



US 20110214830A1

(19) **United States**(12) **Patent Application Publication**
HOLZGRUBER et al.(10) **Pub. No.: US 2011/0214830 A1**(43) **Pub. Date: Sep. 8, 2011**(54) **METHOD AND APPARATUS FOR
PRODUCING HOLLOW FUSING BLOCKS****Publication Classification**(75) Inventors: **Harald HOLZGRUBER**, Bruck
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(AT)(51) **Int. Cl.**
B22D 46/00 (2006.01)
B22D 27/02 (2006.01)
B22D 27/00 (2006.01)
B22D 2/00 (2006.01)
(52) **U.S. Cl. 164/4.1; 164/492; 164/250.1; 164/147.1;**
164/151.3(73) Assignee: **INTECO SPECIAL MELTING**
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a.d. Mur (AT)(21) Appl. No.: **13/038,738**(22) Filed: **Mar. 2, 2011**(30) **Foreign Application Priority Data**

Mar. 2, 2010 (AT) A317/2010

(57) **ABSTRACT**

To produce hollow ingots, at least two consumable electrodes having a diameter of at least 1.0 times the wall thickness of the hollow ingots are melted in a short, water-cooled mold that is flared particularly in a T-shape in the area of the consumable electrodes, wherein the inner wall of the hollow ingot is formed by a mandrel with a conicity of at least 1.5% that is installed in the mold from above, and the level of the liquid heel is maintained below the T-shaped flaring of the mold.

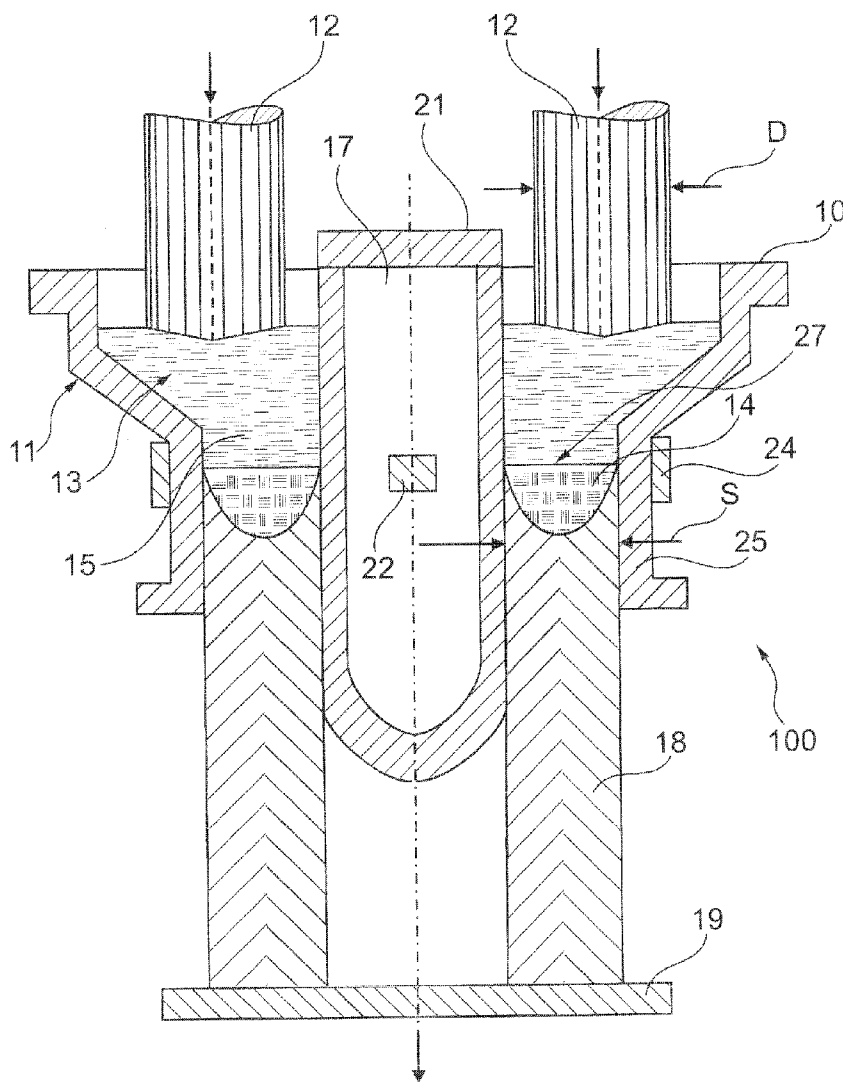


Fig. 1

Fig. 2

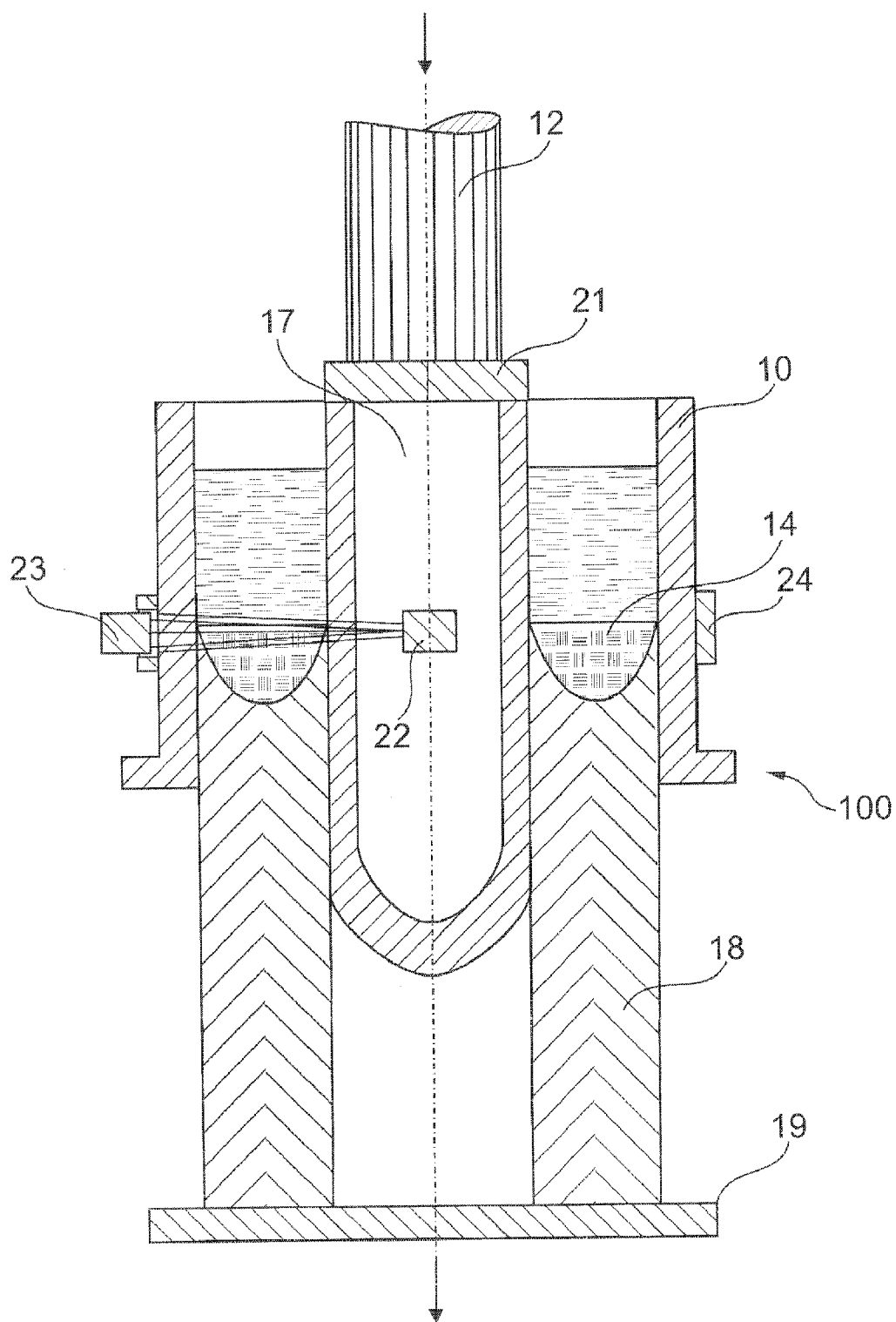


Fig. 3

METHOD AND APPARATUS FOR PRODUCING HOLLOW FUSING BLOCKS

[0001] The present application claims priority of AT A317/2010, filed Mar. 2, 2010, and incorporates the same by reference.

BACKGROUND OF THE INVENTION

[0002] Hollow cast bodies or ingots are used in a variety of applications, particularly for manufacturing mechanical parts in industry.

[0003] These are either processed further immediately after casting, or they undergo further heat treatment by rolling or forging. In order to produce hollow ingots with unalloyed or low-alloyed steels, it is common practice to cast a solid ingot and punch a hole in it while hot before the subsequent hot forming step.

[0004] However, it is practically impossible to perform this process with higher-alloyed steels, including not only austenitic, ferritic and martensitic corrosion and heat resistant steels but also tool steels of various compositions, because these steels do not lend themselves well to heat forming processes. This applies in even greater measure for nickel- and cobalt-based alloys, which are already more difficult to form. Accordingly, in order to manufacture hollow bodies from steels and alloys that are difficult to form, it is often necessary to bore out a solid ingot or even a preformed slug mechanically, and then subject it to a hot forming process. However, this method is associated with high costs, because the high-alloyed steels and alloys are difficult to process mechanically, and in many cases they must also be heat treated before mechanical processing.

[0005] In order to circumvent these difficulties, a number of ideas have been suggested in the past for manufacturing high-alloyed hollow bodies and hollow bodies intended for further processing, particularly by forging, according to an electroslag remelting process with consumable electrodes, since the hollow ingots produced by this method are of high quality.

[0006] For example, a method is known from the related art for producing hollow ingots according to the electroslag remelting process in which a water-cooled conical mandrel is inserted from above into and concentrically with a short, round mould, which is also water-cooled, in such manner that an annular gap is left between the mould and the mandrel. In order to produce a hollow ingot, rod-shaped consumable electrodes are arranged concentrically inside the annular gap, and the melting current is passed through the electrodes and into the slag bath located in the gap, and conducted away again through the slag bath and the bottom plate. The consumable electrodes are melted by the Joule's heat generated as the current passes through the slag bath. The molten metal drips downwards and is collected in the annular gap where it solidifies progressively to form a hollow ingot. With this method, it is possible to produce hollow ingots of satisfactory quality. However, producing and preparing the long, thin, rod-shaped consumable electrodes is a complicated process, and arranging them concentrically inside the annular gap, particularly when manufacturing thin-walled hollow ingots, is also associated with considerable difficulties. In this case, it may be helpful to use "T moulds" in the area of the slag bath, the T-moulds being flared upwardly in the manner of funnels, because this enables consumable electrodes thicker than walls of the hollow ingots to be used.

[0007] In another known method, a mandrel arranged concentrically in the water-cooled mould is moved upwards through an opening in the bottom plate from the underside of the mould in such manner that the ingot is formed on the bottom plate, and the upper extremity of the mandrel always reaches into the slag bath, but always remains completely submerged therein. This enables large consumable electrodes to melt in the slag bath above the mandrel. The metal that is melted from the consumable electrodes drips onto the curved surface of the mandrel, from where it runs into the annular gap between the mould wall and the mandrel, again forming a hollow ingot. With this method, production of the consumable electrodes is much simpler, but the concentric guidance of the mandrel when producing longer ingots presents significant difficulties, often resulting in marked eccentricity of the hole in the hollow cast body. Poor quality of the surface composition in the hole also persistently causes problems during further processing. If these difficulties are to be avoided, the hole must be processed mechanically for a number of reasons before hot forming is carried out.

[0008] A further method for producing hollow ingots by passing a current through the electrodes is described in AT 332.575. In DE 23 03 629 B2, the melting current is also passed through the consumable consumable electrodes, and a rotating bottom plate to achieve better heat distribution in the annular gap is also described.

[0009] Austrian patent AT 409729 B discloses a method in which a known electrically conductive mould is used in conjunction with an electrically conductive mandrel. The melting current is then applied to the slag bath via the mould and passes out of the slag bath again through the mandrel, for example. An electrically conductive electrode is not required. The metal can be introduced either in the form of molten metal or also in the form of solid metal, in which case granules, chippings or even rods may be used, but the metal is not energised. The advantage of this method is that the temperature of the slag bath can then be adjusted independently of the feed rate of the molten or solid metal.

[0010] Although this last method yields results that are usable as such in terms of the quality of the hollow ingots, it requires large amounts of electrical current when consumable electrodes are used, since the energy introduced into the slag bath via the conducting elements only serves indirectly to melt the electrodes, due to the temperature reached in the slag bath. Accordingly, an adequate electrode melting rate can only be achieved by overheating the slag bath, which unfortunately results in high heat losses.

SUMMARY OF THE INVENTION

[0011] However, the disadvantages of the various methods of the related art may be largely avoided according to the invention if consumable electrodes are used that have a diameter substantially larger than the annular gap, which diameter is determined by the difference between the mould wall forming the outer diameter of the hollow ingot and the diameter of the mandrel, and if at least two consumable electrodes are remelted simultaneously, wherein the mould in the area of the consumable electrodes is flared upwardly, particularly in a T-shape, in the area of the slag bath, and the liquid level of the metal is maintained below the level at which the flaring begins.

[0012] Accordingly, the method according to the invention is a method for producing hollow cast ingots by melting consumable electrodes in a slag bath in a short, water-cooled

mould and using a mandrel, also water-cooled, that is introduced into the mould from above in conjunction with at least two consumable electrodes, each of which has a diameter at least 1.0 times the size of the annular gap between the mould wall forming the outer diameter of the hollow ingot and the diameter of the mandrel, wherein the consumable electrodes are melted in a mould that is flared, particularly in a T-shape, in the area of the electrodes to accommodate the slag bath, and wherein the liquid level of the metal content is adjusted and maintained below the flaring.

[0013] Advantageous refinements of the invention are described in the subordinate claims. The scope of the invention includes all combinations of at least two of the features disclosed in the claims, the description and/or the figures. Additionally, in order to avoid repetitions, features that disclosed in respect of the equipment are also claimed for the method, and features that are disclosed in respect of the method are also claimed for the equipment.

[0014] Control and regulation of the liquid level of the metal may be assured in various ways. It is advantageous if the location of the metal liquid level is determined via radioactive γ -rays that are introduced from outside the mould in a position corresponding to the level of the metal and are received by a receiver fitted at the same level inside the water-cooled mandrel. In this way, the liquid level of the metal in the mould may be kept constant by interaction with a suitable controller of the retraction movement of the ingot resting on a bottom plate.

[0015] It has also proved advantageous for producing high-quality hollow bodies having a homogeneous, dense solidification structure if the melting rate in kg/h is adjusted such that it is equivalent to 0.8 to 2.5 times the sum of the external and internal diameters in mm.

[0016] With regard to passing the melting current, a range of options are provided by the use of at least two consumable electrodes, and these may be used variously depending on the prevailing conditions.

[0017] In one variant, the melting current is distributed from one terminal of a single-phase current source to the at least two consumable electrodes and passed to the second terminal of the current source through the slag bath and bottom plate.

[0018] With this type of feed via the consumable electrode, it is also possible to return the melting current from the slag bath to the second terminal of the current source via the mould and/or the mandrel. In this situation, known conducting elements may be used to forward the current from the mould and/or mandrel.

[0019] However, when a single-phase current source is used, the option also exists to pass the entire melting current from one terminal to one of the at least two consumable electrodes, and from there through the slag bath and the liquid heel to the second of the at least two electrodes, and from there to the second terminal of the current source.

[0020] In order to ensure that heat is distributed evenly in the liquid heel, it may be advantageous to set the heel in a horizontal rotating motion inside the gap by the use of suitable agitating coils. Such an agitating movement may also have an advantageous effect on the solidification of the hollow body produced.

[0021] An embodiment of the invention is illustrated in the drawing and will be described in greater detail in the following.

BRIEF DESCRIPTION OF THE DRAWING

[0022] In the drawing:

[0023] FIG. 1 is a simplified plan view of a system according to the invention for producing hollow cast bodies,

[0024] FIG. 2 is a longitudinal section through the system of FIG. 1 along line II-II in FIG. 1, and

[0025] FIG. 3 is a longitudinal section through the system of FIG. 1 along line III-III in FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

[0026] FIGS. 1 to 3 each show a water-cooled mould 10 with a flaring 11 having a preferably T-shaped longitudinal cross section (see FIG. 2) in the area to consumable electrodes 12, which are melted in a slag bath 13, wherein the molten metal is collected in a liquid heel 14 and after solidifying forms a remelt ingot or cast body, referred to in the following as a hollow ingot 18, in a gap 15 between mould 10 and mandrel 17, which is also water-cooled, which ingot is drawn downwards and out of mould 10 by a suitable device, not shown, which moves bottom plate 19. Mandrel 17 is held in position by a retaining plate 21. A γ -ray receiver 22 located in mandrel 17 is also shown as well as a γ -ray source 23 located outside of mould 10. An electromagnetic agitating coil 24 may optionally be situated in the area of liquid heel 14.

[0027] According to the invention, at least two consumable electrodes 12 are arranged in a system 100 suitable for performing the method, the electrodes being supported and moved by appropriate supporting elements, not shown, and through which the melting current is passed, and via which they are introduced into slag bath 13 in such manner that they melt. At the same time, as is shown in FIGS. 1 and 2, mould 10 containing slag bath 13 is flared in the area of consumable electrodes 12, preferably in a T-Shape, about consumable electrodes 12, which have a diameter D, which is equal to at least 1.0 times the size of gap width s of gap 15. Gap width s is defined by the mould wall 25 that forms the outer surface of hollow ingot 18 and the diameter of mandrel 17, wherein mandrel 17 is tapered conically from the top downwards, that is to say towards bottom plate 19. The conicity of mandrel 17 is at least 1.5% relative to the diameter of the mandrel and relative to the length of mandrel 17 in the solidification zone of the metal in mould 10.

[0028] The γ -ray source 23 is preferably located outside mould 10, below the T-shaped flaring 11 and in the desired position of the liquid level of the metal, and the γ -ray receiver 22 for continuous control of the liquid level 27 of the metal is preferably fitted inside the water-cooled mandrel 17. Hollow ingot 18 that is formed and rests on bottom plate 19 is extracted from mould 10 in interaction with a corresponding controller in such manner that the liquid level 27 of the metal remains constant.

[0029] The supply and return path of the melt current to consumable electrodes 12 may be arranged in various ways.

[0030] In a first arrangement, one terminal of a single-phase current source, not shown here, is connected in parallel to the two consumable electrodes 12, while the other terminal is connected to bottom plate 19 on which hollow ingot 18 rests.

[0031] It is also possible for the second terminal to be connected to mould 10 and/or mandrel 17.

[0032] However, an arrangement is also possible in which one of the at least two consumable electrodes 12 is connected to each the melting current source terminal.

[0033] In a particular variant of the equipment, electromagnetic agitating coil 24 is arranged outside of mould 10 in such manner that slag bath 13 may be rotated about the (longitudinal) axis of hollow ingot 18 in liquid heel 14.

1-15. (canceled)

16. A method for producing hollow cast ingots by melting consumable electrodes in a slag bath in a short, water-cooled mould and using a water-cooled mandrel that is introduced into the mould from above, the method comprising:

Simultaneously melting at least two consumable electrodes in the water-cooled mould, the electrodes having a diameter equivalent to at least 1.0 times the size of an annular gap between a part of the mould forming an outer casting cross section and the mandrel, the mould having a T-shaped flaring in an area of the consumable electrodes, wherein an inner diameter of the cast body is formed by the water-cooled mandrel that is introduced into the mould, the mandrel having a diameter that tapers downwardly in an area of a metal liquid level of a liquid heel; and adjusting the liquid level of the metal below a level of the flaring.

17. The method as recited in claim 16, wherein the mandrel tapers downwardly at least in a solidification zone with a conicity of at least 1.5% relative to the diameter of the mandrel.

18. The method as recited in claim 16, including measuring the liquid level of the metal by γ -ray source attached outside the mould and interacting with a receiver installed inside the mandrel, and keeping the liquid level of the metal constant depending on a melting rate of the consumable electrodes.

19. The method as recited in claim 16, including adjusting a melting rate of the consumable electrodes so as to be equivalent in kg/h to 0.8 to 2.5 times a sum of outer and internal diameters in mm of the cast body.

20. The method as recited in claim 16, including sending a melting current in parallel from one terminal of a single-phase melting current source through the at least two consumable electrodes into the slag bath and back to another terminal through a bottom plate.

21. The method as recited in claim 16, including passing a melting current in parallel from one terminal of a single-phase melting current source into the slag bath through the at least two consumable electrodes and to another terminal of the current source via the mould and/or the mandrel.

22. The method as recited in claim 21, including drawing off the melting current from the mould and/or the mandrel via electrically conducting elements in an area between the consumable electrodes.

23. The method as recited in claim 16, including passing a total melting current of a single-phase current source into the slag bath through at least one of the consumable electrodes, and from the slag bath returning the melting current to the current source through at least a second of the consumable electrodes.

24. The method as recited in claim 16, including creating horizontal movement of the liquid heel about a longitudinal axis of the cast body along the gap in an area of the liquid heel by an electromagnetic agitating coil.

25. A system for producing a hollow cast body, comprising: a short, water-cooled mould; a water-cooled mandrel introducible into the mould from above; and at least two consumable electrodes having a diameter equivalent to at least 1.0 times a size of an annular gap between a part of the mould forming a casting cross section and the mandrel, the electrodes being arranged in the system simultaneously, the mould having a T-shaped flaring at least in an area of the consumable electrodes, the mandrel having a diameter that tapers evenly downwardly in an area of a solidification zone corresponding to a conicity of at least 1.5% relative to the diameter of the mandrel.

26. The system as recited in claim 25, wherein the consumable electrodes are connected to one terminal of a single-phase melting current source, and a bottom plate is connected to another terminal.

27. The system as recited in claim 25, wherein the consumable electrodes are connected to one terminal of a single-phase melting current source, and a connection is established from the mould and/or the mandrel to another terminal.

28. The system as recited in claim 27, wherein the mould and/or the mandrel is/are provided with electrically conducting elements in an area between funnel-shaped flarings of the mould, the conducting elements being connected to one terminal of the melting current source.

29. The system as recited in claim 27, wherein each of the at least two consumable electrodes is connected to one terminal of a single-phase melting current source in each case.

30. The system as recited in claim 25, wherein the mould is provided with an electromagnetic agitating coil in an area of the liquid heel, the coil having lines of force that cause the liquid heel to move in a horizontal or tangential direction about a longitudinal axis of the cast body.

31. The system as recited in claim 25, wherein a γ -ray source is located outside of the mould in a position corresponding to a desired liquid level of the metal, and a γ -ray receiver is located inside the mandrel for measuring the position of the liquid level of the metal.

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