(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) EP 4 446 656 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
16.10.2024 Bulletin 2024/42

(21) Application number: **23461559.9**

(22) Date of filing: **14.04.2023**

(51) International Patent Classification (IPC):
F23C 3/00 *(2006.01)* ***C01B 3/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F23C 3/002; F23C 2900/03002; F23C 2900/9901

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(71) Applicant: **Exorta, Jeziorski Lukasz**
62-700 Turek (PL)

(72) Inventors:
- **Zielinski, Jaros aw**
  05-300 Minsk Mazowiecki (PL)
- **Zielinski, Jakub**
  62-700 Turek (PL)

(74) Representative: **AOMB Polska Sp. z.o.o.**
ul. Rondo Ignacego Daszynskiego 1
00-843 Warsaw (PL)

Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) HYDROGEN BURNER AND FURNACE WITH HYDROGEN BURNER

(57) The subject of the invention is a hydrogen burner, which includes a combustion chamber in the form of an open sleeve. This combustion chamber has an inlet and an outlet to which fuel and an oxidizer are supplied from the inlet side to create a combustible mixture. In this combustion chamber, the fuel is ignited to produce a heating flame with a temperature in the range of 600-1650°C. In addition, the hydrogen burner includes a water-filled heater that is a closed vessel and includes at least one water inlet and at least one water outlet. In this hydrogen burner, the water heater extends along the combustion chamber between its inlet and outlet and is configured to absorb heat from the heating flame and transfer it to the water flowing inside the heater. The water flowing in the heater is supplied in the form of water mist, and the water outlet is on the side of the combustion chamber outlet. Water particles heated to a high temperature by the flame decompose into oxygen and hydrogen. The obtained hydrogen is burned in a separate flame in which only hydrogen is burned.

The invention also pertains to a furnace utilizing a ceramic ladle based on the Venturi nozzle principle.

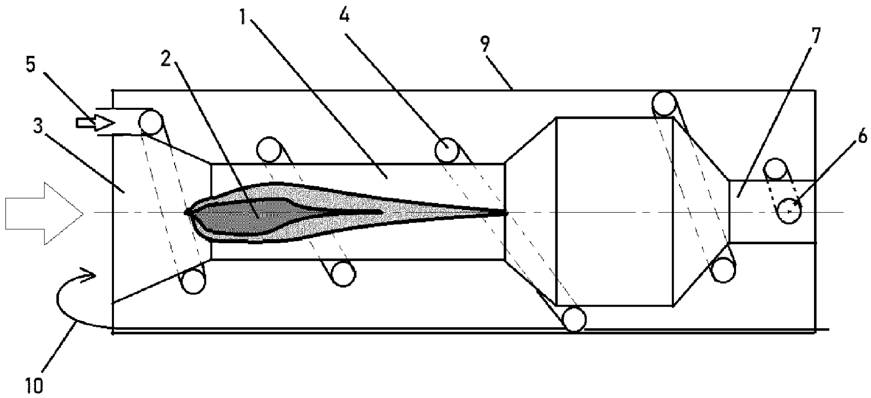

Fig. 1

EP 4 446 656 A1

Description

Technical Field

[0001] Technical Field The subject of the invention is a device in the form of a hydrogen burner, adapted to obtain hydrogen from water and simultaneously burn the obtained hydrogen in the combustion chamber.

State of the art

[0002] Prior Art Methods and devices for obtaining hydrogen and using it as fuel in a simultaneous combustion process are known in the art.

[0003] UA150240U discloses a thermochemical hydrogen gas generator for RDF and SRF fuels. It also includes a two-chamber gas generator with a raw material supply system and a gas-fired mixture, components consisting of: a biomass loading chamber, RDF and SRF fuel (or appropriate carrier), a two-chamber reverse action gasification reactor with a vacuum chamber (suction chamber), a sealed tank for phenolic water (regular water) and saturated steam and oxygen, a stream of saturated steam in the active area of the reactor, a stream of saturated steam in the pyrolysis chamber, a high-temperature pyrolysis chamber, gas pipelines fired with gas from the reactor.

[0004] US8696772B2 publication presents a system and method for producing gaseous hydrogen with a fuel processing system, which includes a hydrogen producing area that produces gaseous hydrogen from a feed stream and a heating assembly that consumes a fuel stream to produce a heated exhaust stream for heating the hydrogen producing area. In some embodiments, the heating assembly heats the hydrogen-producing area to at least a minimum hydrogen production temperature. In some embodiments, the rate at which the air stream is supplied to the heating assembly is controlled to selectively increase or decrease the temperature of the heating exhaust stream. In some embodiments, both the feed stream and the fuel stream contain a feedstock containing a hydrocarbon (carbon) element and at least 25% wt. of water (H2O). In some embodiments, the feed and fuel streams have the same composition.

[0005] US6221117B1 discloses a fuel processing system. The system includes a steam reformer adapted to produce hydrogen from a feedstock consisting of water and at least one hydrocarbon. Hydrogen is produced as a result of the feedstock reacting with the reforming catalyst. The product stream passes through a hydrogen membrane module, where the stream is purified to remove oxide and carbon dioxide, and the byproduct stream is burned to heat the reformer.

Summary of Invention

[0006] The aim of the invention is to develop a device in the form of a hydrogen burner, in which water supplied to the burner, as a result of heating, is broken down into hydrogen and oxygen molecules, and the obtained hydrogen is simultaneously burnt, resulting in a high-temperature flame of about 1650°C. The hydrogen burner, which contains a combustion chamber in the form of an open sleeve, which combustion chamber has an inlet and outlet, to which fuel and oxidizer forming a combustible mixture are supplied from the inlet side, and in which combustion chamber the fuel ignites and a heating flame is created with a temperature in the range of 600-1200°C to 1650°C. Additionally, the hydrogen burner includes a water heater filled with water, which is in the form of a closed vessel and includes at least one water inlet and at least one water outlet, in which hydrogen burner the water heater extends along the combustion chamber between its inlet and outlet and is configured to absorb heat from the heating flame and transfer it to the water flowing inside the heater, characterized in that the water flowing in the heater is supplied in the form of water mist and the water outlet is located on the outlet side of the combustion chamber. Water molecules heated to high temperatures by the flame decompose into oxygen and hydrogen. The obtained hydrogen is burnt in a separate flame, in which only hydrogen is burnt.

[0007] Advantageously, the water mist flowing in the heater is a mixture of carrier gas, preferably air, and water droplets with a diameter from 10 to 1000 micrometers.

[0008] Advantageously, the diameter of the water droplets changes during the operation of the burner. -Advantageously, the diameter of the water droplets in the startup phase is in the range of 400-1000 micrometers, in the heating phase in the range of 200-400 micrometers and in the normal work phase in the range of 10-200 micrometers.

[0009] Advantageously, the water mist flowing in the heater is supplied under a pressure from 12 to 120 bars.

[0010] Advantageously, fuel is supplied from the inlet side using an additional nozzle. - Advantageously, the water outlet is located inside the combustion chamber before its outlet.

[0011] Advantageously, the water outlet is located outside the combustion chamber beyond its outlet.

[0012] Advantageously, the water outlet is located directly in the outlet area.

[0013] Advantageously, the position of the water outlet is variable relative to the outlet, and the water outlet is in the form of a movable nozzle.

[0014] Advantageously, the heater is in the form of a jacket surrounding the combustion chamber from the outside.

[0015] Advantageously, the heater is in the form of a spiral pipe surrounding the combustion chamber from the outside.

[0016] Advantageously, the heater is in the form of a jacket surrounding the heating flame and is located inside the combustion chamber.

[0017] Advantageously, the heater is in the form of a spiral pipe surrounding the heating flame and is located inside the combustion chamber.

[0018] Advantageously, it includes a housing in the form of an open flange surrounding the combustion chamber and heater, and the space between the housing and the combustion chamber preheats part of the oxidizer, which is supplied in whole or in part from the outlet side and is suctioned by the subpressure of the stream to the inlet. The invention also relates to a heating furnace (for solid fill), which includes a ceramic combustion head, a solid fuel tank, an ash pan, a water mist inlet, a burner according to the invention, characterized in that the flue gas chamber is connected to the water mist inlet (diffuser) via a heat exchanger.

[0019] Advantageously, the heat exchanger includes a tube filled with liquid, preferably water or glycol.

[0020] Advantageously, the heat exchanger includes a duct in the form of a tube for transporting hot gases, inside which there is a turbulator for disturbing the flow in its interior in order to clean the duct of accumulated deposits.

Brief Description of Drawings

[0021] The invention will now be presented in more detail in a beneficial embodiment with reference to the attached drawing, in which:

Fig. 1 shows an axial cross-section of the designed device according to the first beneficial embodiment of the invention.

Fig. 2 shows a cross-sectional axial view of the designed device according to the second beneficial embodiment of the invention.

Beneficial effects of the invention

[0022] Thanks to the use of the burner according to the invention, it is possible to achieve high combustion temperatures (in the order of 1250°C), which allows for the use of this device in many aspects. Moreover, by providing the possibility to place the hydrogen outlet hole throughout the entire combustion zone, it is possible to control the combustion temperature of hydrogen, depending on the required application. The hydrogen burner can be primarily used in industrial devices for heating and process purposes (e.g., land reclamation, production of electric ceramics, medical waste disposal, or in recycling.) Detailed Description of the Beneficial Embodiments of the Invention

Detailed description of preferred embodiments of the invention

[0023] In a favorable embodiment, the hydrogen burner includes a combustion chamber 1 in the form of an open sleeve, made of heat-resistant metal. The combustion chamber can have the shape of a cylinder, cone, or be a component with a more complicated shape containing essentially conical and essentially cylindrical parts. In a beneficial embodiment, the combustion chamber is in the form of a diffuser or Venturi nozzle, which allows to achieve increased gas flow velocities and alternately changing pressure, thereby achieving increased temperature values with reduced fuel and oxidizer consumption. The shape of the combustion chamber 1 does not affect the principle of the burner operation, but only optimizes its performance. The combustion chamber 1 has an inlet 3 and an outlet 7, and from the inlet side 3 fuel (nozzle, if in gaseous form, injector, if in liquid form) and oxidizer (oxygen, air, peroxide or other known oxidizer) are supplied. The resulting mixture is ignited in the combustion chamber 1 and produces a heating stream flame 2 with a temperature in the range of about 1650°C. The heating flame 2 burns inside the combustion chamber 1, beneficially along its entire length. The hydrogen burner also includes a heater 4 filled with water, which is a partially closed vessel

[0024] (spiral tube, shell, a network of tubes located inside the combustion chamber 1 or outside the combustion chamber 1, which has at least two holes). The heater 4 has a water inlet 5 and a water outlet 6. Water flows inside the heater 4 from the water inlet 5 to the water outlet 6, and the water heater 4 extends, at least partially, along the combustion chamber 1 between its inlet 3 and outlet 7. The heater 4 receives heat from the heating flame 2 and transfers it to the water flowing inside the heater 4. The heating flame 2 transfers energy to the water inside the heater 4 and, flowing along the heater, increases its temperature.

[0025] In a favorable embodiment, the water flowing in the heater 4 is supplied in the form of water mist and the water outlet 6 is located on the side of the outlet 7 of the combustion chamber 1. The water mist flowing in the heater 4 is a mixture of carrier gas, preferably air (but it can be another gas, flammable or non-flammable, which can be a carrier of water mist, otherwise hydrogen will not be able to be used in the fire stream in a continuous way), and water droplets preferably with a diameter from 10 to 1000 micrometers. The diameter of the water droplets, beneficially changes during the operation of the burner. In the startup phase, it is in the range of 400-1000 micrometers, in the heating phase in the range of 200-400 micrometers and in the normal operation phase in the range of 10-200 micrometers. It is beneficial not to supply water (water mist) before heating the burner to about 600-800°C, or more beneficially 600-1000°C. It is necessary to smoothly adjust the startup speed of supplying the water mist (flow and pressure) as well as the diameter of the water droplets and also saturation. This advantageously results in better control of clean combustion conditions. The beneficial droplet diameter depends on the phase of burner operation: start-up/start-up phase droplet diameter of mist 400-1000 micrometers, temperature increase phase droplet diameter of mist 200 - 400 micrometers, normal operating temperature phase droplet diameter of mist 200 - 10 micrometers. The burner will work at other diameters, but the process will not be optimal. Water mist, provided under appropriately controlled high pressure, can effectively penetrate the core of the flame, but effectively pushes out/takes up the space of the air from the outside. In this way, the operating parameters of the burner are improved, e.g. reduction of NOx. Beneficially, apparatuses for determining the pressure range can be used, which can be divided into beneficial ranges:

Low pressure - working on the nozzle up to 12 bars

Medium pressure - working on the nozzle 12-40 bars

High pressure- working on the nozzle 60-120 bars

[0026] The size of micro droplets (mist droplets) is correlated with the level of pressure. During operation, the pressure (in the fire stream) is adjusted until the burner's stable operation is established. Micro droplets of water (water mist droplets) evaporate at a very rapid rate, increasing their volume by over 1000 times (even 1640 times), thus perfectly (accurately, almost entirely) displacing (from the outside) the air, so when the thermal decomposition of water molecules occurs, oxygen (pure oxygen) takes the place of the air (mainly nitrogen) and is used for the combustion of hydrogen. This results in combustion with better efficiency and higher purity. It should be added that all risk limiting systems cannot be used for the above burner, but only serve as a reference point. After starting the burner, there is a smooth increase in temperature inside the combustion chamber 1 - from the ambient temperature to about ~800°C. From this point, water mist is gradually fed to the heating element - heater 4. Gradually, the portions are increased (flow, pressure, droplet diameter or combinations of these parameters are increased). Depending on the received temperature, the pressure is gradually increased. When equilibrium conditions are reached, i.e, The moment when an increase in the portion of water mist with rising temperature will result in an increase in pressure, then the phenomenon of thermolysis (water decomposition into hydrogen and oxygen) occurs. The fire of the gas stream with hydrogen generated in the burner begins to raise the temperature of the flame, and in this way, a state of stable equilibrium is obtained at the outlet of the combustion chamber 1. Then, after the combustion of hydrogen, emission gases and steam are obtained. Water mist flowing in the heater 4 is supplied under pressure from 12 to 120 bars. The water outlet 6 is either inside the combustion chamber 1 before its outlet 7 or outside the combustion chamber 1 after its outlet 7 or at its outlet 7. In a beneficial embodiment, the position of the water outlet 6 is movable (adjustable) relative to the outlet (7). The hydrogen burner according to a beneficial embodiment may contain more than one inlet 3 and water outlet 7 arranged in different configurations. It is also beneficial to use multiple heaters of similar or different construction. In a beneficial embodiment, the hydrogen burner includes a housing 9 in the form of an open flange surrounding the combustion chamber 1 and the heater 4. This is to protect the environment from high temperatures, place burner mounting elements, measuring devices. Additionally, in the space between the housing 9 and the combustion chamber 1, part of the oxidizer is preheated, increasing the efficiency of the entire device and at the same time cooling the housing 9.

[0027] In a beneficial embodiment, the hydrogen burner according to the invention can be incorporated into the structures of furnaces or combustion chambers of existing installations.

[0028] A beneficial example is a ceramic furnace comprising a chamber for preheating water mist, which mist is transported by Wezyr pipes (channels leading or carrying away gases, combustion products or fuel through the furnace for combustion optimization) in the mold of a ceramic head, in which the fuel combustion (proper ignition) occurs. The temperature prevailing in the ceramic head of the furnace allows for the decomposition of heated water mist (partially converted into superheated (dry) steam). The mist transported by Wezyr pipes through the furnace is additionally heated before reaching the head, but decomposition occurs during the passage through the ceramic mold of the furnace around the ceramic head of the furnace. As a result of the decomposition of the mist, there is an emission of hydrogen and oxygen in the combustion chamber area. Part of the hot flue gases produced is used to preheat the water mist at the entrance to the furnace.

[0029] The Wezyr pipe is a solution presented on the Murator Wezyr forum (https://forum.murator-dom.pl/showthread.php?100061-Ekonomiczne-spalanie-w%C4%99gla-kamiennego&p=4531355&viewfull=1#post4531355). This is a way to overcoming the smokiness of the charging chamber, which is typical for bottom-combustion boilers, and thus its constant tarring. The Wezyr's pipe is a ventilation duct running through the combustion chamber that connects the lower part of the combustion chamber or the space below it to the upper part of the combustion chamber or the space above it. The Wezyrs tube is preferably used to transport a medium (gases, fluids, liquids or solids) through the combustion chamber. Typically, it is used to transport the air taken from the intake under the combustion chamber through the combustion chamber to the space above the combustion chamber where the flue gases are collected. During transport, the air is heated, but the oxygen is not burned, because in the Wezyr's tube, there is no combustion, only heating of the air. The heated air goes to the flue gas zone. The Wezyr pipe sucks in undesirable exhaust fumes (smoke) from the charge zone of the combustion chamber. Thanks to this, there is more oxygen in the combustion chamber and less exhaust gases. This improves combustion in the combustion chamber.

[0030] In a preferred embodiment, the water outlet is located inside the combustion chamber before its outlet or/and/or outside the combustion chamber after its outlet and/or/and the water outlet is located directly in the area of the outlet at its edge. There can be more outlets, they can be fixed or mobile.

Claims

1. A hydrogen burner which comprises a combustion chamber (1) in the form of an open sleeve, which combustion chamber (1) has an inlet (3) and an outlet (7) to which fuel and oxidant forming a mixture are supplied from the inlet side (3) combustible and in which combustion chamber (1) the fuel is ignited and a heating flame (2) with a temperature in the range of 600-1200C is created, additionally the hydrogen burner includes a heater (4) filled with water, which is in the form of a closed vessel and includes at least one inlet water (5) and at least one water outlet (6), in which hydrogen burner the water heater (4) extends along the combustion chamber (1) between its inlet (3) and outlet (7) and is configured to receive heat heating flame (2) and transfer them to the water flowing inside the heater (4) **characterized in that** the water flowing in the heater (4) is fed in the form of water mist and the water outlet (6) is located on the side of the outlet (7) of the combustion chamber (1).

2. A hydrogen burner according to claim 1, **characterized in that** the water mist flowing in the heater (4) is a mixture of carrier gas, preferably air, and water drops with a diameter of 10 to 1000 micrometers.

3. The hydrogen burner according to claim A method according to claim 1 or 2, **characterized in that** the diameter of the water droplets varies during the operation of the burner.

4. The hydrogen burner according to claim The water droplets according to claim 1, 2 or 3, **characterized in that** the diameter of the water droplets in the start-up phase is in the range of 400-1000 microns, in the warm-up phase in the range of 200-400 microns and in the normal phase in the range of 10-200 microns.

5. The hydrogen burner according to claim A method as claimed in claim 1, 2, 3 or 4, **characterized in that** the water mist flowing in the heater (4) is supplied under a pressure of 12 to 120 bar.

6. The hydrogen burner according to any one of claims 1 to 8. from 1 to 5, **characterized in that** the fuel is supplied to the inlet side (3) by means of an additional nozzle.

7. The hydrogen burner according to any one of claims 1 to 8. from 1 to 6, **characterized in that** the water outlet (5) is located inside the combustion chamber (1) before its outlet (7) or outside inside the combustion chamber (1) after its outlet (7) or at the edge inside the combustion chamber (1) directly in the area of the outlet (7).

8. The hydrogen burner according to any one of claims 1 to 8. from 1 to 7, **characterized in that** the position of the water outlet (6) is variable relative to the outlet (7) and the water outlet (6) is in the form of a movable nozzle.

9. The hydrogen burner according to any one of claims 1 to 8. from 1 to 8, **characterized in that** the heater (4) has the form of a jacket surrounding the combustion chamber (1) from the outside or placed inside the combustion chamber (1) surrounding the heating flame (2).

10. The hydrogen burner according to any one of claims 1 to 8. from 1 to 8, **characterized in that** the heater (4) has the form of a spiral pipe surrounding the combustion chamber (1) from the outside.

11. The hydrogen burner according to any one of claims 1 to 3. from 1 to 8, **characterized in that** the heater (4) has a spiral tube surrounding the heating flame (2) and is located inside the combustion chamber (1).

12. The hydrogen burner according to any one of claims 1 to 3. from 1 to 11, **characterized in that** it comprises a housing (9) in the form of an open flange surrounding the combustion chamber (1) and the heater (4), and the space between the housing (9) and the combustion chamber (2) preheats part of the oxidant (10), which it is fed wholly or partially from the outlet (7) and is sucked into the inlet (3).

13. A heating furnace comprising a die or ceramic combustion head, a solid fuel container, an ash pan, a water mist inlet, a burner according to any one of claims 1 to 12, **characterized in that** the exhaust gas chamber is connected to the water mist inlet by means of a heat exchanger.

14. The heating furnace according to claim The heat exchanger according to claim 13, **characterized in that** the heat exchanger comprises a tube filled with a fluid, preferably water or glycol.

15. The heating furnace as claimed in claim 13, wherein the heat exchanger comprises a channel in the form of a pipe for transporting hot gases, inside which there is a turbulator for disturbing the flow inside it in order to clean the channel of accumulated deposits.

Amended claims in accordance with Rule 137(2) EPC.

1. A hydrogen burner which comprises a combustion chamber (1) in the form of an open sleeve, which combustion chamber (1) has an inlet (3) and an outlet (7) to which fuel and oxidant forming a combustible mixture are supplied from the inlet side (3) and in which combustion chamber (1) the fuel is ignited and a heating flame (2) with a temperature in the range of 600-1200C is created, additionally the hydrogen burner includes a heater (4) filled with water, which is in the form of a closed vessel and includes at least one inlet water (5) and at least one water outlet (6), in which hydrogen burner the water heater (4) extends along the combustion chamber (1) between its inlet (3) and outlet (7) and is configured to receive heat heating flame (2) and transfer them to the water flowing inside the heater (4) **characterized in that** the water flowing in the heater (4) is fed in the form of water mist and the water outlet (6) is located on the side of the outlet (7) of the combustion chamber (1), wherein the water outlet (6) is placed inside the combustion chamber (1)in such a way that the water outlet (6) is in the area of combustion chamber (1) in which there is no flame.

2. A hydrogen burner according to claim 1, **characterized in that** the water mist flowing in the heater (4) is a mixture of carrier gas, preferably air, and water drops with a diameter of 10 to 1000 micrometers.

3. The hydrogen burner according to claim 1 or 2, **characterized in that** the diameter of the water droplets varies during the operation of the burner.

4. The hydrogen burner according to claim 1, 2 or 3, **characterized in that** the diameter of the water droplets in the start-up phase is in the range of 400-1000 microns, in the warm-up phase in the range of 200-400 microns and in the normal phase in the range of 10-200 microns.

5. The hydrogen burner according to claim 1, 2, 3 or 4, **characterized in that** the water mist flowing in the heater (4) is supplied under a pressure of 12 to 120 bar.

6. The hydrogen burner according to any one of claims 1 to 5, **characterized in that** the fuel is supplied to the inlet side (3) by means of an additional nozzle.

7. The hydrogen burner according to any one of claims 1 to 6, **characterized in that** the water outlet (5) is located inside the combustion chamber (1) before its outlet (7) or outside inside the combustion chamber (1) after its outlet (7) or at the edge inside the combustion chamber (1) directly in the area of the outlet (7).

8. The hydrogen burner according to any one of claims 1 to 7, **characterized in that** the position of the water outlet (6) is variable relative to the outlet (7) and the water outlet (6) is in the form of a movable nozzle.

9. The hydrogen burner according to any one of claims 1 to 8, **characterized in that** the heater (4) has the form of a jacket surrounding the combustion chamber (1) from the outside or placed inside the combustion chamber (1) surrounding the heating flame (2).

10. The hydrogen burner according to any one of claims 1 to 8, **characterized in that** the heater (4) has the form of a spiral pipe surrounding the combustion chamber (1) from the outside.

11. The hydrogen burner according to any one of claims 1 to 8, **characterized in that** the heater (4) has a spiral tube surrounding the heating flame (2) and is located inside the combustion chamber (1).

12. The hydrogen burner according to any one of claims 1 to 11, **characterized in that** it comprises a housing (9) in the form of an open flange surrounding the combustion chamber (1) and the heater (4), and the space between the housing (9) and the combustion chamber (2) preheats part of the oxidant (10), which it is fed wholly or partially from the outlet (7) and is sucked into the inlet (3).

13. A heating furnace comprising a die or ceramic combustion head, a solid fuel container, an ash pan, a water mist inlet, a burner according to any one of claims 1 to 12, **characterized in that** the exhaust gas chamber is connected to the water mist inlet by means of a heat exchanger.

14. The heating furnace according to claim 13, **characterized in that** the heat exchanger comprises a tube filled with a fluid, preferably water or glycol.

15. The heating furnace as claimed in claim 13, wherein the heat exchanger comprises a channel in the form of a pipe for transporting hot gases, inside which there is a turbulator for disturbing the flow inside it in order to clean the channel of accumulated deposits.

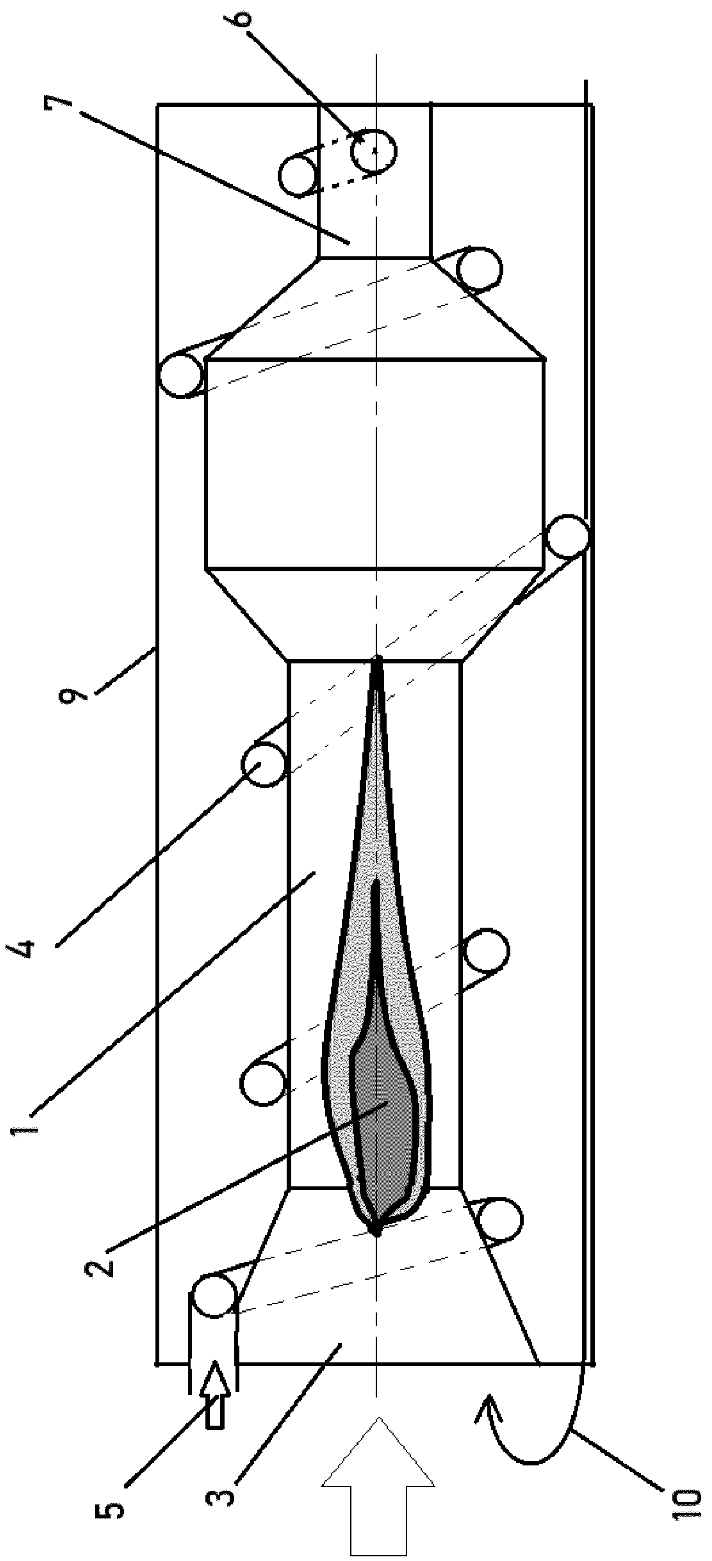

Fig. 1

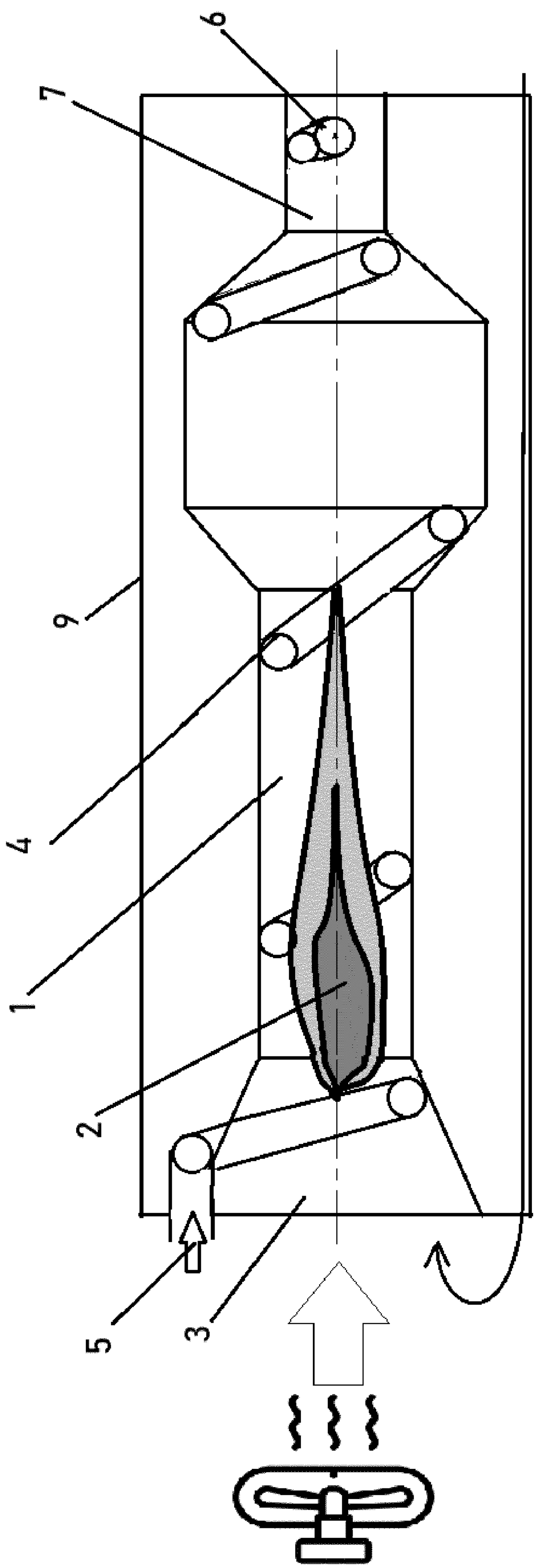

Fig. 2

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 46 1559

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	CN 104 848 216 A (LIN XUEYOU) 19 August 2015 (2015-08-19) * the whole document * * machine translation * -----	1-7,9, 11,13-15 10,12 8	INV. F23C3/00 C01B3/02
Y	US 2001/000380 A1 (BUXBAUM ROBERT E [US]) 26 April 2001 (2001-04-26) * page 8, paragraph 96 - page 9, paragraph 99 * * figure 11 * -----	10,12	

TECHNICAL FIELDS SEARCHED (IPC)
F23C
C01C
C01B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	25 September 2023	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 46 1559

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-09-2023

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
CN 104848216	A	19-08-2015	NONE	
US 2001000380	A1	26-04-2001	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- UA 150240 U **[0003]**
- US 8696772 B2 **[0004]**
- US 6221117 B1 **[0005]**