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(54) **Shaft furnace**

(57) The invention refers to a vertical shaft furnace (100) for a burden (115) moving under the influence of gravity from the top to the bottom of the shaft furnace, in particular for the production of directly reduced iron, with at least one gas bustle line (131, 132), which is connected with at least one gas bustle port (133, 134) in a reduction zone (101), which is characterized in that an injection system (400, 410) for a burnable gas mixture is provided in the gas bustle line (131, 132).

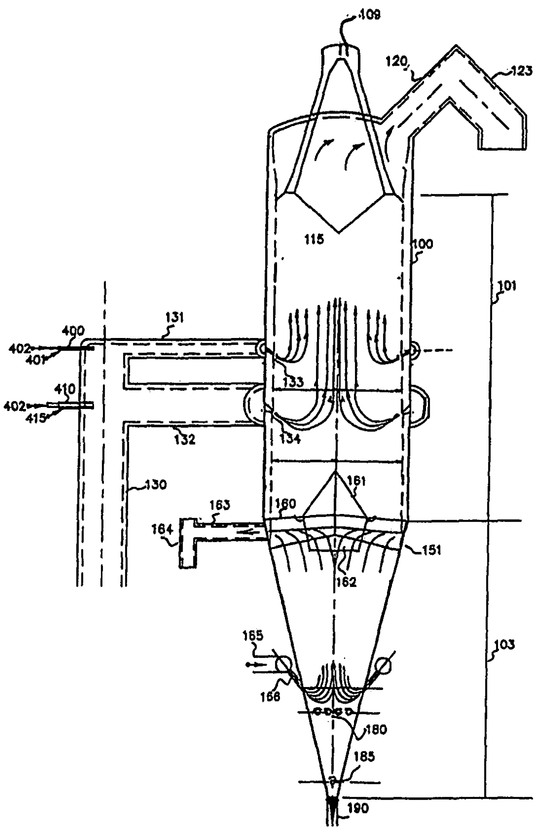

Fig. 1

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Description

[0001] The present invention relates to a vertical shaft furnace for a burden moving under the influence of gravity from the top to the bottom of the shaft furnace, in particular for the production of directly reduced iron, with at least one bustle gas line, which is connected with at least one bustle gas port in a reduction zone.

[0002] Vertical shaft furnaces are known in the prior art, which may in particular be used for the direct reduction of iron oxides. These shaft furnaces are designed in such a way, that the burden fed thereto moves under the influence of gravity and downward pressure from the top to the bottom of the shaft furnace.

[0003] US 4,054,444 discloses such a shaft furnace. In this shaft furnace a feed opening for the burden and furnace gas outlet are provided at the top of the shaft furnace. A burden of iron oxide material may be fed into the shaft furnace through the feed opening. The furnace gas outlet serves for discharging used furnace gas.

[0004] The feed opening forms the upper end of a reduction zone, in which bustle gas ports are provided in order to introduce reduction gas, which contains carbon monoxide and hydrocarbon produced by a reformer. Reduction gas reduces the iron oxide at high temperatures directly into iron called DRI.

[0005] The reduction zone is followed by a transition zone where hot material passes to a cooling zone with minimum changes in the chemistry of the product.

[0006] Just below the transition zone and cooling zone upper cone area a cooling gas collecting chamber is provided. The cooling gas collecting chamber is for receiving hot cooling gas, which has passed through the hot DRI material cooling zone, and recycling it through the cooling gas scrubber to the cooling zone of the furnace. In this ay the DRI is cooled, prior to discharge through the bottom of the shaft furnace discharge feeder.

[0007] In the previous shaft furnace the reduction gas is produced in a reformer and then fed to the bustle gas ports by way of the bustle gas lines. In the bustle lines, however, the reduction gas looses heat, so that after its entry into the shaft furnace it may only contribute to the heating of the burden in the reduction zone in minor way. High temperature in the reaction zone is, however, necessary for an effective reduction.

[0008] It is thus the object of the present invention to provide a shaft furnace, which is designed in such a way, that the temperature of the reaction in the bustle gas line may be increased to the upper limit tolerable to the oxide pellet.

[0009] This object is solved in a shaft furnace of the initially mentioned kind in such a way, that an injection system for a burnable gas mixture is provided in the bustle gas line.

[0010] The injection system feeds a burnable gas mixture into the bustle gas line, which burns under development of heat. This thermal energy is absorbed by the reduction gas, so that the temperature thereof is increased in the bustle line. In this way the reduction gas may feed more thermal energy into the shaft furnace.

[0011] According to a first embodiment it is provided that the injection system is connected with a hydrocarbon source and an oxygen source.

[0012] It is also possible, that the injection system comprises a mixing zone for premixing and preburning the hydrocarbon and the oxygen. In this embodiment a particular high energy efficiency is obtained.

[0013] The injector system may be controllable. In particular the amounts of hydrocarbon and/or oxygen may be regulated separately in order to control the temperature of the combustion and in particular the temperature rise in the duct.

[0014] According to a further embodiment of the invention the injection system comprises two lines, which are connected to the mixing portion, wherein one line is connected to the hydrocarbon source and one line is connected with the oxygen source and one line extends at least partly within the other line.

[0015] In a further preferred embodiment of the invention the shaft furnace comprises two bustle gas lines each having a bustle gas port and an injector system, wherein the bustle gas ports of the two bustle gas lines are arranged one vertically above the other in the reduction zone.

[0016] Also the two injection systems may be connected with different hydrocarbon sources. With the help of this arrangement one may feed to the reduction zone of the shaft furnace reduction gas onto levels.

[0017] An embodiment of the present invention will be described in detail making reference to the attached drawing. In the drawing show

Figure 1 a schematic side elevational view of a shaft furnace according to the present invention,

Figure 2 an enlarged view of a cooling gas collecting member of the shaft furnace according to figure 1,

Figure 3 an enlarged top view of the cooling gas collecting member of the shaft furnace of figure 1, and

Figure 4 an enlarged side elevational view of the cooling gas collecting element of the shaft furnace of figure 1.

[0018] Figure 1 shows a shaft furnace 100 according to the present invention in schematic view, which is in particular adapted for the production of directly reduced iron. The shaft furnace 100 has a generally cylindrical form and is vertically arranged.

[0019] A furnace exit gas outlet 120 is provided at the top of the shaft furnace 100, the central axis of the shaft furnace outlet 120 being inclined with regard to the horizontal axis of the shaft furnace 100 by an angle of 45 to

55°. The furnace gas outlet 120 is connected with a furnace gas main pipe 123 in such a way, that the central axis of the furnace gas outlet 120 and of the furnace gas main pipe 123 turn at an angle of 90°.

[0020] Moreover a feed opening 109 for a burden 115 of iron oxide material is provided at the top of the shaft furnace 100. The shaft furnace 100 is designed in such a way, that the burden 115 will move under the influence of gravity from the top to the bottom of the shaft furnace downwardly through the interior of the shaft furnace 100.

[0021] The interior of the shaft furnace 100 is devided into a reduction zone 101, the upper end of which forms the feed opening 109, and a cooling zone 103, which is arranged immediately underneath the reduction zone 101.

[0022] At the lower end of the cooling zone 103 a discharge opening 190 is provided, through which the reduced iron may be discharged from the shaft furnace 100.

[0023] The shaft furnace 100 comprises a reducing gas feeding device 130, which is connected with two bustle gas lines 131, 132 with two sets of bustle gas ports 133, 134. The bustle gas ports 133, 134 are arranged at two vertically different levels on the periphery of the shaft furnace wall.

[0024] Both bustle gas lines 131, 132 are equipped with an injection system 400, 410 for a gas mixture. The two injection systems 400 410 are each connected with a hydrocarbon source 401, 415 and an oxygen source 402, wherein the two hydrocarbon sources 401, 415 may differ from one another. Both injection systems 400, 410 are designed in such a way, that the amount of hydrocarbon and oxygen may be regulated separately.

[0025] Figure 2 shows an enlarged side view of the injection system 400. The injection system 400 comprises two lines 403, 404, wherein the line 403 is connected with the hydrocarbon source 401 and the line 404 is connected with the oxygen source 402. The line 403 runs coaxially within the line 404, and both lines are connected to a mixing portion 405. The mixing portion 405 has a discharge opening 406 for the hydrocarbon-oxygen-mixture.

[0026] In the cooling zone 103, cooling gas nozzles 166 are provided on the shell, which are connected with a cooling gas inlet header 165. A cooling gas collecting member 160 is provided in the lower part of a transition zone between the reduction zone 101 and the cooling zone 103.

[0027] The cooling gas collecting member 160 is shown in figures 3 and 4 in an enlarged scale. It comprises invertedly tapered channels formed in collector arms 181, 182, 183, 184 arranged in a cross shape, each of which forms a cooling gas off-take 170, 171, 172, 173. The lower side of the collector arms 181, 182, 183, 184 opposite to the shaft furnace bottom have suction openings for the cooling gas formed therein. The cross sectional area of the cooling gas off-takes 170, 171, 172, 173 increases beginning from the crossing point towards the exterior side.

[0028] Moreover the collector arms 181, 182, 183, 184 are inclined with an angle between 5 and 10° from the horizontal direction in the direction of the shaft furnace shell.

[0029] The collector arms 182, 183 and 183, 184 and 181, 184 are connected at their outer edge portions to each other, so that all collector arms 181, 182, 183, 184 form a common off-take header. The off-take header is connected with an outlet 164, in which a suction device may be provided.

[0030] The cooling gas collecting number 160 is further provided with an upper hollow cone 161, which is provided above the collector arms 181, 182, 183, 184 in the center thereof (see fig. 4). The upper cone 161 is hollow. Moreover a lower cone 162 is provided, which in relation of the flow direction of the burden 115 is positioned behind (beneath) the collector arms 181, 182, 183, 184 in the center thereof.

[0031] A gas pipe 151 is connected to the hollow interior of the upper cone 161 and is connected to hydrocarbon source which is not shown in the drawing.

[0032] In the lower third part of the cooling zone 133 rotating shafts 180, 185 are provided for breaking and grinding clusters, if present.

[0033] During operation of the shaft furnace 100 the burden 115 of iron oxide material is fed through the feed opening 109, into the reduction zone 101. At the same time a hot reduction gas of hydrogen and carbon monoxide is blown into the reduction zone 101 through the bustle gas ports 133, 134 in such a way, that it flows in the opposite direction of the burden 115, which flows downwardly under the influence of gravity. Thus the reduction gas reduces the iron oxide at high temperature and in direct contact with the iron.

[0034] The reacted reduction gas then reaches the shaft furnace top, where it enters the furnace gas outlet 120. Due to the inclination of the furnace gas outlet 120 only a small amount of dust particles reaches the furnace gas main pipe 123, because gravity restrains the dust particles.

[0035] The reduced burden 115 descends from the reduction zone 101 into the cooling zone 103. On its way it passes the cooling gas collecting member 160, thereby passing between the collector arms 181, 182, 183, 184, which offer a comparatively small resistance. At the same time the burden 115 is loosened by the top cone 161 in the direction of the shaft furnace wall. The top cone 161 is cooled by the gas entering into the interior thereof.

[0036] In the lower part of the cooling zone 102 a cooling gas is blown in by way of the cooling gas ports 166. The cooling gas streams upwardly against the descending burden 115 thereby cooling the burden 115. Finally hot gas reaches the collector arms 181, 182, 183, 184 and exits through the suction openings thereof into the cooling gas off-takes 171, 172, 173, 174. The cooling gas is then passed to the cooling gas offtake header 164 through the cooling gas off-takes 171, 172, 173, 174 and is thus effectively removed from the shaft furnace 100 at the lower limit of the cooling zone 103. In this way, the cooling gas is effectively prevented from entering into the reduction zone 101.

[0037] The cooled-off burden 115 finally discharges through the discharge port 190 from the shaft furnace 100.

Claims

1. Vertical shaft furnace (100) for a burden (115) moving under the influence of gravity from the top to the bottom of the shaft furnace, in particular for the production of directly reduced iron, with at least one gas bustle line (131, 132), which is connected with at least one gas bustle port (133, 134) in a reduction zone (101), **characterized in that** an injection system (400, 410) for a burnable gas mixture is provided in the gas bustle line (131, 132).

2. Shaft furnace (100) according to claim 1, **characterized in that** the injection system (400, 410) is provided with a hydrocarbon source (401, 415) and an oxygen source (402).

3. Shaft furnace according to claim 2, **characterized in that** the injection system (400, 410) comprises a mixing zone (405) for premixing and preburning the hydrocarbon and the oxygen.

4. Shaft furnace (100) according to any preceding claim, **characterized in that** the injection system (400, 410) is controllable.

5. Shaft furnace (100) according to claim 4, **characterized in that** the injection system (400, 410) comprises two lines (403, 404), which are connected to the mixing portion (405), wherein one line (403) is connected to the hydrocarbon source (401, 415) and one line (404) is connected with the oxygen source (402) and one line (403) extends at least partly within the other line (404).

6. Shaft furnace (100) according to any preceding claim, **characterized in that** it comprises two gas bustle lines (131, 132) each having a gas bustle port (133, 134) and an injector system (400, 410), wherein the gas bustle ports (133, 134) of the two gas bustle lines (131, 132) are arranged one vertically above the other in the reduction zone (101).

7. Shaft furnace according to claim 6, **characterized in that** the two injection systems (400, 410) are connected with different hydrocarbon sources (401, 415).

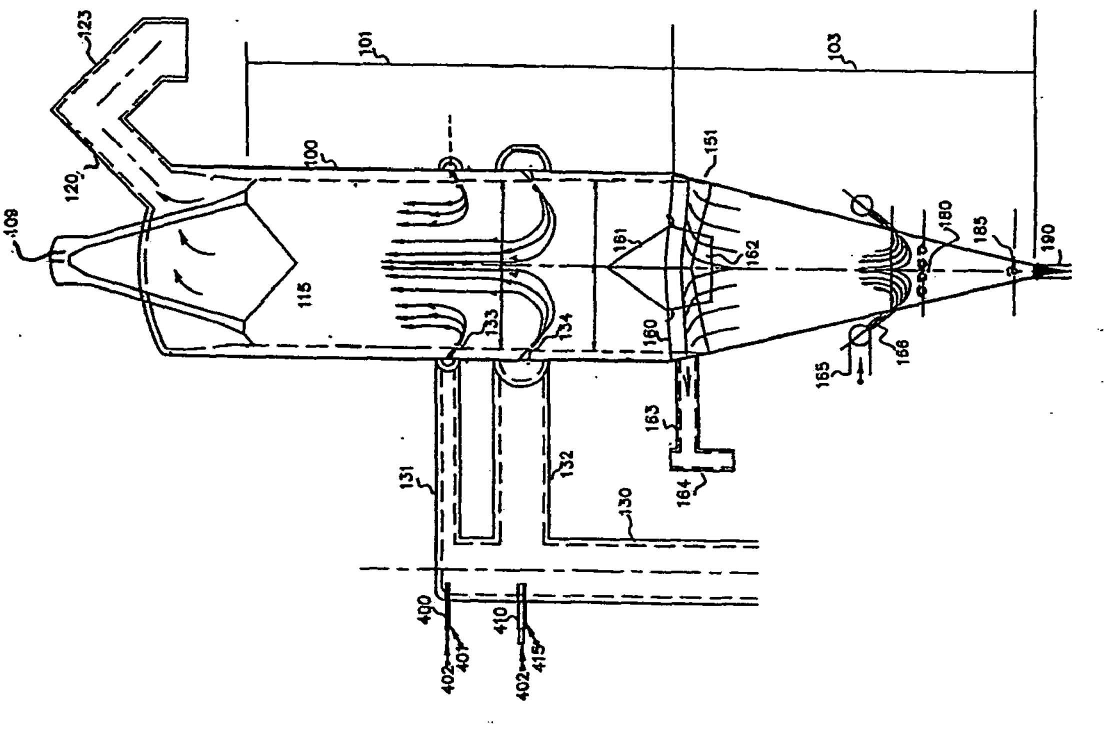
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Fig. 1

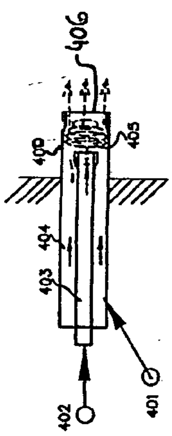

Fig. 2

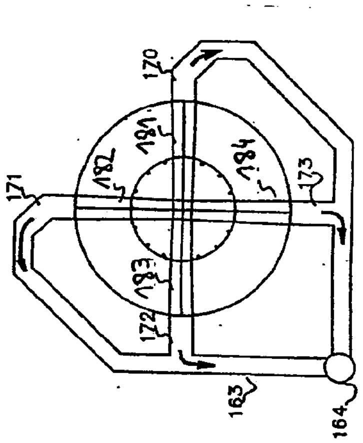

Fig. 3

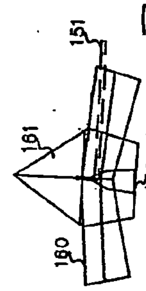

Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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