating at 550 °C for 2 h, which lowers the amount of β-phase to <5 %, preferably ≤1 %, as well as that the alloying additive P lowers the cutting forces to approx. 10 % lower cutting forces.

BRIEF DESCRIPTION OF THE FIGURES

[0031]

Figure 1 - The microstructure of both cast and heat-treated test alloy 10 is illustrated. All pictures are taken using optical light microscopy. The first row is with 200× magnification and the second row is 500× magnification.

Figure 2 - Cross-sections from test plates, which show the degree of corrosion attack for representative test alloys are illustrated.

DESCRIPTION OF THE INVENTION

[0032] The present invention concerns an essentially arsenic-free brass alloy with improved (i) dezincification resistance, (ii) machinability, and (iii) protection against intergranular grain boundary corrosion, wherein said brass alloy comprises 62-68 % by weight of Cu, 0.02-1.00 % by weight of Pb, <0.02 % by weight of As, 0.01-0.06 % by weight of P and/or 0.01-0.06 % by weight of Sb, and balance Zn, and the brass alloy being characterized by it comprising <5 % of β-phase, preferably ≤1 %.

The brass alloy according to the present invention may also comprise alloying additives such as Fe, Al, Ni, Mn, and Si in amounts as defined by the claims with the purpose of improving strength, wear resistance, and/or tensile strength. The presence of Fe, Mn, and Al in the brass alloy entails a certain increased hardness, strength, and tensile strength. Si increases the strength and the resistance to wear of the brass alloy. Nickel improves hardness and tensile strength without significant effect on ductility, which gives improved properties at elevated temperatures. Other elements such as B, Bi, Mg, Cr, and As may also be present in the brass alloy as inevitable impurities.

[0033] The brass alloy comprises ≤0.02 % by weight of As.

[0034] The brass alloy according to the present invention is produced by a method comprising the steps of

a. adding Sb and P to a base alloy in a furnace, the base alloy comprising the quantity of Cu, Zn, Pb, and possibly other alloying additives, such as Fe and Al, which should be included in the brass alloy,
b. the smelt being poured into a mould,
c. the cast brass alloy being heat-treated at 500 °C to 550 °C for 1-2 h, the heat treatment preferably taking place at 550 °C for 2 h.

[0035] By adding the inhibitor Sb and heat treatment, a brass alloy is obtained comprising <5 % of β-phase, preferably

≤1 % of β-phase, which gives improved dezincification resistance and protection against intergranular grain boundary corrosion. The present invention indicates furthermore that in the presence of Al or Fe, P does not which is an unexpected technical effect (see Example 1). Moreover, Sb and the heat treatment at 550 °C for 2 h promotes that the β-zones are not continuous, which in turn promotes protection against intergranular grain boundary corrosion.

[0036] The following examples are there to illustrate a preferred embodiment and do not thereby exclude other brass alloys with both α- and β-phases falling within the scope of protection of the claims according to the present invention. The example also comprises comparative experiments (with the purpose of demonstrating technical effect) between brass alloys containing different combinations of As, Sb, and/or P.

EXAMPLES

Base alloy manufactured by Nordic Brass Gusum (NBG)

[0037] Test alloys 1-11, which were tested in the present application, were produced by using a base alloy having the prototype name 752 wherein the content of As, Sb, and P is as close to zero as possible. The chemical composition of 752 is given in Table 1 in % by weight wherein "NBG standard value" indicates the chemical composition of the base alloy desired to be achieved while "Min" and "Max" gives the tolerances. Moreover, the measured composition of the base alloy is also given.

Table 1: Minimum, maximum, and standard values for 752 and chemical analysis of the base alloy 752, which was used for the production of the test alloys 1-11.

Chemical composition %				
	Min	***Max***	***NBG std. value***	Analysis of the base alloy that was used to produce test alloy 1-11
Cu	63.0	64.0	63.5	63.25
Zn		Balance	35.0	35.23
Pb	0.80	1.00	0.90	0.896
Sn				0.016
Fe	0.07	0.12	0.10	0.070
Al	0.45	0.70	0.500	0.504
Ni		0.200		0.013
Mn		0.100		0.003
Si		0.02		0.015
As		0.002		0.002
Sb				<0.001
Bi				0.001
P				<0.001
B	0.0004	0.0006	0.0005	0.0006
Mg				0.001
Cr				0.002
As+Sb+P			0.005	0.002

Test alloy 1-11

[0038] The test alloys were produced in the form of ingots of 2 kg by adding As, Sb, and/or P to the base alloy in a furnace (Leybold) where the alloys were melted in a melting-pot (Morgan crucible), which had been placed in an inductance coil. The alloys were melted in the presence of air by means of ventilation above the furnace and the smelt was then poured into a mould by tipping the melting-pot together with the coil. The dimension of the mould was 40×40 mm (height, 300 mm).

[0039] Test alloys with different combinations of As, Sb, and/or P tested are given in Table 2. Alloy 3, 8, and 9 serve as comparative examples.

Table 2: The content of As, P, and Sb of the test alloys 1-11 indicated in % by weight. The "Analysed" contents indicate the measured % by weight while the "Planned" contents indicate the contents desired to achieve in the test alloys.

	Planned			**Analysed**		
	As (%w)	**P (%w)**	**Sb (%w)**	**As (%w)**	**P (%w)**	**Sb (%w)**
Alloy 1 (base alloy)	-	-	-	0.002	0.000	0.000
Alloy 2	0.02	-	-	0.020	0.000	0.000
Alloy 3 (comparative alloy)	0.06	-	-	0.066	0.000	0.001
Alloy 4	-	0.02	-	0.002	0.018	0.000
Alloy 5	-	0.06	-	0.002	0.066	0.000
Alloy 6	-	-	0.02	0.002	0.000	0.019
Alloy 7	-	-	0.06	0.002	0.000	0.062
Alloy 8 (comparative alloy)	0.03	0.03	-	0.029	0.030	0.000
Alloy 9 (comparative alloy)	0.03		0.03	0.030	0.000	0.030
Alloy 10		0.03	0.03	0.002	0.029	0.029
Alloy 11	0.02	0.02	0.02	0.021	0.022	0.022

[0040] The chemical composition of the test alloys is presented in Table 3 wherein also inevitable impurities such as B, Bi, Mg, and Cr have been included in the table.

Table 3: The chemical composition of the test alloys in % by weight.

	Cu	*Zn*	*Pb*	*Sn*	*Fe*	*Al*	*Ni*	*Mn*	*Si*	*As*	*Sb*	*B*	*Bi*	*P*	*Mg*	*Cr*
min	63		0.8		.07	.45										
max	64	bal.	0.9		.12	0.7	0.2	0.1	0.02	.002						
NBG std	63.5	35	1		.10	0.5										
1	63.1	35.4	.88	.017	.09	.49	.014	.004	.016	.002	0	.001	.001	0	.001	.002
2	63.2	35.2	.88	.014	.11	.49	.013	.004	.016	.020	0	.001	.001	0	.001	.002
3	63.3	35.1	.89	.016	.09	.50	.013	.004	.016	.066	.001	.001	.001	0	.001	.002
4	63.3	35.1	.89	.016	.08	.50	.013	.004	.015	.002	0	.001	.001	.018	.001	.002
5	63.4	35.0	.91	.018	.09	.49	.014	.004	.016	.002	0	.001	.001	.066	.001	.002
6	63.3	35.2	.89	.016	.08	.48	.013	.004	.017	.002	.019	.001	.001	0	.001	.002
7	63.4	35.0	.89	.016	.09	.49	.013	.004	.016	.002	.062	.001	.001	0	.001	.002
8	63.5	34.9	.89	.013	.10	.49	.013	.004	.016	.029	0	.001	.001	.030	.001	.002
9	63.2	35.2	.91	.018	.09	.50	.014	.004	.016	.030	.030	.001	.001	0	.001	.002
10	63.6	34.8	.89	.016	.10	.48	.013	.004	.017	.002	.029	.001	.001	.028	.001	.002
11	63.5	34.9	.89	.015	.10	.49	.013	.004	.016	.020	.022	.001	.001	.022	.001	.002

Corrosion tests

[0041] The test alloys 1-11 are exposed to corrosion in the form of both cast and heat-treated sample plates. Said heat treatment was made at 550 °C for 2 h, and after removal from the furnace, the samples were quickly quenched in water (with a delay of up to 5 min). As has been indicated previously, the purpose of the heat treatment is to reduce the β-phase in the test alloys.

[0042] The heat treatment was made at 550 °C for 2 h since comparative experiments with other temperatures and time intervals (such as 460 °C to 550 °C for 30 min-8 h) indicate that improved dezincification resistance and protection against intergranular grain boundary corrosion are obtained upon heat treatment at 550 °C for 2 h. Moreover, experiments have shown that heat treatment at 550 °C for 2 h also promotes that the β-zones are not continuous, which in turn promotes protection against IGA.

[0043] Testing of dezincification and intergranular grain boundary corrosion was made by cutting out sample plates from the middle of the ingot. The plates were obtained by the fact that samples were cut out from the ingot and the exposed surfaces were ground using 600 mesh paper. Next, said sample plates were partly masked using nail-varnish to create unexposed reference surfaces, which were used to determine the depth of corrosion attack.

[0044] The test alloys 1-11 were exposed to corrosion in accordance with ISO 6509 "Copper and copper alloys - brass - Determination of dezincification", in 1 % $CuCl_2$ solution for 24 h at 75 ± 2 °C.

[0045] After the corrosion tests, cross-sections were prepared perpendicular to the nail-varnish masking for metallographic examination by grinding and polishing of the sample plates. Corrosion attack was determined by light optical microscopy by measuring using 200× and 500× magnifications.

[0046] Characterizing of structures before corrosion exposure was made in the same way on etched cross-sections. Quantification was made by counting a fraction of the intersection points (mesh-intersection) of the grid which superseded 200 points; i.e., a grid is laid over the picture, then the number of points of α- and β-phase, respectively, are counted and translated into %.

Results - Quantification of the β-phase of the test alloys

[0047] The amount of β-phase of the etched cross-sections was determined and the results are presented in Table 4.

[0048] The comparative experiments show that the heat treatment considerably decreased the amount of β-phase in all test alloys. The results indicate that a value below 5 % of β-phase entailed that there unlikely was formed a continuous network, while a content above 10 % of β-phase entailed that continuous networks were formed. This is evidently indicated in Figure 1 where the microstructure of both cast and heat-treated test alloy 10 is illustrated. The results from the tests emphasize that heat treatment is necessary to decrease the β-phase as much as possible.

Table 4: The amount of β-phase (%) in cast and heat-treated test alloys 1-11 (measured by using grids having intersection points (mesh-intersection), 13×19, with 200× or 500× magnification for low and high, respectively, values)

	As (%w)	P (%w)	Sb (%w)	Cast	Heat treated
Alloy 1	-	-	-	13	2
Alloy 2	0.02	-	-	16	4
Alloy 3	0.06	-	-	13	2
Alloy 4	-	0.02	-	11	1
Alloy 5	-	0.06	-	15	2
Alloy 6	-	-	0.02	10	4
Alloy 7	-	-	0.06	15	2
Alloy 8	0.03	0.03	-	16	1
Alloy 9	0.03		0.03	13	1
Alloy 10		0.03	0.03	11	1
Alloy 11	0.02	0.02	0.02	15	1

Results - Dezincification resistance

[0049] The results from the $CuCl_2$ exposure of test alloy 1-11 are presented in Table 5 where it is seen if corrosion

has occurred in the α- and/or β-phase and how deep (μm) the dezincification (AD - dezincification depth) is present. Figure 2 illustrates cross-sections from test plates showing the degree of corrosion attack for representative test alloys.

[0050] The tests from the preceding sections indicated that heat treatment considerably decreases β-phase contents for all alloys (see Table 4). The comparative experiments in Table 5 show evidently that decreased quantity of β-phase contents considerably decreases the dezincification depth for all alloys containing As and Sb. When test alloy 1 (base alloy 752) is compared with test alloy 2, 3, 6-10. it is in addition possible to conclude that As and Sb inhibit dezincification of the α -phase.

[0051] The results also show that P does not act to inhibit corrosion in the α-phase. On the contrary, the dezincification of the α-phase seems to become more serious after the reduction of β-phase by the heat treatment (compare the "max" values for the alloy 5). This indicates the need of an optimum relationship between α-phase and β-phase to achieve the best corrosion protection.

[0052] It is also interesting to compare the brass alloys containing As without Sb and the brass alloys containing Sb without As, and the results indicate that the presence of As promotes intergranular grain boundary corrosion while Sb only results in small general corrosion. The examinations have demonstrated a somewhat increased content of Sb at grain boundaries, which gives a better protection just at the grain boundaries, which is seen in Table 5. The brass alloys containing Sb in the absence of As have not demonstrated any grain boundary attacks in contrast to the brass alloys containing As in the absence of Sb (see Table 5). It has furthermore been demonstrated that a combination of Sb and As, also at very low contents, protects from both general and grain boundary attacks in a synergetic way.

[0053] Moreover, there seems to be a difference between the lowest and highest concentration of Sb, 0.02 % by weight and 0.06 % by weight of Sb, respectively, which may indicate that a higher concentration than 0.02 % by weight is needed for full effect in the use of Sb. A concentration of 0.03 % by weight as in alloy 10 seems to work well as inhibitor of dezincification.

[0054] The best results were obtained for test alloy 7, 9, 10 and 11, which all comprise Sb ≥ 0.02 % by weight or a combination of As in an amount of ≤ 0.02 % by weight and Sb in an amount of ≥0.02 % by weight.

[0055] To sum up, the results suggest that (i) heat treatment, and (ii) presence of As or Sb, are necessary to obtain dezincification resistance and to counteract intergranular grain boundary corrosion.

Table 5: Dezincification depth (AD) after $CuCl_2$ exposure and identification of coexistent corrosion mechanisms such as intergranular grain boundary corrosion (IGA) and general. "?" indicates that it was difficult to determine type of corrosion, i.e., it may be α or β.

				Type of corrosion Cast		**AD depth**		**Type of corrosion Heat-treated**		**AD depth**	
	As %w	**P %w**	**Sb %w**	**AD type**	**Other attack**	**max (μm)**	**mean (μm)**	**AD type**	**Other attack**	**max (μm)**	**mean (μm)**
Alloy 1	-	-	-	a and β		353	134	α		270	84
Alloy 2	0.02	-	-	β	IGA	325	57	β	IGA	36	**10**
Alloy 3	0.06	-	-	β	IGA	282	52	β	IGA	89	40
Alloy 4	-	0.02	-	a and β		402	319	α		211	73
Alloy 5	-	0.06	-	a and β	IGA	203	100	α		328	76
Alloy 6	-	-	0.02	a and β	IGA	402	155	α	general	106	9
Alloy 7	-	-	0.06	a and β	general	165	57	β	general	38	0
Alloy 8	0.03	0.03	-	β		178	110	β	IGA	92	17

(continued)

				Type of corrosion Cast		AD depth		Type of corrosion Heat-treated		AD depth	
	As %w	P %w	Sb %w	AD type	Other attack	max (μm)	mean (μm)	AD type	Other attack	max (μm)	mean (μm)
Alloy 9	0.03		0.03	β	general	209	84	?	general	42	7
Alloy 10		0.03	0.03	a and β		113	48	α	general	35	0
Alloy 11	0.02	0.02	0.02	β		193	87	?	general	40	0

Results - Cutting forces

[0056] Analyses that were made of the cutting forces of the test alloys showed an unexpected technique of alloy 10. which had good machining and also 10 % lower cutting forces than alloy 1.

[0057] It is more advantageous with lower cutting forces since high cutting forces result in problems in low-power machines, which are usual in this context and in the operations in which the chip width is large. Examples of such operations are turning using profile tools, slotting and parting, drilling, and threading. Precision and accuracy are also affected negatively with greater cutting forces.

[0058] The embodiments according to the present invention have been described in detail with reference to the above specific example. The example is, however, intended to be illustrative only and thereby does not limit the scope of protection of the present invention. Thereby, it should be appreciated that changes and amendments to the above example may be made without deviating from the scope of protection of the invention. Therefore, the scope of protection of the present invention may not be embraced only by the above example but rather by the claims.

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Claims

1. Brass alloy with improved dezincification resistance, machinability, and protection against intergranular grain boundary corrosion, comprising

   a. 62-68 % by weight of Cu,
   b. 0.02-1.00 % by weight of Pb,
   c. ≤0.02 % by weight of As,
   d. 0.01-0.06 % by weight of P and/or 0.01-0.06 % by weight of Sb,

e. balance Zn and unavoidable impurities,

characterized in that the brass alloy comprises <5 % of β-phase, preferably ≤1 % of β-phase.

2. Brass alloy according to claim 1, comprising

c. 0 % by weight of As,
d. 0.02-0.06 % by weight of P and 0.02-0.06 % by weight of Sb.

3. Brass alloy according to claim 2, comprising

a. 63.0-64.0 % by weight of Cu.

4. Brass alloy according to claim 3, comprising

b. 0.80-1.00 % by weight of Pb.

5. Brass alloy according to claim 1, comprising

c. 0 % by weight of As,
d. 0.01 % by weight of P and 0.02 % by weight of Sb.

6. Brass alloy according to claim 1, comprising

c. 0.01 % by weight of As,
d. 0.02 % by weight of Sb.

7. Brass alloy according to claim 1, comprising

c. 0.01 % by weight of As,
d. 0.015 % by weight of P and 0.02 % by weight of Sb.

8. Brass alloy with improved dezincification resistance, machinability, and protection against intergranular grain boundary corrosion, comprising

a. 62-68 % by weight of Cu,
b. 0.02-1.00 % by weight of Pb,
c. ≤0.02 % by weight of As,
d. 0.01-0.06 % by weight of P and/or 0.01-0.06 % by weight of Sb,
e. balance Zn and unavoidable impurities,
f. 0.07-0.12 % by weight of Fe,
g. 0-0.70 % by weight of Al,

characterized in that the brass alloy comprises <5 % of β-phase, preferably ≤1 % of β-phase .

9. Brass alloy according to claim 8, comprising

a. 63.5 % by weight of Cu,
b. 0.9 % by weight of Pb,
c. 0 % by weight of As,
d. 0.02-0.06 % by weight of P and 0.02-0.06 % by weight of Sb.
e. 35.0 % by weight of Zn and unavoidable impurities,
f. 0.10 % by weight of Fe,
g. 0.50 % by weight of Al

10. Brass alloy according to claim 9, comprising

d. 0.03 % by weight of P and 0.03 % by weight of Sb.

11. Brass alloy with improved dezincification resistance, machinability, and protection against intergranular grain boundary corrosion, comprising

a. 62-68 % by weight of Cu,
b. 0.02-1.00 % by weight of Pb,
c. ≤0.02 % by weight of As,
d. 0.01-0.06 % by weight of P and/or 0.01-0.06 % by weight of Sb,
e. balance Zn and unavoidable impurities
f. optionally 0.07-0.12 % by weight of Fe,
g. optionally 0-0.70 % by weight of Al,
h. 0-0.200 % by weight of Ni,
i. 0-0.100 % by weight of Mn,
j. 0-0.02 % by weight of Si,
k. 0.0004-0.0006 % by weight of B,

characterized in that the brass alloy comprises <5 % of β-phase, preferably ≤1 % of β-phase.

12. Method for the production of a brass alloy according to any one of claims 1 to 11, **characterized by** the steps of

a. adding Sb and/or P to a base alloy in a furnace,
b. the smelt obtained in step a being poured into a mould,
c. the cast brass alloy obtained in step b being heat-treated at 500 °C to 550 °C for 1-2 h.

13. Method for the production of brass alloy according to claim 12, **characterized in that** the brass alloy is heat-treated at 550 °C for 2 h.

14. Use of the brass alloy according to any one of claims 1-11 in environments which contact water.

15. Use according to claim 14, wherein said environments are building services fittings, preferably in the form of mixer taps, valves, and couplings.

16. Article which is produced with the use of the brass alloy according to any one of claims 1-11.

17. Use of P in order to decrease cutting forces of the brass alloy according to any one of claims 8-11 in the presence of Al or Fe.

Patentansprüche

1. Messinglegierung mit verbessertem Entzinkungswiderstand, verbesserter maschineller Bearbeitbarkeit und verbessertem Schutz gegen interkristalline Korngrenzkorrosion, umfassend:

a. 62-68 Gew.-% Cu,
b. 0,02-1,00 Gew.-% Pb,
c. ≤ 0,02 Gew.-% As,
d. 0,01-0,06 Gew.-% P und/oder 0,01-0,06 Gew.-% Sb,
e. Rest Zn und unvermeidbare Fremdbestandteile,

dadurch gekennzeichnet, dass die Messinglegierung < 5 % an β-Phase, vorzugsweise ≤ 1 % an β-Phase, umfasst.

2. Messinglegierung nach Anspruch 1, umfassend:

c. 0 Gew.-% As,
d. 0,02-0,06 Gew.-% P und 0,02-0,06 Gew.-% Sb.

3. Messinglegierung nach Anspruch 2, umfassend:

a. 63,0-64,0 Gew.-% Cu.

4. Messinglegierung nach Anspruch 3, umfassend:

b. 0,80-1,00 Gew.-% Pb.

5. Messinglegierung nach Anspruch 1, umfassend:

c. 0 Gew.-% As,
d. 0,01 Gew.-% P und 0,02 Gew.-% Sb.

6. Messinglegierung nach Anspruch 1, umfassend:

c. 0,01 Gew.-% As,
d. 0,02 Gew.-% Sb.

7. Messinglegierung nach Anspruch 1, umfassend:

c. 0,01 Gew.-% As,
d. 0,015 Gew.-% P und 0,02 Gew.-% Sb.

8. Messinglegierung mit verbessertem Entzinkungswiderstand, verbesserter maschineller Bearbeitbarkeit und verbessertem Schutz gegen interkristalline Korngrenzkorrosion, umfassend:

a. 62-68 Gew.-% Cu,
b. 0,02-1,00 Gew.-% Pb,
c. $\leq$ 0,02 Gew.-% As,
d. 0,01-0,06 Gew.-% P und/oder 0,01-0,06 Gew.-% Sb,
e. Rest Zn und unvermeidbare Fremdbestandteile,
f. 0,07-0,12 Gew.-% Fe,
g. 0-0,70 Gew.-% Al,

dadurch gekennzeichnet, dass die Messinglegierung < 5 % an β-Phase, vorzugsweise $\leq$ 1 % an β-Phase, umfasst.

9. Messinglegierung nach Anspruch 8, umfassend:

a. 63,5 Gew.-% Cu,
b. 0,9 Gew.-% Pb,
c. 0 Gew.-% As,
d. 0,02-0,06 Gew.-% P und 0,02-0,06 Gew.-% Sb,
e. 35,0 Gew.-% Zn und unvermeidbare Fremdbestandteile,
f. 0,10 Gew.-% Fe,
g. 0,50 Gew.-% Al.

10. Messinglegierung nach Anspruch 9, umfassend:

d. 0,03 Gew.-% P und 0,03 Gew.-% Sb.

11. Messinglegierung mit verbessertem Entzinkungswiderstand, verbesserter maschineller Bearbeitbarkeit und verbessertem Schutz gegen interkristalline Korngrenzkorrosion, umfassend:

a. 62-68 Gew.-% Cu,
b. 0,02-1,00 Gew.-% Pb,
c. $\leq$ 0,02 Gew.-% As,
d. 0,01-0,06 Gew.-% P und/oder 0,01-0,06 Gew.-% Sb,
e. Rest Zn und unvermeidbare Fremdbestandteile,
f. optional 0,07-0,12 Gew.-% Fe,
g. optional 0-0,70 Gew.-% Al,
h. 0-0,200 Gew.-% Ni,
i. 0-0,100 Gew.-% Mn,

j. 0-0,02 Gew.-% Si,
k. 0,0004-0,0006 Gew.-% B,

dadurch gekennzeichnet, dass die Messinglegierung < 5 % an β-Phase, vorzugsweise ≤ 1 % an β-Phase, umfasst.

12. Verfahren zur Herstellung einer Messinglegierung nach einem der Ansprüche 1 bis 11, **gekennzeichnet durch** die Schritte:

a. Zugeben von Sb und/oder P zu einer Ausgangslegierung in einem Ofen,
b. Gießen der in Schritt α erhaltenen Schmelze in eine Gießform,
c. Wärmebehandlung der in Schritt b erhaltenen Gussmessinglegierung 1-2 Stunden lang bei 500 °C bis 550 °C.

13. Verfahren zur Herstellung der Messinglegierung nach Anspruch 12, **dadurch gekennzeichnet, dass** die Messinglegierung 2 h lang bei 550 °C wärmebehandelt wird.

14. Verwendung der Messinglegierung nach einem der Ansprüche 1 bis 11 in Umgebungen mit Wasserkontakt.

15. Verwendung nach Anspruch 14, wobei es sich bei den Umgebungen um haustechnische Armaturen handelt, vorzugsweise in Form von Mischbatterien, Ventilen und Verbindungsstücken.

16. Artikel, der mit Verwendung der Messinglegierung nach einem der Ansprüche 1 bis 11 hergestellt wird.

17. Verwendung von P zur Verminderung von Zerspankräften der Messinglegierung nach einem der Ansprüche 8 bis 11 in Gegenwart von Al oder Fe.

Revendications

1. Alliage de laiton ayant une résistance à la dézincification, une usinabilité et une protection contre la corrosion des joints de grain intergranulaires améliorées, comprenant

a. 62 à 68 % en poids de Cu,
b. 0,02 à 1,00 % en poids de Pb,
c. ≤ 0,02 % en poids de As,
d. 0,01 à 0,06 % en poids de P et/ou 0,01 à 0,06 % en poids de Sb,
e. le reste étant Zn et des impuretés inévitables,

caractérisé en ce que l'alliage de laiton comprend < 5 % de phase β, de préférence ≤ 1 % de phase β.

2. Alliage de laiton selon la revendication 1, comprenant

c. 0 % en poids de As,
d. 0,02 à 0,06 % en poids de P et 0,02 à 0,06 % en poids de Sb.

3. Alliage de laiton selon la revendication 2, comprenant

a. 63,0 à 64,0 % en poids de Cu.

4. Alliage de laiton selon la revendication 3, comprenant

b. 0,80 à 1,00 % en poids de Pb.

5. Alliage de laiton selon la revendication 1, comprenant

c. 0 % en poids de As,
d. 0,01 % en poids de P et 0,02 % en poids de Sb.

6. Alliage de laiton selon la revendication 1, comprenant

c. 0,01 % en poids de As,
d. 0,02 % en poids de Sb.

7. Alliage de laiton selon la revendication 1, comprenant

c. 0,01 % en poids de As,
d. 0,015 % en poids de P et 0,02 % en poids de Sb.

8. Alliage de laiton ayant une résistance à la dézincification, une usinabilité et une protection contre la corrosion des joints de grain intergranulaires améliorées, comprenant

a. 62 à 68 % en poids de Cu,
b. 0,02 à 1,00 % en poids de Pb,
c. ≤ 0,02 % en poids de As,
d. 0,01 à 0,06 % en poids de P et/ou 0,01 à 0,06 % en poids de Sb,
e. le reste étant Zn et des impuretés inévitables,
f. 0,07 à 0,12 % en poids de Fe,
g. 0 à 0,70 % en poids de Al,

caractérisé en ce que l'alliage de laiton comprend < 5 % de phase β, de préférence ≤ 1 % de phase β.

9. Alliage de laiton selon la revendication 8, comprenant

a. 63,5 % en poids de Cu,
b. 0,9 % en poids de Pb,
c. 0 % en poids de As,
d. 0,02 à 0,06 % en poids de P et 0,02 à 0,06 % en poids de Sb,
e. 35,0 % en poids de Zn et des impuretés inévitables,
f. 0,10 % en poids de Fe,
g. 0,50 % en poids de Al.

10. Alliage de laiton selon la revendication 9, comprenant

d. 0,03 % en poids de P et 0,03 % en poids de Sb.

11. Alliage de laiton ayant une résistance à la dézincification, une usinabilité et une protection contre la corrosion des joints de grain intergranulaires améliorées, comprenant

a. 62 à 68 % en poids de Cu,
b. 0,02 à 1,00 % en poids de Pb,
c. ≤ 0,02 % en poids de As,
d. 0,01 à 0,06 % en poids de P et/ou 0,01 à 0,06 % en poids de Sb,
e. le reste étant Zn et des impuretés inévitables
f. facultativement 0,07 à 0,12 % en poids de Fe,
g. facultativement 0 à 0,70 % en poids de Al,
h. 0 à 0,200 % en poids de Ni,
i. 0 à 0,100 % en poids de Mn,
j. 0 à 0,02 % en poids de Si,
k. 0,0004 à 0,0006 % en poids de B,

caractérisé en ce que l'alliage de laiton comprend < 5 % de phase β, de préférence ≤ 1 % de phase β.

12. Procédé de production d'un alliage de laiton selon l'une quelconque des revendications 1 à 11, **caractérisé par** les étapes de

a. ajout de Sb et/ou P à un alliage de base dans un four,
b. la matière fondue obtenue dans l'étape α étant versée dans un moule,
c. l'alliage de laiton coulé obtenu dans l'étape b étant traité thermiquement à 500 °C à 550 °C pendant 1 à 2 h.

13. Procédé de production d'alliage de laiton selon la revendication 12, **caractérisé en ce que** l'alliage de laiton est traité thermiquement à 550 °C pendant 2 h.

14. Utilisation de l'alliage de laiton selon l'une quelconque des revendications 1 à 11 dans des environnements qui entrent en contact avec de l'eau.

15. Utilisation selon la revendication 14, dans laquelle lesdits environnements sont des accessoires de services de construction, de préférence sous la forme de robinets mélangeurs, de vannes et de raccords.

16. Article qui est produit au moyen de l'alliage de laiton selon l'une quelconque des revendications 1 à 11.

17. Utilisation de P afin de diminuer les forces de coupe de l'alliage de laiton selon l'une quelconque des revendications 8 à 11 en présence de Al ou Fe.

Figure 1

Alloy 10: 0.03 % by weight of P, 0.03 % by weight of Sb

Cast

After heat treatment 550 °C for 2 h

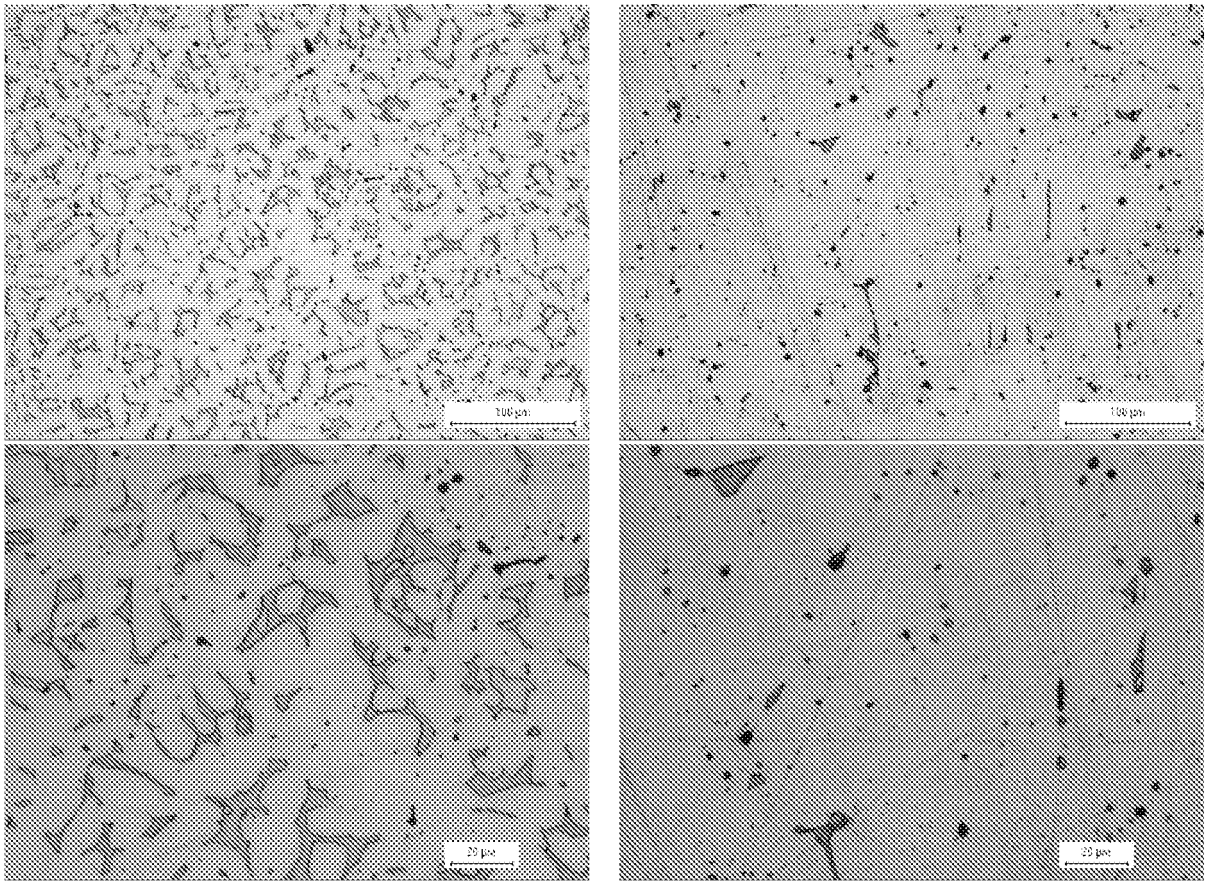
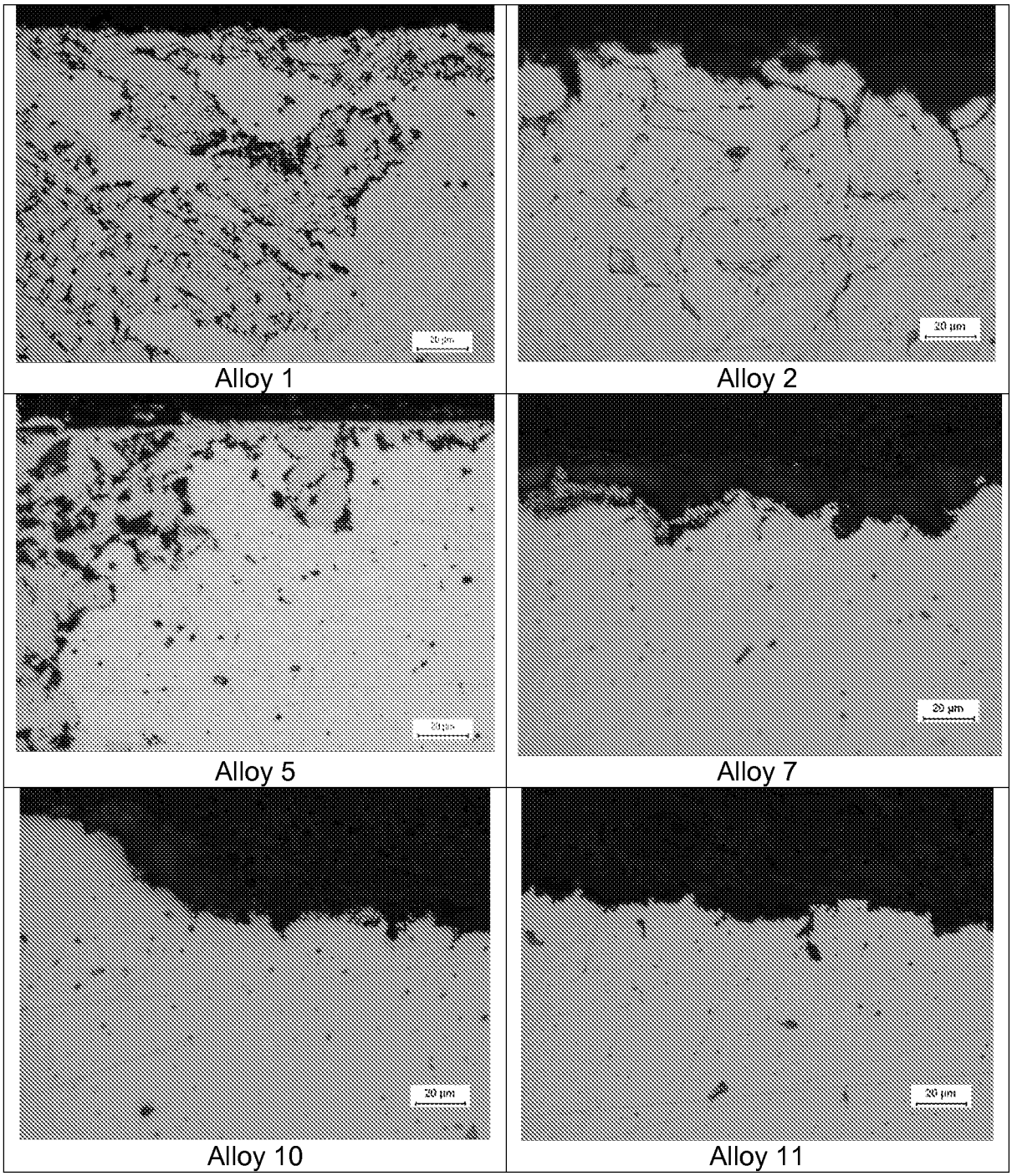


Figure 2



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