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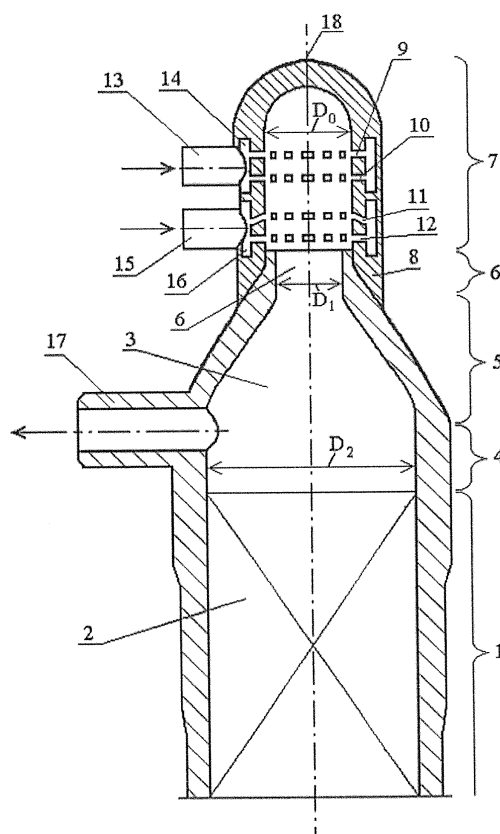
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(54) **SHAFTLESS AIR HEATER**

(57) The invention relates to metallurgy, to designs of top combustion (shaftless) hot air heaters of blast furnaces. A shaftless air heater includes a cylindrical chamber (1) with a checkerwork (2) and a dome (3) located above the checkerwork (2) and having a cylindrical section (4) as well as a tapering section (5) located above the cylindrical section (4) and a cylindrical throat (6) located above the tapering section (5) and communicating with a pre-chamber (7) located above the dome. Channels (9, 10 and 11, 12) for supplying air and gas respectively into the pre-chamber (7) are located in lateral walls (8) of the pre-chamber (7). The shaftless air heater is implemented with a ratio of the diameter (D_1) of the cylindrical throat (6) to the diameter (D_2) of the cylindrical section (4) of the dome (3) ranging from 0.31 to 0.41. The technical result is elimination of conditions for combustion pulsations and increase in completeness of gas combustion.



Description

[0001] The invention relates to metallurgy, particularly to designs of hot stoves for blast furnaces.

[0002] One of the problems with hot stove operation is to provide stability of combustion, to reduce and eliminate combustion pulsations. The combustion pulsation is a closed auto-wave process involving all elements of the air and gas main (supply pipes, butterfly valves, elbows, collectors, extension tubes, combustion space). Relevant calculations of acoustic parameters are required for all the elements of the main. Parameters of the final element of the main, i.e. parameters of combustion chamber and dome space, are of great importance for reduction of combustion pulsations.

Hot stoves with extended internal and external combustion chambers (shafts) are known [RF Patent 2177040 or RF Patent 77865 respectively, Fig.2]. These combustion chambers are located in internal or external stacks of hot stoves and communicate with the dome above the checkerwork.

[0003] The disadvantage of the above hot stoves is that combustion pulsations occur or can grow at an increase of heat capacity due to availability of the extended combustion chambers. Besides, increased thermal stresses on an area unit of the horizontal section of the combustion space, e.g. combustion chamber space, is also a reason for occurrence of combustion pulsations. Hereinafter the horizontal section refers to a section in the plane perpendicular to the vertical centerline of a hot stove.

[0004] A shaftless stove of VNIIMT [RF Patent 926017] is known. It includes a cylindrical chamber with a checkerwork, a dome over the checkerwork and an annular pre-chamber (combustion chamber) communicating with the dome and having channels of gas and air supply at the bottom (at the base), the air supply channels being directed in parallel to the stove centerline and the gas supply channels being directed perpendicularly to the stove centerline and leading to the air supply channels.

[0005] The disadvantage of the VNIIMT shaftless stove is non-uniform mixing of gas and air as the air supply channels are directed perpendicularly to the gas supply channels and mixing is fulfilled in a limited space of the air supply channel where thermal stresses on an area unit of the horizontal section of the air supply channel are increased during combustion. All this is a reason for occurrence of combustion pulsations and incomplete gas combustion in the pre-chamber and dome.

[0006] The closest to the proposed hot stove is a shaftless hot stove [RF Patent 65890] including in particular a cylindrical chamber with a checkerwork, a dome located above the checkerwork and having a cylindrical section. The dome has also a tapering section located above the cylindrical section (e.g. conical [RF Patent 65890] or ball [Patent of Germany DE318068]) and a cylindrical throat located above the tapering section and communicating with a pre-chamber located above the dome. In

the lateral walls of the pre-chamber there are gas and air supply channels.

[0007] The disadvantage of the prototype shaftless air heater is that there are conditions for occurrence of combustion pulsations and incomplete gas combustion due to an indefinite ratio of geometrical dimensions of the final element of the main (combustion chamber and dome).

[0008] The object of the invention is to eliminate conditions for occurrence of combustion pulsations and increase completeness of gas combustion.

[0009] In order to solve this problem, the shaftless air heater including a cylindrical chamber with a checkerwork and a dome which is located above the checkerwork and has a cylindrical section as well as a tapering section located above the cylindrical section and a cylindrical throat located above the tapering section and communicating with a pre-chamber located above the dome, channels for supplying air and gas located in lateral walls of the pre-chamber, is different in that the shaftless air heater is implemented with a ratio of the diameter of the cylindrical throat to the diameter of the cylindrical section of the dome within 0.31 to 0.41.

[0010] The ratio of the diameter of the cylindrical throat to the diameter of the cylindrical section of the dome within 0.31 to 0.41 provides achievement of the technical result consisting in elimination of the conditions for occurrence of combustion pulsations and increase in completeness of gas combustion.

[0011] The ratio of the diameter of the cylindrical throat to the diameter of the cylindrical section of the dome within 0.31 to 0.41 was determined experimentally.

[0012] The lower limit of the diameter ratio (0.31) is conditioned by the fact that at a further reduction of the diameter ratio resistance to the flow of combustion products (gas/air mixture) grows in the pre-chamber and cylindrical throat, the gas/air mixture pressure increases in the cylindrical throat and pre-chamber, thermal stresses grow in the internal space of the pre-chamber and cylindrical throat, which results in combustion pulsations.

[0013] At an increase of the diameter ratio over the upper limit (0.41) completeness of gas combustion in the dome decreases due to degradation in mixing of gas and air.

[0014] The figure shows the general arrangement of the shaftless air heater in profile. Embodiments of the proposed shaftless air heater.

[0015] A shaftless air heater includes a cylindrical chamber 1 with a checkerwork 2 and a dome 3 located above the checkerwork 2 and having a cylindrical section 4 as well as a tapering section 5 located above the cylindrical section 4 and a cylindrical throat 6 located above the tapering section 5 and communicating with a pre-chamber 7 located above the dome. Channels 9, 10 and 11, 12 for supplying air and gas respectively into the pre-chamber 7 are located in lateral walls 8 of the pre-chamber 7. The shaftless air heater is implemented with a ratio of the diameter D_1 of the cylindrical throat 6 to the diam-

eter D_2 of the cylindrical section 4 of the dome 3 ranging from 0.31 to 0.41.

[0016] Besides, the shaftless air heaters include a gas inlet 13 for gas supply through an annular collector 14 to gas supply channels 9, 10 to the pre-chamber 7. The shaftless air heater also includes an air inlet 15 for air supply through an annular collector 16 to air supply channels 11, 12 to the pre-chamber 7. The dome 3 has an outlet 17 for feeding hot air out of the dome 3.

[0017] All the stove walls have a lining providing heat insulation of the internal space of the hot stove from the ambient environment (inclined hatching in the figure).

[0018] The tapering section 5 of the dome 3 can have a conical shape or a shape of a ball portion (not shown in the drawing).

[0019] The quantity and location of the air and gas supply channels (9, 10, 11, 12) to the pre-chamber 7 is mainly determined by the stove capacity.

[0020] In the example of stove embodiment the shaftless air heater has a diameter (D_0) of the pre-chamber 7 equal to 5012 mm, a diameter (D) of the cylindrical throat 6 equal to 3862 mm and diameter (D_2) of the cylindrical section 4 of the dome 3 equal to 10164 mm. In this case the ratio of the diameter of the cylindrical throat 6 to the diameter of the cylindrical section 4 of the dome 3 is equal to 0.38. The cylindrical chamber 1 of the stove, dome 3 (including its sections 4 and 5) as well as pre-chamber 7 are located in the same centerline 18 with possibility of deviation from the centerline 18 to the distance not exceeding 25-35 mm. In this example of stove embodiment combustion pulsations are not observed and gas combustion is the most complete, the content of carbon monoxide (CO) in combustion products is 30 mg/m³ at the allowable value of 100 mg/m³ as per European standards.

[0021] Stove operation is performed as follows. During the heating period of the checkerwork 2 combustion air is supplied through the inlet 15 to the annular collector 16, then through the supply channels 11, 12 to the pre-chamber 7. Gas is supplied through the inlet 13 to the annular collector 14 and then through the supply channels 9, 10 to the pre-chamber 7. Mixing of gas and air results in gas firing at the top of the pre-chamber 7 due to the reaction between this mixture and heated internal walls 8 of the pre-chamber 7. The temperature of the internal walls of the pre-chamber 7 required for gas/air mixture firing is provided by heating the internal walls of the pre-chamber 7 during the blowing period when air heated in the checkerwork 2 is taken out of the stove through the outlet 17. During the heating period of the checkerwork 2 combustion products flow through it and go out of the stove through the checker support system to the chimney stack (not shown in the drawing).

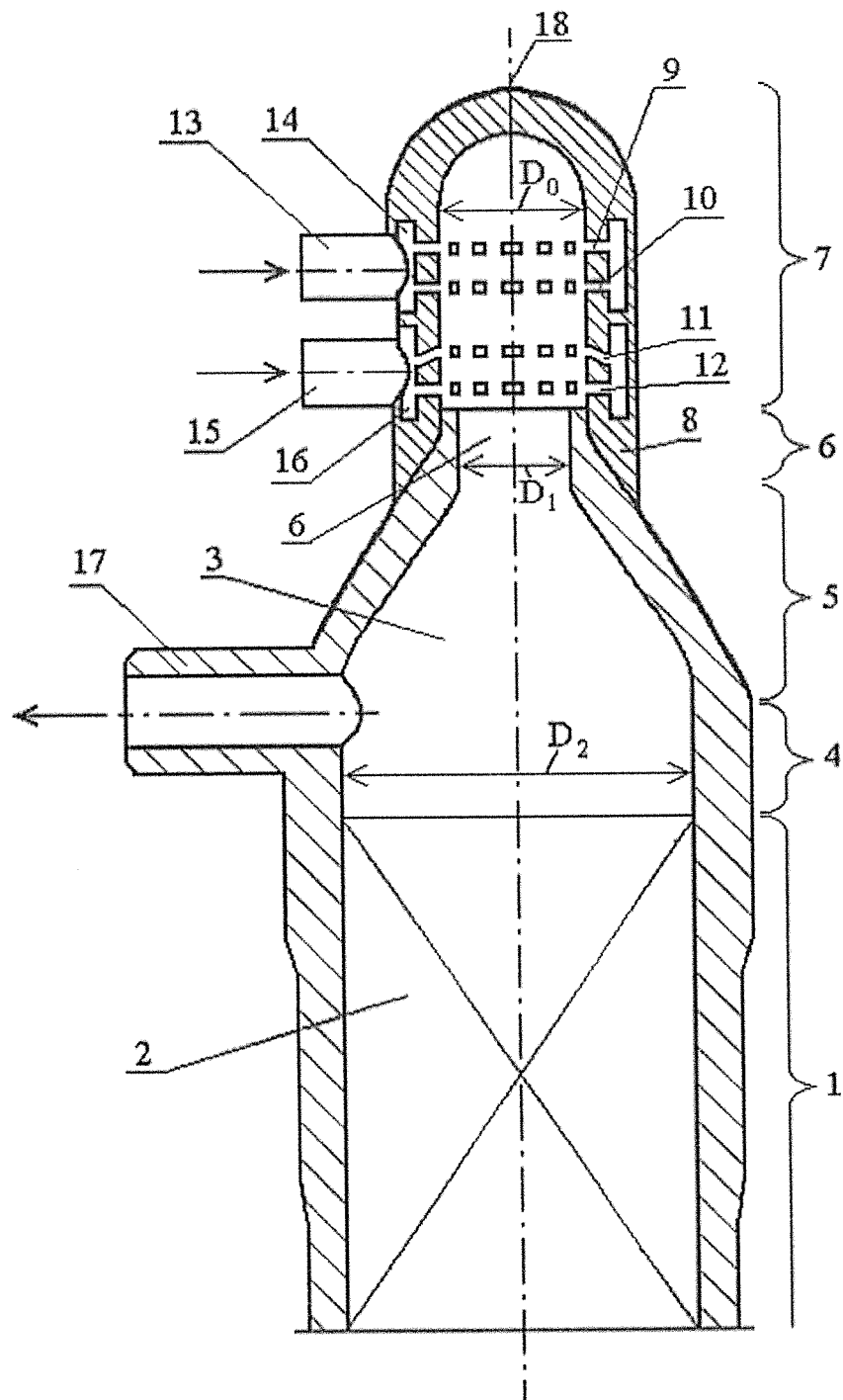
[0022] Combustion of the gas/air mixture occurs in the pre-chamber 7 and in the cylindrical throat 6 as well as in the dome 3. Aftercombustion of gases not burnt in the pre-chamber 7 occurs in the cylindrical throat 6 and dome 3. In this case the degree of gas aftercombustion in the

cylindrical throat 6 and dome 3 depends on the ratio of the diameter of the cylindrical throat 6 to the diameter of the dome 3. When this diameter ratio is in the optimal interval (0.31 - 0.41), the gas mixture pressure is optimal and the most complete combustion of gas occurs. In this case there is such a thermal stress in the space of the pre-chamber 7 and cylindrical throat 6 which provides elimination of conditions for combustion pulsations.

[0023] Thus, application of the proposed shaftless air heater eliminates conditions for occurrence of combustion pulsations and increases completeness of gas combustion.

15 Claims

1. The shaftless air heater including a cylindrical chamber with a checkerwork and a dome which is located above the checkerwork and has a cylindrical section as well as a tapering section located above the cylindrical section and a cylindrical throat located above the tapering section and communicating with a pre-chamber located above the dome, channels for supplying air and gas located in lateral walls of the pre-chamber, is different in that the shaftless air heater is implemented with a ratio of the diameter of the cylindrical throat to the diameter of the cylindrical section of the dome within 0.31 to 0.41.



INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2014/000488

A. CLASSIFICATION OF SUBJECT MATTER

C21B 9/00 (2006.01)

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 9/00, 9/02

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)

RUPAT, RUABRU, RUPAT OLD, PAJ, Espacenet, PatSearch (RUPTO internal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2145637 C1 (KALUGIN YAKOV PROKOPIEVICH) 20.02.2000	1
A	SU 602555 A (VSESOJUZNY NAUCHNO-ISSLEDOVATELSKY INSTITUT METALLURGICHESKOY TEPLOTEKHNIKI) 16.03.1978	1
A	US 3473793 A (MARTIN & PAGENSTECHER AG et al.) 21.10.1969	1
A	EA 15316 B1 (KALUGIN YAKOV PROKOPIEVICH) 30.06.2011	1

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

* Special categories of cited documents:

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"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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06 November 2014 (06.11.2014)

Name and mailing address of the ISA/RU

Authorized officer

Facsimile No.

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- RU 2177040 [0002]
- RU 77865 [0002]
- RU 926017 [0004]
- RU 65890 [0006]
- DE 318068 [0006]