A burner (20) for the combustion of hydrogen on a catalyst, has a body (21), a first self-ignition catalyst (23) and a subsequent group of oxidation catalysts (26), as well as a heat exchanger (35) heated by the burnt gases, wherein in the burner (20) the heat exchanger (35) is obtained as a common heat exchanger and it is arranged outside the body (21) of the burner (20) accommodating the catalysts (23, 26). A head (22) accommodating the self-ignition catalyst (23) may be separated by a body (40) accommodating the oxidation catalysts (26). A second heat exchanger (45), passed through by cold water, allows production of high purity distilled water. In the proposed boiler (41) a first part (42) accommodates the burner modules (20) and another part (43) accommodates the common heat exchanger (35) and the possible additional heat exchanger (45) for producing distilled water.
BURNER FOR THE COMBUSTION OF HYDROGEN ON A CATALYST AND BOILER FOR SAID BURNERS

DESCRIPTION OF THE INVENTION

[0001] 1. Field of Application
[0002] The present invention refers to a burner for the combustion, i.e., by oxidation, of hydrogen on a catalyst according to the preamble of claim 1 and a heater therefor according to the preamble of claim 9.
[0003] 2. Technological Background and State of the Art
[0004] Burners for the combustion of hydrogen mixed with air are known in various embodiments. They use, for such purpose, composite catalysts made up of two types of catalysts i.e., a first self-ignition catalyst, used for triggering the oxidation of hydrogen mixed with air, and a subsequent operating catalyst, usually in several parts, on which the main part of hydrogen combustion/oxidation is performed.
[0005] Document EP 1.179.709 A2 discloses a burner of this type used in which—during the triggering step—is a gas/air/mixture ratio which abundantly exceeds the flammability limit (about 4% in volume of the air/hydrogen mixture ratio) and even with extreme hazardous conditions of detonability (air/hydrogen mixing ratio up to 12.5% in volume). Alongside requiring a regulation system with two states of the hydrogen flow to the mixing chamber, i.e., a first flow rate for said primary phase or pre-combustion and a second rate for the operating combustion, the use of this primary step with respective catalyst, evidently gives rise to safety problems both for the people and for the surrounding environment and the burner itself, thus first entailing damage to the catalyst. Furthermore, an external supply of energy is required in this burner for triggering the oxidation of hydrogen. It should also be observed that the mixing air is supplied by means of a tangential fan, which must also provide for pushing the hot oxidation gases through the heat exchanger for heating the thermal carrier fluid.

[0006] Document PCT/EP2005/005686 of the applicant discloses a zero-emissions hydrogen catalytic burner for heating, wherein the oxidation of hydrogen occurs without a flame as well as by means of a composite catalyst having a first catalyst suitable to trigger the reaction at ambient temperature and a second operating catalyst which continues and completes the reaction. The air/hydrogen mixture is controlled mechanically and kept at a value below 4%. The reaction temperature is about 300 °C, thus this allows preventing the formation of nitrogen oxides harmful for health. Such burner may be advantageously used for residential building heating systems, wherein the outlet water temperature is comprised between about 40-45 °C. For such purpose, the burner incorporates a heat exchanger for heating water. Therefore, such burner is made up of a so-called reaction channel and by an incorporated heat exchanger with igniter plug and therefore the burner itself forms a complete and functional machine, having power in the order of magnitude of 6.38 kW. In order to provide greater power, as usually required for residential building boilers, several catalytic burners used to be accommodated as a “burners module” in a casing serving as a heater. Provided for are different configurations and sizes of casings depending on the number of burner modules to be accommodated. The latter have an extended cylindrical shape of about 800 mm and a diameter of about 120 mm, hence developing in only one direction and this may lead to, for example in the case of few modular burners, a heater with overall dimensions extended length-wise and difficult to manage.

[0007] It should also be observed that in the composite catalysts the self-ignition catalyst is a fragile body and, thus, requires handling with care to avoid breaking thereof.

SUMMARY OF THE INVENTION

[0008] The task of the present invention is that of simplifying the burners and indicating boilers for accommodating the same.

[0009] The abovementioned task is attained, according to the invention, by means of a hydrogen combustion burner on a catalyst having the characteristics outlined in claim 1 and having a boiler having the characteristics outlined in claim 9.

[0010] Several and important advantages both for the burners and for the boilers or heaters accommodated therein are attained according to the invention by separating the reaction channel from the heat exchanger.

[0011] According to the invention, the modules to be accommodated in the heater are no longer formed, as in the previous case, by a burner incorporating the heat exchanger, but by the burner alone, while the heat exchanger is provided separately from therefrom, wherein only one heat exchanger shall be provided for in each boiler regardless of the number of modules, i.e., burners, accommodated in the heat.

[0012] Several and important advantages are attained with burners according to the invention.

Regarding the Burners:

[0013] simplified manufacturing and assembly,
[0014] the self-ignition catalyst is easier to handle and positioning thereof is easy, hence reducing hazards related to breakdowns, and thus the waste, of these catalysts, which are also quite expensive,

[0015] reduction of the overall dimensions is attained,

[0016] the overall exploitation of the produced heat is efficiently integrated with a simple cooling chamber of the burner without inserts,

[0017] by providing for separated heat exchangers, the latter as be is easily manufactured by means of any technology, for example as tube heat exchangers or as radiator heat exchangers.

Regarding the Boiler:

[0018] due to the fact of accommodating smaller modules, the casing itself may be smaller and easier to define configuration thereof, wherein development in vertical direction is equally allowed,

[0019] an easy accommodation of the heat exchanger and simple access to the heat exchanger are attained, hence for example facilitating assembly and maintenance operations,

[0020] an easy possibility of accommodating—between the burner modules and the heat exchanger—a conveyor for the burnt gases towards the heat exchanger is attained,

[0021] easier execution of hydraulic connections between the modules, in series or parallel, and the heat exchanger is obtained in a much easier manner,

[0022] the use of a safety circuit excluding damage in case of possible hydraulic connection between the modules may be provided for,
[0023] according to the invention, further provided for is the use of a second heat exchanger or auxiliary exchanger, which is advantageously accommodated in the heater and which, alongside improving the heat performance, allows producing high purity distilled water. Such high purity distilled water represents a high quality product and it is used, for example, in laboratories, hospitals and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Further characteristics, advantages and details of burners and boilers according to the invention shall be clearer from the following description of some embodiments and connection of burners and boilers according to the invention, illustrated for exemplifying purposes in the attached drawings, schematically illustrating, and as representations of the principle, wherein:

[0025] FIG. 1 is a vertical median section through a burner of the prior art,
[0026] FIG. 2 is a vertical median section through a burner according to the invention with the separate heat exchanger associated,
[0027] FIGS. 3A, 3B, 3C and 3D are three different arrangements of burner modules in a boiler,
[0028] FIG. 4 is a schematic perspective view illustrating a boiler according to the invention,
[0029] FIG. 5 shows an arrangement of three burner modules connected in series and to the external heat exchanger;
[0030] FIG. 6 shows the diagram of the three burners connected parallel and having the external heat exchanger,
[0031] FIG. 7 shows an arrangement of a burner module with the external exchanger and with the auxiliary heat exchanger for producing high purity distilled water associated.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0032] First, reference shall be made to FIG. 1, which corresponds to FIG. 2 of the modular burner illustrated in PCT/EP2006/005686 and shows a median longitudinal section through the same.

[0033] Indicated with 4 in the modular burner 1 is the composite burner made up of the first self-ignition catalyst 3 and a group 2 of single catalysts which form the group of operating catalysts on which the hydrogen oxidation reaction is performed. The air and hydrogen are introduced into the mixing chamber 7 respectively according to arrows 8 and 100 and the air/hydrogen mixture then first impacts the self-ignition catalyst 3 and subsequently the operating catalyst 4 for performing the oxidation of hydrogen with the ensuing formation of burnt gases and water vapour.

[0034] Indicated with 11 is a toroidal jacket enclosing an exchanger 5 of the igniter plug type, i.e. extended longitudinally, and which is impacted by the burnt gases formed thereof. The water to be heated flows in from the inlet 12A of the exchanger 5 and, after heating, it is introduced into the toroidal jacket 11 for further drawing of heat before leaving the burner, arrow 13. Indicated in 18 and 19 are two turbulators for improving heat exchange. The burnt gases and the water vapour collected in the conduction and collection chamber 15 flow out from the burner from the opening 14.

[0035] As illustrated in the introduction, these burners 1, to be inserted as modules in the casing of a boiler, are thus modular burners with incorporated heat exchanger.

[0036] This construction method is entirely abandoned by the invention, according to which the heat production part, i.e. the actual burner channel, is separated from the part forming the heat exchanger, also simultaneously proposed in which is a new construction for said burner, as initially illustrated in FIG. 2.

[0037] In FIG. 2 the burner 20 has a body 21 which is formed by a head 22, which contains the ignition catalyst 23, and a body 40 with an accommodation 24 defining a reaction chamber 25, contained in which is the operating catalyst 26 on which hydrogen oxidation is performed. The accommodation 24 in turn defines, with the front sides 27, 28 and an outer jacket 29 a cooling chamber 30 with an inlet 31 and an outlet 32.

[0038] The composite catalyst 33 is even in this case made up, in a manner similar to that of the prior art, of the ignition catalyst 23 and the oxidation catalyst 26, wherein both may be provided for by a plurality adjacent discs. Regarding the composition of catalysts 23 and 26 reference shall be made to the respective descriptions of document PCT/EP2006/005686.

[0039] Illustrated as a heat exchanger in FIG. 2 is a plate exchanger 35 with an inlet 36 and an outlet 37, wherein a pipe 38 connects the inlet 31 of the burner 20 with the outlet 37 of the exchanger 35.

[0040] Therefore, in the new proposed method of construction, the head 22 represents an independent element fixable, for example by means of screws, to the body 40 of the burner 20 containing the accommodation 24. This solution allows a direct and simple insertion of the self-ignition catalyst 23 into the head 22 and practically eliminates inadvertent breaking of the same during handling thereof. Furthermore, FIG. 2 shows that provided in the head 22 upstream of the self-ignition catalyst 23 is a chamber 41 for premixing the air and hydrogen supplied in a known manner, such mixture directly impacting the self-ignition catalyst 23, wherein also this solution contributes to reduce the overall dimensions of the burner 20 in its entirety.

[0041] In addition, FIG. 2 shows that in the chamber 30, which does not have any insertion, the water flowing out from the heat exchanger 35 is conveyed for cooling the burner, hence allowing, on one hand, to recover all the heat available on the catalyst 26 and, on the other hand, it causes the stabilisation of the temperature of the outer jacket 29.

[0042] Indicated in FIGS. 3A, 3B, 3F and 3C are possible rational arrangements of the burner modules 20 inside the boiler casing not illustrated further.

[0043] An exemplifying arrangement of two burner modules 20 in a boiler is illustrated in FIG. 4, wherein the heater 41 comprises a first casing 42 accommodating the two modules 20, in a suitably insulated manner, and a second casing 43 accommodating the heat exchanger 35. As mentioned above, the heat exchanger 35 according to the invention is always provided separate from the burner modules 20 and is always provided for as a single exchanger regardless of the number of burners 20, wherein the dimensioning thereof shall be matched from time to time to the provided number of burners.

[0044] FIGS. 5 and 6 illustrate the connection circuit diagram between three burner modules 20 and the associated heat exchanger 35, wherein illustrated in FIG. 5 is a series connection and in FIG. 6 is a parallel connection.
According to a further disclosure of the invention, and illustrated in FIG. 7, at a circuit arrangement of the burner 20 and separate heat exchanger 35 analogous to that illustrated in FIG. 2, additionally provided for with respect to the heat exchanger 35 is a further heat exchanger 45. This exchanger 45 is also preferably accommodated in the casing 43 of the boiler 41 and it has a double function. On one hand, it allows recovering further heat and further reducing the temperature of the exhaust steam. On the other hand, this second heat exchanger 45 also allows the production of high purity distilled water, as mentioned in 46 and explained hereinafter.

According to a further aspect of the invention, in order to perform and optimise the performance and reduce thermal dispersions, provided for is a conveyor, not illustrated, arranged in the boiler 41 between the two casings 42 and 43, for directing the hot air coming from the burner modules 20 towards the mouth 47 of the heat exchanger 35.

Furthermore, using this conveyor allows using a vertical geometry for the heat exchanger maintaining the module's of the burner 20 horizontal. This solution, not illustrated, allows further optimising the overall dimensions and improving safety, in that the hydrogen—being extremely light—it tends to disperse upwards very fast.

The separation of the heat exchanger 35 from the burner module 20 allows the abovementioned reduction of the overall dimensions of the modules 20 optimizing the spaces to the utmost and containing—therein—the same catalysts and at the same amount and size as provided for the burner disclosed by the document PCT/EP2006/005686.

In detail, the channel has a length such to contain the packet of oxidation or operating catalysts 26, while the accommodation of the self-ignition catalyst 23 in the head allows incorporating—inside the latter—the mixing chamber 41 and also facilitates the assembly and positioning of control probes, not illustrated.

According to the invention in order to recover all the available heat, the accommodation cylinder or jacket 24 is made of material with good thermal conductivity properties, for example made of copper and the water circulating in the cooling chamber 30 is the same water flowing out from the heat exchanger 35. The outer jacket 29 on the contrary shall be made of material with good thermal insulation properties, so as to prevent excessive heat dispersion, for example made of stainless steel. The head 22 may be made of different material, but preferably material having good insulation properties. The burner modules 20 in the casing 42 shall be surrounded by a highly insulating material, for example polyurethane.

The series or parallel connection illustrated in FIGS. 5 and 6 may be used to integrate the circulation of the water of the heat exchanger 35 and of the burner modules 20. It should be observed that the series connection is made in a simple manner but, in case of inadvertent interruption of the flow of water inside a module the circulation of water inside the heater is stopped with the consequent malfunctioning of the same. Though parallel connection allows overcoming this criticality, manufacturing thereof is more complex to obtain, but in case of interruption of circulation by a burner module 20 the heater operates correctly. According to the invention, provided for higher inherent safety is the integration of two circuits in series and parallel with a bypass circuit, not illustrated, actutable in case of failure of one or more burner modules or, alternatively, each module may be provided with an automatic valve, not illustrated, for actuating the circulation of the water when the reaction begins, wherein this solution is actutable solely through the parallel connection.

Regarding the production of high purity distilled water according to the invention by means of the additional heat exchanger 45 all that shall be required is to pass cold water in the same for total condensation of the burnt gases using water vapour coming out from the heat exchanger 35, wherein the water vapour is formed by the catalytic reaction and hence obtaining high quality water in terms of purity. This heat exchanger 45, operating as a condensation step, shall be dimensioned taking into account the temperature coming out from the heat exchanger 35 and the temperature of the water that is supplied to said heat exchanger 45. It should be observed that the vertical configuration of the heater allows easily recovering the condensate that is formed in the heat exchanger 35 or in the exchanger 45 as the condensation step, wherein—in this manner—the condensate never comes into contact with the catalysts of the burner modules 20.

From the structural and functional description illustrated further above it is observable that the disclosures of the present invention efficiently execute the indicated task and the abovementioned advantages are attained.

Those skilled in the art may introduce modifications and variants regarding, for example, dividing the separated exchanger 35 into a battery of exchangers, the execution of the body of the heaters into one or more parts and so on and so forth, without departing from the scope of protection of the present invention as described in the claims that follow.

1. Burner for the combustion of hydrogen on a catalyst, comprising—in a body for housing the burner—a first self-ignition catalyst and a subsequent group of oxidation catalysts, as well as a heat exchanger heated by the burnt gases, characterised in that the heat exchanger 35 is arranged outside the body (21) of the burner (20) containing the catalysts (23, 26).

2. Burner according to claim 1, characterised in that the body (21) of the burner (20) accommodating the catalysts (23, 26) forms a module for the burner (20).

3. Burner according to claim 2, characterised in that the body (21) of the burner (20) is formed by a head (22) for accommodating the self-ignition catalyst (23) and a body (40) accommodating the oxidation catalyst (26), wherein the head (22) and the body (40) are separable.

4. Burner according to claim 3, characterised in that the oxidation catalysts (26) are accommodated in a tubular accommodation (24) forming the inner wall of a cooling chamber (30) delimited by an outer jacket (29) having an inlet connection (31) and an outlet connection (32) for the cooling liquid coming from the separate heat exchanger (35).

5. Burner according to claim 3, characterised in that provided for in the head (22) upstream of the self-ignition catalyst (23) is a chamber (41) for mixing the supplied air and hydrogen.

6. Burner according to claim 4, characterised in that located in the accommodation (24) holding the oxidation catalyst (26) downstream of the latter (26) is a reaction chamber (25) receiving the moist burnt gases.

7. Burner according to claim 1, characterised in that associated thereto—for supplying the combustion air—is a compressor or a fan having the pumping head required to overcome loss of head of the catalysts (20) and of the heat exchanger (35).
8. Arrangement of burners (20) with separate heat exchanger (35) according to claim 1, characterised in that it comprises an additional heat exchanger (45), which:
   a) is associated fluidically to the common heat exchanger (35) to exploit the heat produced by the burners (20) better, or
   b) still impacted by the moist burnt gases, it is passed through by cold water for the production of high-purity distilled water.

9. Boiler for housing modules for burners (20) according to claim 1, characterised in that it has a part (42) for accommodating the modules for burners (20) provided for and a part (43) for accommodating the sole heat exchanger (35), suitably dimensioned, common for all the accommodated modular burners (20), regardless of the number thereof.

10. Boiler according to claim 9, characterised in that it comprises, between the modular burners (20) and the separate heat exchanger (35), a conveyor for the moist burnt gases.

11. Boiler according to claim 10, characterised in that it accommodates an arrangement of modules for burners (20) and heat exchangers (35, 45).

12. Boiler according to claim 9, characterised in that it has a vertical arrangement.

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