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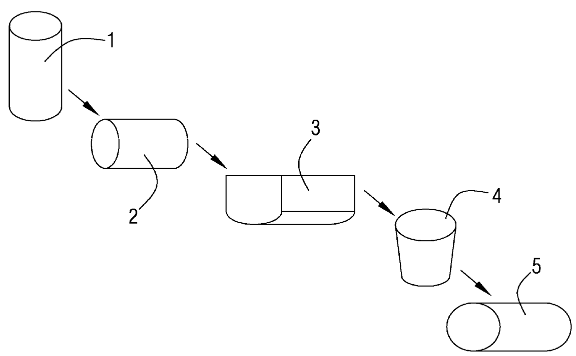
(54) SYSTEM AND METHOD FOR REFINING COPPER ALLOYS

(57) The invention relates to a copper alloy refining system, comprising a vertical furnace, an oxidising furnace, a refining furnace, a reducing furnace and a smelting furnace, arranged sequentially one after the other for the passage therethrough of molten copper resulting from a copper load or copper alloy load introduced into the vertical furnace; wherein the vertical furnace has a melting capacity for the introduced copper load, wherein the oxidising furnace is enabled to exchange oxygen with the molten copper coming from the vertical furnace, wherein the refining furnace is enabled to add additives to the molten copper coming from the oxidising furnace, wherein the reducing furnace is enabled to reduce the molten copper coming from the refining furnace, wherein the smelting furnace is enabled to receive the molten copper coming from the reducing furnace.

FIG.1



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Description

OBJECT OF THE INVENTION

[0001] The object of this invention application is to register a system and method for refining copper alloys, which incorporates considerable innovations and advantages over the techniques used up until now.

[0002] More specifically, the invention proposes the development of a system and method for refining copper alloys, which, due to its particular arrangement, achieves greater energy performance and greater efficiency in a copper refining process.

BACKGROUND OF THE INVENTION

[0003] In the state of the art, it is known that due to climate change, the circular economy must be implemented and products with a minimum carbon footprint in their preparation must be used.

[0004] Modern society requires the use of copper for its development, and currently 35% of copper consumption comes from recycled material. There are currently two industrial processes for recovering recycled copper, the pyrometallurgical process and the hydrometallurgical process. Undoubtedly, the most efficient one from the environmental standpoint is the pyrometallurgical process.

[0005] Nowadays, there are two pyrometallurgical technologies for recycling copper that use raw material with copper content higher than 94%, these being the use of the traditional reverberatory furnace or the use of the so-called "Cosmelt Process", invented by the same applicant in 2001.

[0006] The reverberatory furnace is characterised by working in phases, i.e., loading, melting, oxidation, refining, reduction and smelting phase. To be efficient in the refining phase, the furnace requires a large surface of liquid copper.

[0007] In an in-depth analysis of this process and with a view to sustainability, the following strengths in the use of the traditional reverberatory furnace can be defined:

i. - great refining capacity,
ii. - a single furnace,
iii. - very good exchange between impurities and additives.

[0008] And the following weaknesses:

i. - low energy efficiency in melting,
ii. - it is not a continuous process,
iii. - little exchange in the oxidation and reduction steps.
iv. - greater wear of the refractory due to greater thermal shock in the loading process.

[0009] The "Cosmelt Process" is characterised by working continuously. Loading and melting is carried out in a vertical furnace with high energy efficiency, with the loading door at the top and the burners at the bottom of the furnace. The furnace is filled with recycled material, casting in the bottom and transferring the liquid copper to a set of refining boxes with the incorporation of additives and with porous plugs for the injection of oxygen to oxidise the bath. The set of boxes work continuously until they feed two furnaces for homogenising and reducing purified liquid copper that work alternately to maintain a constant flow of purified liquid copper.

[0010] In an in-depth analysis of this "Cosmelt Process" and with a view to sustainability, the following strengths can be defined:

i. - continuous process,
ii. - high energy efficiency in melting,
iii. - long life of the refractory material.

[0011] And the following weaknesses:

i. - low oxidation capacity,
ii. - limited refining capacity, only recycled material with high copper content can be used,
iii. - impossibility of removing slag from the vertical furnace,
iv. - several furnace units.

[0012] The present invention, due to its particular arrangement, contributes to improving energy performance and greater efficiency in the recycled copper treatment processes known in the state of the art.

DESCRIPTION OF THE INVENTION

[0013] The present invention has been developed to provide a copper alloy refining system, comprising a vertical furnace, an oxidising furnace, a refining furnace, a reducing furnace and a smelting furnace, arranged sequentially one after the other in this order and mutually linked for the passage therethrough of molten copper resulting from a copper load or copper alloy load introduced into the vertical furnace; wherein the vertical furnace has a melting capacity for the introduced copper load, wherein the oxidising furnace is enabled for oxygen exchange with the molten copper coming from the vertical furnace, wherein the refining furnace is enabled to add additives to the molten copper coming from the oxidising furnace, wherein the reducing furnace is enabled to reduce the molten copper coming from the refining furnace, wherein the smelting furnace is enabled to receive the molten copper coming from the reducing furnace.

[0014] In addition, in the copper alloy refining system, the vertical furnace and the smelting furnace have the capacity for continuous output of molten copper, and the oxidising furnace, the refining furnace and the reducing furnace are provided for discontinuous filling and emptying.

[0015] In addition, in the copper alloy refining system, the oxidising furnace, the refining furnace and the reducing furnace have the same volumetric capacity, which is six times higher than the volumetric capacity of the vertical furnace and two times higher than the volumetric capacity of the smelting furnace.

[0016] In addition, in the copper alloy refining system, the oxidising furnace has an arrangement where a ratio between the free surface (S) of the molten copper and the height (A) of the same molten copper is eight.

[0017] In addition, in the copper alloy refining system, the refining furnace has an arrangement where a ratio between the free surface (S) of the molten copper and the height (A) of the same molten copper is higher than fifteen.

[0018] In addition, in the copper alloy refining system, the reducing furnace has an arrangement where a ratio between the free surface (S) of the molten copper and the height (A) of the same molten copper is two.

[0019] Alternatively, in the copper alloy refining system, the vertical furnace allows the copper load to be introduced through its upper portion, and liquid copper and slag resulting from the melting of the copper load to exit through a lower side.

[0020] Alternatively, in the copper alloy refining system, the oxidising furnace incorporates an injection of oxygen through lances or porous plugs.

[0021] Alternatively, in the copper alloy refining system, the refining furnace incorporates porous plugs.

[0022] Alternatively, in the copper alloy refining system, the reducing furnace incorporates an injection of reducing agent through lances or porous plugs.

[0023] A copper alloy refining method, comprising the following successive steps:

a. Melting a copper load and transforming it into liquid copper,
b. Oxidising the liquid copper,
c. Refining the liquid copper,
d. Reducing liquid copper,
e. Smelting the liquid copper.

[0024] In addition, in the copper alloy refining method, melting, oxidation, refining, reduction and smelting take place respectively in a vertical furnace, an oxidising furnace, a refining furnace, a reducer and a smelting furnace, wherein the oxidising furnace, the refining furnace and the reducing furnace have the same volumetric capacity, which is six times higher than the volumetric capacity of the vertical furnace and two times higher than the volumetric capacity of the smelting furnace.

[0025] In addition, in the copper alloy refining method, oxidation takes place in an oxidising furnace that has an arrangement where a ratio between the free surface (S) of the molten copper and the height (A) of the same molten copper is eight.

[0026] In addition, in the copper alloy refining method, refining takes place in a refining furnace that has an arrangement where a ratio between the free surface (S) of the molten copper and the height (A) of the same molten copper is higher than fifteen.

[0027] In addition, in the copper alloy refining method, reduction takes place in a reducing furnace that has an arrangement where a ratio between the free surface (S) of the molten copper and the height (A) of the same molten copper is two.

[0028] In addition, in the copper alloy refining method, melting, oxidation, refining, reduction and smelting take place respectively in a vertical furnace, an oxidising furnace, a refining furnace, a reducer and a smelting furnace, wherein the treatment capacity in tonnes per hour of the oxidising furnace, the refining furnace and the reducing furnace are equal and six times higher than the treatment capacity in tonnes per hour of the vertical furnace and two times higher than the treatment capacity in tonnes per hour of the smelting furnace.

[0029] In addition, in the copper alloy refining method, the vertical furnace continuously discharges the liquid copper in the oxidising furnace, the oxidising furnace discharges the liquid copper in the refining furnace every six hours, the refining furnace discharges the liquid copper in the reducing furnace every six hours, the reducing furnace discharges the liquid copper in the smelting furnace every three hours, and the smelting furnace continuously delivers the liquid copper.

[0030] In addition, the copper alloy refining method is carried out by a described copper alloy refining system.

[0031] As a result of the present invention, it is possible to improve energy performance and greater efficiency in the recycled copper treatment processes known in the state of the art.

[0032] Other features and advantages of the system and method for refining copper alloy will become apparent from the description of a preferred, but non-exclusive embodiment, illustrated by way of non-limiting example in the attached drawings, in which:

BRIEF DESCRIPTION OF THE FIGURES

[0033]

Figure 1 is a schematic view of a preferred embodiment of the copper alloy refining system of the present invention.

Figure 2 is a schematic view of a vertical furnace in a preferred embodiment of the copper alloy refining system of the present invention.

Figure 3 is a schematic view of an oxidising furnace in a preferred embodiment of the copper alloy refining system of the present invention.

Figure 4 is a schematic view of a refining furnace in a preferred embodiment of the copper alloy refining system of the present invention.

Figure 5 is a schematic view of a reducing furnace in a preferred embodiment of the copper alloy refining system of the present invention.

Figure 6 is a schematic view of a preferred embodiment of the copper alloy refining method of the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0034] The present invention relates to a copper alloy refining system, which, due to its particular arrangement, provides notable advantages to the state of the art.

[0035] As shown schematically in figure 1, the copper alloy refining system comprises a vertical furnace 1, an oxidising furnace 2, a refining furnace 3, a reducing furnace 4 and a smelting furnace 5, which are arranged sequentially one after the other in this order, and mutually linked for the passage therethrough of molten copper 12 resulting from a copper load 11, copper alloy load or copper scrap load introduced into the vertical furnace 1.

[0036] The copper load 11 introduced into the copper alloy refining system of the invention and the molten copper 12 resulting from its melting in the vertical furnace 1 therefore follows a sequential path through the vertical furnace 1, the oxidising furnace 2, the refining furnace 3, the reducing furnace 4 and the smelting furnace 5 in this order.

[0037] As shown in figure 1, the vertical furnace 1 is arranged at the beginning of the copper alloy refining system of the invention, and it is where the copper load 11 to be treated is introduced, and it has a melting capacity for said copper load 11 introduced for its transformation into liquid copper 12. Figure 2 represents a possible arrangement of the vertical furnace 1, with an introduction of the copper load 11 through its upper portion, and a continuous output of liquid copper 12 resulting from its melting and slag 13 through a lower side.

[0038] Next, the liquid copper 12 coming from the same molten copper load 11 passes to the oxidising furnace 2, which is enabled for oxygen exchange with the molten liquid copper 12 coming from the vertical furnace 1.

[0039] Afterward, the liquid copper 12 passes to the refining furnace 3, which is in turn enabled to add additives to the liquid copper 12 coming from the oxidising furnace 2.

[0040] Subsequently, the liquid copper 12 passes to the reducing furnace 4, which is enabled to reduce the liquid copper 12 coming from the refining furnace 3.

[0041] Lastly, the liquid copper 12 passes to the smelting furnace 5, which is enabled to receive the liquid copper 12 coming from the reducing furnace 4, and its continuous delivery.

[0042] The copper alloy refining system of the proposed invention also has a number of particularities.

[0043] On the one hand, the oxidising furnace 2, the refining furnace 3 and the reducing furnace 4 have the same volumetric capacity.

[0044] Furthermore, said same volumetric capacity of the oxidising furnace 2, the refining furnace 3 and the reducing furnace 4 is six times higher than the volumetric capacity of the vertical furnace 1, and is simultaneously two times higher than the volumetric capacity of the smelting furnace 5. Therefore, the volumetric capacity of the smelting furnace 5 is three times higher than that of the vertical furnace 1.

[0045] On the other, as shown schematically in figure 3, the oxidising furnace 2 has an arrangement where a ratio between the free surface S of the molten liquid copper load 12 and the height A of the same molten liquid copper load 12 is eight, in other words, $S(m^2)/A(m)=8$, obviously using coherent units of surface and height, metres in this case.

[0046] This detail of the oxidising furnace 2 provides the advantage of having a high capacity for oxygen exchange with copper, as well as sufficient surface for the exchange of copper with fluxes. The oxidising furnace 2 can also incorporate an injection of oxygen through lances or porous plugs to allow good slagging.

[0047] In the same manner, as shown schematically in figure 4, the refining furnace 3 has an arrangement where a ratio between the free surface S of the liquid copper 12 and the height A of the same liquid copper load 12 is higher than fifteen, in other words, $S(m^2)/A(m)>15$, obviously using coherent units of surface and height, metres in this case.

[0048] This detail of the refining furnace 3 provides the advantage of a high capacity for surface exchange, with a low height of liquid copper 12 and a large section, with great ease of slagging and great movement of the copper through porous plugs, allowing the loading of additives and good automatic slagging.

[0049] Likewise, figure 5 also shows that the reducing furnace 4 has an arrangement where a ratio between the free surface S of the molten liquid copper 12 and the height A of the same molten copper load is two, in other words, $S(m^2)/A(m)=2$, obviously using coherent units of surface and height, metres in this case.

[0050] This detail of the reducing furnace 4 entails the advantage of a high capacity for reduction exchange, with a large height of liquid copper 12 and a small section.

[0051] The reducing furnace 4 can also have an injection of reducing agent through lances or porous plugs.

[0052] The copper alloy refining system of the present invention avoids the drawbacks of the pyrometallurgical processes known in the state of the art, allows for operation and continuous casting called Circular Copper Smelter (CCS) by the applicant himself, and allows for circular copper of all types with a minimum copper content of 94% to be processed, incorporating the advantages and eliminating the limitations of the current processes known in the state of the art (reverberation and "Cosmelt Process").

[0053] The copper alloy refining system of the present invention optimises each furnace based on the phase that is required to purify circular copper, thus obtaining greater energy performance and greater efficiency in each copper refining process.

[0054] Figure 2 shows the vertical furnace 1 in greater detail, wherein the copper load 11 to be treated in its upper portion and an outlet for liquid copper 12 and slag 13 through a lower side can be seen. The combustion burners 14 are displaced to the rear and allow the generation of a pool of liquid copper 12 that facilitates the transfer and exit of the slag 13 to the oxidising furnace 2.

[0055] In the case, for example, of wanting to continuously refine X tonnes/hour of copper recycling in the copper alloy refining system of the invention, the melting treatment capacity of the vertical furnace 1 will then be X tonnes/hour.

[0056] Therefore, and according to the aforementioned detail that the volumetric capacity of the oxidising furnace 2, the refining furnace 3 and the reducing furnace 4 is six times higher than the volumetric capacity of the vertical furnace 1, the treatment capacity of the oxidising furnace 2 is 6X, considering X as the continuous treatment capacity in tonnes/hour for refining copper recycling by the vertical furnace 1. The oxidising furnace 2 continuously receives the liquid copper 12 from the vertical furnace 1, and the liquid copper 12 is emptied and delivered to the refining furnace 3 every six hours.

[0057] Next, the refining furnace 3 also with a treatment capacity of 6X, after loading the liquid copper 12 from the oxidising furnace 2, empties the liquid copper 12 to the reducing furnace 4 every six hours.

[0058] The treatment capacity of the reducing furnace 4 is also 6X, receiving liquid copper 12 from the refining furnace 3 every six hours.

[0059] However, taking into account that the volumetric capacity of the smelting furnace 5 is half that of the reducing furnace 4, the smelting furnace 5 has a treatment capacity of 3X.

[0060] Therefore, the reducing furnace 4 discharges the liquid copper 12 to the smelting furnace 5 every three hours, and the liquid copper 12 subsequently exits the smelting furnace 5 continuously.

[0061] In other words, the vertical furnace 1 and the waiting and smelting furnace 5 are provided for continuous operation and transfer of the liquid copper 12, while the oxidising furnace 2, the refining furnace 3 and the reducing furnace 4 are provided for discontinuous filling and emptying.

[0062] The invention further includes a copper alloy refining method. In one embodiment, said method of the invention can also be carried out by using the copper alloy refining system described above and also included in the invention.

[0063] The copper alloy refining method included in the invention comprises the following successive steps, as represented schematically in figure 6:

a. Melting 100 a copper load 11 and transforming it into liquid copper 12,
b. Oxidising 101 the liquid copper 12,
c. Refining 102 the liquid copper 12,
d. Reducing 103 the liquid copper 12,
e. Smelting 104 the liquid copper 12.

[0064] The said copper alloy refining method, melting 100, oxidation 101, refining 102, reduction 103 and smelting 104 take place respectively in a vertical furnace 1, an oxidising furnace 2, a refining furnace 3, a reducer 4 and a smelting furnace 5, wherein the oxidising furnace 2, the refining furnace 3 and the reducing furnace 4 have the same volumetric capacity, which is six times higher than the volumetric capacity of the vertical furnace 1 and two times higher than the volumetric capacity of the smelting furnace 5.

[0065] Also in said copper alloy refining method, the oxidising furnace 2 where oxidation 101 takes place has an arrangement where a ratio between the free surface (S) of the molten copper 12 and the height (A) of the same molten copper 12 is eight.

[0066] Also in the same copper alloy refining method, the refining furnace 3 where refining 103 takes place has an arrangement where a ratio between the free surface (S) of the molten copper 12 and the height (A) of the same molten copper 12 is higher than fifteen.

[0067] Also in the same copper alloy refining method, reduction 104 takes place in a reducing furnace 4 that has an arrangement where a ratio between the free surface (S) of the molten copper 12 and the height (A) of the same molten copper 12 is two.

[0068] In this copper alloy refining method of the invention, melting 100, oxidation 101, refining 102, reduction 103 and smelting 104 take place respectively in a vertical furnace 1, an oxidising furnace 2, a refining furnace 3, a reducer 4 and a smelting furnace 5, wherein the treatment capacity in tonnes per hour of the oxidising furnace 2, the refining furnace 3 and the reducing furnace 4 are equal and six times higher than the treatment capacity in tonnes per hour of the vertical furnace 1 and two times higher than the treatment capacity in tonnes per hour of the smelting furnace 5.

[0069] Furthermore, in the copper alloy refining method of the invention, the vertical furnace 1 continuously discharges the liquid copper 12 in the oxidising furnace 2, the oxidising furnace 2 discharges the liquid copper 12 in the refining furnace 3 every six hours, the refining furnace 3 discharges the liquid copper 12 in the reducing furnace 4 every six hours, the reducing furnace 4 discharges the liquid copper 12 in the smelting furnace 5 every three hours, and the smelting furnace 5 continuously delivers the liquid copper 12.

[0070] The copper alloy refining method of the invention can also be carried out in the copper alloy refining system also included in the same invention.

[0071] Details, shapes, dimensions and other accessory elements, as well as the materials used in the manufacture and execution of the system and method for refining copper alloys of the invention, may be suitably replaced with others that are technically equivalent and do not depart from the essential nature of the invention or from the scope defined by the claims included below.

Claims

1. A copper alloy refining system, **characterised in that** it comprises a vertical furnace (1), an oxidising furnace (2), a refining furnace (3), a reducing furnace (4) and a smelting furnace (5), arranged sequentially one after the other in this order and mutually linked for the passage therethrough of molten copper (12) resulting from a copper load (11) or copper alloy load introduced into the vertical furnace (1); wherein the vertical furnace (1) has a melting capacity for the introduced copper load (11), wherein the oxidising furnace (2) is enabled for oxygen exchange with the molten copper (12) coming from the vertical furnace (1), wherein the refining furnace (3) is enabled to add additives to the molten copper (12) coming from the oxidising furnace (2), wherein the reducing furnace (4) is enabled to reduce the molten copper (12) coming from the refining furnace (3), wherein the smelting furnace (5) is enabled to receive the molten copper (12) coming from the reducing furnace (4).

2. The copper alloy refining system according to claim 1, wherein the vertical furnace (1) and the smelting furnace (5) have the capacity for continuous output of molten copper (12), and the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) are provided for discontinuous filling and emptying.

3. The copper alloy refining system according to any of the preceding claims, wherein the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) have the same volumetric capacity, which is six times higher than the volumetric capacity of the vertical furnace (1) and two times higher than the volumetric capacity of the smelting furnace (5).

4. The copper alloy refining system according to any of the preceding claims, wherein the oxidising furnace (2) has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is eight.

5. The copper alloy refining system according to any of the preceding claims, wherein the refining furnace (3) has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is higher than fifteen.

6. The copper alloy refining system according to any of the preceding claims, wherein the reducing furnace (4) has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is two.

7. The copper alloy refining system according to any of the preceding claims, wherein the vertical furnace (1) allows the copper load (11) to be introduced through its upper portion, and liquid copper (12) and slag (13) resulting from the melting of the copper load (11) to exit through a lower side.

8. The copper alloy refining system according to any of the preceding claims, wherein the oxidising furnace (2) incorporates an injection of oxygen through lances or porous plugs.

9. The copper alloy refining system according to any of the preceding claims, wherein the refining furnace (3) incorporates porous plugs.

10. The copper alloy refining system according to any of the preceding claims, wherein the reducing furnace (4) incorporates an injection of reducing agent through lances or porous plugs.

11. A copper alloy refining method, **characterised in that** it comprises the following successive steps:

    f. Melting (100) a copper load (11) and transforming it into liquid copper (12),
    g. Oxidising (101) the liquid copper (12),
    h. Refining (102) the liquid copper (12),
    i. Reducing (103) the liquid copper (12),
    j. Smelting (104) the liquid copper (12).

12. The copper alloy refining method according to claim 11, wherein melting (100), oxidation (101), refining (102), reduction (103) and smelting (104) take place respectively in a vertical furnace (1), an oxidising furnace (2), a refining furnace (3), a reducer (4) and a smelting furnace (5), wherein the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) have the same volumetric capacity, which is six times higher than the volumetric capacity of the vertical furnace (1) and two times higher than the volumetric capacity of the smelting furnace (5).

13. The copper alloy refining method according to any of claims 11 to 12, wherein oxidation (101) takes place in an oxidising furnace (2) that has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is eight.

14. The copper alloy refining method according to any of claims 11 to 13, wherein refining (103) takes place in a refining furnace (3) that has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is higher than fifteen.

15. The copper alloy refining method according to any of claims 11 to 14, wherein reduction (104) takes place in a reducing furnace (4) that has an arrange-

ment where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is two.

16. The copper alloy refining method according to any of claims 11 to 15, wherein melting (100), oxidation (101), refining (102), reduction (103) and smelting (104) take place respectively in a vertical furnace (1), an oxidising furnace (2), a refining furnace (3), a reducer (4) and a smelting furnace (5), wherein the treatment capacity in tonnes per hour of the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) are equal and six times higher than the treatment capacity in tonnes per hour of the vertical furnace (1) and two times higher than the treatment capacity in tonnes per hour of the smelting furnace (5).

17. The copper alloy refining method according to any of claims 13 to 16 when they are dependent on claim 12, wherein the vertical furnace (1) continuously discharges the liquid copper (12) in the oxidising furnace (2), wherein the oxidising furnace (2) discharges the liquid copper (12) in the refining furnace (3) every six hours, wherein the refining furnace (3) discharges the liquid copper (12) in the reducing furnace (4) every six hours, wherein the reducing furnace (4) discharges the liquid copper (12) in the smelting furnace (5) every three hours, and wherein the smelting furnace (5) continuously delivers the liquid copper (12).

18. The copper alloy refining method according to any of claims 11 to 17, which is carried out by a copper alloy refining system according to any of claims 1 to 10.

Amended claims in accordance with Rule 137(2) EPC.

1. A copper alloy refining system, **characterised in that** it comprises a vertical furnace (1), an oxidising furnace (2), a refining furnace (3), a reducing furnace (4) and a smelting furnace (5), arranged sequentially one after the other in this order and mutually linked for the passage therethrough of molten copper (12) resulting from a copper load (11) or copper alloy load introduced into the vertical furnace (1); wherein the vertical furnace (1) has a melting capacity for the introduced copper load (11), wherein the oxidising furnace (2) is enabled for oxygen exchange with the molten copper (12) coming from the vertical furnace (1), wherein the refining furnace (3) is enabled to add additives to the molten copper (12) coming from the oxidising furnace (2), wherein the reducing furnace (4) is enabled to reduce the molten copper (12) coming from the refining furnace (3), wherein the smelting furnace (5) is enabled to receive the molten copper (12) coming from the reducing furnace (4); and wherein the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) have the same volumetric capacity, which is six times higher than the volumetric capacity of the vertical furnace (1) and two times higher than the volumetric capacity of the smelting furnace (5).

2. The copper alloy refining system according to claim 1, wherein the vertical furnace (1) and the smelting furnace (5) have the capacity for continuous output of molten copper (12), and the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) are provided for discontinuous filling and emptying.

3. The copper alloy refining system according to any of the preceding claims, wherein the oxidising furnace (2) has an arrangement where this oxidising furnace (2) works with a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is eight.

4. The copper alloy refining system according to any of the preceding claims, wherein the refining furnace (3) has an arrangement where this refining furnace (3) works with a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is higher than fifteen.

5. The copper alloy refining system according to any of the preceding claims, wherein the reducing furnace (4) has an arrangement where this reducing furnace (4) works with a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is two.

6. The copper alloy refining system according to any of the preceding claims, wherein the vertical furnace (1) allows the copper load (11) to be introduced through its upper portion, and liquid copper (12) and slag (13) resulting from the melting of the copper load (11) to exit through a lower side.

7. The copper alloy refining system according to any of the preceding claims, wherein the oxidising furnace (2) incorporates an injection of oxygen through lances or porous plugs.

8. The copper alloy refining system according to any of the preceding claims, wherein the refining furnace (3) incorporates porous plugs.

9. The copper alloy refining system according to any of the preceding claims, wherein the reducing furnace (4) incorporates an injection of reducing agent through lances or porous plugs.

10. A copper alloy refining method, **characterised in that** it comprises the following successive steps:

a. Melting (100) a copper load (11) and transforming it into liquid copper (12),
b. Oxidising (101) the liquid copper (12),
c. Refining (102) the liquid copper (12),
d. Reducing (103) the liquid copper (12),
e. Smelting (104) the liquid copper (12);

wherein melting (100), oxidation (101), refining (102), reduction (103) and smelting (104) take place respectively in a vertical furnace (1), an oxidising furnace (2), a refining furnace (3), a reducer (4) and a smelting furnace (5), wherein the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) have the same volumetric capacity, which is six times higher than the volumetric capacity of the vertical furnace (1) and two times higher than the volumetric capacity of the smelting furnace (5).

11. The copper alloy refining method according to claim 10, wherein oxidation (101) takes place in an oxidising furnace (2) that has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is eight.

12. The copper alloy refining method according to any of claims 10 to 11, wherein refining (103) takes place in a refining furnace (3) that has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is higher than fifteen.

13. The copper alloy refining method according to any of claims 10 to 12, wherein reduction (104) takes place in a reducing furnace (4) that has an arrangement where a ratio between the free surface (S) of the molten copper (12) and the height (A) of the same molten copper (12) is two.

14. The copper alloy refining method according to any of claims 10 to 13, wherein melting (100), oxidation (101), refining (102), reduction (103) and smelting (104) take place respectively in a vertical furnace (1), an oxidising furnace (2), a refining furnace (3), a reducer (4) and a smelting furnace (5), wherein the treatment capacity in tonnes per hour of the oxidising furnace (2), the refining furnace (3) and the reducing furnace (4) are equal and six times higher than the treatment capacity in tonnes per hour of the vertical furnace (1) and two times higher than the treatment capacity in tonnes per hour of the smelting furnace (5).

15. The copper alloy refining method according to any of claims 11 to 14 when they are dependent on claim 12, wherein the vertical furnace (1) continuously discharges the liquid copper (12) in the oxidising furnace (2), wherein the oxidising furnace (2) discharges the liquid copper (12) in the refining furnace (3) every six hours, wherein the refining furnace (3) discharges the liquid copper (12) in the reducing furnace (4) every six hours, wherein the reducing furnace (4) discharges the liquid copper (12) in the smelting furnace (5) every three hours, and wherein the smelting furnace (5) continuously delivers the liquid copper (12).

16. The copper alloy refining method according to any of claims 10 to 15, which is carried out by a copper alloy refining system according to any of claims 1 to 9.

FIG.1

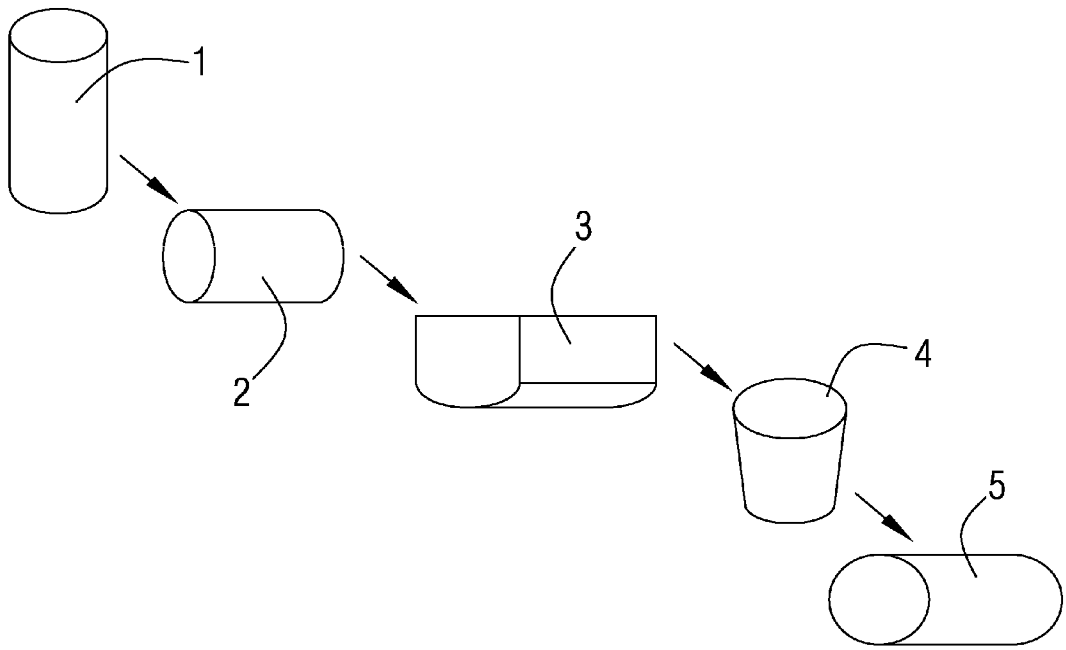


FIG.2

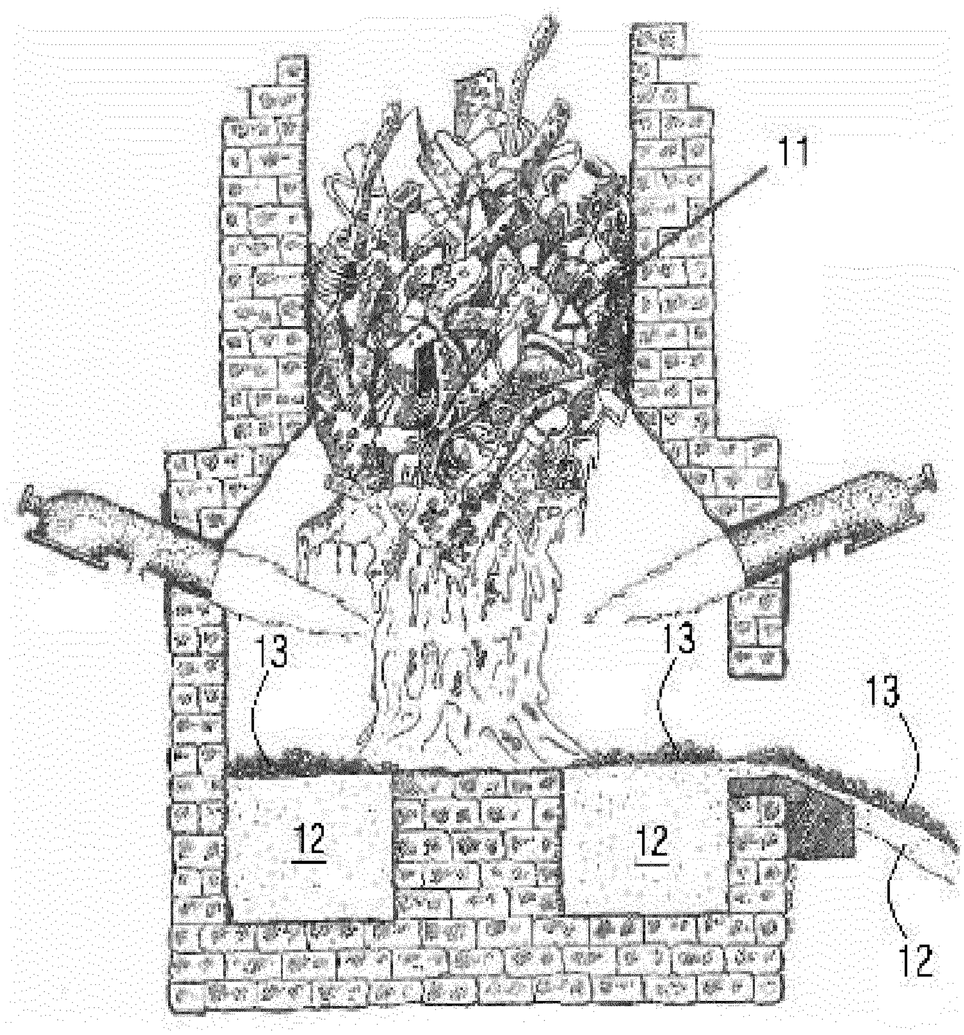


FIG.3

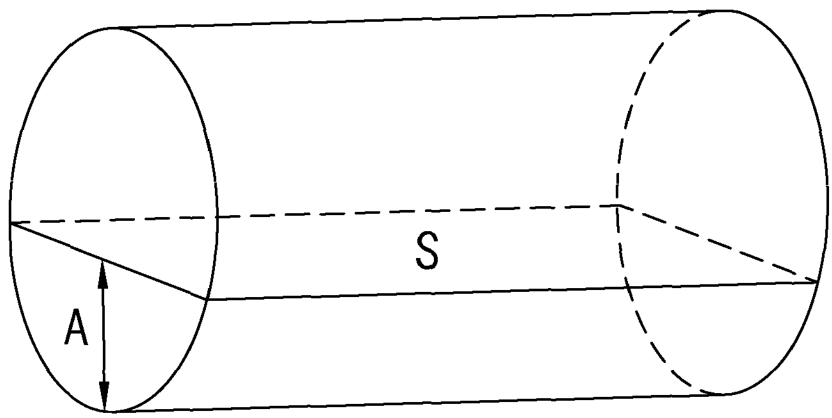


FIG.4

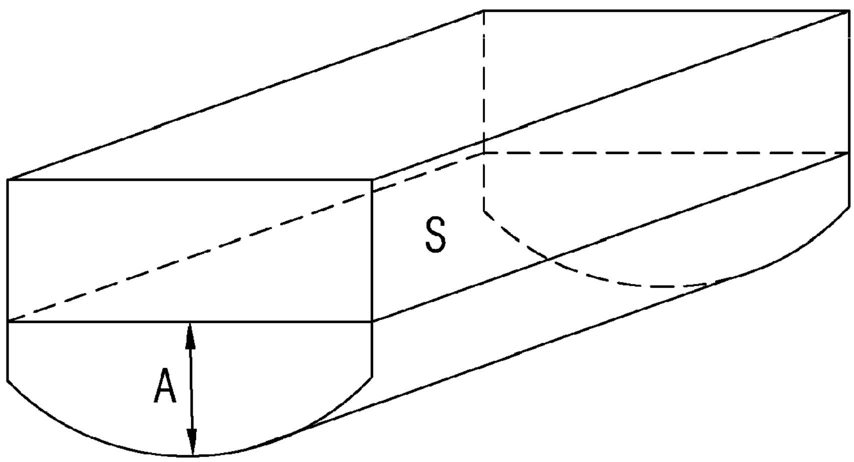


FIG.5

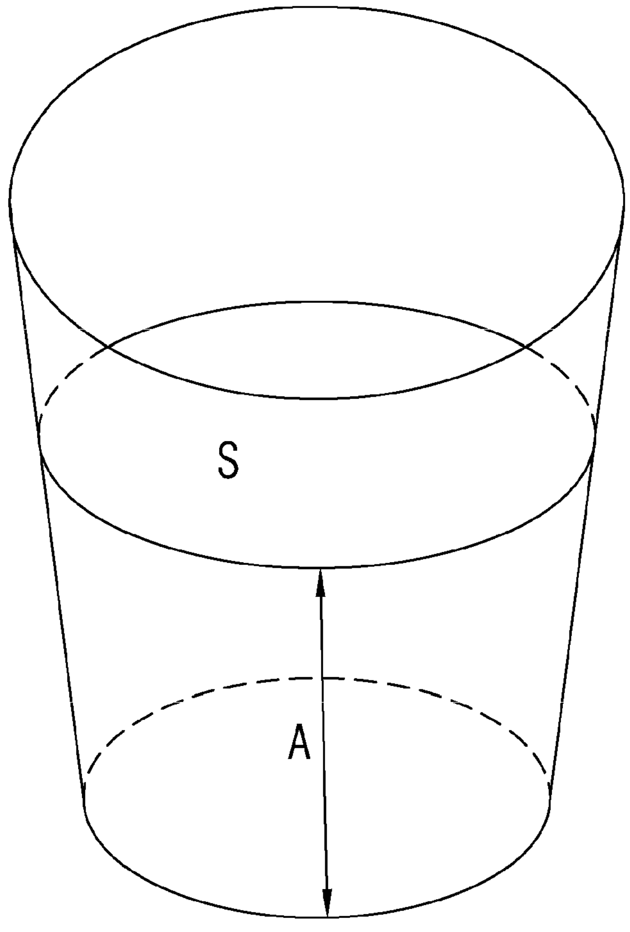
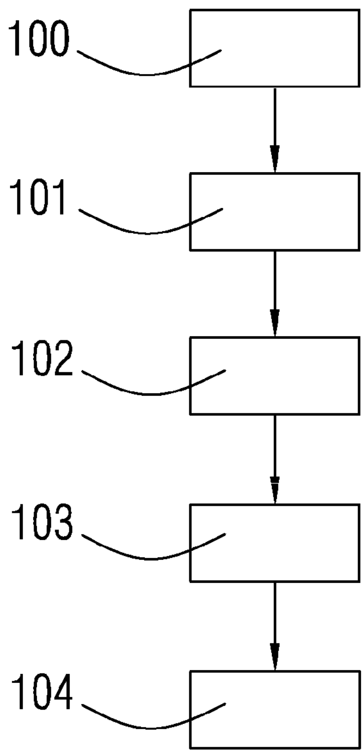


FIG.6



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EUROPEAN SEARCH REPORT

Application Number
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C22B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 October 2023	Porté, Olivier

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