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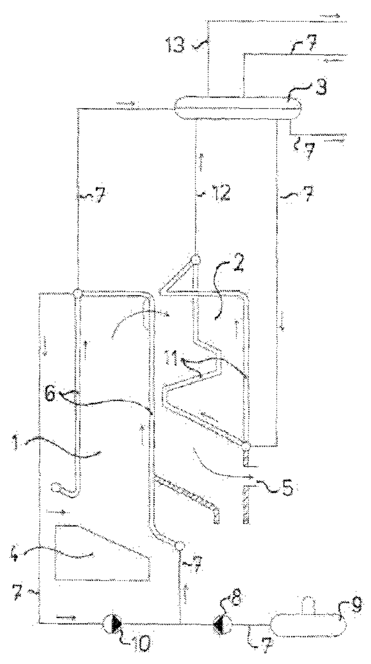

Fig. 1

(57) Abstract: Steam boiler for waste incineration, including a combustion chamber (1) comprising a combustion chamber cavity surrounded by combustion chamber walls, to the combustion chamber (1) by an opening for flue gas flow followed by at least one or more consecutive flue-gas ducts (2) interconnected by openings for flue gas flow, where each flue-gas duct (2) comprises a flue-gas duct cavity surrounded by flue- gas duct walls, where the steam boiler further comprises at least one evaporator (11) for steam production, a feed pump (8) connected to a water source (9), a steam drum (3), at least one heater (6) having an inlet connected through the feed pump (8) to a water source (9), at least one heater (6) having an outlet connected to the steam drum (3), wherein all included evaporators (11) have inlet and outlet connected to the steam drum (3), from which a steam piping (13) leads to the connection to the steam turbine the summary of the invention is based on that at least one heater (6) and/or at least one evaporating surface with its heat exchange surfaces form walls of the combustion chamber (1), wherein at least one evaporator (11), included in the steam boiler, is located in a flue-gas duct (2).

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Steam boiler for waste incineration

Field of the Invention

The invention relates to a steam boiler for waste incineration, intended for production of steam in a cogeneration unit.

Background of the Invention

Currently known device for energy recovery is usually arranged as a cogeneration energy source for production of electricity and heat. Such energy source also includes a steam boiler for incineration of municipal waste, comprising a combustion chamber and one flue-gas duct connected downstream, or several consecutive flue-gas ducts. The waste supplied to the boiler is incinerated in the combustion chamber and the produced flue gas is, by flowing through flue-gas ducts, gradually cooled down to required temperature, e.g. to approx. 200 °C, and cooled in this manner it is delivered to a flue-gas cleaning device. Usually, water that heats in the steam boiler and produces steam, which is then used for production of electricity and supply of heat, is used for cooling flue gases in the steam boiler. Therefore, every steam boiler has some part of heat exchange surfaces arranged as a water heater, in which the supplied water is mostly heated to a temperature lower than the boiling temperature at given pressure, and the other part of heat exchange surfaces is embodied as an evaporator, in which the supplied water evaporates, and which comprises a steam drum in whose lower part boiling temperature water accumulates and above the water level, in the upper part of the steam drum, separated saturated steam accumulates, and the last part of heat exchange surfaces is embodied as a steam overheater, in which saturated steam, extracted from the steam drum, is heated to a higher temperature suitable for steam turbine operation. The above mentioned makes it obvious that the existing steam boilers comprise a steam drum, at least one water heater, at least one evaporator, and at least one steam overheater. Water heater denotes a device with heat exchange surfaces which are connected through a feed pump to a water inlet from a suitable water source, usually a tank, wherein the outlet of the heat exchange surfaces is connected to the inlet to the steam drum. Evaporator denotes a device with heat exchange surfaces which have their inlet connected to a steam drum. Steam overheater denotes a device whose inlet is connected to the upper part of the steam drum, which is a part where steam accumulates, and the outlet is connected to the inlet of the steam turbine. The existing devices have the overheater, or its heat exchange surfaces, located in one of flue-gas ducts, usually downstream of the evaporator. The evaporator in an existing device is formed by heat exchange surfaces, arranged as membrane walls of the combustion chamber, or even as walls of flue-gas ducts. The overheater is usually embodied as a heat exchange surface located in one of flue-gas ducts, usually downstream of the combustion chamber. Water heater is located in one of flue-gas ducts, however, it is usually located as the last heat exchange surface in the last flue-gas duct.

For example, patent specification JP2012017923 (A) describes a steam boiler, in which waste is incinerated in a combustion chamber with a fire grate, and the produced flue gases then flow through the three connected flue-gas ducts. The first duct is empty and in the second and third ducts heat exchange surfaces of the steam boiler are located. The water heater is located as the last heat exchange surface at the flue gas outlet of the third duct, its inlet connected to the outlet of the feed pump and its outlet connected to the steam drum of the boiler. All cooled membrane walls of the combustion chamber and flue-gas ducts are connected, forming an evaporator, wherein the lower inlet to these walls is connected to the lower part of the steam drum and the upper outlet of these walls is connected to the steam drum, usually at the water level in the steam drum.

The construction of some embodiments of steam boilers requires placement of part of the evaporator heat exchange surface in flue gas in one of flue-gas ducts of the boiler. Also, with this evaporator embodiment, the existing devices have the lower inlet of the evaporator connected to the lower part of the steam drum and the upper outlet of the evaporator is connected to the steam drum, usually at the water level in the steam drum. The first duct is empty and in the second flue-gas duct in flue gases a steam overheater is located, having the inlet connected to the upper part of the steam drum and the outlet to the steam turbine.

The drawback of the existing devices is, since incinerated waste contains chlorine, that the heat exchange surfaces with higher wall temperature, on which a deposit layer from the incinerated waste ash is formed, are exposed to intensive effects of chloride corrosion. It is currently necessary to protect, at least partially, steam boiler surfaces against damage by chloride corrosion by either choosing low steam values, e.g. MPa and 420 °C, or various protection decreasing chloride corrosion intensity and increasing steam boiler surfaces durability. For example, steam overheater pipes are protected by a welded layer from an alloy resistant to chloride corrosion, such as nickel alloy, or they are protected by ceramic tiles on the flue gas side. The membrane walls of the evaporator, located in the combustion chamber, are protected by lining in their lower part. The upper part of the evaporator, under the ceiling and ceiling in transition to the first duct, are protected by a welded protection layer, e.g. nickel alloy. All these measures are rather expensive and fail to remove chloride corrosion, they just reduce its intensity. Durability of the heat exchange surfaces is low, the parts affected by chloride corrosion need to be replaced, thus increase the operating costs.

With a steam boiler according to patent US6264465 B1, the supplied waste is incinerated in a combustion chamber with a fluid-bed furnace with a circulating fluid layer and produced flue gases then flow through the two connected flue-gas ducts. The first flue-duct duct is empty and in the second flue-gas duct heat exchange surfaces are located. A water heater is located in the second flue-gas duct cavity, as a last heat exchange surface at the flue gas outlet of the second flue-gas duct. This water heater inlet is connected through a feed pump to a feed tank equipped with a degasification device, and its outlet is connected to the steam drum of the boiler. The combustion chamber and flue-gas ducts have walls made as membrane heat exchange surfaces. All membrane walls, combustion chambers and flue-gas ducts are forming an evaporator. These evaporators have the lower inlet to the membrane walls, which is further connected to the lower part of the steam drum. Furthermore, they have an upper outlet out of the membrane walls, which is further connected to the steam drum, usually at the steam drum water level. The construction of some embodiments of steam boilers requires placement of part of the evaporator heat exchange surfaces in flue gas in one of flue-gas ducts of the boiler. Also, in this evaporator embodiment, the lower inlet thereof is connected to the lower part of the steam drum and its upper outlet is connected to the steam drum, usually at the water level. The first flue-duct is empty, at the flue gas inlet to the second flue-gas duct in flue gases a first part of the steam overheater is located, the inlet of which is connected to the upper part of the steam drum, and the outlet of which is connected to the inlet of the output part of the steam overheater. The output part of the steam overheater is embodied here as a fluid heat exchanger, located in between a cyclone separator outlet and the inlet for fluid layer material, which is in the lower part of the combustion chamber.

Also, a serious drawback of this device is that the heat exchange surfaces with higher wall temperature are exposed to intensive chloride corrosion due to the content of chlorine in incinerated waste. The chloride corrosion usually affects the most the combustion chamber walls, the walls of the first flue-gas duct and steam overheater surfaces, which are located in flue gases leaving the combustion chamber. Steam boiler surfaces of these devices must be protected against the effects of chloride corrosion by low temperature of the walls. For example, the first part of the overheater, which is located in the second duct, is operated in such way that the wall temperature would only reach 420 °C, wherein the required steam heating to higher temperature, e.g. 500 °C, is performed in the second part of the overheater, which is located in the fluid exchanger upstream of the inlet to the combustion chamber. Since there are no flue gases containing chlorine in the fluid exchanger, the second part of the overheater is not exposed to the effects of chloride corrosion, even though it works with high wall temperature. In this device, the pipes of the first part of the overheater, located in the second flue-gas duct, are protected by a welded layer of an alloy resistant to chloride corrosion, e.g. nickel alloy, and/or by ceramic tiles on the side of flue gases. Evaporator membrane walls in the combustion chamber are protected by lining at least in the lower part. Evaporator membrane walls under the combustion chamber ceiling, and also in the combustion chamber ceiling in the place of transition into the first flue-gas duct, are protected by a welded protection layer, e.g. nickel alloy.

All these measures, which need to be performed particularly for protection of the input part of the steam overheater and for protection of the evaporator are rather expensive and fail to remove chloride corrosion, just reducing its intensity. The durability of the heat exchange surfaces is low, the parts damaged by chloride corrosion must be replaced, thus increasing the operating costs.

Summary of the Invention

The above-mentioned disadvantages of the existing state of the art are removed by the present invention. The proposed steam boiler for waste incineration includes a combustion chamber comprising a combustion chamber cavity surrounded by combustion chamber walls, the combustion chamber, through an opening for flue gas flow, connected to at least one or several consecutive connected flue-gas ducts, interconnected through the openings for flue gas flow, where each flue-gas duct comprises a combustion chamber cavity surrounded by flue-gas duct walls, at least one evaporator for production of steam, a feed pump connected to a water source, a circulator included in water piping interconnecting the inlet and the outlet of an overheater, a steam drum and at least one overheater having its inlet connected through a feed pump to a steam drum. The evaporator is characterized in that it has its inlet and outlet connected to a steam drum. The new solution is based on that the first heater, in the direction of flue gas flow, forms a combustion chamber wall with its heat exchange surfaces, wherein the evaporator is located, completely or partially, in the cavity of at least one flue-gas duct and/or forms, completely or partially, a wall of at least one flue-gas duct. If more than one evaporator is included, all included evaporators are located in a flue-gas duct or ducts in this manner, and all of them have their inlet and outlet connected to the steam drum.

In the flue-gas duct, the evaporator is arranged in such way that its heat exchange surfaces are located in the cavity and/or form at least part of the flue-gas duct wall.

Similarly to the above described state of the art, where the steam drum is described as part of the evaporator and located outside the flue-gas duct, in the text below the steam drum is also considered to be a part of the evaporator, however, the term evaporator is only used in the meaning of a heated exchange surface located in the flue-gas duct.

The steam boiler preferably comprises at least two heaters, wherein the first heater, in the direction of flue gas flow, forms a combustion chamber wall, and the second heater is located, completely or partially, in the cavity of at least one flue-gas duct and/or forms, completely or partially, a wall of at least one flue-gas duct.

In case at least two flue-gas ducts are included, at least one heater is located in the cavity and/or forms walls of the last flue-gas duct and at least one evaporator is located in the cavity and/or forms walls of a different one than the last flue-gas duct.

In case at least three flue-gas ducts are included, at least one heater and/or evaporator is preferably located in the cavity and/or forms walls of every flue-gas duct.

The heaters are preferably connected in parallel with their inlets to the feed pump and with their outlets they are connected in parallel to the steam drum.

The feed pump has preferably two pumping parts, namely the low-pressure part and high-pressure part, where the low-pressure part is provided in between a water source and the inlet to at least one heater and the high-pressure part is provided in between the outlet of at least one heater and the steam drum. The feed pump arranged from two parts, a low-pressure one and high-pressure one, is a common pump type available on the market, wherein the low-pressure part means the design type for pressure of 0.2 to 5.0 MPa and the high-pressure part means the design type for pressure of 5 to 17 MPa. The pump consisting of two pumping parts herein also means the use of a low-pressure and high-pressure pump, each embodied as a separate machine.

In case of using a feed pump with a low-pressure and a high-pressure part, at least two heaters are preferably connected with their inlets in parallel to the low-pressure part of the feed pump, and with their outlets connected in parallel to the inlet of the high-pressure part of the feed pump.

Preferably, at least one heater, different from the heater located in the combustion chamber, is connected with its inlet in parallel in relation to the outlet of the high-pressure part of the feed pump, wherein the outlet of this heater is connected to the steam drum.

The advantage of the embodiment according to the invention is that, in contrast to the state of the art, the designed steam boiler has no steam overheater in flue gases. The state of the art overheater is used in flue gases, and since the steam boiler solution is designed without using an overheater, the problems with the overheater chloride corrosion are eliminated. The costs for acquisition of an overheater from highly alloyed steel, on overheater protection against corrosion, and on overheater maintenance and frequent replacements are significantly reduced.

In contrast to the described state of the art, the steam boiler according to the invention does not produce overheated steam, since it has no flue-gas steam overheater, but produces, from a smaller part of the delivered supply water, high-pressure saturated steam, and, from a bigger part of the delivered supply water, hot water at the boiling temperature at the same pressure. This high-pressure hot water at the boiling temperature is, in a system of expanders, used for production of a smaller amount of saturated steam and a higher amount of hot water at the boiling temperature at lower pressure. Such produced low-pressure saturated steam is delivered to the steam turbine and upstream of the steam turbine it is heated to higher temperature by high-pressure saturated steam supplied from the steam boiler drum, which condensates at cooling and returns back to the boiler steam drum. Therefore, low-pressure steam before entering a steam turbine is not heated by the heat of flue gases produced from waste incarceration. The hot water produced by the above-described method is used for heat supply or is led into another expander, where by further expansion to lower pressure, saturated steam is produced again for another steam turbine stage and hot water, again for the heat supply or led to another expander, the number of expanders is the same as the number of saturated steam inlets to the steam turbine.

Steam boiler according to the invention is particularly designed for waste incineration in a cogeneration unit with a turbine and an electric generator. The invention can be preferably used, for example, in a device according to CZ PV 2019-126, which is in the form of a cogeneration unit, including a steam boiler, which is provided with a steam drum. The cogeneration unit also includes a steam turbine and an electric generator. The steam drum has both a hot water inlet for hot water from the steam boiler and a steam-water inlet for a mixture of steam and hot water from the steam boiler, and a hot water outlet with connected hot water piping led into the first expander. Hot water piping for the condensate and steam piping for saturated steam is led out of the expander of this cogeneration unit. The steam turbine is provided on the steam piping downstream of this expander, and the condenser is provided downstream of the steam turbine. The device also comprises necessary connecting hot water piping and steam piping. In this device, a heating circuit for temperature regulation of saturated steam led from the expander is provided and arranged in such way that, from the steam drum, the steam piping of saturated steam is led into the steam overheater and, subsequently, hot water piping is led from a steam heater for extraction of condensed saturated steam delivered back to the steam drum, wherein simultaneously this steam heater is provided on the steam piping in between the expander and steam turbine. The steam generator in this cogeneration unit works in such way that in the steam boiler high-pressure hot water is produced, e.g. 13MPa, at boiling temperature and further saturated steam with the same parameters. Hot water from the steam drum of the steam boiler is led into the expander, where it expands to lower pressure, corresponding with steam pressure at the inlet of the steam turbine, e.g. 4MPa. In the expander, when pressure drops, saturated steam is produced from a smaller part of the supplied hot water which is led to the steam turbine, and from a bigger part of the supplied hot water hot water with lower parameters, e.g. 4 MPa, is produced which is used for heat supply. Saturated steam, e.g. with the mentioned pressure of 4 MPa, is, before entering the steam turbine, heated to a higher temperature in the exchanger, e.g. 320 °C; for heating high-pressure saturated steam at pressure, e.g. 13 MPa, produced in the steam boiler steam drum, is used for heating. This steam condenses in the exchanger and the produced condensate is delivered back into the steam boiler drum. In the steam boiler, only sufficient amount of saturated steam is produced which is necessary for heating the steam upstream of the steam turbine. If a multi-stage turbine is used, the same number of expanders is provided at the water side in series so that hot water from the first expander is supplied into the second expander inlet, wherein it further expands to lower pressure, corresponding with the steam pressure in the further steam turbine stage. This is repeated based on the number of turbine stages.

Another advantage is that the heat exchange surfaces located in high temperature flue gases, e.g. higher than 600 °C, potentially in special operation conditions up to 950 °C, are designed as a water heater, whereby negligible intensity of chloride corrosion is reached even at these temperatures. In addition, acquisition costs are reduced by both the fact that conventional steel is used for this heater production, as well as that no special surface protection of this designed heater against corrosion is necessary. Further savings are reached by reducing operating costs on maintenance, or potential replacements of steam boiler elements. The invention brings benefits by that it proposes, in spaces with flue gases with temperature lower than 600 °C, to include a low-pressure evaporator and/or a heater, wherein the mentioned devices located therein have a significantly lower wall temperature, so that they are exposed to low intensity of chloride corrosion, and their acquisition and operating costs on maintenance are significantly reduced. Furthermore, one advantage of the boiler is that even during operation, the pressure in the steam drum can be changed and thus, if necessary, the ratio of electricity and heat supply can be changed in turn, so that the operation would be as economical as possible.

In summary, the proposed steam boiler is structurally designed to significantly reduce or fully eliminate chloride corrosion. The mentioned need is achieved by the present invention, and thus the durability of steam boiler and its parts can be substantially prolonged. The use of the designed steam boiler both prolongs the durability of a newly acquired steam boiler and brings results in the form of reduced maintenance costs. The designed steam boiler can be potentially produced by remodeling of an existing steam boiler if that boiler is embodied as a high-pressure steam boiler, which is another advantage.

Brief Description of Drawings

The invention is further described by means of drawings, wherein these schematically illustrate

Fig. 1 an example of a steam boiler according to the invention with a single flue-gas duct

Fig. 2 an example of a steam boiler according to the invention with two flue-gas ducts

Fig. 3 an example of a steam boiler according to the invention with two flue-gas ducts and with a feed pump consisting of two parts, where all the included heaters are connected in parallel downstream of the low-pressure part of the feed pump

Fig. 4 an example of a steam boiler according to the invention with three flue-gas ducts and with a feed pump consisting of two parts, where one of the heaters is connected downstream of the high-pressure part of the feed pump.

Fig. 5 an example of a steam boiler according to the invention, where the heater and flow evaporating surface are provided as low-pressure heat exchange surfaces

Fig. 6 an example of a steam boiler according to the invention, where the heater and evaporating surface with natural circulation are provided as low-pressure heat exchange surfaces.

Example Embodiment of the Invention

The simplest exemplary embodiment of the invention is a single-pressure steam boiler with a single flue-gas duct according to Fig. 1.

The main structural elements of this steam boiler are a combustion chamber 1, a flue-gas duct 2 and a steam drum 3. In the combustion chamber 1, a grate 4 is located, to which a fuel supply, not displayed, is connected. The steam boiler is arranged so that in particular, municipal waste could be used as fuel. The combustion chamber 1 is, in this exemplary embodiment, followed by one flue-gas duct 2, terminated with a flue-gas outlet 5. The walls of the combustion chamber 1 form a water heater 6 consisting of the heat exchange surfaces, embodied as membrane walls. The interconnection of elements is provided by a common interconnecting piping 7. The heater 6 has its inlet connected through a feed pump 8 to a tank which is a source 9 of supply water. The inlet of the heater 6 is connected to the steam drum 3. The outlet and the inlet of the heater 6 are connected by the water piping 7, on which a circulator 10 is provided. The steam boiler further includes an evaporator 11, which is located in the flue-gas duct 2. This exemplary embodiment comprises an optimal evaporator 11, which consists of a heat exchange surface forming walls of the flue-gas duct 2, and of a heat exchange surface located in the cavity of the flue-gas duct 2, in the space for flue gas flow. The evaporator 11 is with its outlet and inlet connected to the steam drum 3. Alternatively, the evaporator 11 may be formed exclusively by heat exchange surfaces forming walls of the flue-gas duct 2, or heat exchange surfaces located in the cavity of the flue-gas duct 2. Regarding the heat exchange surfaces forming walls of flue-gas duct 2, it is preferred that they are in the form of a membrane wall, in case of heat exchange surfaces located in the cavity of the flue-gas duct 2 they can be in the form of just a bundle of pipes.

When operating this steam boiler, the supply fuel is incinerated on a grate 4, wherein the incineration flame and flue gases produced by fuel incineration heat water in the heater 6 at relatively low temperature of heater 6 walls. Hot flue gases, which transferred part of their heat to water, proceed through the combustion chamber 1 into the flue-gas duct 2, where they transfer heat to the evaporator 11, and further flue gases leave through the flue-gas outlet 5 out of the steam boiler, through a cleaning device, not displayed, into a chimney, also not displayed. Water is delivered to the heater 6 from a source 9 with the use of a feed pump 8. By the flow of water through the heater 6, the supply water in the heater 6 is heated to the maximum temperature corresponding to the boiling temperature at the corresponding pressure in the steam drum 3. For example, at the pressure of 13MPa, it is 330°C. Hot water from the heater 6 is supplied to the steam drum 3, where it accumulates. The heat exchange surfaces of the evaporator 11 are cooled by circulating hot boiler water, which is extracted from the steam drum 3, and after being heated by flue gases, it partially evaporates, whereby a steam-water mixture is produced. Such produced steam-water mixture is delivered back by the steam-water piping 12 to the steam drum 3. In the steam drum 3, from delivered steam-water mixture, both boiling temperature water, i.e. in the mentioned example at pressure of 13MPa of 330 °C, and saturated steam of the same temperature are separated. Water at the temperature of 330 °C is mixed in the lower part of the steam drum 3 with hot water delivered from the heater 6, while saturated steam accumulates in the upper part of the steam drum 3. The circulator 10 provides required water flow in the heater 6, allowing to maintain the required temperature of the combustion chamber 1 wall concerning the chloride corrosion. High-pressure hot water for cogeneration production of electricity and heat is extracted from the steam drum 3 by the water piping 7, high-pressure saturated steam for steam heating upstream of the steam turbine is extracted from the steam drum 3 by the steam piping 13 and the condensate is delivered back to the steam drum 3 by the water piping 7. In the evaporator 11, only the amount of saturated steam is produced that is necessary for heating the saturated steam produced in expanders before entering the steam turbine.

The advantage of this steam boiler embodiment is that when suitable pressure in the steam drum 3 is chosen, it is possible to provide lower temperature than boiling temperature in the heater 6, which significantly reduces chloride corrosion intensity, prolongs steam boiler durability and reduces maintenance costs. Another advantage is that steam boiler in this example embodiment can be used for operation with variable pressure in the steam drum 3, which allows, when used in a cogeneration unit, during steam boiler operation, at maintained power on the fuel side, to change the ratio of produced electricity and supplied heat. For example, in winter, when the required heat supplies are higher, the pressure in the steam drum 3 is reduced and thus the supplied electric power of the cogeneration unit is reduced at the simultaneous increase of heat supplies. In summer, when the demand for heat is lower, the pressure in the steam drum 3 is increased, thus reaching higher supplied electric power at the expense of lower heat supplies. In such way the ratio of supplied electricity and heat can be changed even during the daily operation of the steam boiler. The designed steam boiler has no chloride corrosion of the steam overheater, simply because it does not include flue-gas steam overheater.

An example of another embodiment of the invention is a single-pressure steam boiler with two flue-gas ducts 2, 14 according to Fig. 2.

The main structural elements of this steam boiler are a combustion chamber 1, two flue-gas ducts 2, 14 and a steam drum 3. In the combustion chamber 1, a grate 4 is located, to which a fuel supply, not displayed, is connected. The combustion chamber 1 is followed by the first flue-gas duct 2 and by the second flue-gas duct 14, terminated with a flue-gas outlet 5. The second flue-gas duct 14 have walls embodied as a steel channel with insulation. The steam boiler comprises two water heaters 6, 15. The walls of the combustion chamber 1 form the first heater 6 consisting of heat exchange surfaces embodied as membrane walls. The first overheater 6 has its water inlet connected through a feed pump 8 to a tank, which is a source 9 of supply water, and it has the water outlet connected to the steam drum 3. The second heater 15 is located in the second flue-gas duct 14 and it is in the steam boiler connected in parallel, relative to the first heater 6. The first heater 6 outlet and inlets into both heaters 6, 15 are interconnected with the water piping 7, which is provided with a circulator 10. Apart from those, the steam boiler includes an evaporator 11, which is located in the first flue-gas duct 2. This exemplary embodiment of the invention also comprises an optimal evaporator 11, which consists of a membrane heat exchange surface and a bundle of pipes. The membrane heat exchange surface forms walls of the first flue-gas duct 2, and the bundle of pipes is located in the first flue-gas duct 2 cavity, in the space for flue gas flow. The evaporator 11 is, by its inlet and outlet, connected to the steam drum 3. Alternative embodiment possibilities for the evaporator 11 are the same as in the previous example. The second heater 15 has its inlet connected to the outlet of the feed pump 8 and its outlet is connected to the outlet of the first heater 6, both of these outlets are, by the joint water piping 7, connected to the steam drum 3. Alternatively, the outlets of both heaters 6, 15 can be connected directly to the steam drum 3. Alternatively, it is also possible to provide the heaters 6, 15 consecutively in series.

The steam boiler, according to Fig. 2, works similarly to the steam boiler in the previous example, with the exception that it has two ducts. Flue gases produced by incarceration of fuel proceed from the first flue-gas duct 2 to the second flue-gas duct 14, and only then they leave it through a flue-gas outlet 5. The second flue-gas duct 14 is, by means of the second heater 15, cooled by water from the feed pump 8 parallel to the walls of the combustion chamber 1, i.e. with the first heater 6. The water heated by the flow through the second heater 15 is mixed with water heated from the first heater 6 and this mixture is delivered to the steam drum 3. In an alternative embodiment, the water heated in the first heater 6 and the second heater 15 is delivered individually directly to the steam drum 3. By flow of the supply water through the second heater 15, the supply water is heated to the temperature lower than the boiling temperature at the corresponding pressure in the steam drum 3. High-pressure hot water for cogeneration production of electricity and heat is, as well as in the previous example, extracted from the steam drum 3 by water piping 7. High-pressure saturated steam for steam heating upstream of the steam turbine is extracted from the steam drum 3 by the steam piping 13 and the condensate is returned back to the steam drum 3 by water piping 7. Also, in this exemplary embodiment in the evaporator 11 of the steam boiler only the sufficient amount of saturated steam is produced that is necessary for heating the saturated steam produced in the expanders before entering the steam turbine.

The advantage of this example embodiment of the steam boiler, in comparison with the embodiment according to the previous example, is that flue gas temperature in the flue-gas duct outlet 5 can be maintained at the required value of approx. 200 °C for devices for cleaning of flue gases at any pressure in the steam drum 3. Other advantages are identical to the advantages mentioned in the previous example.

Another exemplary embodiment of the invention is a double-pressure steam boiler with two flue-gas ducts and a feed pump consisting of two parts according to Fig. 3.

This steam boiler also comprises a combustion chamber 1 with a grate 4, two flue-gas ducts 2, 14, a steam drum 3 and an evaporator 11. The arrangement of these parts of the steam boiler is identical to the previous example. The number of the heaters 6, 15 and their location in the steam boiler is identical. This steam boiler differs from the previous example particularly by including a feed pump 8 having two pumping parts 16, 17, a low-pressure part 16 and a high-pressure part 17. In the case of using a feed pump embodied as a single machine, both parts, the low-pressure and high-pressure part 16, 17, are mounted on a joint shaft with a drive 18 of the feed pump 8, e.g. an electric motor. It is a readily available two-part feed pump having a special design of the low-pressure part 16 for pressure 0.2 to 5.0 MPa and the high-pressure part 17 for pressure 5 to 17 MPa. Regarding the choice of the feed pump 8, this embodiment has specific provision of heaters 6, 15. The low-pressure part 16 of the feed pump 8 has the inlet connected to a water source 9 and the outlet is designed as connected to an inlet of at least one, in this case both, heaters 6, 15. The high-pressure part 17 is provided in between the outlet of at least one, in this case both, heaters 6, 15 and the steam drum 3. At the high-pressure part outlet 17 of the feed pump 8 regulation fittings 19 may be located. The invention does not exclude provision of water heaters 6, 15 in series, where the second heater 15 would be provided as the first one and the first heater 6 in series downstream, in the direction of water flow. In the presented embodiment the heaters 6, 15 are provided in parallel. These heaters 6, 15 are connected in parallel with their inlets to the outlet of the low-pressure part 16 of the feed pump 8, wherein their outlets are connected to the inlet of the high-pressure part 17 of the feed pump 8. The outlet of the high-pressure part 17 is connected by connecting water piping 7 to the steam drum 3.

In operation of the steam boiler according to this example embodiment, flue gases flow identically to those in the steam boiler according to a previous example. From the combustion chamber 1 they flow through the first flue-gas duct 2 and the second flue-gas duct 14 and leave the steam boiler through a flue-gas outlet 5. The evaporator 11, similarly to the device according to Figs. 1 and 2, is cooled by high-pressure supply water, e.g. 13MPa. The difference is that the first heater 6 as well as the second heater 15 are cooled by low-pressure supply water, e.g. at pressure of1MPa. Since the low-pressure part 16 and the high-pressure part 17 of the feed pump 8 are on a joint shaft with a drive 18, their equal mas flow rate is maintained. By the regulation fittings 19 at the outlet of the high-pressure part 17 of the feed pump 8 the required water pressure is set in the previous, low-pressure, first heater

6. For reliable operation of the high-pressure part 17 of the feed pump 8, such water temperature must be provided that water evaporation does not occur at its inlet.

An advantage of this exemplary embodiment, in comparison with the previous example, is that at the mentioned low water pressure, e.g. 1MPa, in the first heater 6, namely at combustion chamber 1 walls, the temperature of pipes is lower than approx. 200 °C, so that chloride corrosion can be excluded, even in the area of combustion chamber 1 ceiling. Chloride corrosion elimination is also reached at higher flue gas temperature, as high as 950 °C, which can be reached by changing calorific values of incinerated waste. Since this steam boiler has no flue-gas steam overheater, chloride corrosion in the area of steam overheater, which affects the existing known steam boilers that include an overheater, is excluded. However, if, in the operation of this steam boiler, the temperature of flue gases exceeds 850 °C due to changing calorific values of incinerated waste, even for this example embodiment potential occurrence of chloride corrosion is not fully excluded in the area of the ceiling of the first flue-gas duct 2 and in part of the pipe heat exchange surface of the evaporator 11 in the area under the ceiling of the first flue-gas duct 2, since these parts are provided as a high-pressure evaporator.

Another exemplary embodiment of the invention is a double-pressure steam boiler with three flue-gas ducts 2, 14, 20 according to Fig. 4.

The steam boiler comprises a combustion chamber 1 with a grate 4, three flue-gas ducts 2, 14, 20, a steam drum 3 and an evaporator 11. The arrangement of these parts of the steam boiler is similar to the previous example with a difference that the evaporator 11 is arranged in the second flue-gas duct 14. The steam boiler comprises three water heaters 6, 15, 21. The first heater 6 is located in the combustion chamber 1, where it forms its walls similarly to previous examples. The second heater 15 is located in the first flue-gas duct 2 and the third heater 21 is located in the third flue-gas duct 20. The second heater 15 is embodied as a membrane wall of the first flue-gas duct 2 and the bundle of pipes in the first flue-gas duct 2 cavity. The third heater 21 is embodied as a bundle of pipes in the third flue-gas duct 20 cavity. The feed pump 8, connected to a water source 9, has a low-pressure and a high-pressure part 16, 17 on a joint shaft. The first and the second heater 6, 15 are provided as low-pressure ones, downstream of the low-pressure part 16 of the feed pump 8, working with the pressure of, for example, 1.0MPa. The evaporator 11 is, in this example embodiment, embodied as walls of the second flue-gas duct 14 and pipe heat exchange surface in the second flue-gas duct 14 cavity. It has the inlet and outlet connected to the steam drum 3, to which it is provided as a high-pressure one, working with the pressure of, for example, 13MPa. The first and second heater 6, 15 have a joint outlet to water piping 7, which is connected through the regulation fittings 19 to the outlet of the high-pressure part 17 of the feed pump 8. The outlet of the high-pressure part 17 is then by further water piping 7 connected to the steam drum 3. The invention does not exclude an alternative embodiment where these heaters 6, 15 are provided in series or embodied from more parts provided in series. The first and second heater 6, 15 have a circuit with at least one circulator 10 provided in a suitable place. Then in this example embodiment at least two heaters 6, 15, the first and second, are connected with their inlets in parallel to the low-pressure part 16 of the feed pump 8 and with their outlets connected in parallel to the outlet of the high-pressure part 17 of the feed pump 8. The third heater 21 is with its inlet connected to water piping 7, leading from the outlet of the high-pressure part 17 of the feed pump 8 to the steam drum 3. The outlet of the third heater 21 in this presented example is by further water piping 7 led directly to the steam drum 3, outside the water piping 7 interconnecting the high-pressure part 17 of the feed pump 8 with the steam drum 3. Alternatively, it is possible to connect this third heater 21 back, to a following segment of water piping 7 leading to the steam drum 3.

An advantage of this invention embodiment is that the boiler has no steam overheater in flue gases, so there are no problems with overheater chloride corrosion, some costs on material from highly alloyed steel, maintenance and frequent replacements are saved. Another advantage is that heat exchange surfaces located in high temperature flue gases, e.g. 600 °C to 950 °C, form the first and second water heater 6, 15 with low wall temperature, e.g. 200 °C, and thus with negligible intensity of chloride corrosion. It is possible to use common steel for production of these heaters 6, 15 and no special protection of their surface against corrosion is required, so the acquisition costs and operating maintenance costs, or potentially replacement, are low. Another advantage is that in flue gases with temperature lower than 600 °C a high-pressure evaporator 11 and third heater 21 are used, which, at the mentioned flue gas temperature, have wall temperature lower than 370 °C, so they are also exposed to low intensity of chloride corrosion. In this invention embodiment it is also possible for the steam boiler in operation to change pressure in the steam drum 3 and thus, if necessary, the ratio of electricity and heat supplies can be changed in turn, so that the operation would be as much economical as possible.

Another exemplary embodiment of the invention is a steam boiler with low-pressure surfaces provided as a water heater and as a flow evaporating surface according to Fig. 5. The steam boiler comprises a combustion chamber 1 with a grate 4, three flue-gas ducts 2, 14, 20, a steam drum 3 and an evaporator 11 with similar arrangement as in an example embodiment according to Fig. 4 with the difference that walls of combustion chamber 1 and the second flue-gas duct 2 are formed by an evaporating surface 22 consisted of heat exchange surfaces embodied as membrane walls, which is in this example embodiment embodied as a flow evaporator, or potentially as a water heater with partial steam production. The inlet to the evaporating surface 22 is connected to a heater 21 outlet located in the third flue-gas duct 20 cavity, wherein the inlet of this heater 21 is connected to the outlet of the low-pressure part 16 of the feed pump 8. The outlet of the evaporating surface 22 is connected to a separator 23, whose water outlet is in its lower part connected to the inlet to the high-pressure part 17 of the feed pump 8, or potentially through a circulator 10 to the inlet to evaporating surfaces 22, and the steam outlet of the separator 23 in its upper part is connected through steam piping 13 to the steam turbine upstream of the inlet to the steam turbine or upstream of an inlet to some other steam turbine parts with lower pressure.

Water from the outlet of the low-pressure part 16 of the feed pump 8 is in the heater 21 in the flue-gas duct 20 cavity heated by flue gases to higher temperature and such heated enters the evaporating surface 22, where, because of the heat from flue gases, in the combustion chamber 1 and in flue-gas duct 2 a small part of water evaporates, e.g. up to 15 %, and the produced steam-water mixture is led to a separator 23, where water and steam are separated from the supplied steam-water mixture, wherein the separated water accumulates in its lower part and separated steam in its upper part.

Such obtained steam is led by steam piping 13 to the steam turbine and is used for production of electricity and water is led away by water piping 7 and after increasing pressure in the high-pressure part 17 of the feed pump 8 it is heated to higher temperature in the heater 15 in first flue-gas duct 2 and led to the steam drum 3, or potentially it is led directly to the steam drum 3. In the evaporator 11, which is located in the second flue-gas duct 14, and whose inlet is, by water piping 7 as well as its outlet by steam piping 12, connected to the steam drum 3, from a smaller part of water saturated steam is produced, which is from the upper part of the steam drum extracted by steam piping 13 for further use, similarly to previous example embodiments.

A permissible operation of the steam boiler is when in the evaporating surface 22 no steam is produced and just hot water of boiling temperature or lower enters the separator 23, in this case a steam cushion of the same pressure as in the place of connection to the steam turbine is maintained above the water level in the separator 23.

An advantage of this embodiment is that the heat obtained by cooling flue gases in the combustion chamber 1 and partially also in flue-gas duct 2 is not only used for heating water from the low-pressure part 16 of the feed pump 8, but also in some operation states when the heat obtained from cooling flue gases is too big, e.g. when incinerating fuel with higher calorific value, or potentially in operation with changing pressure in the steam drum 3, and also to partial production of steam, which is then used in the steam turbine to produce electricity.

Another advantage is that during partial steam production the evaporating surface 22 has identical wall temperature corresponding with boiling temperature, e.g. at steam pressure of 3MPa approx. 280 °C, and in operation without steam production it has identical temperature or lower, which is reflected in significantly lower intensity of chloride corrosion.

Another exemplary embodiment of the invention is a steam boiler with low-pressure surfaces provided as a water heater and as an evaporating surface with natural circulation according to Fig. 6. The steam boiler comprises a combustion chamber 1 with a grate 4, three flue-gas ducts 2, 14, 20, a steam drum 3 and an evaporator 11 with similar arrangement as in an example embodiment according to Fig. 5 where the walls of combustion chamber 1 and the second flue-gas duct 2 are formed by an evaporating surface 22 consisting again of heat exchange surfaces embodied as membrane walls, which are in this example embodiment embodied differently as an evaporator with natural circulation. The inlet to the evaporating surface 22 is through water piping 7 connected to the steam drum 24 and the outlet is through steam-water piping 12 also connected to the steam drum 24. The outlet of the low-pressure part 16 of the feed pump 8 is connected to the inlet of the heater 21 located in the third flue-gas duct 20 cavity, wherein the outlet of this heater 21 is connected to the low-pressure steam drum 24 to which the outlet of evaporating surfaces 22 is connected as well and whose water outlet is connected through water piping 7 to the inlet to the high-pressure part 17 of the feed pump 8 and to the inlet of evaporating surfaces 22, directly or alternatively through a circulator 10. The steam outlet in the upper part of the steam drum 24 is through steam piping 13 connected to the steam turbine upstream of the inlet to the steam turbine or upstream of an inlet to some other steam turbine parts with lower pressure.

In an alternative embodiment the heater 21 may be in the third flue-gas duct 20 embodied as a two-part one, wherein the second outlet part may be located in between the first flue-gas duct 2 and the second flue-gas duct 14.

In example embodiment according to Fig. 6 water from the outlet of the low-pressure part 16 of the feed pump 8 is in the heater 21 in the cavity of flue-gas duct 20 heated by flue gases to higher temperature and such heated enters the steam drum 24, where it is mixed with a steam-water mixture entering the steam drum 24 from evaporating surfaces 22 and is led through water piping 7 to the inlet of evaporating surfaces 22, where a small part of water evaporates with flue gases in the combustion chamber 1 and in flue-gas duct 2, and the produced steam-water mixture is delivered back to the steam drum 24, wherein by the difference in densities of the delivered hot water and discharged steam-water mixture from evaporating surfaces 22 natural water circulation is set. In the steam drum 24 water and steam are separated from the delivered steam-water mixture, wherein the separated water accumulates in its lower part and separated steam in its upper part.

The remaining part of water is led through water piping 7 from the lower part of the steam drum 24 delivered to the inlet of the high-pressure part 17 of the feed pump 8. Such obtained steam is in the steam turbine used for production of electricity and the water, after increasing pressure in the high-pressure part 17 of the feed pump 8, is heated to higher temperature in the heater 15 in the second flue-gas duct 2 and led to the steam drum 3, or potentially it is led to it directly by water piping 7. In the evaporator 11 from its smaller part saturated steam is produced, which is extracted from its upper part of the steam drum 3 by steam piping 13 for further use, as well as in previous example embodiments.

A permissible operation of the steam boiler is when in the evaporating surface 22 no steam is produced and just hot water of boiling temperature or lower enters the steam drum 24, in this case a steam cushion of identical pressure as in the place of connection to the steam turbine is maintained above the water level in the steam drum 24.

An advantage of this embodiment is that the heat obtained by cooling flue gases in the combustion chamber 1 and partially also in flue-gas duct 2 is not only used for heating water from the low-pressure part 16 of the feed pump 8, but also in some operation states when the heat obtained from cooling flue gases is big, e.g. when incinerating fuel with higher calorific value, or potentially in operation with changing pressure in the steam drum 3, and also to partial production of steam, which is then used in the steam turbine to produce electricity.

Another advantage is that during partial steam production the evaporating surface 22 has identical wall temperature corresponding with boiling temperature, e.g. at steam pressure of 3MPa approx. 280 °C, and in operation without steam production it has identical temperature or lower, which is reflected in significantly lower intensity of chloride corrosion.

Another advantage is that cooling the evaporating surfaces 22 is ensured by natural water circulation, thus the pressure at the outlet of the low-pressure part 16 of the feed pump 8 is reduced as well as its required electric power. Natural circulation ensures the required cooling of the evaporating surfaces 22 even during start-up and shut-down of the boiler.

In an alternative exemplary embodiment according to Fig. 5 or 6, one of the walls of the evaporating surface 22 is replaced by the heater 6. In other exemplary embodiments some or all evaporating walls, or potentially their parts, may be embodied as a heater 6.

In all exemplary embodiments, the use of a circulator is optional. Further in example embodiments the used evaporator 11 is a high-pressure one and is connected to the high-pressure part 17 of the feed pump 8, in contrast, the evaporating surface 22 is a low-pressure one and is connected to the outlet of the low-pressure part 16 of the feed pump 8.

List of reference numbers

1 combustion chamber

2, 14, 20 flue-gas duct

3, 24 steam drum

4 grate

5 flue-gas duct

6, 15, 21 heater

7 water piping

8 feed pump

9 source

10 circulator

11 evaporator

12 steam-water piping

13 steam piping

16 low-pressure part

17 high-pressure part

18 drive

19 regulation fittings

22 evaporating surface

23 separator

PATENT CLAIMS

1. A steam boiler for waste incineration comprising a combustion chamber (1) comprising a combustion chamber cavity surrounded by combustion chamber walls, at least one or more consecutive flue-gas ducts (2, 14, 20) interconnected by openings for flue gas flow further connected the combustion chamber (1) by means of an opening for flue gas flow, where each flue-gas duct (2, 14, 20) comprises a flue-gas duct cavity surrounded by flue-gas duct walls, where the steam boiler further comprises at least one evaporator (11) for steam production, a feed pump (8) connected to a water source (9), a steam drum (3), at least one heater (6, 15, 21) having an inlet connected through the feed pump (8) to the water source (9), at least one heater (6, 15, 21) having an outlet connected to the steam drum (3), wherein all included evaporators (11) have inlet and outlet connected to the steam drum (3), from which a steam piping (13) extends for connection to the steam turbine **characterized in that** the walls of the combustion chamber (1) are completely or at least partially formed by heat exchange surfaces of the heater (6) and/or the evaporating surfaces (22), and further, all evaporators (11) included in the steam boiler are located in the flue-gas ducts (2, 14, 20).

2. The steam boiler according to claim 1, **characterized in that** each evaporator (11) is completely or partially located in the respective flue-gas duct (2, 14, 20) cavity and/or completely or partially forms wall of this flue-gas duct (2, 14, 20).

3. The steam boiler according to any of claims 1 to 2, **characterized in that** walls of the flue-gas duct (2) immediately adjacent to the combustion chamber are at least partially formed by the heat exchange surfaces of the heater (6) and/or the evaporating surface (22).

4. The steam boiler for waste incineration according to any of claims 1 to 3 **characterized in that** the combustion chamber is followed by three flue-gas ducts (2, 14, 20) in the order of the first, the second and the third flue-gas

duct, wherein the evaporator (11) is located in the second flue-gas duct (14) and the inlet of the evaporating surface (22) is, through a heater (21), arranged in the third flue-gas duct (20), connected to the outlet of the low-pressure part (16) of the feed pump (8) and subsequently to the water source (9), and the outlet of the evaporating surface (22) is connected to a separator (23), the water outlet (7) of which is, through the high-pressure part (17) of the feed pump (8), connected to the steam drum (3) and in parallel through the heater (15) in the first flue-gas duct to the steam drum (3), wherein the water outlet (7) from the separator (23) is also connected through a circulator (10) to the inlet of the evaporating surface (22), and the steam piping (13) extends form the separator (23) for connection to the steam turbine.

5. The steam boiler for waste incineration according to any of claims 1 to 3, in which the steam drum (3) is the first steam drum, **characterized in that** the combustion chamber is followed by three flue-gas ducts (2, 14, 20) in the order of the first, the second and the third flue-gas duct, wherein the evaporator (11) is located in the second flue-gas duct (14) and, to the outlet of the evaporating surface (22), the second steam drum (24) is connected, the water inlet of which is, through the heater (21) located in the third flue-gas duct (20), connected to the outlet of the low-pressure part (16) of the feed pump (8) further connected to the water source (9) and the water outlet of which is connected to the inlet of the evaporating surface (22), and the water outlet of this second steam drum (24) is also connected, through the high-pressure part (17) of the feed pump (8), to the first steam drum (3), and in parallel, through the heater (15) located in the second flue-gas duct (2), to the first steam drum (3); and the steam piping (13) extends from the second steam drum (24) for connection to the steam turbine.

6. The steam boiler for waste incineration according to claims 1 to 3, **characterized in that** it comprises at least two heaters (6, 15), wherein the first heater (6), in the direction of flue gas flow, forms wall of the combustion chamber (1) and at least one additional heater (15) is located completely or

partially in the cavity of at least one flue-gas duct (2, 14, 20) and/or completely or partially forms wall of at least one flue-gas duct (2, 14, 20).

7. The steam boiler for waste incineration according to claim 6, **characterized in that** when at least two flue-gas ducts (2, 14, 20) are included, at least one heater (21) is located in the cavity and/or forms walls of the last flue-gas duct (14, 20) and at least one evaporator (11) is located in the cavity and/or forms walls of a duct different from the last flue-gas duct (2, 14), in the direction of flue gas flow.

8. The steam boiler for waste incineration according to claim 7, **characterized in that** when at least three flue-gas ducts (2, 14, 20) are included, at least one heater (15, 21) and/or evaporator (11) is located in the cavity and/or forms walls of each flue-gas duct (2, 14, 20).

9. The steam boiler for waste incineration according to claims 6 to 8, **characterized in that** the heaters (6, 15, 21) are connected in parallel with their inlets to the feed pump (8) and with their outlets connected in parallel to the steam drum (3).

10. The steam boiler for waste incineration according to claims 6 to 9, **characterized in that** the feed pump (8) thereof has two pumping parts, the low-pressure part (16) for pressure 0.2 to 5.0 MPa, and the high-pressure part (17) for pressure 5 to 17 MPa, wherein the low-pressure part (16) has the inlet connected to the water source (9) and the outlet connected to the inlet of at least one heater (6, 15) and the high-pressure part (17) is provided between the outlet of at least one heater (6, 15) and the steam drum (3).

11. The steam boiler for waste incineration according to claim 10, **characterized in that** at least two heaters (6, 15) are with their inlets connected in parallel to the low-pressure part (16) of the feed pump (8) and with their outlets

connected in parallel to the inlet of the high-pressure part (17) of the feed pump (8).

12. The steam boiler for waste incineration according to any of claims 10 or 11, **characterized in that** at least one heater (21) other from the heater (6) located in the combustion chamber is with its inlet connected to the outlet of the high-pressure part (17) of the feed pump (8), wherein the outlet of this heater (21) is connected to the steam drum (3).

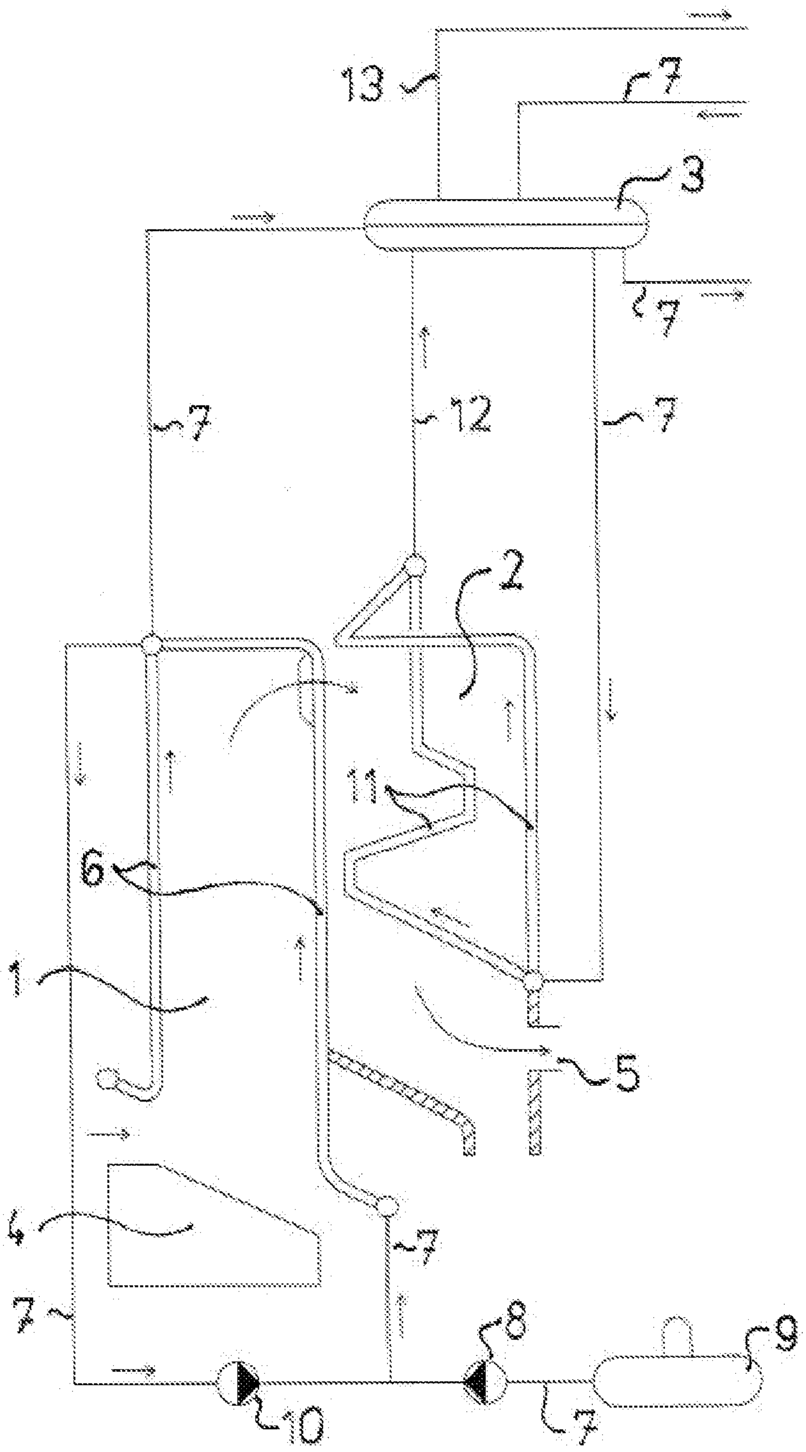

Fig. 1

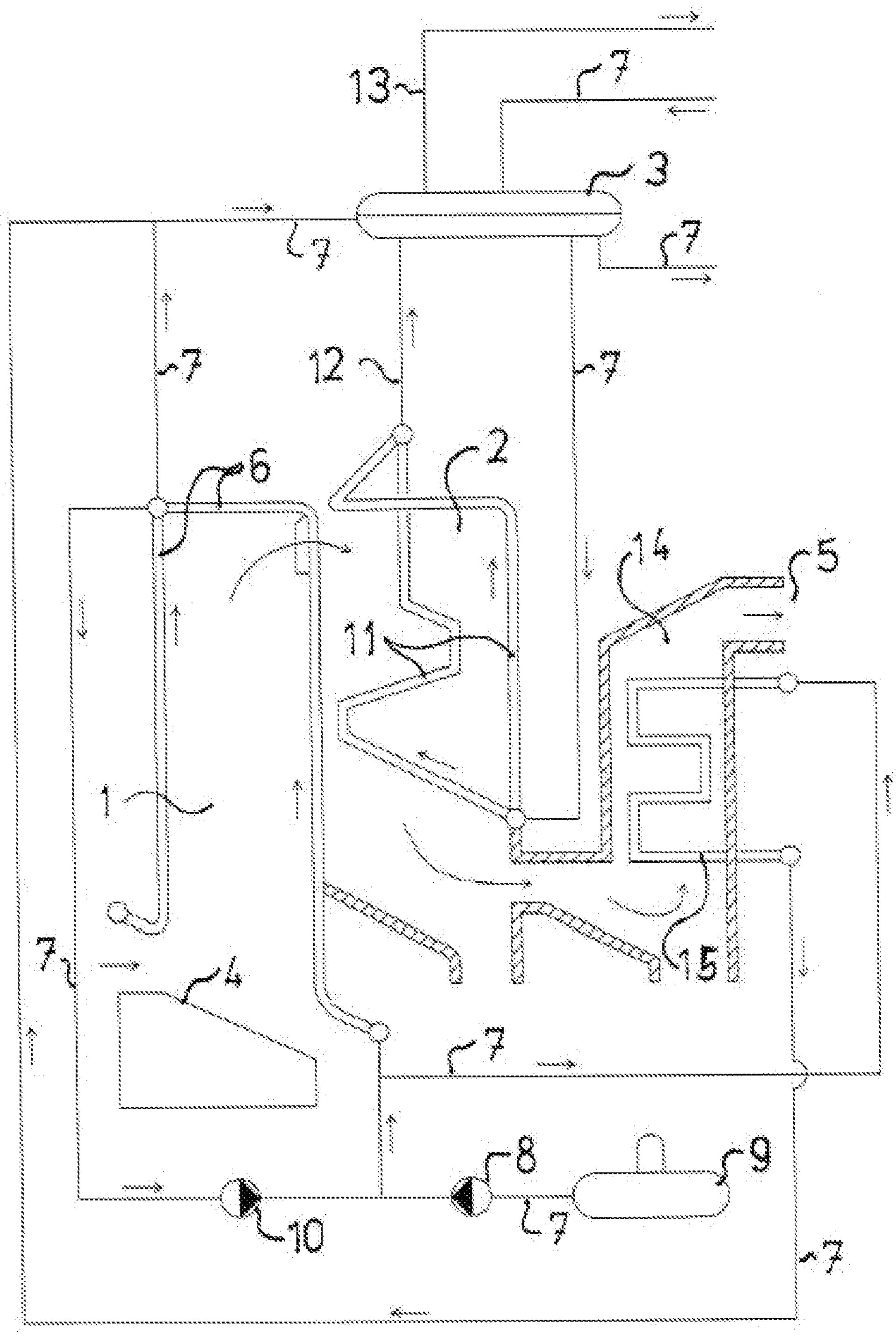

Fig. 2

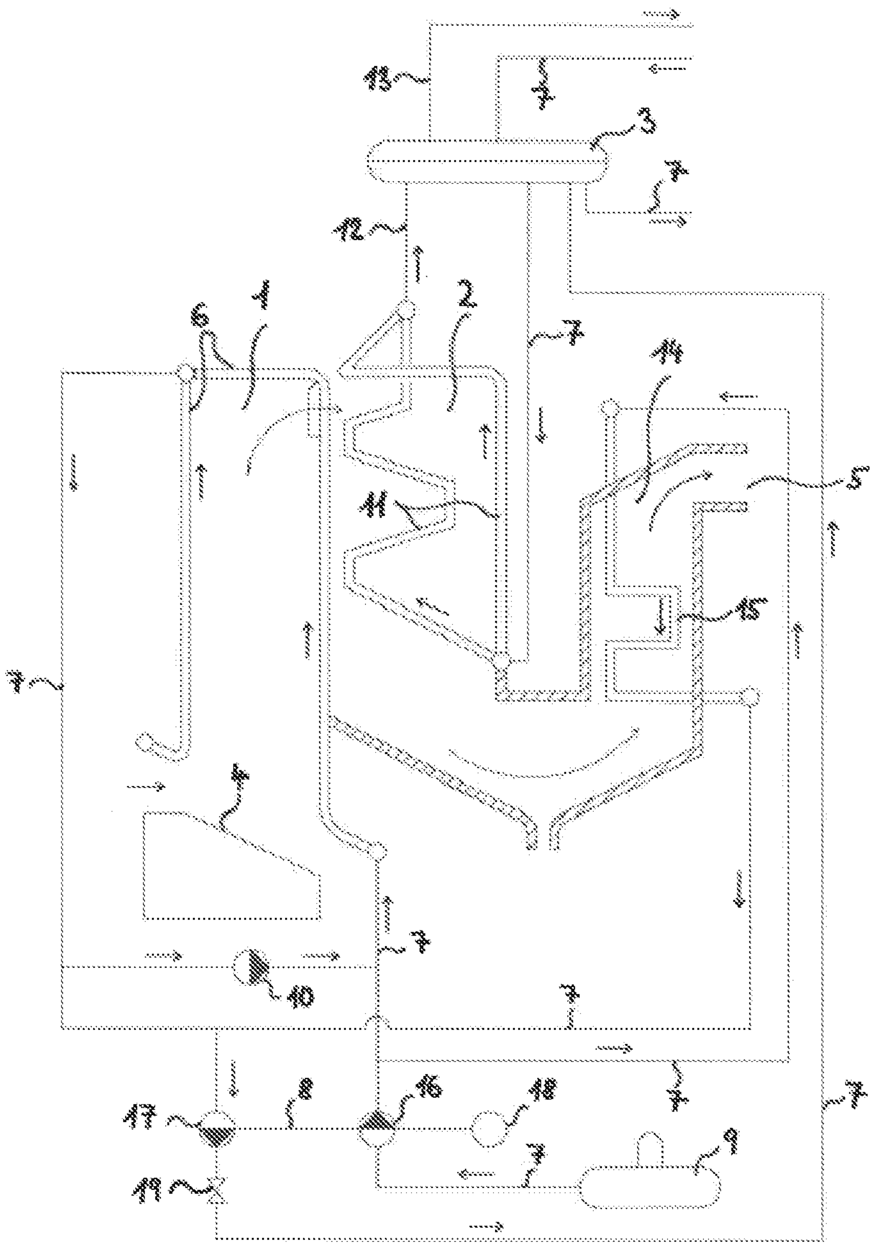

Fig. 3

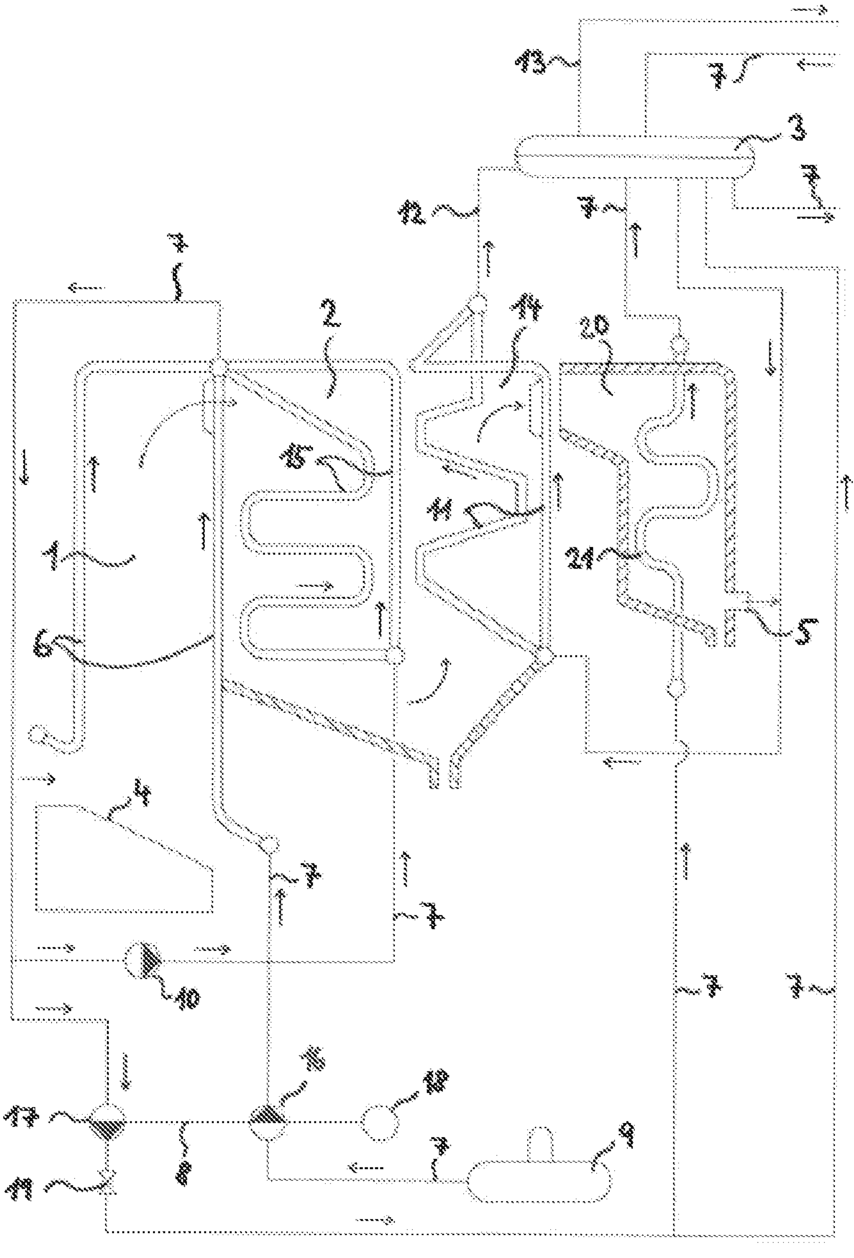

Fig. 4

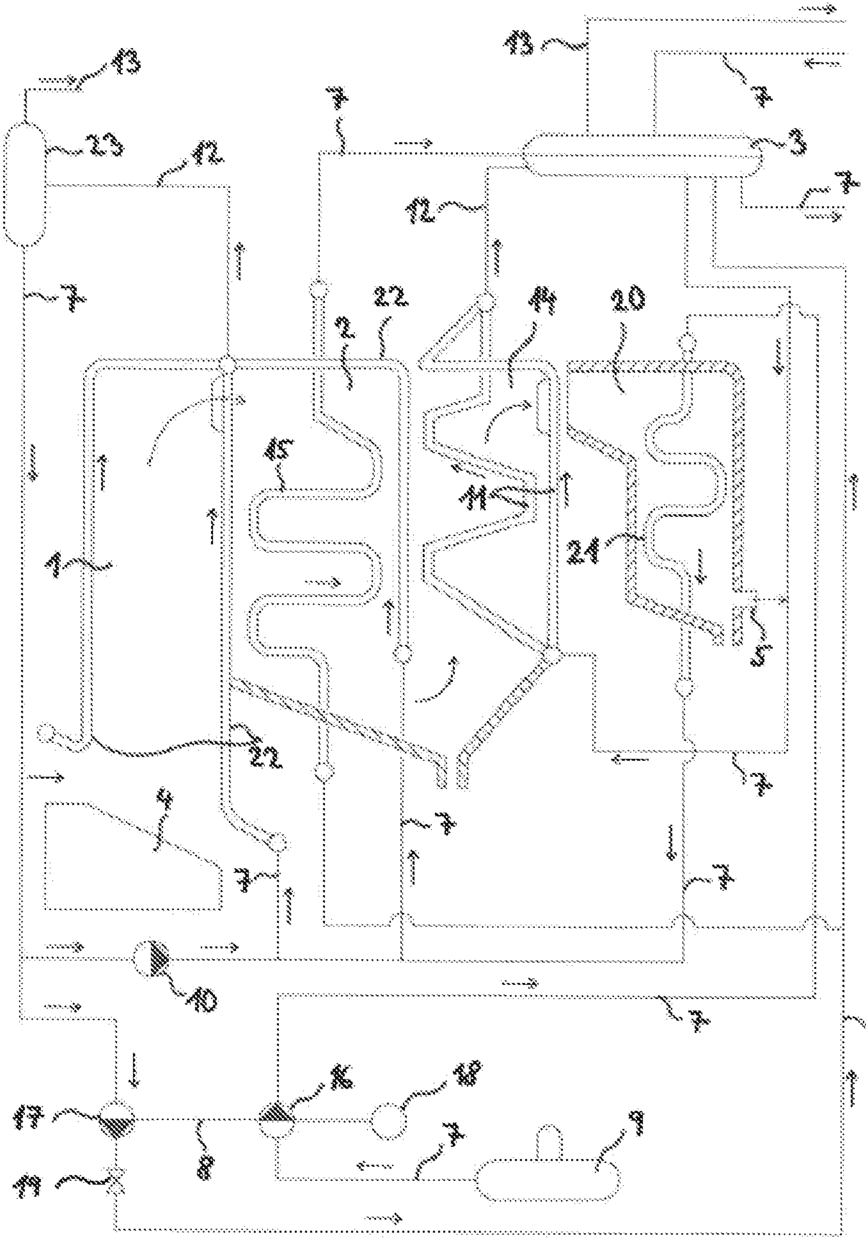
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Fig. 5

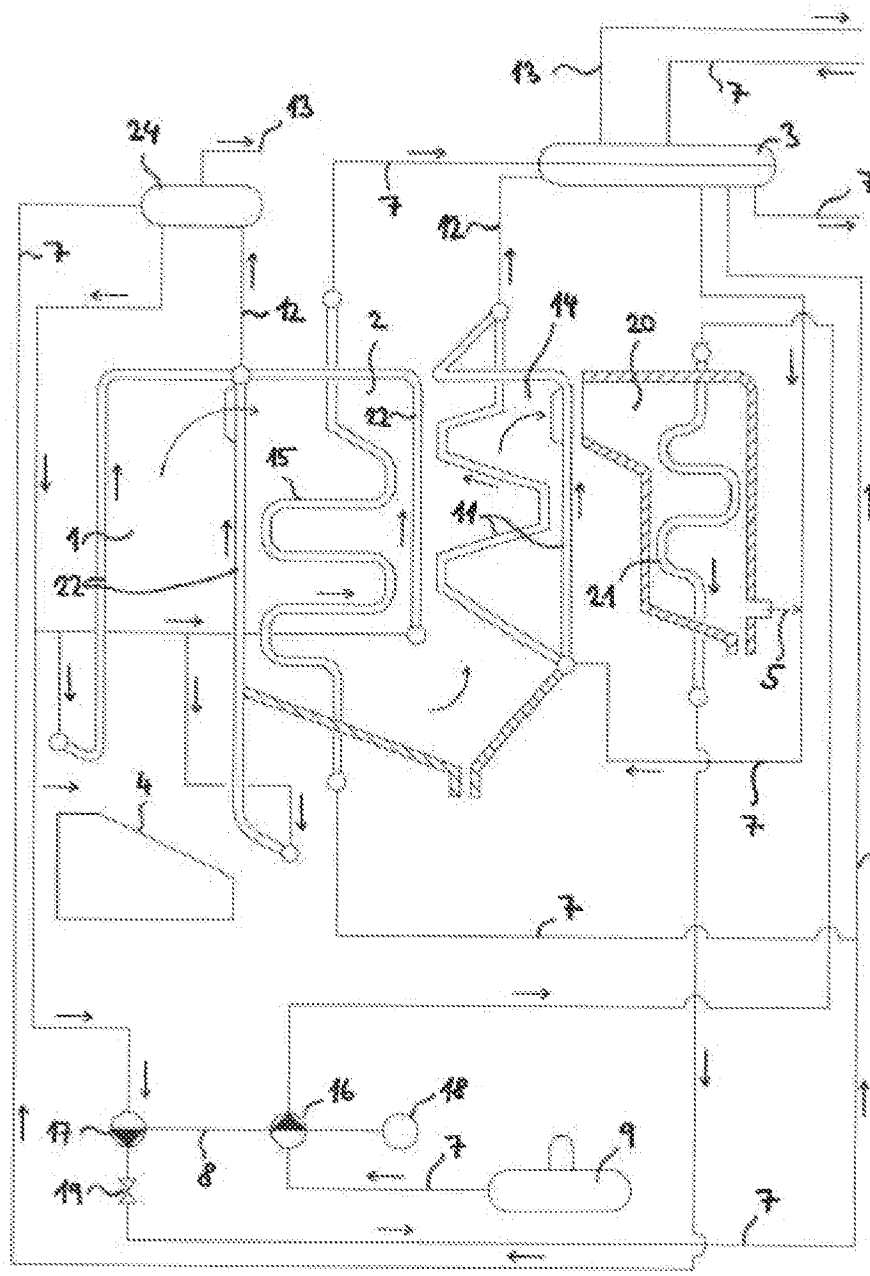

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2019/050056

A. CLASSIFICATION OF SUBJECT MATTER
INV. F22B31/04 F23G5/00 F23G5/44
ADD.

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)
F22B F23G

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/152205 A1 (AAF CONSULT OY [FI]; JANKA PENTTI [FI] ET AL.) 18 December 2008 (2008-12-18) page 3, line 30 - page 8, line 10; claims; figures 1A, 1B abstract -----	1-12
X	EP 1 188 986 A2 (KVAERNER PULPING OY [FI]) 20 March 2002 (2002-03-20) paragraph [0008] - paragraph [0014]; claims; figure abstract -----	1-12
X	WO 98/43017 A1 (AHLSTROM MACHINERY OY [FI]) 1 October 1998 (1998-10-01) page 10, line 8 - page 16, line 14; claims; figures abstract -----	1-12
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

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Date of the actual completion of the international search	Date of mailing of the international search report
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