US 20250263814A1

(19) **United States**

(12) **Patent Application Publication**

Hansen

(10) **Pub. No.: US 2025/0263814 A1**

(43) **Pub. Date: Aug. 21, 2025**

(54) **PROCESS FOR THE PRODUCTION OF METALLIC COMPONENTS FROM A COPPER ALLOY**

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(21) Appl. No.: **19/057,408**

(22) Filed: **Feb. 19, 2025**

(30) **Foreign Application Priority Data**

Feb. 19, 2024 (EP) 24158375.6

Publication Classification

(51) **Int. Cl.**

C22C 9/02 (2006.01)

C22C 1/02 (2006.01)

C22F 1/08 (2006.01)

(52) **U.S. Cl.**

CPC ***C22C 9/02*** (2013.01); ***C22C 1/02*** (2013.01); ***C22F 1/08*** (2013.01)

(57) **ABSTRACT**

The present invention relates to a process for producing metallic components, preferably for guiding media in drinking water systems, from a copper alloy, comprising melting an alloy with the constituents, conditioning the material before and/or during the solidification process, preferably by grain refinement, and hot forming the material at a temperature between 680 and 780° C. The present invention is intended to provide a process for manufacturing metallic components, in particular for guiding media in a drinking water system, which can be carried out economically.

PROCESS FOR THE PRODUCTION OF METALLIC COMPONENTS FROM A COPPER ALLOY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This Application claims the benefit of European Application No. 24158375.6, filed Feb. 19, 2024, the contents of which are incorporated herein in their entirety.

BACKGROUND

[0002] The present invention relates to a method for manufacturing metallic components, preferably for guiding media in drinking water systems, from a copper alloy.

[0003] Water is an indispensable resource for the survival of living beings. When drinking water is taken from the supply system for consumption, it must be of such a quality, that it does not cause illness in humans. In order to achieve this, high demands are placed on the materials that come into direct contact with drinking water. Copper is considered an indispensable material for water-bearing systems in industry and technology, as it is highly resistant to corrosion and has antibacterial properties. Copper also has other positive material properties, such as good castability, high strength and toughness as well as formability. However, not all copper alloys are suitable for the manufacture of components that bear drinking water.

[0004] DE 10 2019 106 131 A1 and DE 10 2019 106 136 A1 each describe lead-free copper alloys, one with 3.87 wt % Sn, 1.4 wt % Zn, 0.42 wt % S, 0.01 wt % Fe and 0.01 wt % Ni and another one with 3.2 wt % Sn, 1.6 wt % Zn, 0.19 wt % S, 0.01 wt % Fe and 0.02 wt % Ni, the remainder being copper in each case. This copper alloy is used to produce components for media-carrying gas or water pipes in a process which comprises melting the said alloy and producing a pressed blank with subsequent pressing. The selected pressing temperature during pressing is in the range of 750° C. to 900° C. The prior art discloses that temperatures of 800° C. and 860° C. or 880° C. should be set in order to achieve good fine graining with positive forming properties. According to the disclosure of these publications, a lower forming temperature leads to significantly higher forming forces, which ultimately has an effect on the economic efficiency of the process.

[0005] The production of molded parts from a copper alloy with 4.5% by weight Sn, 5.4 to 13% by weight Zn, 0.08% by weight Pb, 0.01% by weight Fe and 0.4% by weight Ni—the remainder copper—is described in DE 10 2012 013 817 A1. The manufacturing process comprises melting the aforementioned alloy, continuous casting of semi-finished products and subsequent cutting to length to form pressed blanks, heating the pressed blanks to a temperature of between 750° C. and 850° C. and subsequent pressing to form the molded components. Furthermore, mechanical preconditioning is carried out during the melting and casting process by means of electromagnetic stirring. As a result, the material has an average grain size of less than 1 mm before the hot pressing process. Such mechanical preconditioning enables the formation of fine grains without the need to alloy additional elements such as B or Zr.

[0006] EP 3 225 707 A1 also discloses a component for media-carrying gas or water pipes made from a lead-free copper alloy. This publication deals with the role of sulphides in order to ensure sufficient machinability of the aforementioned alloy

[0007] EP 3 581 667 A2 discloses a copper alloy with 2 to 6% by weight Sn, 0 to 5% by weight Zn, 0.05 to 0.6% by weight S, less than 0.25% by weight Pb, less than 0.6% by weight Ni and less than 0.25% by weight Sb and the remainder copper. The said copper alloy is used for the production of molded parts by means of a process, comprising a hot pressing process between 700° C. and 900° C. and subsequent machining. For this purpose, an average grain size of 2 mm is set before the hot pressing process by adding between 0.005 and 0.03% by weight of Zr and/or B.

BRIEF SUMMARY

[0008] The present invention seeks to provide a method for manufacturing metallic components, in particular for guiding media in a drinking water system, which can be carried out economically.

[0009] To solve this problem, the present invention proposes a method with the features of claim **1**.

DETAILED DESCRIPTION

[0010] The present invention describes the processing of a specific copper alloy that requires compliance with defined upper limits with regard to the components that can migrate from the component into the water. This also applies in particular to the control of impurities. Here, the present invention proposes to comply with upper limits for certain impurities, namely contamination with Al, Cd, Cr and Si, which are fixed. This means that the corresponding elements may, but need not, be present in the alloy up to the specified upper limit. Neither the impurities, nor the other elements mentioned in the patent claim only with upper limits, are necessary components of the alloy. However, according to preferred embodiments of the present invention, specific elements may be required as necessary elements with a minimum content in order to favor certain properties within the alloy or the metallic component produced therefrom.

[0011] In the process according to the invention, the alloy used in the context of the present invention is melted with the alloy components according to claim **1**. The material formed by the alloy is then conditioned before and/or during the solidification process. The conditioning is carried out with the preferred aim of grain refinement. Conditioning can be carried out by chemical-metallurgical influence, in particular during solidification by introducing foreign nuclei.

[0012] To produce the semi-finished product, the alloy is preferably cast or continuously cast. Preferably, the melt is superheated during casting and cast at a temperature that is at least 15° C. above the melting temperature of the alloy. The so-called casting temperature is preferably between 20° C. and 70° C. and particularly preferably between 30° C. and 50° C. above the melting temperature of the alloy. The casting temperatures of the alloy according to the invention can be between 1500° C. and 1100° C. or 1070° C. and 1090° C. These casting temperatures influence the resulting microstructure of the material and can lead to the formation of finer grains.

[0013] Accordingly, in the process according to the invention, semi-finished material is hot-formed at a temperature of between 680° C. and 780° C., preferably between 700° C. and 770° C., particularly preferably between 710° C. and

740° C., to produce the component. Furthermore, hot forming takes place at a temperature of at least 700° C., preferably at least 710° C., particularly preferably at a temperature between 720 and 730° C.

[0014] At forming temperatures outside this range, the semi-finished product may tend to crack, for example at lower temperatures, or exhibit surface oxidation, for example at higher temperatures

[0015] Surprisingly, it has been shown that components of the aforementioned type can also be produced at a significantly lower hot forming temperature without the need for considerably higher forming forces. It has also been shown that the temperature for hot forming can be lowered with a smaller grain size. With regard to reliable process control, however, an average grain size of between 0.5 mm and 3 mm is preferably produced in the semi-finished product and before hot forming. Preferably, the grain size is between 1.0 mm and 2.5 mm. Particularly preferred is between 1.5 mm and 2 mm. Another particularly preferred grain size is between 1.6 mm and 1.8 mm.

[0016] In view of the economic requirements and other properties of the components to be produced, the process should be carried out at a hot forming temperature of between 720° C. and 730° C., which, based on practical tests by the inventors, results in a grain size in a range of between 1.5 mm and 2 mm, which is set before hot forming and after solidification of the alloy to form the semi-finished product.

[0017] It has also been shown that the deformation speed of hot forming can influence the mechanical properties of the component to be produced. If the forming speed is too high, for example, the material can crack. However, if the forming speed is reduced too drastically, this forming speed may not be useful, even if the forming results are positive, due to the resulting process duration and the resulting economic disadvantages. Therefore hot forming should be carried out at a forming speed of between 1 1/s and 1/10 1/s.

[0018] Nickel is to be set at between 0.05 and 0.4% by weight, preferably in a range of between 0.1 and 0.3% by weight, particularly preferably in a range of 0.15 to 0.25% by weight. Nickel increases the strength after hot forming. However, an excessively high proportion of nickel hinders the formability of the alloy for the production of the semi-finished product.

[0019] The alloy according to the invention contains tin in a proportion of 3.5 to 4.8% by weight. Tin acts as a solid solution strengthening agent in the alloy and thus increases the tensile strength, as well as the yield strength and the hardness. However, tin reduces the elongation at break. Tin also has a positive influence on corrosion resistance. However, an excessively high proportion of tin shows stronger segregation during hot forming, which makes subsequent hot forming more difficult. It is possible to use heat treatment to break up these segregations. However, heat treatment is time-consuming and energy-intensive and leads to a coarsening of the microstructure, which is to be avoided with the present invention.

[0020] A certain proportion of sulphur in combination with zinc favors the solidification behaviour of the alloy and the chip-breaking properties during subsequent machining of the semi-finished product. However, the proportion of zinc must be controlled with regard to the tendency of zinc to accumulate inhomogeneously and concentrated in the microstructure in places, which makes subsequent hot forming more difficult. Accordingly, 1.0 to 2.5% by weight of Zn and 0.02 to 0.5% by weight of S are added to the alloy.

[0021] Lead acts as a chip breaker, but can only be tolerated to a limited extent with regard to its harmful effects on health, not least because there is a risk of lead migrating from the metallic components into the drinking water during long-term use. The same applies to the proportion of Sb. There is an upper limit of 0.1% by weight for both alloys.

[0022] Zr, Fe and B promote grain refinement. Fe and B should be added in combination. The Fe content is between 0.005 and 0.3% by weight and the B content is between 0.005 and 0.02% by weight. The sole addition of between 0.005 and 0.02% by weight of Zr is preferable in comparison and more effective in terms of grain refinement. If the amount of zirconium in the alloy is not sufficiently balanced or becomes too high, zirconium-rich sulphides can form along the grain boundaries. These precipitates can reduce the amount of dissolved zirconium in the solid solution and thus inhibit the resulting grain refinement effect. The mechanical properties of the material, e.g. strength and toughness, can also be impaired by such precipitates.

[0023] The copper alloy described above is particularly suitable for the production of media-carrying metallic components that are used in drinking water pipes. Such components include, in particular, fittings, end caps and connecting pieces for pipelines. The corresponding components are usually formed by hot forming alone, preferably by extrusion. However, hot forming can also be carried out using pressing or stamping processes. Eccentric presses or hydraulic presses can be used for this purpose.

[0024] After hot forming, the components can be machined to length or, in particular, machined to produce threads or connection or sealing surfaces.

1. Process for the production of metallic components, preferably for guiding media in drinking water systems, from a copper alloy, comprising

(a) Melting of an alloy with the components
- 3.5-4.8 wt. % Sn
- 1.0-2.5% by weight Zn
- 0.02-0.5% by weight S
- ≤0.10% by weight Pb
- <0.1% by weight Sb
- 0.05-0.4% by weight Ni
- 0.01-0.06% by weight P
- and unavoidable impurities, including
- <0.01% by weight Al
- <0.01% by weight Cd
- <0.02% by weight Cr
- <0.01% by weight Si
- and the remainder Cu,

(b) conditioning of the alloy before and/or during the solidification of a semi-finished product formed from the alloy, preferably by grain refinement, and

(c) Hot forming of the semi-finished product at a temperature between 680 and 780° C. to produce the component.

2. Process for producing metallic components from a copper alloy according to claim **1**, characterized by a Zr content of between 0.005-0.02% by weight.

3. Process for producing metallic components from a copper alloy according to claim **1**, characterized by an Fe content of between 0.005-0.3% by weight and a B content of between 0.005-0.02% by weight.

4. Process for producing metallic components from a copper alloy according to claim **1**, characterized in that the Zn content is between 1.0-2.4% by weight.

5. Process for producing metallic components from a copper alloy according to claim **1**, characterized in that the Ni content is between 0.1-0.3% by weight.

6. Process for producing metallic components from a copper alloy according to claim **1**, characterized in that the hot forming takes place at a temperature of at least 700° C.

7. Process for producing metallic components from a copper alloy according to claim **1**, characterized in that the mean grain size of the semi-finished product before hot forming is between 0.5-3 mm.

8. Process for producing metallic components from a copper alloy according to claim **1**, characterized in that the hot forming is extrusion.

9. Process of manufacturing metallic components from a copper alloy according to claim **1**, characterized by stress-relieving machining after hot forming.

10. Process for producing metallic components from a copper alloy according to claim **1**, characterized in that the hot forming is carried out at a deformation rate of between 1 1/s and 1/10 1/s.

11. The process of claim **1**, wherein the hot forming takes place at a temperature of at least 710° C.

12. The process of claim **1**, wherein the mean grain size of the semi-finished product before hot forming is between 0.5-3 mm; and

wherein the hot forming takes place at a temperature of at least 700° C.

13. The process of claim **12**, further comprising stress-relieving machining after hot forming.

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