LIQUID HEATER AND STEAM BOILER

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ABSTRACT

This invention consists of a demountable heat recovery device, which can turn any tube into an efficient heat recovery, for applications in fire tube liquid heaters and steam boilers; the present heat recovery device is comprised by a tube, which may be cylindrical or square, inside which a gas diffuser is placed having a transversal cylindrical, pentagonal, hexagonal, octagonal or square shape, and the most important is that the cavity formed between the fire tube and the gas diffuser shall be narrow, of at least 0.001 m, and that the combustion gases shall flow at high speed, of at least 6 m/sec through said narrow cavity; since only in this way a great amount of heat is transferred to the inner wall of the fire tube; according to this invention, high thermal efficiency heaters and boilers can be built and with a less number of tubes, wherein a mechanical blower has to be installed for them to operate.
LIQUID HEATER AND STEAM BOILER

FIELD OF THE INVENTION

[0001] This invention consists of a demountable heat recovery device that operates inside fire tubes and which is applicable to fire tube liquid heaters and steam boilers, with vertical design and horizontal return design, for domestic, commercial and industrial use.

BACKGROUND OF THE INVENTION

[0002] Currently, fire tube liquid heaters and steam boilers of vertical design and horizontal return design, for domestic, commercial and industrial use, which achieve a high thermal efficiency, have high manufacturing costs since they require a very complicated and expensive construction and others use non efficient elements to recover the heat of the combustion gases; this occurs because there is not in the known art a heat recovery device being simple as well as effective to recover heat from combustion gases inside fire tubes, since nowadays to build a high efficiency thermal fire tube heater or boiler it is needed to place inside it a great number of small diameter tubes, and even though it is needed to cause turbulence in the combustion gases current inside such small diameter tubes, or alternatively, it is required to place a great number of very small heat recovery fins inside the fire tube; also another method is to restrict the combustion gases flow for them to flow slowly and to be as much as possible inside the fire tubes, which is mentioned in the U.S. Pat. No. 4,344,479.

[0003] The two techniques most frequently used described in first place in the preceding paragraph, imply a complicated and expensive construction, and the last mentioned technique, has an inefficient heat recovery, which is caused because the combustion gases flow at very low speed inside the fire tubes.

[0004] Therefore, one purpose of this invention is to develop an efficient demountable heat recovery device, which is based mainly in making combustion gases to flow through the device at a high speed, and with such device it can be easy to convert any fire tube of any diameter, into an efficient heat recovery device, for building fire tube liquid heaters and steam boilers of vertical design and horizontal return design, of any capacity, new, by applying the novel heat recovery device proposed herein.

[0005] Another purpose of this invention is to develop a heat recovery device, with which fire tube liquid heaters and steam boilers of vertical design and horizontal return design, for domestic, commercial and industrial use, are smaller, with less number of tubes, this means, with a simplified and low construction cost with respect to the known art and with a high thermal efficiency.

[0006] It is yet another purpose of the present invention to provide alternative heat recovery devices wherein the heat is recovered with high efficacy.

[0007] It is another purpose of the invention to provide demountable heat recovery devices adaptable to heaters and boilers fire tubes already in use, therefore the heat recovery device proposed herein is very versatile.

[0008] It is another purpose of the invention to provide a heat recovery device which increase the thermal efficiency in heaters and boilers, allowing a decrease in the combustion gases emission to the atmosphere, important ecologic aspect having less gases emission as avoiding fuel wastes in domestic and industrial fields, achieving the above with more efficient and cheaper heaters and boilers.

[0009] Additional purposes of the proposed invention will be evident while reading the following description.

BRIEF DESCRIPTION OF THE FIGURES

[0010] FIG. 1 shows the tank of a vertical design liquid heater having four heat recovery devices as the one proposed herein.

[0011] FIG. 2 shows the tank of a horizontal return boiler, including the firebox and three heat recovery devices as the one proposed herein.

[0012] FIG. 3 shows, on an individual basis, the heat recovery device proposed herein, which includes inside a cylindrical shaped gas diffuser and four guides to center it within the fire tube.

[0013] FIG. 4 shows a cross-sectional side view of the heat recovery device of FIG. 3, proposed herein, and two gas diffuser supports.

[0014] FIG. 5 shows a plant view of the heat recovery device proposed herein, which includes a hexagonal shaped gas diffuser and two gas diffuser supports.

[0015] FIG. 6 shows a plant view of the heat recovery device proposed herein, which includes a square shaped gas diffuser.

[0016] FIG. 7 shows a plant view of the heat recovery device proposed herein, which consists of a square shaped fire tube including a cylindrical shaped gas diffuser.

[0017] FIG. 8 shows a plant view of the heat recovery device proposed herein, which consists of a square shaped fire tube including a square shaped gas diffuser.

[0018] FIG. 9 partially shows the heat recovery device proposed herein and shows a cross sectional view of the fire tube, including inside a cylindrical shaped gas diffuser and a helicoidal shaped guide to center it.

DETAILED DESCRIPTION OF THE INVENTION

[0019] This invention refers to heat recovery devices located inside of fire tubes, applicable to fire tube liquid heaters and steam boilers, with vertical design and horizontal return design.

[0020] Applicant discovers and experimentally proved that allowing combustion gases to flow at high speed, of at least 6 m/sec through a vary narrow cavity of at least 1 mm width between two solid walls, the heat transferred per area unit results very high, without using a traditional heat recovery element, such as heat recovery fins.

[0021] According to the experimental results, it can be understood that when the combustion gases passes through two closer solid walls at high speed, the friction between the gases and the walls provokes a very quick mixture of the gases reason why the all gas molecules contact with the walls in a short path through the narrow cavity, favoring the transference of a great amount of heat by convection to any of the two walls being cooled by a liquid. According to this invention, as wider said cavity or as higher the gases speed therethrough, higher would have to be the length of the narrow cavity and viceversa, since only in this manner the combustion gases leave the cavity at low temperature.

[0022] According to this invention, if the heat recovery device proposed herein is included in the construction of any fire tube heater or boiler, either of vertical design or horizontal return design, it will be necessary to install a mechanical
blower in order for said heater or boiler to work, and with the mechanical blower it can be produced forced draft or induced draft, depending on the elected design; the mechanical blower is not illustrated in the figures accompanying the description of the present invention, because its use is typical in fire tube heaters and boilers for commercial and industrial use, therefore it is considered that it is sufficient with the description to understand the unavoidable operation carried out by the mechanical blower in this invention. In addition, applicant experimentally proved that by using natural draft in the narrow cavity, the combustion gases will flow at a very low speed therethrough. Furthermore, the low speed combustion gases leave by the contrary cavity end at a higher temperature than the gases flowing at at least 6 m/sec in the same cavity, moreover, with the same run length, which demonstrate that low speed combustion gases imply a decrease in the heat transferred by area unit, and also a decrease in the power per area in the narrow cavity, therefore, the heat recovery device proposed herein is very efficient and of low cost, since a narrow cavity is used, for example, of at least 1 mm, through which the combustion gases pass at high speed of at least 6 m/sec to obtain the desired results.

[0023] It is provided a vertical design liquid heater according to FIG. 1, comprised by a tank 1 containing inside four heat recovery devices as the one proposed herein, which are integrated by four fire tubes 2 and four demountable gas diffusers 3; nevertheless, the liquid heater pursuant to this invention may have inside from at least one fire tube 2 up to any number of tubes 2, as may be required in relation to the diameter of the tubes 2 and the liquid heater design power; in this vertical heater it is required to include a mechanical blower in order to operate, which can be placed at the top or lower part of such heater and the combustion gases could flow in an upward or downward direction, depending on the heater end in which the combustion chamber is located, because the vertical heater and this heat recovery device operate both the same with the flow of combustion gases in the two already mentioned directions.

[0024] It is provided a fire tube horizontal return boiler according to FIG. 2, integrated by a tank 1, containing inside a firebox 4 and three heat recovery devices as the one proposed herein; the heat recovery devices are integrated by three return tubes 2 and three demountable gas diffusers 3; this horizontal boiler may have inside from at least one return tube 2 up to any number of return tubes 2, as required, with respect to the diameter of the tubes 2 and the return boiler design power; the use of a mechanical blower is typical in horizontal return blowers to produce a forced draft in the firebox 4.

[0025] FIG. 3 shows, on an individual basis, the heat recovery device according to this invention, which is comprised by a fire tube 2, including inside a demountable gas diffuser 3, such diffuser 3 has preferably a cylindrical shape and is integrated by only one part from end to end with a constant diameter in full length as can be noticed in FIG. 4, which shows two supports 10 having a very thin profile which are used to fasten the gas diffuser 3 on vertical position inside the tube 2; a cavity 5 is formed between the inner wall of the tube 2 and the outer wall 7 of the gas diffuser 3, which must be very narrow, of at least 1 mm, so that the combustion gases are mixed very fast when flowing in contact with the inner wall of the tube 2 and the outer wall of the gas diffuser 7, and the combustion gases must flow at high speed, for example, at least 6 m/sec through the cavity 5 and in this way a great amount of heat per area unit is transferred to the inner wall of the tube 2 and the tube 2, as it can be understood, is cooled by means of any liquid contained in the heater or boiler shown in FIGS. 1 and 2. This heat recovery device includes at least four guides 6 to center it inside the tube 2, which are axially fastened with any kind of welding to the wall 7 of the gas diffuser 3 and have an equidistant distribution so that the cavity 5 be axially uniform in full length of the gas diffuser 3; such guides 6 might be manufactured with steel sheet or steel wire and can have a length equal to the length of the gas diffuser 3, or might be shorter with respect to the gas diffuser 3 and at least four of them are placed on each end of the gas diffuser 3.

[0026] The main variables that allow determining the length of the heat recovery device shown in this figure are: the cavity 5 width and the speed of the combustion gases, because if subsequently to a determined design it is decided to increase the combustion gases speed through the cavity 5 by means of an increase in the mechanical blower discharge pressure, or if it is decided to increase the cavity 5 width, the result is that the heat recovery power is increased and therefore, it would be required to increase such heat recovery device length; since only in this way the heat contained in the combustion gases is recovered, for example, to increase the cavity 5 width of this figure, the gas diffuser 3 has to be changed for another having a smaller diameter and guides 6 should be placed with the same width of the new cavity 5 and vice versa.

[0027] FIG. 5 shows, on an individual basis, a plant view of another embodiment of the same heat recovery device shown in FIGS. 3 and 4, which is integrated by a fire tube 2, including inside a preferably hexagonal shaped, demountable gas diffuser 3, and includes at least two very thin profile supports 10 to fasten the gas diffuser 3 on a vertical position inside the tube 2 as in FIG. 4; gas diffuser 3 is the same as the above, formed by only one piece from end to end and it has a constant transversal dimension in full length as in FIG. 4; in addition, the hexagonal shape of the gas diffuser 3 according to this figure is not limiting, since it can have a pentagonal or octagonal shape, because the most important feature is that the combustion gases flow at high speed, at least at 6 m/sec through the cavities 5, which are formed on the gas diffuser 3, and the cavities 5 must be very narrow, of at least 2 mm between the inner wall of the tube 2 and the outer wall 7 of the gas diffuser 3. The main variables that allow determining the length of the heat recovery device shown in this figure, are the same as for FIG. 3, the width of cavities 5 and the combustion gases speed, if after a determined design it is decided to increase the combustion gases speed through cavities 5 by the mechanical blower discharge pressure increase, or if it is decided to increase the cavities 5 width, as a result the heat recovery device power is increased and therefore, it would be required to increase the heat recovery device length and vice versa, since only in this manner is possible to recover the combustion gases heat, for example, to increase the width of cavities 5 in this figure, a higher diameter tube 2 has to be located, and inside it a gas diffuser 3 having a proper size may be located and vice versa.

[0028] FIG. 6 shows, on an individual basis, a plant view of another embodiment of the heat recovery device shown in FIGS. 3 and 4, which is integrated by a fire tube 2 including inside a preferably square shaped, demountable gas diffuser 3, said gas diffuser 3 is formed by only one piece from end to end and has a constant transversal dimension in full length, in this heat recovery device, as well as in the former ones, the
most important is that the combustion gases flow at high speed, for example, at least at 6 m/sec through the four cavities 5 that are formed in this gas diffuser 3, and the cavities 5 shall be very narrow, for example, from at least 3 mm between the inner wall of the tube 2 and the outer wall of the gas diffuser 3. The main variables that shall be considered to determine the length of this heat recovery device are: the width of cavities 5 and the combustion gases speed, once again, as in the device of FIG. 3, if after a determined design it is decided to increase the combustion gases speed through cavities 5 by the mechanical blower discharge pressure increase, or if it is decided to increase the cavities 5 width, as a result the heat recovery device power is increased and therefore, it would be required to increase the heat recovery device length and vice versa, since only in this manner is possible to recover the combustion gases heat, for example, to increase the width of cavities 5 according to this figure, it is required to change the square gases diffuser 3 by one having less width and guides 6 having a width equal to the new cavity shall be placed, and vice versa, the present gas diffuser 3 also requires at least two supports 10 as illustrated and described in FIGS. 4 and 5.

[0029] FIG. 7 shows, on an individual basis, a plant view of another embodiment of the heat recovery device shown and described in FIGS. 3 and 4, which consists of a square shaped fire tube 2, including inside a demountable preferably cylindrically shaped, gas diffuser 3, which is formed only by one piece from end to end with a constant diameter in full length; in this heat recovery device as well as in the former ones, the combustion gases shall flow at high speed of at least 6 m/sec through the four cavities 5 formed in the corners of the square shaped fire tube 2 and said cavities 5 shall be very narrow to obtain good results, of at least 3 mm between the inner wall of the tube 2 and the outer wall 7 of the gas diffuser 3. The main variables that shall be considered to determine the length of this heat recovery device are: once again, the width of cavities 5 and the combustion gases speed, if after a determined design it is decided to increase the combustion gases speed through cavities 5 by the mechanical blower discharge pressure increase, or if it is decided to increase the cavities 5 width, as a result the heat recovery device power is increased and therefore, it would be required to increase the heat recovery device length and vice versa, since only in this manner is possible to recover the combustion gases heat, for example, to increase the width of cavities 5 according to this figure, it is required to change the square gases diffuser 3 by one having less width and guides 6 having a width equal to the new cavity shall be placed, and vice versa, the present gas diffuser 3 also requires at least two supports 10 as illustrated and described in FIGS. 4 and 5.

[0031] FIG. 9 shows, on an individual basis, another variable of the heat recovery device that is shown and described in FIGS. 3 and 4, and in a cross sectional view it is noticed the fire tube 2 having inside a preferably cylindrically shaped demountable gas diffuser 3, which is formed only by one piece from end to end with a constant diameter in full length; in addition, the diffuser 3 has an helicoidal shaped guide 8 which may be located at full length of the gas diffuser 3, and which can be manufactured from steel sheet or steel wire and can be fixed with any solder type at the outer wall 7 of the gas diffuser 3, guide 8 has two functions, first, to radially center the gas diffuser 3 inside tube 2 to achieve an axially uniform cavity 5, substituting guides 6 illustrated in FIG. 3, besides having the function of deviating the combustion gases as indicated with arrow 9, then achieving the faster mixing of the combustion gases in a shorter run length than the gases flowing in axial direction as described in FIG. 3. According to this Figure, the helicoidal shaped guide 8 shall complete, at least, one turn around such gas diffuser 3 in order to maintain a uniform cavity 5 in full length of the diffuser 3; the guide 8 may be formed only by one piece or by a plurality of sections, which may be fixed in a helicoidal manner to wall 7 of gas diffuser 3, additionally, this helicoidal shaped guide 8 can be placed in the square shaped gas diffuser 3 of FIG. 8, as described in this figure, cavity 5 according to this Figure to give good results shall be very narrow of at least 2 mm between the inner wall of the tube 2 and the outer wall 7 of the gas diffuser 3, and the combustion gases shall flow at high speed of at least 6 m/sec through the cavity 5 so that a great amount per area unit is transferred to the inner wall of the tube 2. The main variables that shall be considered to determine the length of this heat recovery device are: once again, the width of cavities 5 and the combustion gases speed, if after a determined design it is decided to increase the combustion gases speed through cavities 5 by the mechanical blower discharge pressure increase, or if it is decided to increase the cavities 5 width, as a result the heat recovery device power is increased and therefore, it would be required to increase the heat recovery device length and vice versa, since only in this manner is possible to recover the combustion gases heat, for example, to increase the width of cavities 5 according to this figure, it is required to change the gas diffuser 3 by one having a less diameter and a guide 8 having a width equal to the new cavity shall be placed, and vice versa, the present gas diffuser 3 also requires at least two supports 10 as illustrated and described in FIGS. 4 and 5.

PREFERRED EMBODIMENT OF THE INVENTION

[0032] According to that illustrated in FIG. 1, it is provided as example a vertical design fire tube liquid heater, which has
four heat recovery devices inside, which in turn are integrated by four tubes 2 and each tube 2 has inside a cylindrically shaped demountable gas diffuser 3, similar as the one shown in FIGS. 3 and 4; the tubes 2 have an inner diameter of 100 mm and gas diffusers 3 have an outside diameter of 90 mm, giving as a result a cavity 5 with a width of 5 mm; the combustion gases average speed through the four cavities 5 is of 12 m/sec and the heater power is of 60 kw, which is equivalent to 216000 kj/h; the mechanical blower has a power of 15 W, with a discharge pressure of 1.8 cm of water column.

With the width having the four cavities 5 of the example and the average speed the combustion gases reach through said cavities 5, the heat recovery devices of this example only require a length of 700 mm for the liquid heater to reach a 93% thermal efficiency with respect to the lower calorific power of the fuel gas. The description of this invention is for illustrative and not for limiting purposes, because additional embodiments will be evident when reading this description and the claims, without separating from the invention spirit.

1. A liquid heater and steam boiler, of fire tubes, of vertical design and horizontal return design, requiring unavoidably a mechanical blower to operate, having inside a plurality of cylindrically shaped tubes to recover heat, wherein the tubes turn into heat recoverers since each tube has inside a cylindrically shaped gas diffuser formed by a single section from end to end and having a constant diameter in full length, also because between the inner wall of the tube and the outer wall of the gas diffuser a narrow cavity is formed, of at least 1 mm width where combustion gases flow at high speed of at least 6 m/sec through the narrow cavity, also because it has a plurality of guides having the same length as the diffuser and axially located, and equidistant in the outer wall of the gas diffuser to center it inside the tube, also because it has a helicoidal shaped guide of a single section and located at full length and around the gas diffuser to center it inside the tube and to deviate the combustion gases, besides because it has at least to supports in the gas diffuser to vertically hold it inside the tube.

2. The liquid heater and steam boiler, according to claim 1, wherein the gas diffuser has, transversely, a pentagonal, hexagonal, octagonal and squared shape.

3. The liquid heater and steam boiler, according to claim 1, wherein the gas diffuser is demountable.

4. The liquid heater and steam boiler, according to claim 1, wherein the heat recovery tubes are square tubular.

5. The liquid heater and steam boiler, according to claim 1, wherein the helicoidal shaped guide of the gas diffuser is integrated by a plurality of sections.

6. The liquid heater and steam boiler, according to claim 1, wherein the axial location guides are short with respect to the gas diffuser, and at least four are places at each end and in the middle part of the gas diffuser.

7. The liquid heater and steam boiler, according to claim 1, wherein the plurality of short axially located guides with respect to the gas diffuser are placed deviated in any direction regarding the axial axis of the gas diffuser.

8. The liquid heater and steam boiler, according to claim 1, wherein the axially placed guides and the helicoidal shaped guide are from steel sheet.

9. The liquid heater and steam boiler, according to claim 1, wherein the axially placed guides and the helicoidal shaped guide are from steel wire.

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