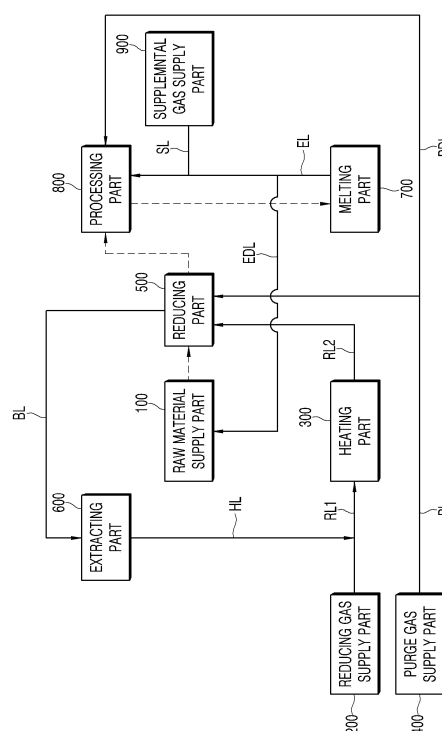


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(71) Applicant: **POSCO Co., Ltd**
Pohang-si, Gyeongsangbuk-do 37859 (KR)

Fig. 1



Description**TECHNICAL FIELD**

5 **[0001]** The present disclosure relates to a facility and method for manufacturing molten iron, and more particularly, to a facility and method for manufacturing reduced iron and melting the manufactured reduced iron to manufacture molten iron.

BACKGROUND ART

10 **[0002]** Generally, melted iron, i.e., molten iron is manufactured through a furnace process. The furnace process is carried out by processing iron ore and coal into a form that is suitable for use, inserting the processed iron ore and coal in a furnace, and blowing hot air into the furnace. Here, the hot air burns the coal, and a carbon monoxide gas generated at this time causes a reduction reaction that removes oxygen from the iron ore. In addition, heat over approximately 1,500°C generated inside the furnace causes a melting reaction that melts the iron ore or iron reduced by the carbon monoxide gas to manufacture molten iron. In such a furnace process, the reduction reaction and the melting reaction are carried out simultaneously within the furnace by the coal and the carbon monoxide gas generated from the coal. However, the furnace process has a limitation of generating a large amount of carbon dioxide, which causes environmental problems such as global warming, due to the reduction reaction between the carbon monoxide gas and the iron ore.

15 **[0003]** To solve this limitation, a hydrogen reduction iron-making process technology, which manufactures molten iron using a hydrogen gas instead of fossil fuels such as coal, is being researched and developed. The fossil fuels such as coal generate carbon dioxide when reacting with the iron ore, but since the hydrogen gas reacts with the iron ore to generate water or steam, the hydrogen reduction iron-making process may innovatively reduce carbon emission in manufacturing of the molten iron.

20 **[0004]** In the hydrogen reduction iron-making process, the reduced iron may be manufactured by the reduced iron ore, and the molten iron may be manufactured by melting the manufactured reduced iron. However, the reduced iron manufactured by the reaction between a hydrogen gas and iron ore has a very high melting point, and thus, there is a limitation that a lot of energy is required to melt the reduced iron. In addition, in the process of melting the reduced iron, a large amount of exhaust gas is generated, and it is necessary to prepare a method to recycle the large amount of exhaust gas generated in this manner.

30 (PRIOR ART DOCUMENTS)

[0005] Korean Patent Registration No. 10-1699236

DISCLOSURE OF THE INVENTION**TECHNICAL PROBLEM**

35 **[0006]** The present disclosure provides a facility and method for manufacturing molten iron, which are capable of minimizing an amount of energy required for melting.

TECHNICAL SOLUTION

40 **[0007]** In accordance with an exemplary embodiment, a facility for manufacturing molten iron includes: a reducing part configured to manufacture reduced iron; a melting part configured to melt the reduced iron; and a processing part installed to receive the reduced iron from the reducing part and an exhaust gas discharged from the melting part so that the supplied reduced iron and exhaust gas react with each other to supply the reacting reduced iron to the melting part.

45 **[0008]** The facility may further include an exhaust gas supply line installed to connect the melting part to the processing part, wherein the reducing part may include a reducing furnace having a reducing space in which a reducing gas is supplied to manufacture the reduced iron, and the melting part may include an electric furnace having a melting space in which the reduced iron supplied from the processing part is melted using electric heat.

50 **[0009]** The processing part may include: a main body having a processing space; a reduced iron inlet provided in the main body to allow the reduced iron to flow into the processing space; and an exhaust gas inlet provided in the main body and connected to an exhaust gas supply line so that the exhaust gas is introduced into the processing space, wherein the exhaust gas inlet may be disposed at a position lower than the reduced iron inlet.

55 **[0010]** The processing part may further include a heater installed in the main body to heat the processing space.

[0011] The processing part may include: a collector connected to the main body to collect the reduced iron discharged from the main body; and a circulation line configured to connect the collector to the main body so that the reduced iron

collected through the collector is supplied to the main body.

[0012] The processing part may further include a supplemental gas supply part connected to the main body so that a supplemental gas having at least a portion of the same component as the exhaust gas is supplied to the processing space.

[0013] The facility may further include: a raw material supply part having a storage space in which a raw material is stored and installed to supply the raw material stored in the storage space to the reducing space; and an exhaust gas branch line branched from the exhaust gas supply line and configured to supply a portion of the exhaust gas discharged from the electric furnace to the raw material supply part.

[0014] The exhaust gas branch line may be connected to the raw material supply part to directly supply the exhaust gas to the storage space or transfer heat of the exhaust gas to air supplied to the storage space.

[0015] The facility may further include: a purge gas supply line connected to the reducing furnace to supply a purge gas to the reducing space; and a purge gas branch line branched from the purge gas supply line and configured to supply a portion of the purge gas supplied to the reducing space to the processing space.

[0016] In accordance with another exemplary embodiment, a method for manufacturing molten iron includes: manufacturing reduced iron; allowing the manufactured reduced iron to react with a processing gas; melting the reacting reduced iron to manufacture a molten product; and utilizing at least a portion of an exhaust gas generated while manufacturing the molten iron as a processing gas that reacts with the reduced iron.

[0017] The manufacturing of the reduced iron may include: preheating a raw material using the exhaust gas; and allowing the preheated raw material to react with the reducing gas to reduce the raw material.

[0018] The preheating of the raw material may include injecting the exhaust gas into the raw material or receiving heat of the exhaust gas to inject heated air into the raw material.

[0019] The raw material may include powdered iron ore having a particle size of more than approximately 0 mm and less than or equal to approximately 8 mm.

[0020] The processing gas may include a gas containing a carbon component, and the reacting with the processing gas may include carbonizing at least a portion of the reduced iron.

[0021] the allowing of the reduced iron to react with the processing gas may include reacting with the processing gas without performing separate thermal process on the manufactured reduced iron.

[0022] The allowing of the reduced iron to react with the processing gas may include allowing the manufactured reduced iron to react with the processing gas at a temperature of approximately 600°C to approximately 800°C.

[0023] The method may further include: collecting the reduced iron discharged from the processing space in which the reduced iron reacts with the processing gas; and supplying the collected reduced iron to the processing space.

[0024] The manufacturing of the molten iron may include supplying a purge gas to a reducing space, in which the reduced iron is manufactured, and the allowing of the reduced iron to react with the processing gas may include supplying a portion of a purge gas supplied to the reducing space to the processing space.

[0025] The utilizing of the at least a portion of the exhaust gas as the processing gas may include utilizing the exhaust gas and a supplemental gas having at least a portion of the same component as the exhaust gas as the processing gas.

[0026] The exhaust gas may include a carbon monoxide gas, and the supplemental gas may include at least one of a natural gas or a biomass gas.

ADVANTAGEOUS EFFECTS

[0027] In accordance with the exemplary embodiment, the melting point of the reduced iron may be lowered by allowing the exhaust gas generated during the process to react with the reduced iron to minimize the amount of energy used to melt the reduced iron.

[0028] In addition, the reduced iron manufactured at the high temperature may directly react with the high-temperature exhaust gas to minimize the facility and resources required for the reaction.

[0029] In addition, the energy may be efficiently collected by using the sensible heat of the high-temperature exhaust gas to preheat the raw materials and produce the hydrogen gas.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a schematic view of a facility for manufacturing molten iron in accordance with an exemplary embodiment.

FIG. 2 is a view illustrating an example of a reducing furnace for manufacturing reduced iron and an electric furnace for melting the reduced iron;

FIG. 3 is a view illustrating an example of a processing part in accordance with an exemplary embodiment;

FIG. 4 is a view illustrating conditions under which the reduced iron reacts with an exhaust gas;

FIG. 5 is a view illustrating a state in which a raw material is preheated using the exhaust gas in a raw material supply

part; and

FIG. 6 is a schematic view of a method for manufacturing molten iron in accordance with an exemplary embodiment.

MODE FOR CARRYING OUT THE INVENTION

[0031] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. The present invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that the present invention will be thorough and complete, and will fully convey the scope of the present invention to those skilled in the art. In order to explain the present disclosure in detail, the drawings may be exaggerated, and the same symbols in the drawings refer to the same elements.

[0032] FIG. 1 is a schematic view of a facility for manufacturing molten iron in accordance with an exemplary embodiment, FIG. 2 is a view illustrating an example of a reducing furnace for manufacturing reduced iron and an electric furnace for melting the reduced iron, and FIG. 3 is a view illustrating an example of a processing part in accordance with an exemplary embodiment. In addition, FIG. 4 is a view illustrating conditions under which the reduced iron reacts with an exhaust gas, and FIG. 5 is a view illustrating a state in which a raw material is preheated using the exhaust gas in a raw material supply part. In the drawings, an arrow indicated by dotted lines indicates a flow of raw materials and reduced iron, and an arrow indicated by solid lines indicates a flows of by-products and gases.

[0033] Referring to FIG. 1 to 5, a facility for manufacturing molten iron in accordance with an exemplary embodiment may include a reducing part 500 that is capable of manufacturing reduced iron, a melting part 700 that is capable of melting the reduced iron, and a processing part 600 that receives the molten iron from the reducing part 500, is installed to receive an exhaust gas discharged from the melting part 700, and allows the supplied reduced iron and exhaust gas to react with each other so that the reacting reduced iron is supplied to the melting part 700. In addition, the facility for manufacturing the molten iron in accordance with an exemplary embodiment may further include a raw material supply part installed to supply a raw material to the reducing part 500 and a reducing gas supply part installed to supply a reducing gas to the reducing part 500.

[0034] The raw material supply part 100 may be installed to supply the raw material to the reducing part 500. Here, the raw material may include iron ore, and the iron ore may include reduced fine iron ore, that is, powdered iron ore which has a particle size greater than approximately 0 mm and less than or equal to approximately 8 mm. The raw material supply part 100 may include a reservoir 110 having a storage space in which the raw material is stored. The raw material may be stored in the storage space of the reservoir 110 for a long time or may be temporarily stored before supplying the raw material to the reducing part 500. The reservoir 110 may include, for example, a hopper.

[0035] The raw material may be preheated in the storage space of the reservoir 110, and the raw material preheated in the storage space may be supplied to the reducing part 500. Here, the reservoir 110 may receive a portion of the exhaust gas discharged from the melting part 700 to preheat the raw material. For this, the facility for manufacturing the molten iron in accordance with an exemplary embodiment may further include an exhaust gas branch line EDL branched from an exhaust gas supply line EL to supply a portion of the exhaust gas discharged from the melting part 700 to the reservoir 110. The preheating of the raw material using the exhaust gas supplied through the exhaust gas branch line EDL will be described later with reference to FIG. 5.

[0036] A reducing gas supply part 200 may be installed to store the reducing gas and supply the reducing gas to the reducing part 500. Here, the reducing gas may include a hydrogen gas, and the hydrogen gas may be contained at a ratio of approximately 80% to approximately 100% of the total reducing gas. The hydrogen gas stored in the reducing gas supply part 200 may be produced by electrolyzing water, but is not limited thereto, and may be produced by various methods such as decomposing an ammonia gas or producing the hydrogen gas by chemically reacting a natural gas. For example, the ammonia gas may be decomposed into a hydrogen gas and a nitrogen gas at a high temperature, the decomposed hydrogen gas may be used as the reducing gas, and the nitrogen gas may be used as a purge gas, which will be described later.

[0037] The reducing gas supply part 200 may supply the reducing gas to the reducing part 500 through reducing gas supply lines RL1 and RL2 that connect the reducing gas supply part 200 to the reducing part 500. Here, an amount of reducing gas supplied by the reducing gas supply part 200 to the reducing part 500 may be more than twice an amount required to entirely reduce the raw material supplied to the reducing part 500. To improve reaction efficiency between the raw material and the reducing gas, the amount of reducing gas may be controlled, for example, to a range of two to three times the amount required to entirely reduce the raw material supplied to the reducing part 500.

[0038] A heating part 300 may be installed in each of the reducing gas supply lines RL1 and RL2 to heat the reducing gas supplied from the reducing gas supply part 200 to the reducing part 500. In the reducing part 500, the raw material containing the iron ore and the reducing gas containing the hydrogen gas may react to reduce the iron ore. Since the reaction between the iron ore and the hydrogen gas is a strong endothermic reaction, the reaction efficiency may be improved when the hydrogen gas supplied to the reducing part 500 is heated and supplied to a temperature of

approximately 800°C or more, more preferably approximately 850°C or more. As a result, the heating part 300 may be connected to the reducing gas supply part 200 through the first reducing gas supply line RL1 and also be connected to the reducing part 500 through the second reducing gas supply line RL2 to heat the low-temperature hydrogen gas supplied through the first reducing gas supply line RL1 to a temperature of approximately 800°C to approximately 1,200°C, thereby supplying the hydrogen gas to the reducing part 500 through the second reducing gas supply line RL2. Since the heating part 300 may have various structures for heating the reducing gas in a direct or indirect heating manner, a detailed description thereof will be omitted.

[0039] The facility for manufacturing the molten iron in accordance with an exemplary embodiment may further include a purge gas supply part 400 installed to store a purge gas and supply the purge gas to the reducing part 500. The reducing part 500 may have a reducing space capable of producing the reduced iron, and the reducing space may need to be purged for maintenance between processes. In addition, there are cases in which the purge gas needs to be supplied during the process. For example, when using the powdered iron ore as the raw material, the purge gas may be supplied to increase in fluidity of the powdered iron ore, thereby preventing the iron ore from sticking in the reducing space. Thus, the purge gas supply part 400 may supply the purge gas to the reducing space through a purge gas supply line PL that connects the purge gas supply part 400 to the reducing part 500, and an inert gas such as nitrogen may be used as the purge gas.

[0040] The reducing part 500 may produce the reduced iron by reducing the raw material. That is, the reducing part 500 may receive the iron ore as the raw material from the raw material supply part 100, receive the reducing gas from the reducing gas supply part 200, and react the iron ore with the reducing gas to manufacture the reduced iron. The reducing part 500 may include a reducing furnace having a reducing space capable of manufacturing the reduced iron using the reducing gas. The reducing furnace may include fluid reducing furnaces 510, 520, 530, and 540 that manufacture the reduced iron while allowing the raw material to flow, and the fluid reducing furnaces 510, 520, 530, and 540 may be provided as a single unit. However, to effectively reduce low-grade iron ore or powdered iron ore having a low iron content, as illustrated in FIG. 2, the plurality of fluid reducing furnaces 510, 520, 530, and 540 may be connected to sequentially move the raw material, thereby manufacturing the reduced iron. Here, there is no limit to the number of fluid reducing furnaces 510, 520, 530, and 540, but in order to sufficiently reduce the raw material, and as illustrated in FIG. 2, the reducing part 500 may include four reducing furnaces including a first fluid reducing furnace 510, a second fluid reducing furnace 520, a third fluid reducing furnace 530, and a fourth fluid reducing furnace 540. Here, the raw material supply part 100 may supply the raw material to the first fluid reducing furnace 510, and the reducing gas supply part 200 may supply the reducing gas to the fourth fluid reducing furnace 540. The raw material supplied to the first fluid reducing furnace 510 may be reduced by sequentially moving through the second fluid reducing furnace 520, the third fluid reducing furnace 530, and the fourth fluid reducing furnace 540 and thus be manufactured into the reduced iron.

[0041] The reduced iron manufactured in the reducing part 500 may be supplied to a processing part 800 that will be described later. As illustrated in FIG. 2, the reduced iron manufactured through the first fluid reducing furnace 510, the second fluid reducing furnace 520, the third fluid reducing furnace 530, and the fourth fluid reducing furnace 540 may be discharged from the fluid reducing furnace 540 and supplied to the processing part 800. Here, as described above, the preheated raw material and the reducing gas having a temperature of approximately 800°C or more may be supplied to the reducing space to manufacture the reduced iron. Thus, the reduced iron manufactured in the reducing part 500 may be discharged at a high temperature of, for example, approximately 600°C to approximately 800°C, even in consideration of a heat loss. As described above, the reduced iron discharged at the high temperature may be directly supplied to the processing part 800 without passing through a separate thermal processing device. In the processing part 800, the reduced iron manufactured at a high temperature may directly react with the high-temperature exhaust gas to minimize the facility and resources required for the reaction, which will be described later in relation to the processing part 800.

[0042] In the reducing part 500, a large amount of by-products may be discharged in addition to the reduced iron. The by-products discharged from the reducing part 500 may include steam. As described above, in the reducing part 500, the iron ore and the hydrogen gas may react to manufacture the reduced iron. Here, an oxygen component of the iron ore and a hydrogen component of the hydrogen gas may react to generate a large amount of steam in the reducing space, and the generated steam may be discharged from the reducing part 500 as a by-product. In addition, the by-products discharged from the reducing part 500 may include the hydrogen gas and the nitrogen gas. As described above, the reducing gas may be supplied in a range of two to three times the amount required to entirely reduce the raw material supplied to the reducing part 500, and thus, the remaining hydrogen gas that does not react with the raw material may be discharged from the reducing part 500 as the by-product. In addition, as described above, the purge gas, for example, the nitrogen gas may be supplied to the reducing part 500 for various reasons. As described above, the nitrogen gas supplied for purge may be discharged from the reducing part 500 as the by-product. The by-products may move along a flow of the reducing gas within the reducing part 500 and then be discharged from the first fluid reducing furnace 510. Then, the discharged by-products may be supplied to the extracting part 600 through the by-product supply line BL connected to the reducing part 500.

[0043] That is, the facility for manufacturing the molten iron in accordance with an exemplary embodiment may further include an extracting part 600 that is installed to receive the by-products discharged from the reducing part 500 and

extracts a hydrogen gas from the by-products.

[0044] The extracting part 600 may extract the hydrogen gas from the by-products discharged from the reducing part 500. As described above, the by-products discharged from the reducing part 500 may include steam, a hydrogen gas, and a nitrogen gas. The extracting part 600 may be connected to the reducing part 500 through a by-product supply line BL to extract the hydrogen gas from the by-products supplied through the by-product supply line BL. This extracting part 600 may extract the hydrogen gas from the by-products using a pressure swing absorption (PSA) method. That is, in the pressure swing adsorption method, a gas may be extracted using adsorption selectivity of each component with respect to an adsorbent, and the extracting part 600 may use a carbon molecular sieve as the adsorbent that is capable of adsorbing hydrogen components to extract the hydrogen gas from the by-products including various gases other than the hydrogen gas. Here, the hydrogen component adsorbed on the adsorbent may be desorbed and extracted as the hydrogen gas, and the extracting part 600 may extract the hydrogen gas from the by-products by repeatedly performing adsorption and desorption of the hydrogen component.

[0045] A residue discharged from the extracting part 600 without being adsorbed may include the steam and the nitrogen gas. Here, the residue containing the steam and the nitrogen gas may be supplied to the reducing part 500 as a purge gas. The steam may have low reactivity with the iron ore and the reducing gas as a reaction product produced by the reaction between the iron ore that is the raw material and the hydrogen gas in the reducing gas and thus may be supplied to the reducing part 500 as the purge gas. In addition, when the steam is supplied to the reducing part 500 as the purge gas, the heat of the steam may be utilized for the reduction reaction to save energy required for the reduction reaction. To supply the residue as the purge gas to the reducing part 500, a residue discharge line (not shown) may be connected to the extracting part 600, and the residue discharge line may be connected to a purge gas supply line PL or be directly connected to the reducing part 500 to supply the residue to the reducing part 500 through a path different from that of the purge gas.

[0046] The hydrogen gas extracted from the extracting part 600 may be used for various purposes. For example, the reducing part 500 may reduce the raw material, that is, the iron ore using the extracted hydrogen gas. The hydrogen gas may be used in a large amount more than twice the amount required to entirely reduce the raw material supplied to the reducing part 500, but is a very expensive gas, and thus, to reduce costs through resource recycling, the hydrogen gas extracted from the extracting part 600 may be reused as the reducing gas to reduce the iron ore. For this, the hydrogen gas supply line HL may be connected to the extracting part 600, and the hydrogen gas supply line HL may be connected to the first reducing gas supply line RL1, and thus, the extracting part 600 may supply the hydrogen gas to the first reducing gas supply line RL1, and the extracted hydrogen gas may be supplied to the reducing part 500 along the hydrogen gas supply line HL, the first reducing gas supply line RL1, and the second reducing gas and then be used when reducing the iron ore.

[0047] The melting part 700 may receive the reduced iron that reacts in a processing part 800 to be described later to melt the reduced iron in various manners. For example, the melting part 700 may receive the fine or compacted reacting reduced iron from the processing part 800 to heat and melt the reduced iron. In addition, the melting part 700 may receive additional iron scrap in addition to the reacting reduced iron and melt the reacting reduced iron and the iron scrap together. The melting part 700 may include electric furnaces 710 and 720 having a melting space capable of melting the reacting reduced iron using electric heat. The above-described electric furnaces 710 and 720 may include an electric furnace main body 710 having a melting space and an electrode rod 720 of which at least a portion is partially disposed in the melting space to generate the electric heat. When the reacting reduced iron is charged into the melting space, the electric furnaces 710 and 720 may apply power to the electrode rod 720 to melt the reacting reduced iron.

[0048] In the melting part 700, a recarburizing agent containing a carbon component may be introduced to adjust a carbon content of the molten product manufactured by melting the reacting reduced iron. In addition, the recarburizing agent may be added to generate a large amount of slag when melting the molten product. In this case, the electrode rod 720 may generate resistance heat by receiving power while immersed in the slag, and the reduced iron may be more easily melted by the generated resistance heat. At least partially unreduced raw material, that is, partially reduced iron or iron ore may be supplied to the melting part 700. As described above, at least a portion of the unreduced raw material may have an oxygen component, and the oxygen component may react with the carbon component of the recarburizing agent or carbon component of the reacting reduced iron, which will be described later, within the melting space. Thus, in the melting part 700, the exhaust gas containing the carbon monoxide gas, that is, the exhaust gas having a high carbon monoxide concentration (CO-rich) may be discharged while melting the reduced iron by receiving the reacting reduced iron from the processing part 800. As described above, the exhaust gas discharged from the melting part 700 may be discharged at a high temperature of approximately 1,200°C or more.

[0049] When the reduced iron manufactured in the reducing part 500 is charged to the melting part 700 without separate processing, a lot of energy may be required to melt the reduced iron in the melting part 700. That is, the reduced iron manufactured in the reducing part 500 without any additional processing may have a component of metallic iron (Fe), that is, pure iron, and the pure iron may have a melting point of approximately 1,538°C. In addition, the reduced iron may contain a large amount of gangue in addition to the pure iron component, and the reduced iron may be melted only when heated to a temperature above the melting point of the pure iron. In addition, when the reduced iron manufactured in the reducing part 500 is charged to the melting part 700 without separate processing, the use of the large amount of

recarburizing agent may be required to control a carbon content of the molten product.

[0050] On the other hand, when the reduced iron is carbonized, the pure iron component may be changed into a cementite (Fe₃C) phase, which has a melting point of approximately 1,200°C or less. As described above, when melting the reduced iron in which at least a portion of the components is changed to the cementite (Fe₃C) phase, the amount of energy used to melt the reduced iron may be minimized. In addition, when melting the reduced iron that is carbonized, that is, iron carbide, the molten product may have some carbon components. Thus, when melting the iron carbide, the amount of recarburizing agent used to control the carbon content of the melt may be minimized.

[0051] Thus, in an exemplary embodiment, the processing part 800 in which the reduced iron supplied from the reducing part 500 reacts with the exhaust gas having a high carbon monoxide concentration (CO-rich) discharged from the melting part 700, and the reacting iron carbide is supplied to the melting part 700 may be installed. For this, the facility for manufacturing the molten iron in accordance with an exemplary embodiment may further include an exhaust gas supply line EL installed to connect the melting part 700 to the processing part 800.

[0052] Here, the processing part 800 may include a main body 810 having a processing space as illustrated in FIG. 3, a reduced iron inlet 812 provided in the main body 810 to allow the reduced iron to flow into the processing space, and an exhaust gas inlet 816 provided in the main body 810 and connected to the exhaust gas supply line EL so that the exhaust gas is introduced into the processing space.

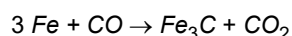
[0053] The main body 810 may have a processing space in which the reduced iron supplied from the reducing part 500 is accommodated. To introduce the reduced iron into the processing space, the reduced iron inlet 812 may be provided in the main body 810, and a reduced iron supply tube FL may be connected to the reduced iron inlet 812 so that the reduced iron manufactured and transferred from the reducing part 500 is introduced into the processing space through the reduced iron supply tube FL. In addition, the exhaust gas discharged from the melting part 700 may be introduced into the processing space of the main body 810. For this, the exhaust gas inlet 816 may be provided in the main body 810, and the exhaust gas inlet 816 may be connected to the exhaust gas supply line EL. In FIG. 3, the processing part 800 may be illustrated as being provided as a single body 810, but the processing part 800 may carbonize the reduced iron while sequentially moving the reduced iron by connecting a plurality of bodies 810 to each other.

[0054] Here, the exhaust gas inlet 816 may be provided at a position lower than the reduced iron inlet 812. For example, as illustrated in FIG. 3, the exhaust gas inlet 816 may be provided on a bottom surface of the main body 810, and the reduced iron inlet 812 may be provided on a side surface of the main body 810. As described above, the exhaust gas inlet 816 may be provided at the position lower than the reduced iron inlet 812, and thus, the reduced iron supplied from the reduced iron inlet 812 may flow within the main body 810 to react with the exhaust gas. The processing part 800 may further include a dispersion plate 817 installed in the main body 810 and provided with a plurality of nozzles (not shown) to uniformly disperse the exhaust gas supplied from the exhaust gas inlet 816 into the processing space.

[0055] Here, the reduced iron manufactured in the reducing part 500 may be discharged at a high temperature of, for example, approximately 600°C to approximately 800°C, and the discharged reduced iron may be directly supplied to the processing part 800 without passing through a separate thermal processing device. In addition, since the high-temperature exhaust gas having a temperature of approximately 1,200°C or more is supplied to the processing space, the processing space may maintain a temperature of approximately 600°C to approximately 800°C even in consideration of a heat loss of the reduced iron during the transfer process. Thus, the processing part 800 may not be installed with a separate heating means for heating the processing space. However, since there is a need to additionally rise a temperature of the processing space during an initial operation of the facility, the processing part 800 may further include a heater 820 installed in the main body 810 to heat the processing space. Here, the heater 820 may selectively operate to heat the processing space when it is necessary to heat the processing space. For example, the heater 820 may be installed on the side surface of the main body 810 to supply an oxygen gas, and the supplied oxygen gas may react with the exhaust gas in the processing space to rise the temperature of the processing space. Here, an amount of oxygen gas supplied from the heater 820 may be controlled to maintain the processing space within a temperature range of approximately 600°C to approximately 800°C.

[0056] The processing part 800 may carbonize the reduced iron supplied from the reducing part 500 by reacting the reduced iron with the exhaust gas. As shown in a Bauer-Glaessner diagram that shows conditions under which the reduced iron illustrated in FIG. 4 reacts with the exhaust gas, when the processing space is maintained at a temperature of approximately 600°C to approximately 800°C, when a partial pressure of carbon monoxide and a partial pressure of carbon dioxide in the processing space specify specific conditions, the reduced iron may be carbonized by reacting in accordance with the following reaction formula.

[Reaction Formula]



[0057] That is, when the reduced iron and the exhaust gas at a high temperature are supplied to the processing space, and the processing space is maintained at a temperature of approximately 600°C to approximately 800°C, when the partial pressure P_{co} of the carbon monoxide is greater than about 90% of the sum (P_{co}+P_{co2}) of the partial pressure P_{co} of the

carbon monoxide and the partial pressure P_{CO_2} of the carbon dioxide, the reduced iron may react according to the above-described reaction formula and be carbonized. Here, as described above, the melting part 700 may include electric furnaces 710 and 720 that are capable of melting the reduced iron, i.e., an electric smelting furnace (ESF) or a submerged arc furnace (SAF), which is immersed into slag provided in the electric furnace main body 710 to melt the reduced iron with slag resistance heat. As described above, the electric furnaces 710 and 720 may have a closed structure, and there may be almost no inflow of oxygen or atmosphere, and thus, a carbon dioxide content in the exhaust gas may be very low, and an oxygen component of the unreduced raw material may react with the carbon component of the recarburizing agent, resulting in a high carbon monoxide concentration. That is, the partial pressure P_{CO} of the carbon monoxide discharged from the electric furnaces 710 and 720 may be approximately 90% or more of the sum ($P_{CO} + P_{CO_2}$) of the partial pressure P_{CO} of the carbon monoxide and the partial pressure P_{CO_2} of the carbon dioxide, and thus, the reduced iron may be effectively carbonized under a temperature condition of approximately 600°C to approximately 800°C.

[0058] The facility for manufacturing the molten iron in accordance with an exemplary embodiment may further include a supplemental gas supply part 900 installed to supply a supplemental gas having at least a portion of the same component as the exhaust gas to the processing space of the processing part 800. The supplemental gas supply part 900 may supply the supplemental gas, that is, a carbon-containing gas having at least some of the same components as the exhaust gas, to the processing part 800, and the supplemental gas supply part 900 may supply a carbon-containing gas to the processing part 800 through the supplemental gas supply line SL. Here, the supplemental gas supply line SL may be connected to the exhaust gas supply line EL to supply the supplemental gas together with the exhaust gas or may supply the supplemental gas to the processing part 800 through a path different from the exhaust gas supply line EL, and the supplemental gas may include at least one of a natural gas containing carbon or a biomass gas obtained by gasifying biomass.

[0059] In addition, the facility for manufacturing the molten iron in accordance with an exemplary embodiment may further include a purge gas branch line PDL that is branched from the purge gas supply line PL to supply a portion of the purge gas supplied to the reduction space to the processing space. The processing space needs to be purged for maintenance, and the purge gas may be supplied to prevent the reduced fine iron from sticking to the processing space during the process. Thus, the purge gas branch line PDL may be branched from the purge gas supply line PL to supply the purge gas to the processing space.

[0060] As described above, the reduced iron, that is, iron carbide reacting in the processing part 800 may be supplied to the melting part 700. Here, the reaction between the reduced iron and the exhaust gas in accordance with the above-mentioned reaction equation may correspond to an exothermic reaction. Thus, the iron carbide supplied from the processing part 800 to the melting part 700 may be discharged at a high temperature in a range similar to the temperature of the processing space, for example, approximately 600°C to approximately 800°C, even in consideration of a heat loss. As described above, the iron carbide discharged in a high temperature state may be directly supplied to the melting part 700 in a high temperature state without passing through a separate cooling device to minimize an amount of energy used for melting the reduced iron.

[0061] On the other hand, most of the reduced iron supplied to the processing space may react in the processing space and then be supplied to the melting part 700, but the reduced iron in molten fine iron may not react sufficiently with the exhaust gas to flow by the exhaust gas and then be discharged to the outside of the processing space together with the exhaust gas. Thus, the processing part 800 may further include a collector 840 connected to the main body 810 to collect the reduced iron discharged from the main body 810 and a circulation line CL through which the reduced iron collected from the collector 840 is supplied to the main body 810. Here, the collector 840 may be installed to be connected to an upper portion of the main body 810 and connected to a discharge tube XL through which the exhaust gas is discharged, and the reduced fine iron collected from the collector 840 may be re-supplied to the processing space of the main body 810 through the circulation line CL. Here, the circulation line CL may be directly connected to the processing space, but may also be connected to the above-mentioned reduced iron supply tube FL to re-supply the reduced fine iron collected from the collector 840 to the processing space of the main body 810.

[0062] As described above, the exhaust gas discharged from the melting part 700 may be supplied to the processing part 800 and used to carbonize the reduced iron. However, as described above, the exhaust gas discharged from the melting part 700 may be discharged at a high temperature of approximately 1,200°C or more. Thus, in an exemplary embodiment, the raw material may be preheated by utilizing thermal energy of the exhaust gas.

[0063] As illustrated in FIG. 5, the raw material supply part 100 may include a reservoir 110, and the reservoir 110 may have a storage space for storing the raw material. The raw material may be preheated in the storage space of the reservoir 110, and the raw material preheated in the storage space may be supplied to the reducing part 500. For this, the raw material supply part 100 may further include a preheating gas supply part 120 installed to supply a preheating gas to the storage space of the reservoir 110. Here, as illustrated in (a) of FIG. 5, the preheating gas supply part 120 may be connected to the exhaust gas branch line EDL to directly supply the high-temperature exhaust gas E having a temperature of approximately 1,200°C or more to the storage space, thereby performing the preheating. In addition, as illustrated in (b) of FIG. 5, the preheating gas supply part 120 may heat external air A supplied to the storage space with the heat of the exhaust gas having a temperature of approximately 1,200°C or more to supply the heated air to the storage space, thereby

preheating the raw material. For this, the preheating gas supply part 120 may be disposed on the exhaust gas branch line EDL to intersect the exhaust gas branch line EDL, and thus, the sensible heat of the exhaust gas passing through the exhaust gas branch line EDL may be transferred to the external air A.

[0064] The facility for manufacturing the molten iron in accordance with an exemplary embodiment may manufacture the molten iron reacting by moving the reduced iron and the exhaust gas along each of the above-described tubes. The movement of the reduced iron and the exhaust gas may be controlled through valves (not shown) installed in the tubes, and the valves may be installed at various positions to control a flow amount and flow rate of the reduced iron and the exhaust gas, which move along the respective tubes.

[0065] Hereinafter, a method for manufacturing molten iron in accordance with an exemplary embodiment will be described. The method for manufacturing the molten iron in accordance with an exemplary embodiment may be a method for manufacturing molten iron using the above-described facility for manufacturing the molten iron, and thus, since the above-described contents in relation to the facility for manufacturing the molten iron are applied as there are, description of duplicated contents will be omitted.

[0066] FIG. 6 is a schematic view of a method for manufacturing molten iron in accordance with an exemplary embodiment.

[0067] Referring to FIG. 6, a method for manufacturing molten iron in accordance with an exemplary embodiment may include a process (S100) of manufacturing reduced iron, a process (S200) of allowing the manufactured reduced iron to react with a processing gas, a process (S300) of melting the reacting reduced iron to manufacture a molten product, and a process (S400) of using at least a portion of the exhaust gas generated in the process of manufacturing the molten product as a processing gas that reacts with the reduced iron. Here, since each process are continuously performed to manufacture the molten iron, it may not correspond to a time-series relationship in which another process is performed after one process is completed.

[0068] The process (S100) of manufacturing the reduced iron may be performed by supplying a raw material and the reducing gas to a reducing part 500. That is, the process (S100) of manufacturing the reduced iron may include a process of supplying the raw material to the reducing part 500, a process of supplying a reducing gas to the reducing part 500, and a process of reducing the raw material by allowing the raw material to react with the reducing gas.

[0069] The process of supplying the raw material may be performed by a raw material supply part 100, which is installed to supply the raw material to the reducing part 500 so as to supply the raw materials to the reducing part 500. Here, the raw material may include iron ore, and the iron ore may include reduced fine iron ore, that is, powdered iron ore which has a particle size greater than approximately 0 mm and less than or equal to approximately 8 mm. The process of supplying the raw material may include a process of preheating the raw material. In an exemplary embodiment, energy required for the reduction may be minimized by supplying and reducing the preheated raw materials, that is, the iron ore.

[0070] The process of supplying the reducing gas may be performed by a reducing gas supply part 200 supplying the reducing gas to the reducing part 500. Here, the reducing gas may include a hydrogen gas, and the hydrogen gas may be contained at a ratio of approximately 80% to approximately 100% of the total reducing gas. The process of supplying the reducing gas may be performed by allowing the reducing gas supply part 200 to supply the reducing gas to the reducing part 500 through reducing gas supply lines RL1 and RL2 that connect the reducing gas supply part 200 to the reducing part 500. Here, in the process of supplying the reducing gas, an amount of reducing gas supplied to the reducing part 500 may be controlled to be in a range of more than 2 times and less than 3 times an amount required to entirely reduce the raw material supplied to the reducing part 500.

[0071] In the process of supplying the reducing gas, the reducing gas may be heated to a temperature of approximately 800°C to approximately 1,200°C and then supplied to the reducing part 500. When the hydrogen gas is used as the reducing gas, the reduced iron may be manufactured by allowing the iron ore and the hydrogen gas supplied to the reducing part 500 to react with each other. Since the reaction between the iron ore and the hydrogen gas is a strong endothermic reaction, the iron ore supplied to the reducing part 500 may be heated at a temperature of approximately 800°C or more, more preferably approximately 850°C or more, and when the heated reducing gas is supplied, reduction efficiency may be improved.

[0072] In addition, the process (S100) of manufacturing the reduced iron may further include a process of supplying a purge gas to the reducing part 500. Here, the process of supplying the purge gas may be performed by a purge gas supply part 400, which is installed to supply the purge gas to the reducing part 500, so as to supply the purge gas to a reducing space through the purge gas supply line PL. Here, an inert gas such as nitrogen may be used as the purge gas.

[0073] In the process of reducing the raw material by allowing the raw material to react with the reducing gas, the reducing part 500 may receive the raw material from the raw material supply part 100, receive the reducing gas from the reducing gas supply part 200, and react the iron ore with the reducing gas to reduce the iron ore. The reducing part 500 may include a reducing furnace having a reducing space capable of manufacturing the reduced iron using the reducing gas. The reducing furnace may be provided as a single unit, but to effectively reduce low-grade iron ore or powdered iron ore having a low iron content, the plurality of reducing furnaces may be connected to sequentially move the raw material, thereby manufacturing the reduced iron, as described above.

[0074] In the process of reducing the raw material by allowing the raw material to react with the reducing gas, a large amount of by-products may be generated in addition to the reduced iron. The by-products generated and discharged from the reducing part 500 may include steam generated by the reaction of the iron ore and the hydrogen gas and also may include the hydrogen gas that does not react with the raw material and the nitrogen gas supplied as the purge gas. In addition, dust generated in the reducing part 500 may be contained in the by-products and discharged, and the by-products may move along a flow of the reducing gas within the reducing part 500 and be discharged from the reducing furnace.

[0075] As described above, the by-products discharged from the reducing furnace may be used to produce a hydrogen gas. That is, the method for manufacturing the molten iron in accordance with an exemplary embodiment may further include a process of collecting by-products generated in the process of manufacturing the reduced iron and a process of extracting a hydrogen gas from the collected by-products. As described above, the by-products discharged from the reducing part 500 may include steam, a hydrogen gas, a nitrogen gas, and dust, and the reducing part 500 may be provided with an extracting part 600 to receive the by-products discharged from the reducing part 500. Here, the dust may be removed before the by-products are supplied to the extracting part 600 or within the extracting part 600. The extracting part 600 may extract the hydrogen gas from the by-products supplied through a by-product supply line BL using a pressure swing adsorption method.

[0076] The hydrogen gas extracted during the process of extracting the hydrogen gas may be used for various purposes. However, the reducing part 500 may use the hydrogen gas to reduce the raw material, that is, the iron ore, and the hydrogen gas may be used in a large amount more than twice the amount required to entirely reduce the raw material supplied to the reducing part 500, but is a very expensive gas, and thus, to reduce costs through resource recycling, the hydrogen gas extracted from the extracting part 600 may be reused as the reducing gas to reduce the iron ore. For this, the method for manufacturing the molten iron in accordance with an exemplary embodiment may be used to reduce the iron ore by supplying the extracted hydrogen gas as the reducing gas during the process (S100) of manufacturing the reduced iron. The residue that is not extracted and discharged during the process of extracting the hydrogen gas may be supplied to the reducing part 500 as a purge gas. The steam of the residue may have low reactivity with the iron ore and the reducing gas as a reaction product produced by the reaction between the iron ore that is the raw material and the hydrogen gas in the reducing gas and thus may be supplied to the reducing part 500 as the purge gas. In addition, when the steam is supplied to the reducing part 500 as the purge gas, the heat of the steam may be utilized for the reduction reaction to save energy required for the reduction reaction.

[0077] In the process (S200) of reacting with the processing gas, the reduced iron manufactured in the reducing part 500 may react with a processing gas. Here, the processing gas may include a gas containing a carbon component, and the process (S200) of reacting with the processing gas may include a process of carbonizing at least a portion of the reduced iron manufactured in the reducing part 500.

[0078] That is, as described above, when the reduced iron manufactured in the reducing part 500 is melted without any additional processing, a melting point of the reduced iron may be very high, and thus, a lot of energy may be required to melt the reduced iron. In contrast, when the reduced iron is carbonized, the melting point may be lowered to a temperature of several hundreds of degrees (°C) or more. Thus, in the method for manufacturing the molten iron in accordance with an exemplary embodiment, the reduced iron may react with the processing gas, and the reacting reduced iron, that is, iron carbide may be supplied to the melting part 700 for melting to minimize an amount of energy used for the melting. Here, the processing gas may include a gas containing a carbon component.

[0079] Here, in the process (S200) of reacting with the processing gas, the reduced iron may react with the processing gas without separate thermal processing. That is, the reduced iron manufactured in the reducing part 500 may be discharged at a high temperature of, for example, approximately 600°C to approximately 800°C, and the discharged reduced iron may be directly supplied to the processing part 800 without passing through a separate thermal processing device. In addition, since the high-temperature exhaust gas having a temperature of approximately 1,200°C or more is supplied to the processing space, the processing space may maintain a temperature of approximately 600°C to approximately 800°C even in consideration of a heat loss of the reduced iron during the transfer process. Thus, in the process (S200) of reacting with the processing gas, the manufactured reduced iron may react with the processing gas at a temperature of approximately 600°C to approximately 800°C, and at the beginning of the process or when there is a need for additional temperature increase, the processing space may be selectively heated through a heater 820.

[0080] when the processing space is maintained at a temperature of approximately 600°C to approximately 800°C, when a partial pressure of carbon monoxide and a partial pressure of carbon dioxide in the processing space specify specific conditions, the reduced iron may be carbonized by reacting in accordance with the above-described reaction formula. That is, when the reduced iron and the exhaust gas at a high temperature are supplied to the processing space, and the processing space is maintained at a temperature of approximately 600°C to approximately 800°C, when the partial pressure P_{CO} of the carbon monoxide is greater than about 90% of the sum ($P_{CO} + P_{CO_2}$) of the partial pressure P_{CO} of the carbon monoxide and the partial pressure P_{CO_2} of the carbon dioxide, the reduced iron may react according to the above-described reaction formula and be carbonized.

[0081] Here, to carbonize the reduced iron by reacting with a processing gas, the method for manufacturing the molten

iron in accordance with an exemplary embodiment may include a process (S400) of using at least a portion of the exhaust gas generated during the manufacturing of the molten material as the processing gas that reacts with the reduced iron. That is, in the process (S400) of using the exhaust gas as the processing gas, at least a portion of the exhaust gas generated in the process (S300) of manufacturing the molten product may be used as the processing gas that reacts with the reduced iron in the process (S200) of allowing the manufactured reduced iron to react with the processing gas. As described above, the melting part 700 may include electric furnaces 710 and 720 having a melting space capable of melting the reduced iron using electric heat. In the melting part 700, a recarburizing agent containing a carbon component may be introduced to adjust a carbon content of the molten product manufactured by melting the reduced iron. At least partially unreduced raw material, that is, partially reduced iron or iron ore may be supplied to the melting part 700. As described above, at least a portion of the unreduced raw material may have an oxygen component, and the oxygen component may react with the carbon component of the recarburizing agent within the melting space. Thus, in the melting part 700, the exhaust gas containing the carbon monoxide gas, that is, the exhaust gas having a high carbon monoxide concentration (CO-rich) may be discharged while melting the reduced iron. As described above, the exhaust gas discharged from the melting part 700 may be discharged at a high temperature of approximately 1,200°C or more.

[0082] At this time, the melting part 700 may include electric furnaces 710 and 720 that are capable of melting the reduced iron, i.e., an electric smelting furnace (ESF) or a submerged arc furnace (SAF), which is immersed into slag provided in the electric furnace main body 710 to melt the reduced iron with slag resistance heat. As described above, the electric furnaces 710 and 720 may have a very low carbon dioxide content in the exhaust gas, and an oxygen component of the unreduced raw material may react with the carbon component of the recarburizing agent, resulting in a high carbon monoxide concentration. Thus, the partial pressure P_{CO} of the carbon monoxide discharged from the electric furnaces 710 and 720 may be approximately 90% or more of the sum ($P_{CO} + P_{CO_2}$) of the partial pressure P_{CO} of the carbon monoxide and the partial pressure P_{CO_2} of the carbon dioxide, and thus, the reduced iron may be effectively carbonized under a temperature condition of approximately 600°C to approximately 800°C.

[0083] In the process (S200) of reacting with the processing gas, a supplemental gas having at least a portion of the same component as the exhaust gas may be used as the processing gas. As described above, the supplemental gas supply part 900 may supply the supplemental gas, that is, a carbon-containing gas having at least some of the same components as the exhaust gas, to the processing part 800, and the supplemental gas supply part 900 may supply a carbon-containing gas to the processing part 800 through the supplemental gas supply line SL. Here, the supplemental gas supply line SL may be connected to the exhaust gas supply line EL to supply the supplemental gas together with the exhaust gas, and the supplemental gas may include at least one of a natural gas containing carbon or a biomass gas obtained by gasifying biomass.

[0084] Here, most of the reduced iron supplied to the processing space in the process (S200) of reacting with the processing gas may react with the exhaust gas and be supplied to the melting part 700, but the reduced iron in reduced fine iron may not react sufficiently with the exhaust gas to flow by the exhaust gas and then be discharged to the outside of the processing space together with the exhaust gas.

[0085] Thus, the method for manufacturing the molten iron in accordance with an exemplary embodiment may further include a process of collecting the reduced iron discharged from the processing space in which the reduced iron reacts with the processing gas and a process of supplying the collected reduced iron to the processing space.

[0086] Here, the process of collecting the reduced iron that is discharged may be performed through a collector 840 connected to the main body 810 to collect the reduced iron discharged from the main body 810, and the collector 840 may be connected to an upper portion of the main body 810 and thus be connected to a discharge tube XL through which the exhaust gas is discharged. In addition, in the process of supplying the collected reduced iron to the processing space, the reduced fine iron collected from the collector 840 may be re-supplied to the processing space of the main body 810 through the circulation line CL. Here, the circulation line CL may be directly connected to the processing space, but may also be connected to the above-mentioned reduced iron supply tube FL to re-supply the reduced fine iron collected from the collector 840 to the processing space of the main body 810.

[0087] The process (S300) of manufacturing the molten product may be performed by the melting part 700 receiving the reacting reduced iron, that is, the iron carbide from the processing part 800 to melt the supplied iron carbide. That is, the melting part 700 may receive the fine or compacted carbonized iron from the processing part 800 to heat and melt the reduced iron. In addition, the process (S300) of manufacturing the molten product may be performed by the melting part 700 receiving the carbonized iron from the reducing part 800 to melt the supplied carbonized iron using electric heat. Here, the melting part 700 may include an electric furnace having a melting space capable of melting the carbonized iron using electric heat. Such an electric furnace may include an electric furnace main body having a melting space and an electrode rod of which at least a portion is disposed in the melting space to generate electric heat, and the melting part 700 may provide electric power to the electrode rod when the reduced iron is charged into the melting space, thereby melting the carbonized iron.

[0088] Here, the process (S300) of manufacturing the molten product may include the process of putting a recarburizing agent into the melting part 700, that is, the melting space of the electric furnace. In the melting part 700, a recarburizing

agent containing a carbon component is introduced to adjust the carbon content of the melt produced by melting the reduced iron. In addition, the recarburizing agent may be added to generate a large amount of slag when melting the molten product. The electrode rod 720 may generate resistance heat by being immersed in slag, and the iron carbide may be more easily melted by the generated resistance heat. Here, since the iron carbide supplied from the processing part 800 already contains a large amount of carbon components, the amount of recarburizing agent used may be minimized in the process (S300) of manufacturing the molten product.

[0089] As described above, in the melting part 700, the exhaust gas containing the carbon monoxide gas, that is, the exhaust gas having a high carbon monoxide concentration (CO-rich) and a temperature of approximately 1,200°C or more may be discharged while melting the reduced iron. Thus, the process of preheating the raw material described above may be performed using the exhaust gas discharged from the melting part 700, that is, the exhaust gas discharged during the process of manufacturing the molten product, which will be described later. Since the exhaust gas discharged from the melting part 700 is discharged at a high temperature of approximately 1,200°C or more, the raw material may be preheated by utilizing the heat energy of the exhaust gas.

[0090] To explain this in more detail, the process of preheating the raw material may include a process of directly injecting a portion of the exhaust gas discharged from the melting part 600 onto the raw material. In the process of supplying the raw material, the raw material stored in a storage space of a reservoir 110 may be supplied to the reducing part 500. Thus, a preheating gas supply part 120 may be installed in the reservoir 110 to supply a preheating gas to the storage space of the reservoir 110. Here, the process of preheating the raw material may be performed by injecting a high-temperature exhaust gas having a temperature of approximately 1,200°C or more from the preheating gas supply part 120 to the raw material stored in the storage space. In addition, the preheating gas supply part 120 may inject heated external air to the raw material stored in the storage space to preheat the raw material. Here, in the process of preheating the raw material, the preheating gas supply part 120 may heat the external air using heat of the exhaust gas having a temperature of approximately 1,200°C or more, and the heated air may be supplied to the storage space to preheat the raw material.

[0091] As described above, the melting point of the reduced iron may be lowered by allowing the exhaust gas generated during the process to react with the reduced iron to minimize the amount of energy used to melt the reduced iron.

[0092] In addition, the reduced iron manufactured at the high temperature may directly react with the high-temperature exhaust gas to minimize the facility and resources required for the reaction.

[0093] In addition, the energy may be efficiently collected by using the sensible heat of the high-temperature exhaust gas to preheat the raw materials and produce the hydrogen gas.

[0094] Although the specific embodiments are described and illustrated by using specific terms, the terms are merely examples for clearly explaining the embodiments, and thus, it is obvious to those skilled in the art that the embodiments and technical terms can be carried out in other specific forms and changes without changing the technical idea or essential features. Therefore, it should be understood that simple modifications in accordance with the embodiments of the present invention may belong to the technical spirit of the present invention.

Claims

1. A facility for manufacturing molten iron, the facility comprising:

a reducing part configured to manufacture reduced iron;
a melting part configured to melt the reduced iron; and
a processing part installed to receive the reduced iron from the reducing part and an exhaust gas discharged from the melting part so that the supplied reduced iron and exhaust gas react with each other to supply the reacting reduced iron to the melting part.

2. The facility of claim 1, further comprising an exhaust gas supply line installed to connect the melting part to the processing part,

wherein the reducing part comprises a reducing furnace having a reducing space in which a reducing gas is supplied to manufacture the reduced iron, and
the melting part comprises an electric furnace having a melting space in which the reduced iron supplied from the processing part is melted using electric heat.

3. The facility of claim 2, wherein the processing part comprises:

a main body having a processing space;
a reduced iron inlet provided in the main body to allow the reduced iron to flow into the processing space; and

an exhaust gas inlet provided in the main body and connected to an exhaust gas supply line so that the exhaust gas is introduced into the processing space,
wherein the exhaust gas inlet is disposed at a position lower than the reduced iron inlet.

4. The facility of claim 3, wherein the processing part further comprises a heater installed in the main body to heat the processing space.

5. The facility of claim 3, wherein the processing part comprises:

a collector connected to the main body to collect the reduced iron discharged from the main body; and
a circulation line configured to connect the collector to the main body so that the reduced iron collected through the collector is supplied to the main body.

6. The facility of claim 3, wherein the processing part further comprises a supplemental gas supply part connected to the main body so that a supplemental gas having at least a portion of the same component as the exhaust gas is supplied to the processing space.

7. The facility of claim 2, further comprising:

a raw material supply part having a storage space in which a raw material is stored and installed to supply the raw material stored in the storage space to the reducing space; and
an exhaust gas branch line branched from the exhaust gas supply line and configured to supply a portion of the exhaust gas discharged from the electric furnace to the raw material supply part.

8. The facility of claim 7, wherein the exhaust gas branch line is connected to the raw material supply part to directly supply the exhaust gas to the storage space or transfer heat of the exhaust gas to air supplied to the storage space.

9. The facility of claim 3, further comprising:

a purge gas supply line connected to the reducing furnace to supply a purge gas to the reducing space; and
a purge gas branch line branched from the purge gas supply line and configured to supply a portion of the purge gas supplied to the reducing space to the processing space.

10. A method for manufacturing molten iron, the method comprising:

manufacturing reduced iron;
allowing the manufactured reduced iron to react with a processing gas;
melting the reacting reduced iron to manufacture a molten product; and
utilizing at least a portion of an exhaust gas generated while manufacturing the molten iron as a processing gas that reacts with the reduced iron.

11. The method of claim 10, wherein the manufacturing of the reduced iron comprises:

preheating a raw material using the exhaust gas; and
allowing the preheated raw material to react with the reducing gas to reduce the raw material.

12. The method of claim 11, wherein the preheating of the raw material comprises injecting the exhaust gas into the raw material or receiving heat of the exhaust gas to inject heated air into the raw material.

13. The method of claim 11, wherein the raw material comprises powdered iron ore having a particle size of more than approximately 0 mm and less than or equal to approximately 8 mm.

14. The method of claim 10, wherein the processing gas comprises a gas containing a carbon component, and the reacting with the processing gas comprises carbonizing at least a portion of the reduced iron.

15. The method of claim 10, wherein the allowing of the reduced iron to react with the processing gas comprises reacting with the processing gas without performing separate thermal process on the manufactured reduced iron.

16. The method of claim 10, wherein the allowing of the reduced iron to react with the processing gas comprises allowing the manufactured reduced iron to react with the processing gas at a temperature of approximately 600°C to approximately 800°C.

17. The method of claim 10, further comprising:

collecting the reduced iron discharged from the processing space in which the reduced iron reacts with the processing gas; and
supplying the collected reduced iron to the processing space.

18. The method of claim 17, wherein the manufacturing of the molten iron comprises supplying a purge gas to a reducing space, in which the reduced iron is manufactured, and
the allowing of the reduced iron to react with the processing gas comprises supplying a portion of a purge gas supplied to the reducing space to the processing space.

19. The method of claim 10, wherein the utilizing of the at least a portion of the exhaust gas as the processing gas comprises utilizing the exhaust gas and a supplemental gas having at least a portion of the same component as the exhaust gas as the processing gas.

20. The method of claim 19, wherein the exhaust gas comprises a carbon monoxide gas, and
the supplemental gas comprises at least one of a natural gas or a biomass gas.

Fig. 1

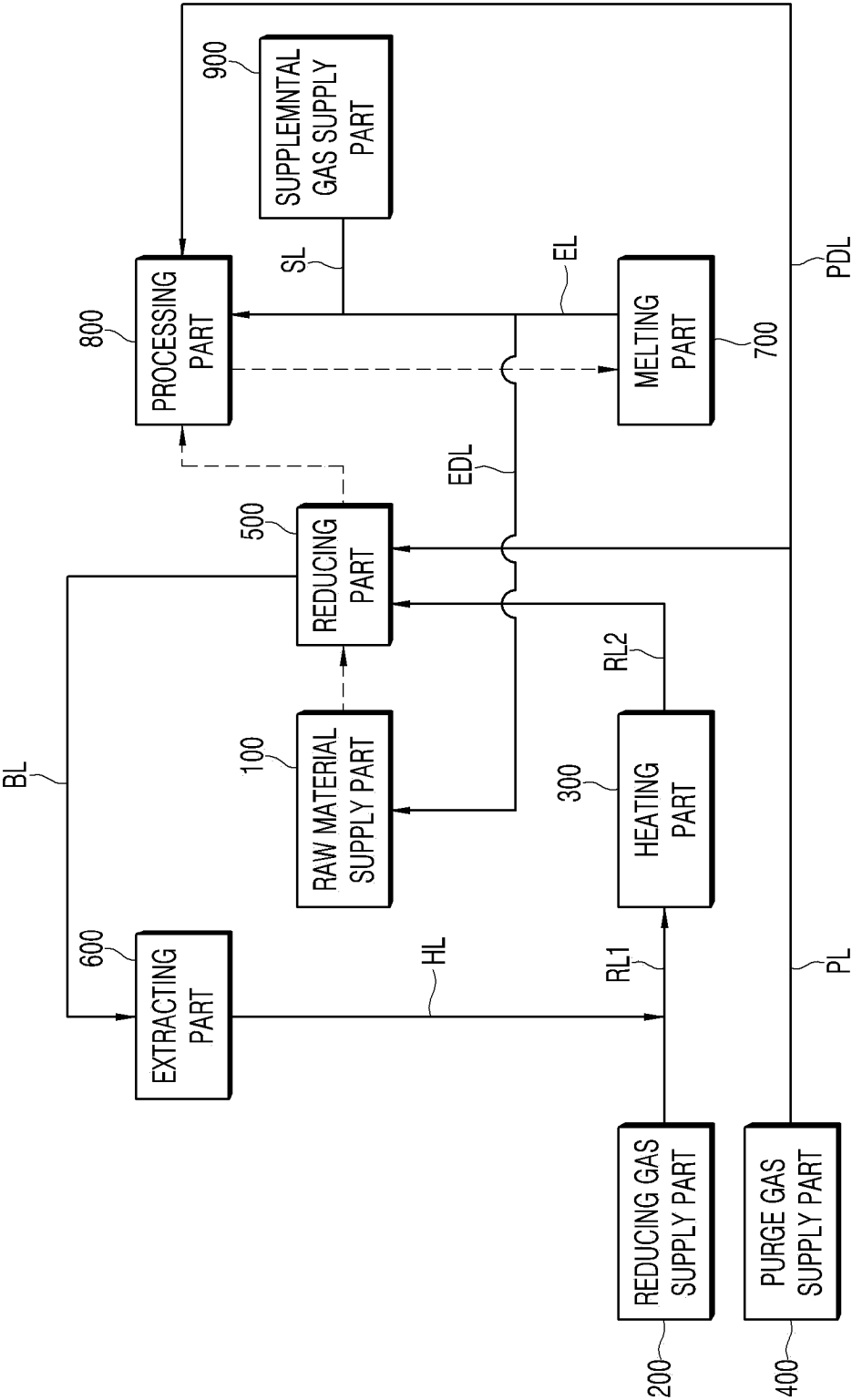


Fig. 2

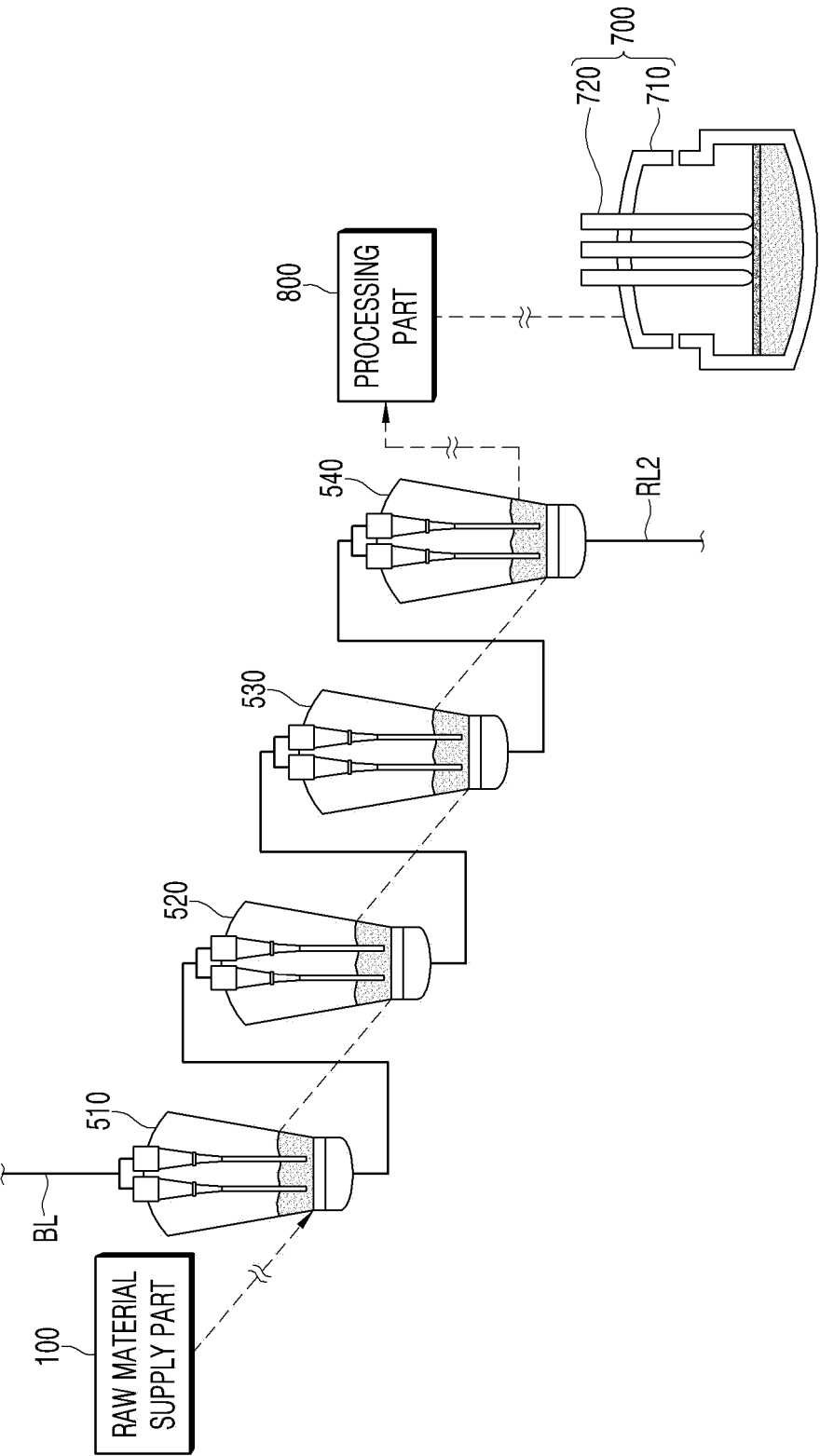


Fig. 3

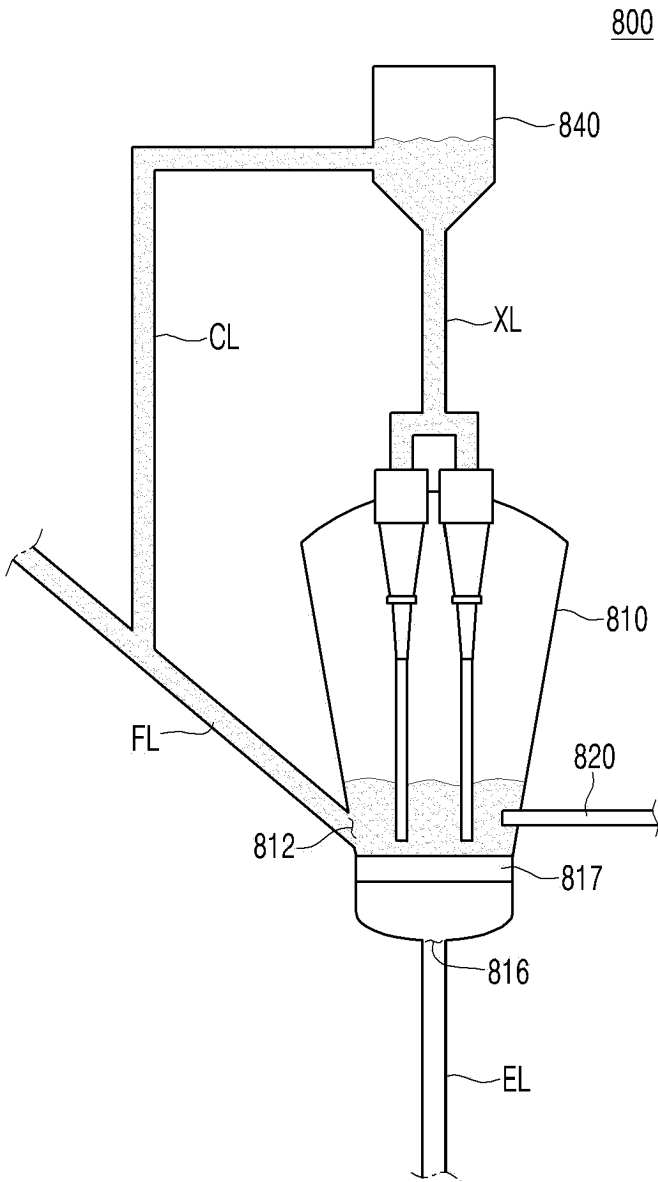


Fig. 4

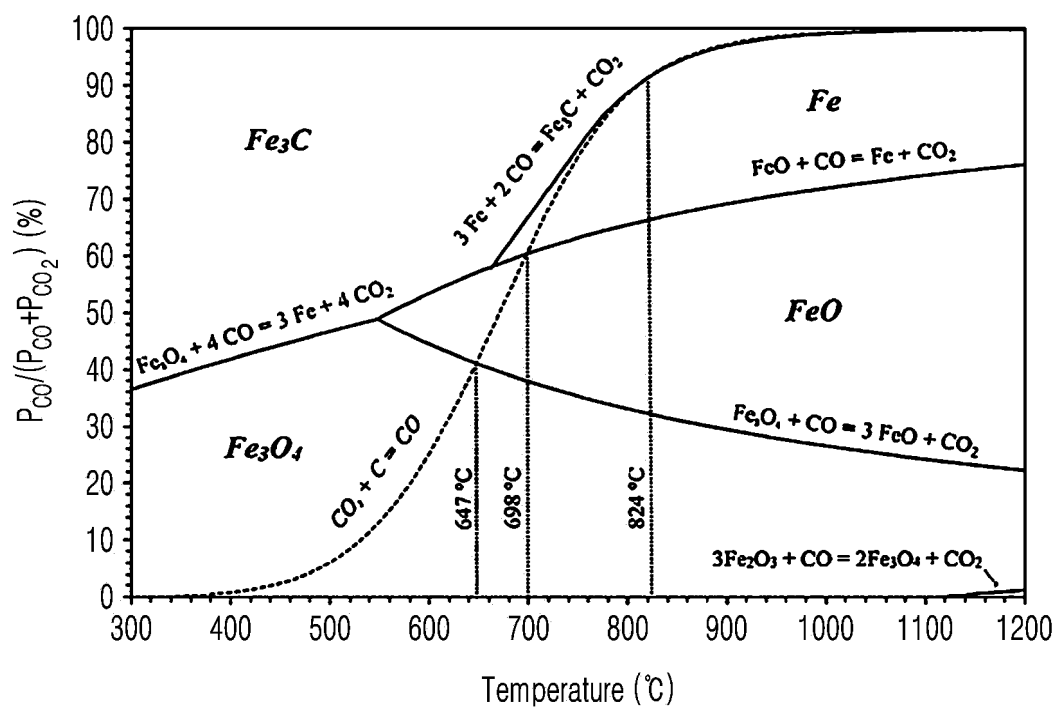


Fig. 5

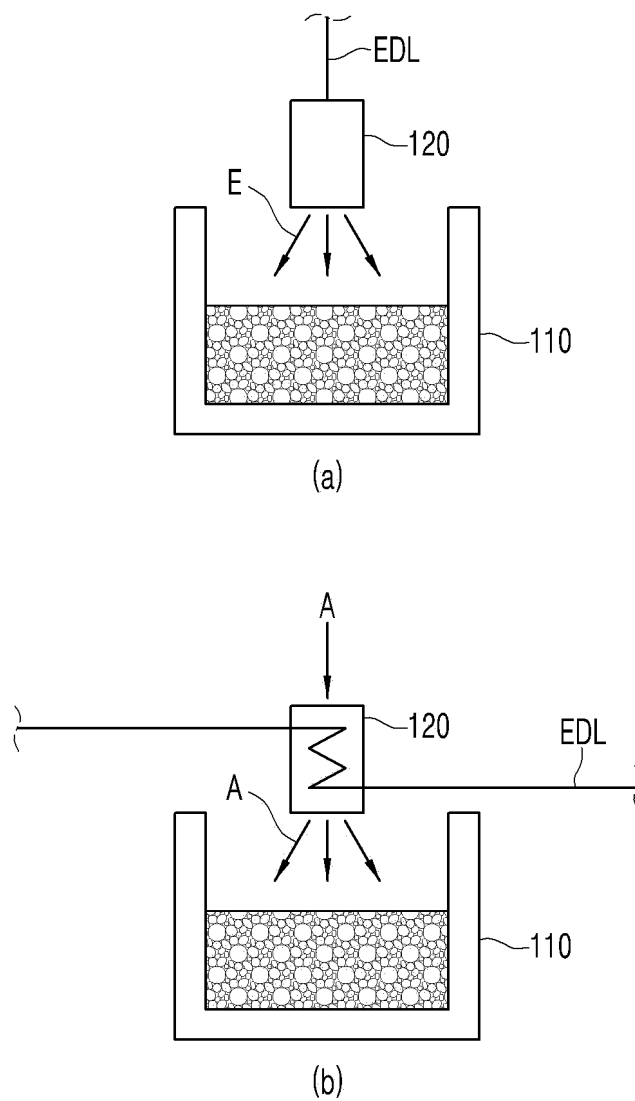
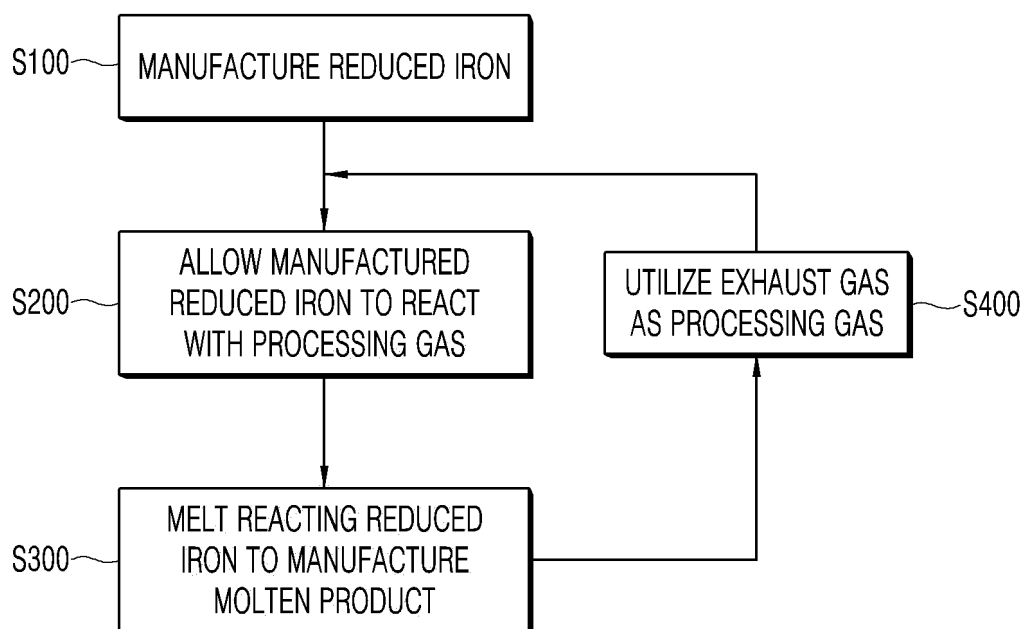


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2023/010632

A. CLASSIFICATION OF SUBJECT MATTER**C21B 13/00**(2006.01)i; **C21B 13/12**(2006.01)i; **C21B 13/02**(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)

C21B 13/00(2006.01); C01B 31/30(2006.01); C21B 13/12(2006.01); C22B 1/16(2006.01)

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

Korean utility models and applications for utility models: IPC as above

Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & keywords: 환원철(reduced iron), 용철(molten iron), 배가스(exhaust gas), 환원로(reduced furnace), 전기로(electric furnace)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2012-0036510 A (POSCO) 18 April 2012 (2012-04-18) See paragraphs [0026], [0036], [0038], [0041], [0044], [0067]-[0071] and [0074], claim 4 and figure 2.	1,10-14,19-20
Y		2-9,15-18
Y	이상호 등. 수소 기반 환원 제철 공정과 전환 기술. 대한금속 재료학회지. Vol. 59, No. 1, 2021, pp. 41-53 (YI, Sang-Ho et al. Hydrogen-Based Reduction Ironmaking Process and Conversion Technology. Korean Journal of Metals and Materials.) See page 50.	2-9
Y	KR 10-2002-0015900 A (POSCO et al.) 02 March 2002 (2002-03-02) See paragraphs [0024] and [0030] and claim 1.	4-5,15-18
Y	KR 10-2005-0054849 A (POSCO et al.) 10 June 2005 (2005-06-10) See claim 12.	9,18

☒ 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

“D” document cited by the applicant in the international application

“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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Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208

Facsimile No. +82-42-481-8578

Authorized officer

Telephone No.

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