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(54) SIDE-SUBMERGED COMBUSTION SMELTING APPARATUS FOR SPRAYING OXYGEN-ENRICHED AIR AND PULVERIZED COAL

(57) A side-submerged combustion smelting apparatus (1) for spraying oxygen-enriched air and pulverized coal includes: a smelting furnace (100); a pulverized coal delivery pipe (200) for delivering the pulverized coal; an air delivery pipe (300) for delivering the oxygen-enriched air; a plurality of coal injection assemblies (400) arranged at intervals on two opposite side walls of the smelting furnace (100), each coal injection assembly (400) including a pulverized coal lance (410) and an air lance (420) that are adjacent to each other and arranged as a pair, and each coal injection assembly (400) at least partially extending into the smelting furnace (100).

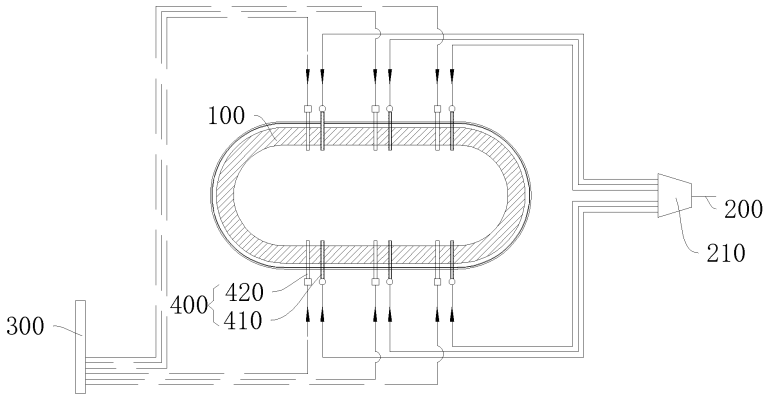

Fig. 1

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Description

FIELD

[0001] The present disclosure relates to a technical field of metallurgy. To be specific, it involves a side-submerged combustion smelting apparatus with the blowing of oxygen-enriched air and pulverized coal.

BACKGROUND

[0002] A side-submerged combustion (SSC) smelting process is to inject oxygen-enriched air and gaseous fuel into a molten bath through the tuyeres or lances on both sides of a smelting furnace, and the injected gas stirs the molten bath to accelerate heat and mass transfer and chemical reaction in the molten bath. The SSC smelting process is widely used in the field of non-ferrous metal treatment (such as lead smelting, zinc slag smelting, copper smelting, etc.) and solid waste treatment.

[0003] If the side-submerged combustion smelting apparatus in the related art employs natural gas, coke oven gas, and producer gas as fuels, fuel gas cannot be economically used in fuel gas-deficient regions, which limits the applicability of side-submerged combustion technology.

[0004] If the side-submerged combustion smelting apparatus in the related technology employs pulverized coal as fuel, the pulverized coal and air are mixed within the lance or the tuyere. Therefore, the oxygen concentration in the air cannot be too high to ensure safety, thus causing the hearth area efficiency and thermal efficiency to fail to adapt to the needs of current development of non-ferrous metal smelting industry and fail to achieve large-scale industrial production.

SUMMARY

[0005] The present disclosure aims to solve at least one of technical problems in the related art to a certain extent. Accordingly, the present disclosure provides a side-submerged combustion smelting apparatus for spraying oxygen-enriched air and pulverized coal. The side-submerged combustion smelting apparatus uses the pulverized coal as a fuel, and thus has advantages of high productivity, low operating cost, and wide applicability.

[0006] To achieve above objectives, the embodiments in the present disclosure provide a side-submerged combustion smelting apparatus for spraying oxygen-enriched air and pulverized coal. The side-submerged combustion smelting apparatus includes: a smelting furnace, a pulverized coal delivery pipe configured to deliver the pulverized coal, an air delivery pipe configured to deliver the oxygen-enriched air and communicated with an air source, and a plurality of coal injection assemblies arranged at intervals on two opposite side walls of the smelting furnace in which each coal injection assembly includes a pulverized coal lance and an air lance adjacent to each other and arranged as a pair, each pulverized coal lance being in communication with the pulverized coal delivery pipe, and each air lance being in communication with the air delivery pipe, and each coal injection assembly at least partially extends into the smelting furnace.

[0007] The side-submerged combustion smelting apparatus in the embodiments of the present disclosure can use the pulverized coal as fuel and thus has advantages of the high productivity, the low operating cost, and the wide applicability.

[0008] In addition, the side-submerged combustion smelting apparatus based on the above embodiments in the present disclosure can also have the following additional technical features.

[0009] According to an embodiment of the present disclosure, the pulverized coal lance of one of two mutually opposite coal injection assemblies is opposite to the pulverized coal lance of the other of the two mutually opposite coal injection assemblies, and the air lance of the one of the two mutually opposite coal injection assemblies is opposite to the air lance of the other of the two mutually opposite coal injection assemblies.

[0010] According to an embodiment of the present disclosure, the pulverized coal lance of one of two mutually opposite coal injection assemblies is opposite to the air lance of the other of the two mutually opposite coal injection assemblies, and the air lance of the one of two mutually opposite coal injection assemblies is opposite to the pulverized coal lance of the other of the two mutually opposite coal injection assemblies.

[0011] According to an embodiment of the present disclosure, lengths of respective portions of a plurality of pulverized coal lances extending into the smelting furnace are equal and are each 50-200 mm.

[0012] According to an embodiment of the present disclosure, lengths of respective portions of a plurality of air lances extending into the smelting furnace are equal and are each 50-200 mm.

[0013] According to an embodiment of the present disclosure, a portion of each pulverized coal lance that extends into the smelting furnace and a portion of each air lance that extends into the smelting furnace are equal in length.

[0014] According to an embodiment of the present disclosure, a distance between the pulverized coal lance and the air lance in the plurality of coal injection assemblies is equal.

[0015] According to an embodiment of the present disclosure, each pulverized coal lance and each air lance are of equal height on the smelting furnace.

[0016] According to an embodiment of the present disclosure, the side-submerged combustion smelting apparatus further includes a pulverized coal distributor, and a plurality of pulverized coal lances are communicated with the pulverized coal delivery pipe by means of the pulverized coal distributor.

[0017] According to an embodiment of the present disclosure, the pulverized coal lance includes: an inner injection pipe provided with a pulverized coal inlet, a pulverized coal injection port, and a pulverized coal clearing port; an outer injection pipe fitted over the inner injection pipe, and defining a cooling chamber together with the inner injection pipe, the outer injection pipe being provided with a cooling gas inlet and a cooling gas injection port both in communication with the cooling chamber; a sealing member arranged to the inner injection pipe and movable between a closed position where the pulverized coal clearing port is blocked and an open position where the pulverized coal clearing port is open; and a wear-resistant lining provided to an inner circumferential surface of the inner injection pipe.

[0018] According to an embodiment of the present disclosure, the air lance includes: an inner injection pipe provided with an air inlet, an air injection port, and an impurity clearing port; an outer injection pipe fitted over the inner injection pipe, and defining a cooling chamber together with the inner injection pipe, the outer injection pipe being provided with a cooling gas inlet and a cooling gas injection port both in communication with the cooling chamber; and a sealing member arranged to the inner injection pipe and movable between a closed position where the impurity clearing port is blocked and an open position where the impurity clearing port is open.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a schematic view of a side-submerged combustion smelting apparatus for spraying oxygen-enriched air and pulverized coal based on a specific embodiment of the present disclosure.

Fig. 2 is a schematic view of a side-submerged combustion smelting apparatus for spraying oxygen-enriched air and pulverized coal based on another specific embodiment of the present disclosure.

Fig. 3 is a sectional view of a pulverized coal lance of a side-submerged combustion smelting apparatus for spraying oxygen-enriched air and pulverized coal based on yet another specific embodiment of the present disclosure.

[0020] Fig. 4 is a sectional view of an air lance of a side-submerged combustion smelting apparatus for spraying oxygen-enriched air and pulverized coal based on still another specific embodiment of the present disclosure.

[0021] Reference numerals:
side-submerged combustion smelting apparatus 1 for spraying oxygen-enriched air and pulverized coal, smelting furnace 100, pulverized coal delivery pipe 200, pulverized coal distributor 210, air delivery pipe 300, coal injection assembly 400, pulverized coal lance 410, inner injection pipe 411, pulverized coal inlet 4111, pulverized coal injection port 4112, pulverized coal clearing port 4113, outer injection pipe 412, cooling chamber 4121, cooling gas inlet 4122, cooling gas injection port 4123, sealing member 413, wear-resistant lining 414, air lance 420, air inlet 4211, air injection port 4212, impurity clearing port 4213.

DETAILED DESCRIPTION

[0022] Embodiments of the present disclosure will be described in detail below, and examples of the embodiments are shown in accompanying drawings. The same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions. The embodiments described herein with reference to the drawings are illustrative, and used to generally understand the present disclosure. The embodiments should not be construed to limit the present disclosure.

[0023] The side-submerged combustion smelting apparatus 1 for spraying oxygen-enriched air and pulverized coal based on embodiments of the present disclosure will be described below with reference to the drawings.

[0024] As illustrated in Figs. 1-4, the side-submerged combustion smelting apparatus 1 based on embodiments of the present disclosure includes a smelting furnace 100, a pulverized coal delivery pipe 200, an air delivery pipe 300 and a coal injection assembly 400.

[0025] The pulverized coal delivery pipe 200 is used to deliver the pulverized coal. The air delivery pipe 300 is used to deliver the oxygen-enriched air and is communicated with an air source. A plurality of coal injection assemblies 400 are arranged at intervals on two opposite side walls of the smelting furnace 100. A portion of each coal injection assembly 400 extends into the smelting furnace 100. Each coal injection assembly 400 includes a pulverized coal lance 410 and an air lance 420 which are adjacent to each other and arranged as a pair. Each pulverized coal lance 410 is in communication with the pulverized coal delivery pipe 200, and each air lance 420 is in communication with the air delivery pipe 300. Each coal injection assembly 400 at least partially extends into the smelting furnace 100. It should be understood herein that "adjacent to each other and arranged as a pair" means that each pulverized coal lance 410 is arranged adjacent to one air lance 420 paired therewith, rather than two pulverized coal lances 410 are arranged adjacent to two air lances 420.

[0026] By providing the plurality of coal injection assemblies 400, the side-submerged combustion smelting apparatus 1 based on embodiments of the present disclosure can utilize the plurality of coal injection assemblies 400 to inject the pulverized coal and air into the smelting furnace 100, thereby achieving uniform delivery of the pulverized coal and air into the smelting furnace 100. Moreover, since the coal injection assembly 400 includes the pulverized coal lance 410 and the air lance

420 arranged adjacently, each pulverized coal lance 410 being in communication with the pulverized coal delivery pipe 200, and each air lance 420 being in communication with the air delivery pipe 300, the pulverized coal lance 410 and the air lance 420 can be used to spray the pulverized coal and the air respectively. This allows the pulverized coal and the air to be mixed in the smelting furnace 100 to prevent the mixing of the pulverized coal and the air in the coal injection assembly 400. Therefore, the oxygen content in the air delivered by the air lance 420 can be increased, and the hearth area efficiency and thermal efficiency of the side-submerged combustion smelting apparatus 1 can be improved, thereby improving the production efficiency of the side-submerged combustion smelting apparatus 1, and enabling the side-submerged combustion smelting apparatus 1 to carry out large-scale industrial production with the pulverized coal as fuel.

[0027] Furthermore, since the side-submerged combustion smelting apparatus 1 can use the pulverized coal as the fuel, the side-submerged combustion smelting apparatus 1 can not only have a reduced operating cost, but also be applied to regions where gas fuel is scarce, thereby improving the applicability of the side-submerged combustion smelting apparatus 1.

[0028] Additionally, by providing the plurality of coal injection assemblies 400, when a part of pulverized coal lances 410 are worn, the remaining pulverized coal lances 410 can be used to continue delivering the pulverized coal, and the worn pulverized coal lances 410 can be reused after centralized maintenance at an appropriate time. Thus, it is possible to reduce the holding time after the furnace shutdown, avoid frequent interruption of the normal operation of the smelting apparatus 1, and further improve the production efficiency of the smelting apparatus 1.

[0029] Further, since the pulverized coal and the air are delivered through the pulverized coal lance 410 and the air lance 420 respectively, once the pulverized coal lance 410 is clogged or damaged, the air delivery in the air lance 420 will not be affected. Compared with a multilayer-channel lance used in the related art, it is possible to ensure the delivery of oxygen-enriched air while clearing the clogged pulverized coal lance 410, and improve the safety and reliability of the smelting apparatus 1. Moreover, in a case where the same amount of pulverized coal is injected and the injection pressure is the same, since the pulverized coal and the air are delivered through the pulverized coal lance 410 and the air lance 420 respectively, the quantity of the pulverized coal lance 410 and the pipeline for delivering the pulverized coal can be reduced, which can further prevent the pulverized coal from clogging the pipeline and the pulverized coal lance 410 on the one hand, and can reduce the cost of the smelting apparatus 1 on the other hand.

[0030] Therefore, the side-submerged combustion smelting apparatus 1 based on embodiments of the present disclosure is able to use the pulverized coal as the fuel, and has the advantages of high productivity, low operating cost, and wide applicability.

[0031] The side-submerged combustion smelting apparatus 1 according to specific embodiments of the present disclosure will be described below with reference to the drawings.

[0032] In some specific embodiments of the present disclosure, as illustrated in Figs. 1-4, the side-submerged combustion smelting apparatus 1 according to embodiments of the present disclosure includes the smelting furnace 100, the pulverized coal delivery pipe 200, the air delivery pipe 300, and the coal injection assembly 400. The air source can deliver oxygen-enriched air to the air delivery pipe 300.

[0033] Fig. 1 illustrates the side-submerged combustion smelting apparatus 1 according to a specific embodiment of the present disclosure. As illustrated in Fig. 1, the pulverized coal lance 410 in one of two mutually opposite coal injection assemblies 400 is opposite to the pulverized coal lance 410 in the other of two mutually opposite coal injection assemblies 400, and the air lance 420 in the one of two mutually opposite coal injection assemblies 400 is opposite to the air lance 420 in the other of two mutually opposite coal injection assemblies 400. Thus, the pulverized coal and air injected into the smelting furnace 100 can be evenly distributed, so that the pulverized coal can be fully combusted.

[0034] Fig. 2 illustrates the side-submerged combustion smelting apparatus 1 according to another specific embodiment of the present disclosure. As illustrated in Fig. 2, the pulverized coal lance 410 in one of two mutually opposite coal injection assemblies 400 is opposite to the air lance 420 in the other of two mutually opposite coal injection assemblies 400, and the air lance 420 in the one of two mutually opposite coal injection assemblies 400 is opposite to the pulverized coal lance 410 in the other of two mutually opposite coal injection assemblies 400. Likewise, the pulverized coal and air injected into the smelting furnace 100 can be evenly distributed, so that the pulverized coal can be fully combusted.

[0035] Optionally, as illustrated in Figs. 1 and 2, lengths of respective portions of a plurality of pulverized coal lances 410 that extend into the smelting furnace 100 are equal and are 50-200 mm. By doing so, the pulverized coal can be combusted more fully, and the smelting apparatus 1 can achieve an optimal combustion effect, so as to improve the production efficiency of the side-submerged combustion smelting apparatus 1.

[0036] Further, as illustrated in Figs. 1 and 2, lengths of respective portions of a plurality of air lances 420 that extend into the smelting furnace 100 are equal and are each 50-200 mm. By doing so, the pulverized coal can be combusted more fully, and the smelting apparatus 1 can achieve the optimal combustion effect, so as to improve the production efficiency of the side-submerged combustion smelting apparatus 1.

[0037] Advantageously, as illustrated in Figs. 1 and 2, a portion of each pulverized coal lance 410 that extends into the smelting furnace 100 and a portion of each air

lance 420 that extends into the smelting furnace 100 are equal in length. In this way, the pulverized coal injected into the smelting furnace 100 by the pulverized coal lance 410 can be sufficiently mixed with the air injected from the air lance 420 adjacent to the pulverized coal lance 410, so that the pulverized coal can be sufficiently combusted.

[0038] Specifically, as illustrated in Figs. 1 and 2, a distance between the pulverized coal lance 410 and the air lance 420 in the plurality of coal injection assemblies 400 is equal. In such a way, the combustion in the smelting furnace 1 becomes more sufficient, and the temperature in the smelting furnace 1 is more uniform.

[0039] More specifically, each pulverized coal lance 410 and each air lance 420 are of equal height on the smelting furnace 100, which can facilitate the control over a liquid level in a molten bath of the side-submerged combustion smelting apparatus 1, and be convenient for the injected air to fully stir the molten bath.

[0040] As illustrated in Figs. 1 and 2, the side-submerged combustion smelting apparatus 1 further includes a pulverized coal distributor 210, and the plurality of pulverized coal lances 410 are communicated with the pulverized coal delivery pipe 200 through the pulverized coal distributor 210. Thus, the pulverized coal delivered to each of the pulverized coal lances 410 can be uniform to ensure uniform combustion in the smelting furnace 100.

[0041] Figs. 3 and 4 illustrate the side-submerged combustion smelting apparatus 1 according to some specific embodiments of the present disclosure. As illustrated in Fig. 3, the pulverized coal lance 410 includes an inner injection pipe 411, an outer injection pipe 412, a sealing member 413, and a wear-resistant lining 414. The inner injection pipe 411 is provided with a pulverized coal inlet 4111, a pulverized coal injection port 4112, and a pulverized coal clearing port 4113. The outer injection pipe 412 is fitted over the inner injection pipe 411, and defines a cooling chamber 4121 together with the inner injection pipe 411. The outer injection pipe 412 is provided with a cooling gas inlet 4122 and a cooling gas injection port 4123 both in communication with the cooling chamber 4121. The sealing member 413 is arranged to the inner injection pipe 411 and is movable between a closed position where the pulverized coal clearing port 4113 is blocked and an open position where the pulverized coal clearing port 4113 is open. The wear-resistant lining 414 is provided to an inner circumferential surface of the inner injection pipe 411. Therefore, when the pulverized coal lance 410 is working normally, the pulverized coal clearing port 4113 is blocked off by the sealing member 413, so that the pulverized coal cannot pass through the pulverized coal clearing port 4113; and when the inner injection pipe 411 needs to be cleaned, the sealing member 413 can be moved to the open position to clean the inner injection pipe 411 through the pulverized coal clearing port 4113 to prevent the pulverized coal from clogging the inner injection pipe 411, thereby ensuring the reliability of the delivery of the pulverized coal.

[0042] In the related art, during the replacement of the pulverized coal lance, the smelting apparatus has to stop working temporarily, and the liquid level in the molten bath of the smelting apparatus is lowered below the height of the pulverized coal lance, which seriously affects the operating rate. However, for the side-submerged combustion smelting apparatus 1, the pulverized coal lance 410 is cleaned through the pulverized coal clearing port 4113, without need to lower the liquid level in the smelting apparatus 1 or shut down the smelting apparatus 1, such that the production efficiency of the smelting apparatus 1 is ensured, and the large-scale industrial production using pulverized coal as raw material is realized.

[0043] In addition, by providing the cooling chamber 4121, cooling gas can be utilized to cool the outer injection pipe 412 and the inner injection pipe 411 to prevent temperature of the portion, extending into the smelting furnace 100, of the pulverized coal lance 410 from being too high, thus prevent the pulverized coal lance 410 from being damaged due to excessive temperature, and prolong the service life of the pulverized coal lance 410. By providing the wear-resistant lining 414, it is possible to prevent the inner injection pipe 411 from being worn, reduce the wear of the inner injection pipe 411 caused by the pulverized coal scouring an inner wall when the pulverized coal is delivered by the pulverized coal lance 410, and prolong the service life of the pulverized coal lance 410.

[0044] Specifically, when a part of pulverized coal lances 410 are clogged, unclogged pulverized coal lances 410 can be used to continue maintaining the normal operation of the smelting apparatus 1, and the clogged pulverized coal lances 410 can return to work after they are cleaned through the pulverized coal clearing port 4113 in time. During the cleaning, the pulverized coal lance 410 can be switched from injecting pulverized coal to injecting nitrogen by means of the pulverized coal distributor 210, to facilitate the cleaning of an operator and improve the operating environment of the operator.

[0045] Optionally, the wear-resistant lining 414 can be a ceramic lining, and the cooling gas can be nitrogen.

[0046] Specifically, as illustrated in Fig. 4, the air lance 420 includes an inner injection pipe 411, an outer injection pipe 412 and a sealing member 413. The inner injection pipe 411 is provided with an air inlet 4211, an air injection port 4212, and an impurity clearing port 4213. The outer injection pipe 412 is fitted over the inner injection pipe 411 and defines a cooling chamber 4121 together with the inner injection pipe 411. The outer injection pipe 412 is provided with a cooling gas inlet 4122 and a cooling gas injection port 4123 both in communication with the cooling chamber 4121. The sealing member 413 is arranged to the inner injection pipe 411 and is movable between a closed position where the impurity clearing port 4213 is blocked and an open position where the impurity clearing port 4213 is open. Therefore, when

the air lance 420 is working normally, the impurity clearing port 4213 is blocked off by the sealing member 413, so that the air cannot pass through the impurity clearing port 4213; and when the inner injection pipe 411 needs to be cleaned, the sealing member 413 can be moved to the open position to clean the inner injection pipe 411 through the impurity clearing port 4213 to prevent impurities from clogging the inner injection pipe 411, thereby ensuring the reliability of the air delivery. Additionally, by providing the cooling chamber 4121, the cooling gas can be utilized to cool the outer injection pipe 412 and the inner injection pipe 411 to prevent temperature of the portion, extending into the smelting furnace 100, of the air lance 420 from being too high, thus prevent the air lance 420 from being damaged due to excessive temperature, and prolong the service life of the air lance 420.

[0047] In the specification, it is to be understood that terms such as "central," "longitudinal," "transverse," "length," "width," "thickness," "upper," "lower," "front," "rear," "left," "right," "vertical," "horizontal," "top," "bottom," "inner," "outer," "clockwise," "counterclockwise," "axial," "radial," and "circumferential" should be construed to refer to the orientation as then described or as shown in the drawings under discussion. These relative terms are for convenience and ease of description, and do not require that the present disclosure have a particular orientation or be constructed or operated in a particular orientation. Thus, these terms should not be constructed to limit the present disclosure.

[0048] In addition, terms such as "first" and "second" are used herein for purposes of description and are not intended to indicate or imply relative importance or significance or to imply the number of indicated technical features. Thus, the feature defined with "first" and "second" may comprise one or more of this feature. In the description of the present disclosure, "a plurality of' means two or more than two, unless specified otherwise.

[0049] In the present disclosure, unless specified or limited otherwise, the terms "mounted," "connected," "coupled," "fixed" and the like are used broadly, and may be, for example, fixed connections, detachable connections, or integral connections; may also be mechanical or electrical connections; may also be direct connections or indirect connections via intervening structures; may also be inner communications of two elements, which can be understood by those skilled in the art according to specific situations.

[0050] In the present disclosure, unless specified or limited otherwise, a structure in which a first feature is "on" or "below" a second feature may include an embodiment in which the first feature is in direct contact with the second feature, and may also include an embodiment in which the first feature and the second feature are not in direct contact with each other, but are contacted via an additional feature formed therebetween. Furthermore, a first feature "on," "above," or "on top of' a second feature may include an embodiment in which the first feature is right or obliquely "on," "above," or "on top of' the second feature, or just means that the first feature is at a height higher than that of the second feature; while a first feature "below," "under," or "on bottom of' a second feature may include an embodiment in which the first feature is right or obliquely "below," "under," or "on bottom of' the second feature, or just means that the first feature is at a height lower than that of the second feature.

[0051] Reference throughout this specification to "an embodiment," "some embodiments," "an example," "a specific example," or "some examples," means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. Thus, the appearances of the phrases in various places throughout this specification are not necessarily referring to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples. In addition, those skilled in the art can combine or incorporate different embodiments or examples, as well as features in different embodiments or examples described herein, without any contradiction.

[0052] Although embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that the above embodiments are explanatory and cannot be construed to limit the present disclosure, and changes, alternatives, modifications and variations can be made in the embodiments without departing from scope of the present disclosure.

Claims

1. A side-submerged combustion smelting apparatus for spraying oxygen-enriched air and pulverized coal comprising:

   a smelting furnace;
   a pulverized coal delivery pipe configured to deliver the pulverized coal;
   an air delivery pipe configured to deliver the oxygen-enriched air, and communicated with an air source; and
   a plurality of coal injection assemblies arranged at intervals on two opposite side walls of the smelting furnace, wherein each coal injection assembly comprises a pulverized coal lance and an air lance adjacent to each other and arranged as a pair, each pulverized coal lance being in communication with the pulverized coal delivery pipe, and each air lance being in communication with the air delivery pipe, and each coal injection assembly at least partially extends into the smelting furnace.

2. The side-submerged combustion smelting apparatus based on claim 1, wherein the pulverized coal

lance in one of two mutually opposite coal injection assemblies is opposite to the pulverized coal lance in the other of the two mutually opposite coal injection assemblies, and the air lance in the one of the two mutually opposite coal injection assemblies is opposite to the air lance in the other of the two mutually opposite coal injection assemblies.

3. The side-submerged combustion smelting apparatus based on claim 1, wherein the pulverized coal lance in one of two mutually opposite coal injection assemblies is opposite to the air lance in the other of the two mutually opposite coal injection assemblies, and the air lance in the one of the two mutually opposite coal injection assemblies is opposite to the pulverized coal lance in the other of the two mutually opposite coal injection assemblies.

4. The side-submerged combustion smelting apparatus based on claim 1, wherein lengths of respective portions of a plurality of pulverized coal lances extending into the smelting furnace are equal and are each 50-200 mm.

5. The side-submerged combustion smelting apparatus based on claim 1, wherein lengths of respective portions of a plurality of air lances extending into the smelting furnace are equal and are each 50-200 mm.

6. The side-submerged combustion smelting apparatus based on claim 1, wherein a portion of each pulverized coal lance that extends into the smelting furnace and a portion of each air lance that extends into the smelting furnace are equal in length.

7. The side-submerged combustion smelting apparatus based on claim 1, wherein a distance between the pulverized coal lance and the air lance in the plurality of coal injection assemblies is equal.

8. The side-submerged combustion smelting apparatus based on claim 1, wherein each pulverized coal lance and each air lance are of equal height on the smelting furnace.

9. The side-submerged combustion smelting apparatus based on claim 1, further comprising a pulverized coal distributor, a plurality of pulverized coal lances being communicated with the pulverized coal delivery pipe by means of the pulverized coal distributor.

10. The side-submerged combustion smelting apparatus based on any one of claims 1 to 9, wherein the pulverized coal lance comprises:

an inner injection pipe provided with a pulverized coal inlet, a pulverized coal injection port, and a pulverized coal clearing port;

an outer injection pipe fitted over the inner injection pipe, and defining a cooling chamber together with the inner injection pipe, the outer injection pipe being provided with a cooling gas inlet and a cooling gas injection port both in communication with the cooling chamber;

a sealing member arranged to the inner injection pipe and movable between a closed position where the pulverized coal clearing port is blocked and an open position where the pulverized coal clearing port is open; and

a wear-resistant lining provided to an inner circumferential surface of the inner injection pipe.

11. The side-submerged combustion smelting apparatus based on any one of claims 1 to 9, wherein the air lance comprises:

an inner injection pipe provided with an air inlet, an air injection port, and an impurity clearing port;

an outer injection pipe fitted over the inner injection pipe, and defining a cooling chamber together with the inner injection pipe, the outer injection pipe being provided with a cooling gas inlet and a cooling gas injection port both in communication with the cooling chamber; and

a sealing member arranged to the inner injection pipe and movable between a closed position where the impurity clearing port is blocked and an open position where the impurity clearing port is open.

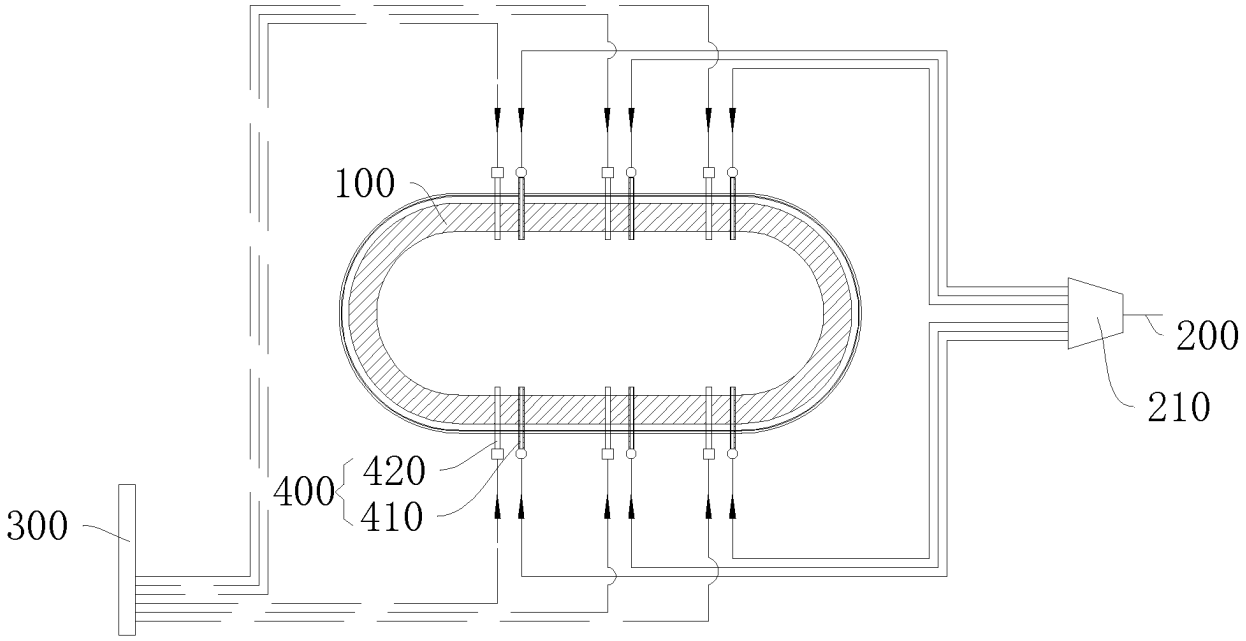

Fig. 1

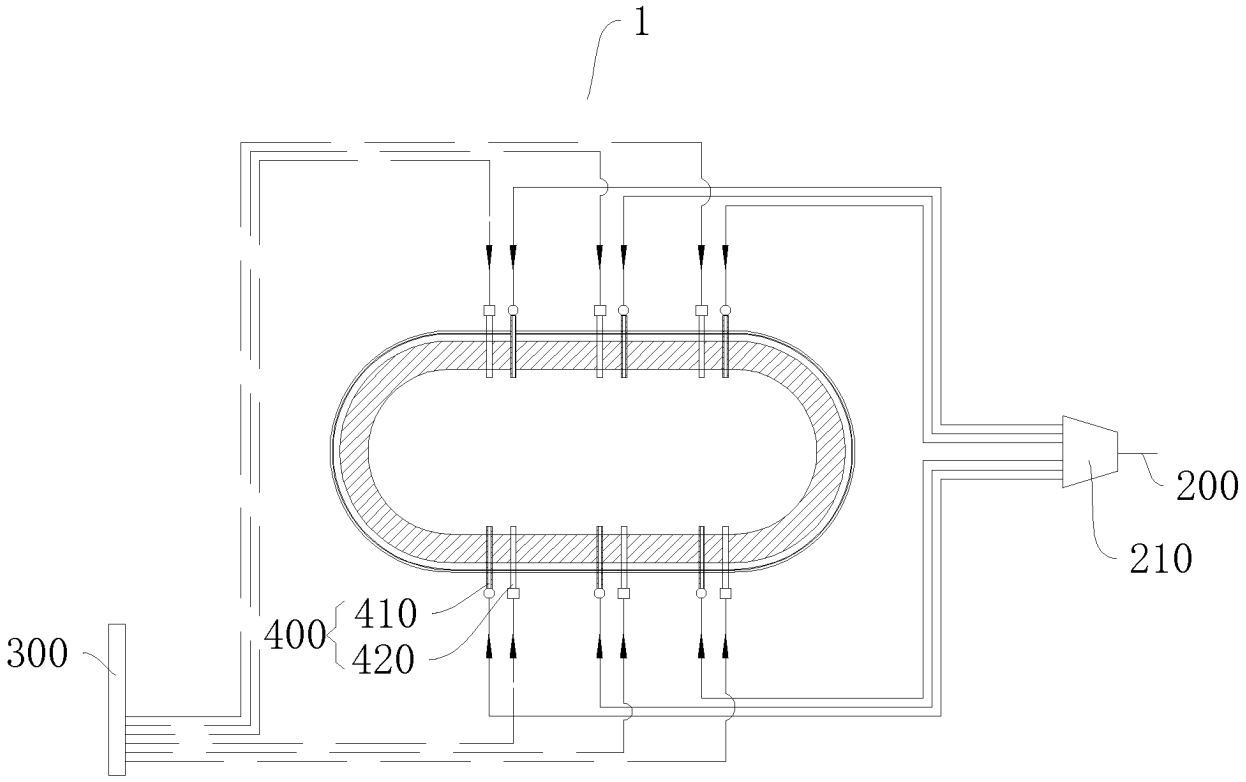

Fig. 2

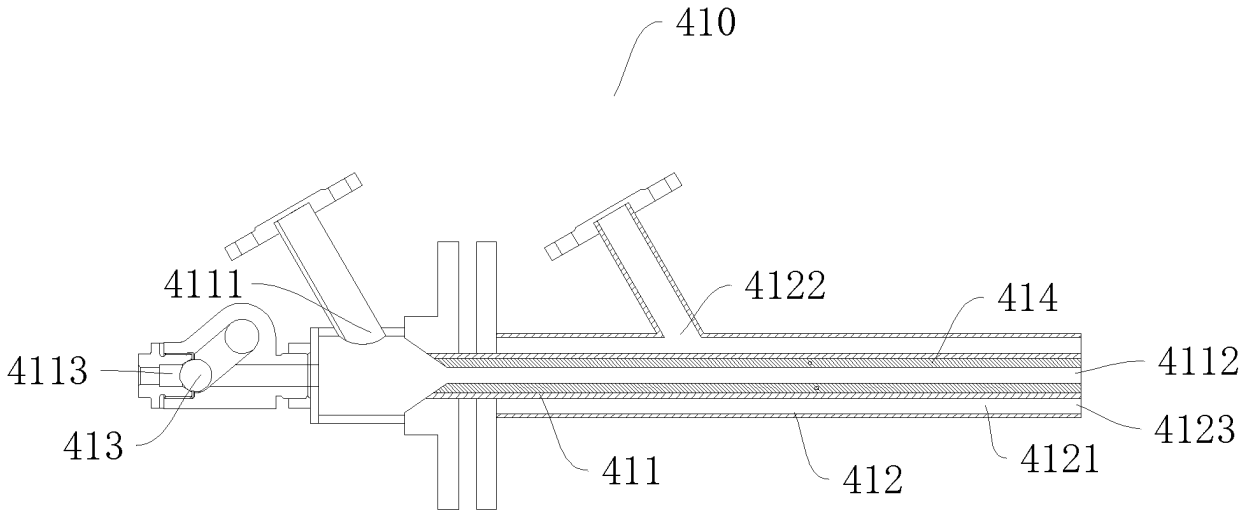

Fig. 3

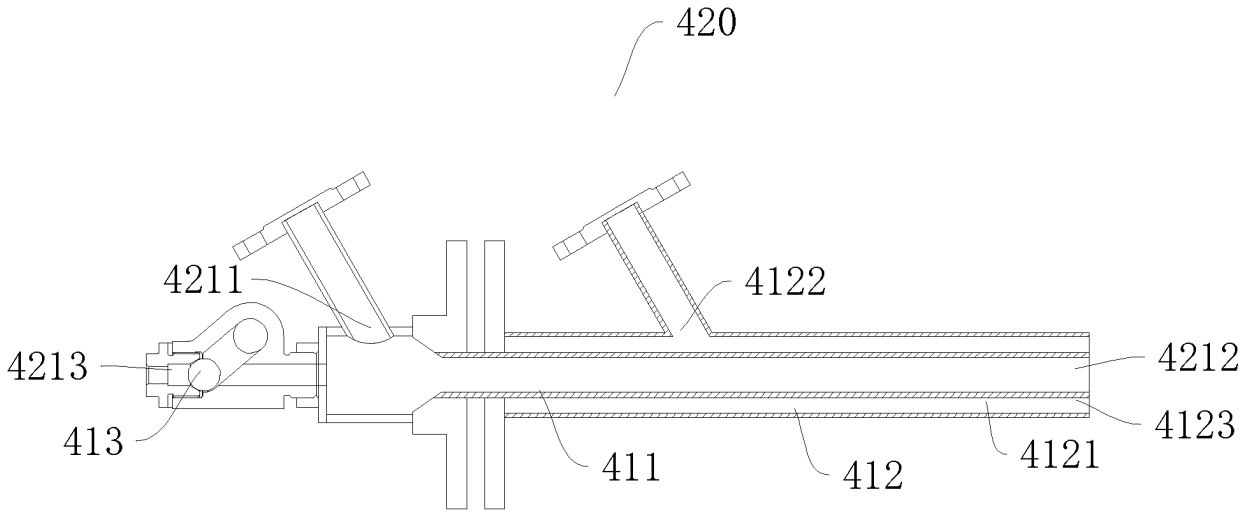

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/078653

A. CLASSIFICATION OF SUBJECT MATTER

F27D 3/16 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F27D, F27B, C22B, F23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

VEN, CPRSABS, CNKI: side blowing, metallurg+, melt+, smelt+, hearth, furnace, side, cross, air, lateral, blow+, blast+, immers+, submer+, coal, powder, jet+, airbrush, gun, nozzle, adjacent, alternate, interval

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 105823334 A (CHINA ENFI ENGINEERING CORPORATION), 03 August 2016 (03.08.2016), claims 1-11	1-11
PX	CN 205843366 U (CHINA ENFI ENGINEERING CORPORATION), 28 December 2016 (28.12.2016), claims 1-11	1-11
A	CN 201901695 U (CHINA ENFI ENGINEERING CORPORATION), 20 July 2011 (20.07.2011), description, paragraphs 0006-0062, and figures 1 and 2	1-11
A	CN 204125511 U (KUNMING UNIVERSITY OF SCIENCE AND TECHNOLOGY), 28 January 2015 (28.01.2015), the whole document	1-11
A	JP 3516136 B2 (HITACHI LTD.), 08 June 2001 (08.06.2001), the whole document	1-11
A	CN 203960305 U (CHINA ENFI ENGINEERING CORPORATION), 26 November 2014 (26.11.2014), the whole document	1-11
A	CN 104152713 A (CHINA ENFI ENGINEERING CORPORATION), 19 November 2014 (19.11.2014), the whole document	1-11

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 June 2017 (16.06.2017)	**06 July 2017 (06.07.2017)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **DUAN, Xiaoning** Telephone No.: (86-10) **010-62084193**

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/078653

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 204825011 U (CHINA NERIN ENGINEERING CO., LTD.), 02 December 2015 (02.12.2015), the whole document	1-11
A	CN 103451446 A (CHINA ENFI ENGINEERING CORPORATION), 18 December 2013 (18.12.2013), the whole document	1-11
A	CN 103602827 A (JINQIAN BRANCH OF ANHUI HUAXIN LEAD INDUSTRY GROUP CO., LTD.), 26 February 2014 (26.02.2014), the whole document	1-11

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/078653

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 105823334 A	03 August 2016	None	
CN 205843366 U	28 December 2016	None	
CN 201901695 U	20 July 2011	None	
CN 204125511 U	28 January 2015	None	
JP 3516136 B2	08 June 2001	JP 2001153336 A	08 June 2001
CN 203960305 U	26 November 2014	None	
CN 104152713 A	19 November 2014	None	
CN 204825011 U	02 December 2015	None	
CN 103451446 A	18 December 2013	None	
CN 103602827 A	26 February 2014	CN 103602827 B	03 December 2014

Form PCT/ISA/210 (patent family annex) (July 2009)