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(72) Inventors:
• **Nippert, Russell
Columbus
OH 43221 (US)**
• **Swank, Brian
Marengo
OH 43334 (US)**
• **Koppinen, Ilpo
Delaware
OH 43015 (US)**

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(71) Applicant: **Outokumpu Copper Products Oy
02200 Espoo (FI)**

(74) Representative: **Zipse + Habersack
Wotanstrasse 64
80639 München (DE)**

(54) **Method for manufacturing copper alloys**

(57) The invention relates to a method for manufacturing copper based precipitation hardenable alloys, such as copper-chromium (CuCr), copper-chromium-zirconium (CuCrZr) and copper-zirconium (CuZr), wherein the method contains at least the steps:

- an elongated piece made of the desired alloy and having an essentially circular, rectangular or ring-like cross-section is cast by continuous casting,
- the cast piece is drawn, and
- at least one aging treatment is carried out for the final product.

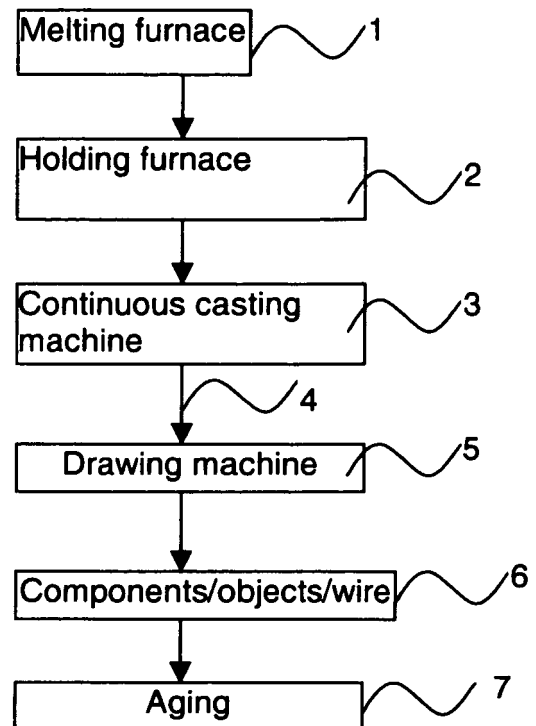


FIG. 1

Description

[0001] The invention relates to a method for manufacturing copper alloys, particularly copper based precipitation hardenable alloys, in which method hot extrusion of the copper alloy is avoided.

[0002] Manufacturing of precipitation hardening alloys requires a process stage for putting the alloying elements into a solid solution. Usually that is done by having a separate solution annealing heat treatment or by combining hot working, such as hot extrusion or hot rolling with rapid quenching. According to this developed technology the solid solution is achieved by controlling the solidification and subsequent cooling.

[0003] The conventional method for manufacturing a rod of copper based precipitation hardenable alloys, such as copper-chromium (CuCr), copper-chromium-zirconium (CuCrZr) and copper-zirconium (CuZr), is to cast a billet and then to treat the billet by hot extrusion. This kind of a treatment is described in the US patent 4,421,570 for the material to be used in a method for making molds for continuous casting. Typical conventionally cast billets have surface defects that have to be corrected before extrusion by machining or by another overhauling method. Further, depending on the billet casting conditions the copper alloying elements, chromium and/or zirconium, may start to precipitate out of the solution. Therefore, it becomes necessary to heat the billet to a fixed temperature prior to extruding the billet into water. After extrusion the rod is drawn to a given size, aged and further drawn to a final diameter, if necessary. In some cases the rod may be drawn to a given size and then formed into components prior to being aged.

[0004] The object of the present invention is to eliminate some drawbacks of the prior art and to achieve an improved method for manufacturing copper based precipitation hardenable alloys, such as copper-chromium (CuCr), copper-chromium-zirconium (CuCrZr) and copper-zirconium (CuZr), by using a continuous casting for an elongated casting, such as a rod, instead of a cast billet and thus to shorten the manufacturing process. The essential features of the present invention are enlisted in the appended claims.

[0005] According to the method of the invention, a copper based precipitation hardenable alloy, such as copper-chromium (CuCr), copper-chromium-zirconium (CuCrZr) and copper-zirconium (CuZr), is cast by continuous casting directly into an elongated casting having advantageously an essentially circular, rectangular or ring-like cross-section, preferably a rod having advantageously an external diameter between 8 mm and 50 mm. The casting is then drawn to a predetermined size. This drawn product is further aged in some alternative manner for the final product. These embodiments for aging are for instance solution annealing, forming directly into components or drawn further into a fine wire followed by an aging thermal treatment.

[0006] The copper based precipitation hardenable alloys to be manufactured in the method of the invention contain 0,1 to 1,5 % in weight chromium and/or 0,01 to 0,25 % in weight zirconium, the remainder being copper and the usual impurities.

[0007] The continuous casting in the method of the invention is carried out horizontally, vertically upwards or vertically downward or even in some direction between the horizontal and the vertical direction. For the purpose of describing the technology of the invention, the term "continuous casting" is used for describing continuously-operated casting of at least one elongated piece having advantageously essentially circular, rectangular or ring-like cross-section with a thickness or an external diameter maximum for further cold working of the material. Other sizes, or even other shapes, may also be cast depending on the final size requirements. When using continuous casting in the method of the invention, very long lengths of the castings up to 5 ton in weight are produced when comparing with the cast billet in the prior art ready for extrusion having a typical weight of 160 kg. When using the method of the invention there is no need for an extrusion process step as in the prior art and a solution treatment is avoided at least in one of the embodiments. Further, because the casting is in a shape of elongated piece, i.e. nearer to the final dimension than the cast billet, the drawing of the casting is also shortened.

[0008] When using the method of the invention, the alloying elements, chromium and/or zirconium, are kept during the continuous casting stage in a supersaturated solid solution. This solution is accomplished by casting the copper alloy through a die having a connection with a cooler that enables fast solidification of 23 °C/s to 70 °C/s for the copper alloy. This solidification further allows for a reduction in temperature below the temperature necessary for precipitation of the copper based alloy.

[0009] After the casting stage in accordance with the method of the invention, the casting of the copper based alloy, preferable in a shape of a rod, is drawn to a predetermined size. The further treatment of the drawn product to the final product in accordance with the invention can be carried out by alternative ways: One embodiment is to make for the drawn product a solution annealing, another embodiment is to form the drawn product directly into components, for instance cold heading resistance welding electrodes as the final product or a still another embodiment is to age at the temperature 440 to 470 °C for 2 to 3 hours and to draw further down into the final product, such as a fine wire. If necessary, all the embodiments are followed by an ageing thermal treatment.

[0010] The solution annealing in accordance with one embodiment of the invention is carried out in the temperature range of 980 - 1000 °C for 5 - 30 minutes in the case of the copper chromium alloy and in the temperature range of 900 - 925 °C for 10 - 30 minutes in the case of the copper zirconium alloy in order to recrystallize the predetermined size drawn product. Depending on the target of use for the final product the annealed product is

formed directly into components as the final product or the annealed product is further drawn into a new desired dimension. This product having the new desired dimension is further formed into components as the final product or the product having the new desired dimension is aged before forming into components as the final product.

[0011] The invention is described in more details referring to the appended drawings wherein

Fig. 1 shows one preferred embodiment of the invention as a flow sheet for the process stages, Fig. 2 shows another preferred embodiment of the invention as a flow sheet for the process stages, and Fig. 3 shows still one preferred embodiment of the invention as a flow sheet for the process stages.

[0012] In accordance with Fig. 1 copper chromium alloy is melted in a melting furnace 1 and the melt is flowed to a holding furnace 2. From the holding furnace 2 the melt is directed to a continuous casting machine 3, which is operated so that the cast direction is essentially vertically upwards so that the holding furnace 2 is under the continuous casting machine 3 and the melt is sucked upwards into a nozzle of the continuous casting machine 3. In the continuous casting machine 3 the melt is solidified with cooling media circulating the melt to be solidified and to create a solid casting 4.

[0013] The casting 4 from the continuous casting machine 3 is in a shape of a rod. The rod is further fed into a drawing machine 5 where the rod is drawn to the desired dimensions of a final product 6, which is for instance a wire. If necessary, depending on the use of the final product 6, an aging 7 at the temperature of 440 - 470 °C for 2 to 3 hours is carried out.

[0014] In the embodiment of Fig. 2 copper zirconium alloy is melted in a melting furnace 11 and the melt is flowed to a holding furnace 12. From the holding furnace 12 the melt is directed to a continuous casting machine 13, which is operated so that the cast direction is essentially vertically downward so that the holding furnace 12 is above the continuous casting machine 13 and the melt is fed downward into a die of the continuous casting machine 13. In the continuous casting machine 13 the melt is solidified with cooling media circulating the melt to be solidified inside the casting machine and to create a solid casting 14.

[0015] The casting 14 from the continuous casting machine 13 is in a shape of a rod. The rod is further fed into a drawing machine 15 where the cast rod is drawn to the dimensions desired for further processing. The drawn rod 16 from the drawn machine 15 is further fed into a solution annealing treatment in a furnace 17. The annealed rod 18 from the furnace 17 is alternatively for instance cut into desired objects 19 as final products of the method of the invention, which objects 19 are aged 24, if necessary.

[0016] Another alternative to treat the annealed rod 18

is to draw the rod 18 in another drawing machine 23 into a desired final dimension of the method of the invention. The drawn product 20 is further alternatively for instance cut into desired objects 21, which are aged 26, if necessary. Alternatively the drawn product 20 will be aged 25 before forming 22 the desired objects or keeping the product 21 for instance in the form of a wire.

[0017] In the embodiment of Fig. 3 copper chromium zirconium alloy is melted in a melting furnace 31 and the melt is flowed to a holding furnace 32. From the holding furnace 32 the melt is directed to a continuous casting machine 33, which is operated so that the cast direction is essentially horizontal so that the holding furnace 32 is essentially on the same level as the continuous casting machine 33 and the melt is fed into a die of the continuous casting machine 33. In the continuous casting machine 33 the melt is solidified with cooling media circulating the melt to be solidified inside the casting machine and to create a solid casting 34.

[0018] The casting 34 from the continuous casting machine 33 is in a shape of a rod. The rod 34 is further fed into a drawing machine 35 where the cast rod is drawn to the dimensions desired for further processing. The drawn product 34 is aged 40 at temperature 440 - 470 °C for 2 to 3 hours and the aged product 36 is formed for desired components 42 or kept in a form of for instance a wire depending on the purpose of further processing. Alternatively, the aged product 36 is further fed into another drawing machine 37 to draw the product to a final dimension. The drawn product 38 from the drawing machine 37 is further cut into components or kept as a form of a wire. The final product 39 in the form of for instance cut components or a wire made of the drawn product 38 is again aged 41, if necessary depending on the use of the final product 39.

[0019] Even though in the descriptions of Fig. 1, Fig. 2 and Fig. 3 there is mentioned only one alloy in accordance with the invention, without weakening the value of the embodiment the mentioned alloy can be replaced in the embodiment in question with another alloy of the invention.

Claims

1. Method for manufacturing copper based precipitation hardenable alloys, such as copper-chromium (CuCr), copper-chromium-zirconium (CuCrZr) and copper-zirconium (CuZr), wherein the method contains at least the steps:

- a) an elongated piece made of the desired alloy and having an essentially circular, rectangular or ring-like cross-section is cast by continuous casting,
- b) the cast piece is drawn, and
- c) at least one aging treatment is carried out for the final product.

2. Method according to the claim 1, wherein a solution annealing is carried out before the aging treatment.
3. Method according to the claim 1, wherein the melt to be solidified during casting is flowed to the casting machine essentially vertically. 5
4. Method according to the claim 3, wherein the melt to be solidified during casting is flowed to the casting machine essentially vertically upwards. 10
5. Method according to the claim 3, wherein the melt to be solidified during casting is flowed to the casting machine essentially vertically downward. 15
6. Method according to the claim 1, wherein the melt to be solidified during casting is flowed to the casting machine essentially horizontally.
7. Method according to any of the preceding claims, wherein the alloy to be cast contains 0,1 to 1,5 % by weight chromium. 20
8. Method according to any of the preceding claims 1 - 6, wherein the alloy to be cast contains 0,01 to 0,25 % by weight zirconium. 25
9. Method according to any of the preceding claims 1 - 6, wherein the alloy to be cast contains 0,1 to 1,5 % by weight chromium and 0,01 to 0,25 % by weight zirconium. 30

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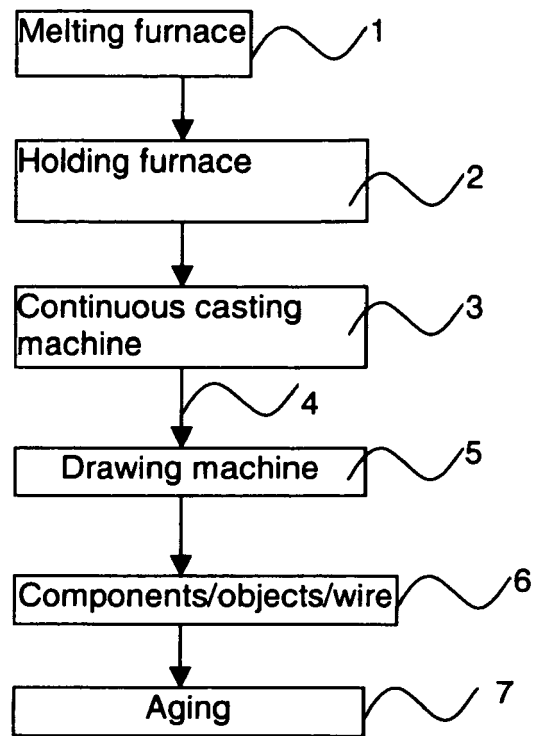


FIG. 1

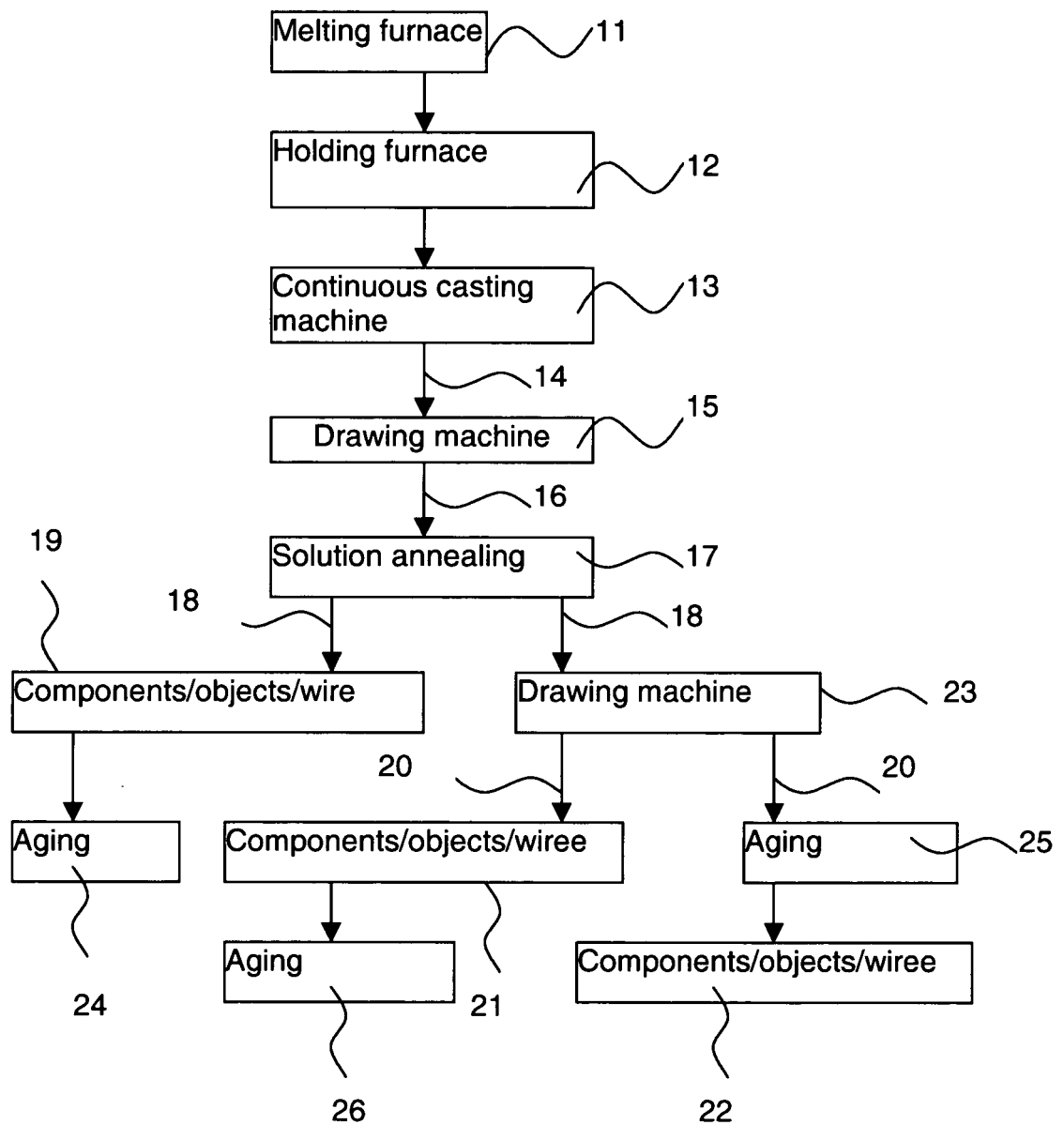


Fig. 2

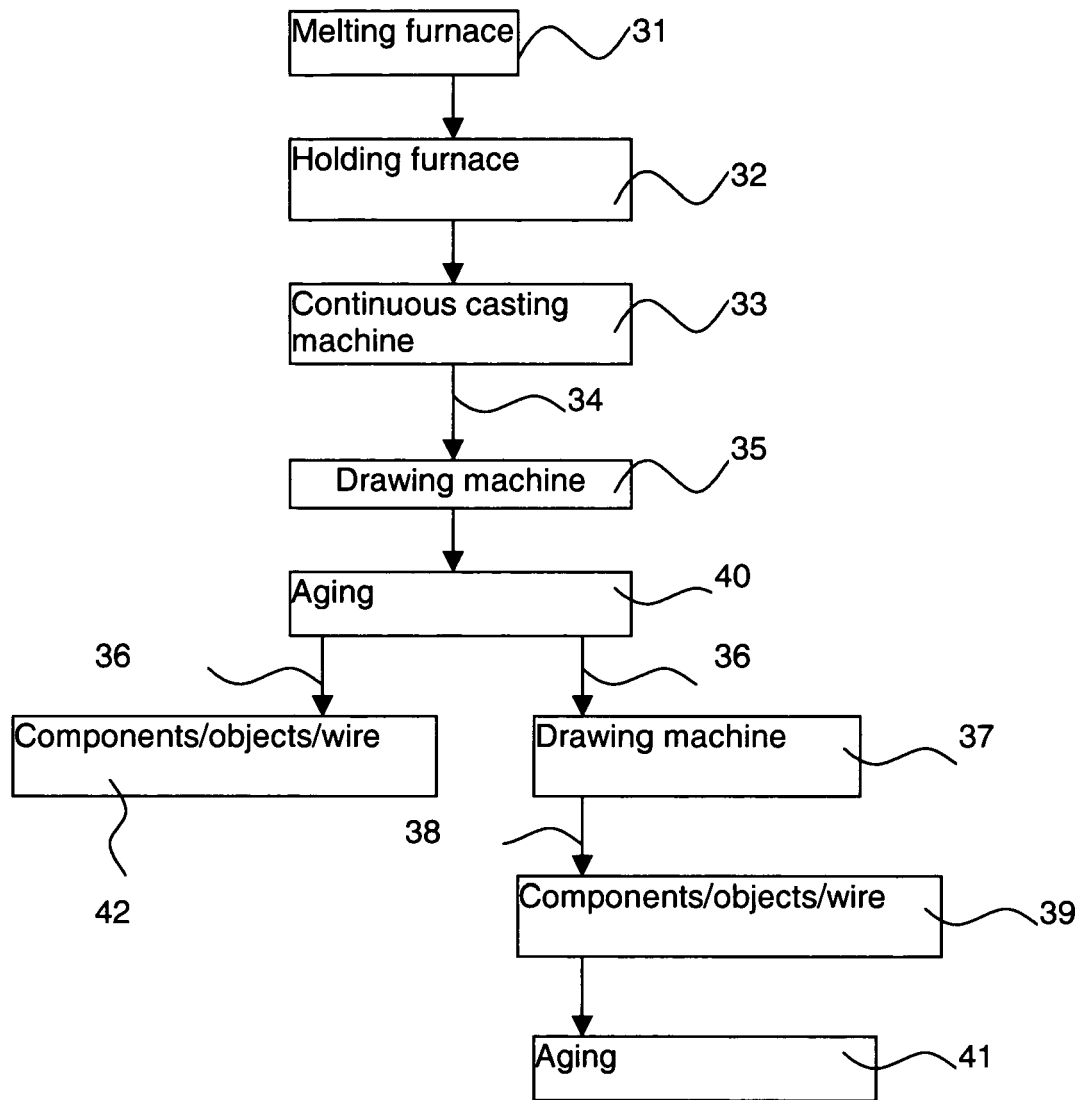


FIG. 3