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(54) **Energy recovery unit**

(57) An energy recovery unit (10) comprising a vessel (12) having a condensate inlet (50) and a condensate outlet (34,36) and a fluid feed line (18) defining a fluid path. First and second heat exchangers (14,16) are located within the vessel and are arranged to transfer heat

from flash vapour and condensate respectively, to fluid in the fluid feed line. The energy recovery unit can be used to recover waste energy from condensate and flash steam and use it to pre-heat process water, such as boiler feed water.

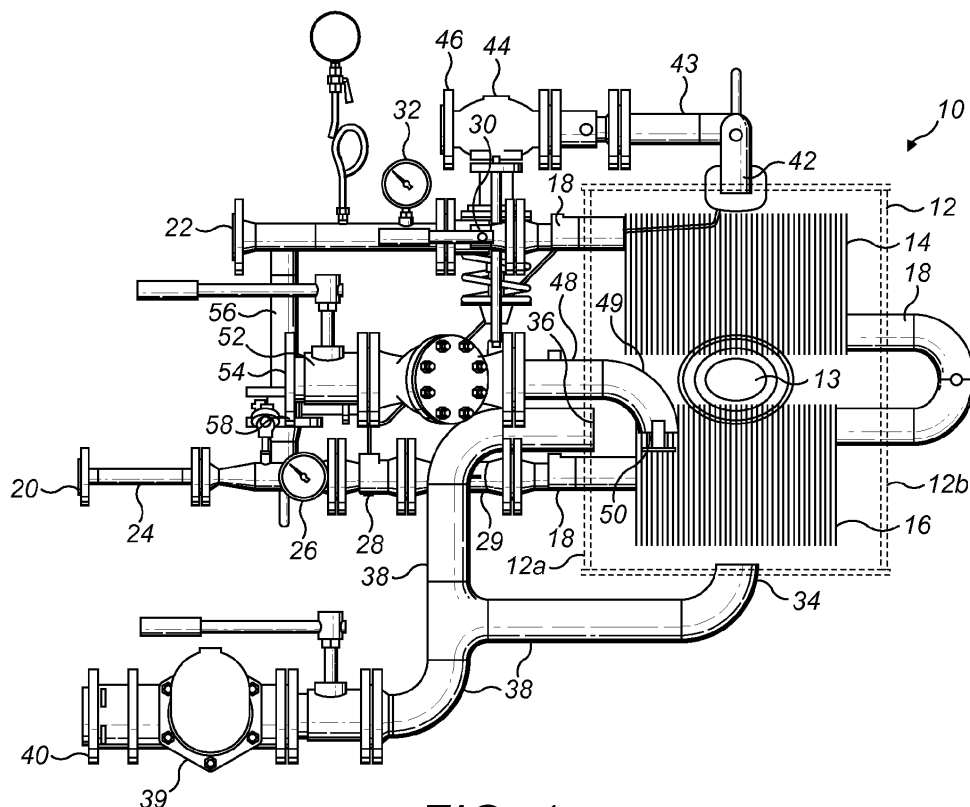


FIG. 1

Description

[0001] The present invention relates to an energy recovery unit which is particularly, although not exclusively, suited for recovering thermal energy from condensate from an industrial process utilising steam as a heating medium.

[0002] In an industrial and heating process utilising steam, steam is generated in a boiler and transferred through pipework at high temperature and pressure to various industrial processes where the energy in the steam is utilised. As the heat in the steam reduces, condensate can form, and it is common for this condensate to be collected at a lower part of the system and periodically removed by means of steam traps. It is common practice for steam traps to discharge to atmospheric pressure. Although the condensate is liquid water under the high pressure prevailing within the system, its temperature may be above 100°C and so it will turn to flash steam when vented to atmospheric pressure. The heat in the condensate is thus lost. This not only represents a waste of energy, but can also incur financial penalties under measures implemented to reduce usage of carbon fuels.

[0003] It is known to use hot condensate, and flash steam derived from the condensate, to pre-heat boiler feed water. For example, US 4,878,457 discloses a system in which boiler feed water flows in series through a heat exchanger, in which heat is transferred to the feed water from recovered condensate, and through a flash condenser to which recovered condensate is supplied.

[0004] However, the prior art system described above comprises a relatively large number of parts that must be assembled on site which results in a relatively complicated, expensive and large installation.

[0005] It is therefore desirable to provide an energy recovery unit which is easier and less expensive to install.

[0006] According to an aspect of the present invention there is provided an energy recovery unit, comprising: a vessel having a condensate inlet and a condensate outlet; a fluid feed line defining a fluid path; and first and second heat exchangers located within the vessel and arranged to transfer heat from flash vapour and condensate respectively, to fluid in the fluid feed line.

[0007] The first heat exchanger may be located above the second heat exchanger in the vessel.

[0008] The first and/or second heat exchanger may comprise a plurality of heat transfer fins in thermal contact with the fluid feed line. The plurality of fins may be stacked horizontally.

[0009] The condensate inlet may be arranged to direct condensate towards the second heat exchanger.

[0010] Preferably the condensate outlet is located towards the bottom of the vessel. The condensate outlet may be one of two or more condensate outlets disposed at different levels in the vessel.

[0011] A condensate outlet pipe may connect the or each condensate outlet to a steam trap.

[0012] The energy recovery unit may further comprise a flash vapour outlet. The flash vapour outlet may be located towards the top of the vessel. A flash vapour outlet pipe may connect the flash vapour outlet to a pressure control valve.

[0013] In an embodiment in accordance with the present invention, the fluid feed line passes through the vessel and the fluid feed path passes through the first and the second heat exchangers. The fluid feed line may be a boiler feed line.

[0014] According to a further aspect of the present invention there is provided a steam utilisation system including a condensate energy recovery unit in accordance with any statement herein.

[0015] The invention may comprise any combination of the features and/or limitations referred to herein, except combinations of such features as are mutually exclusive.

[0016] An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawing, which schematically shows a flash steam and condensate energy recovery unit according to the present invention.

[0017] The condensate energy recovery unit 10 (hereinafter referred to as the energy recovery unit) comprises a cylindrical flash vessel 12, having first and second circular end faces 12a, 12b, with first and second heat exchangers 14, 16 located within the flash vessel 12. In other embodiments the flash vessel 12 may have a square cross-section and/or may be vertically orientated. The first and second heat exchangers 14, 16 are finned-tube heat exchangers and the first heat exchanger 14 is located above the second heat exchanger 16. The first and second heat exchangers 14, 16 each comprise a plurality of substantially circular fins that are horizontally stacked. In other words, the plurality of fins are parallel to one another and each fin lies in a vertical plane.

[0018] It is not essential that the first and second heat exchangers 14, 16 are finned-tube heat exchangers. For example, the heat exchangers 14, 16 may be coiled pipes, heat pipes or loop heat pipes. Further, the first and second heat exchangers 14, 16 may be separate portions of a single heat exchanger.

[0019] The energy recovery unit is provided with a fluid feed line in the form of a boiler feed line 18 that defines a fluid path through the flash vessel 12. The boiler feed line 18 enters the flash vessel 12 through the first end wall 12a and passes through the second heat exchanger 16 before exiting the flash vessel 12 through the second end wall 12b. The feed line 18 is welded to the first and second end walls 12a, 12b. The boiler feed line 18 then re-enters the flash vessel 12 through the second end wall 12b and passes through the first heat exchanger 14 before exiting the flash vessel 12 through the first end wall 12a. Again, the feed line 18 is welded to the first and second end walls 12a, 12b. The fins (or plates) of the first and second heat exchangers 14, 16 are directly attached to the boiler feed line 18 and therefore the fluid

path passes through the first and second heat exchangers 14, 16. The inlet 20 and outlet 22 of the boiler feed line 18 are provided with a coupling flange.

[0020] The portion of the boiler feed line 18 between the inlet 20 and the flash vessel 12 may be fitted with an energy meter 24, a temperature gauge 26, an isolation valve 28 and a strainer 29. The feed line 18 may be provided with other suitable ancillaries. The portion of the boiler feed line 18 between the flash vessel 12 and the outlet 22 is provided with an isolation valve 30 and a temperature gauge 32.

[0021] The flash vessel 12 is provided with first and second condensate outlets 34, 36. The first condensate outlet 34 is positioned at the bottom of the flash vessel 12 and the second condensate outlet 36 is located above the first condensate outlet 34 in the end wall 12a of the flash vessel 12. The first and second condensate outlets 34, 36 are connected by pipework 38 to a steam trap 39. The outlet 40 of the steam trap is provided with a coupling flange. As will be readily apparent to one skilled in the art, only one condensate outlet is necessary.

[0022] The flash vessel 12 is also provided with a flash steam outlet 42 that is located at the top of the flash vessel 12. A flash outlet pipe 43 connects the flash steam outlet 42 to a pressure control valve 44, the outlet 46 of which is provided with a coupling flange.

[0023] The energy recovery unit 10 also comprises a condensate inlet pipe 48, a portion of which extends into the flash vessel 12 through the first end wall 12a. The portion of the condensate inlet pipe 48 located within the flash vessel 12 has a right-angle bend 49 that is angled downwards. In other embodiments the inlet pipe 48 may be straight. The inlet pipe 48 provides the flash vessel 12 with a condensate inlet 50 (the outlet of the condensate inlet pipe 48) that is located towards the top of the stack of fins of the second heat exchanger 16. The condensate inlet 50 is located above the second condensate outlet 36. The portion of the condensate inlet pipe 48 located outside of the flash vessel 12 is provided with an isolation valve 52, the inlet 54 of which is provided with a coupling flange.

[0024] The energy recovery unit 10 further comprises a bypass line 56 that provides fluid communication between the inlet 20 and outlet 22 of the boiler feed line 18, bypassing the flash vessel 12. The inlet of the bypass line 56 is upstream of the isolation valve 28 and the outlet is downstream of the isolation valve 30. The bypass line 56 is also provided with its own isolation valve 58. The bypass line 56 allows the feed water to bypass the heat exchangers 14, 16 of the energy recovery unit 10.

[0025] The unit 10 is in the form of a module or "skid" which is self-contained and can be assembled off site for connection to an existing system. The components and associated pipework are mounted on a rigid support so as to be transportable from an assembly facility to the site at which the unit will be utilised. It will be appreciated that the pipework couplings of the unit are all situated and oriented in the unit so as to make connection to the

associated existing pipework relatively simple. Thus they are situated at or close to the outer extremity of the unit and face outwardly, unobstructed by other pipes or ancillaries. Further, provided that the relative locations of existing pipework connectors are known, the unit can be assembled off site and can be installed rapidly once delivered to site by making the appropriate pipework connections.

[0026] In use, the coupling flanges of the energy recovery unit 10 are connected to the existing pipework of a steam utilisation system.

[0027] The energy recovery unit 10 is connected with the inlet 20 of the boiler feed line 18 connected to a feed tank (not shown) and the outlet 22 of the boiler feed line 18 connected to pipework leading to a boiler (not shown). The outlet 40 of the steam trap 39 is connected to pipework leading to the feed tank (not shown) and the outlet 46 of the pressure control valve 44 is connected to an excess flash steam line (not shown). The inlet 54 of the condensate inlet pipe 48 is connected to the steam utilisation system such that condensate can enter the flash vessel 12 through the condensate inlet 50 of the flash vessel 12.

[0028] In normal operation the isolation valves 28, 30 of the boiler feed line 18 are open and the isolation valve 58 of the bypass line 56 is closed. This allows boiler feed water to flow from the feed tank, through the boiler feed line 18 of the energy recovery unit to the boiler.

[0029] The isolation valve 52 of the condensate inlet pipe 48 is open and therefore condensate enters the flash vessel 12 through the inlet 50. As the condensate enters the flash vessel 12, the pressure is reduced and consequently at least some of the condensate flashes into steam as it enters the flash vessel.

[0030] The flash steam rises within the flash vessel 12 and passes through the horizontal stack of fins of the first heat exchanger 14. The first heat exchanger 14 extracts thermal energy from the flash steam and transfers it to the boiler feed water flowing in the boiler feed line 18. As heat is transferred from the flash steam to the boiler feed water the flash steam condenses and accumulates in the bottom of the flash vessel 12. The first heat exchanger 14 thus operates as a vapour condenser. The condensate passes through the horizontal stack of fins of the second heat exchanger 16 which extracts energy from the condensate and transfers it to the boiler feed water flowing in the boiler feed line 18. The second heat exchanger 16 thus operates as a condensate cooler. The cooler condensate exits the flash vessel 12 through the first and/or second condensate outlets 34, 36 and is returned to the feed water tank via the steam trap 39. Any excess flash steam flows to the feed tank (not shown) through the manual pressure control valve 44 which will be set at an appropriate pressure.

[0031] The location and size of the various inlets and outlets may be chosen so as to maintain a predetermined level of condensate within the flash vessel 12.

[0032] The first heat exchanger 14 is designed to trans-

fer the maximum amount of energy from the flash steam to the boiler feed water. Similarly, the second heat exchanger 16 is designed to transfer the maximum amount of energy from the condensate to the boiler feed water. The first and second heat exchangers 14, 16 may be designed differently in order to extract the maximum amount of thermal energy from steam and condensate respectively. For example, the first and second heat exchangers 14, 16 may have different numbers of fins.

[0033] As an example, the boiler feed water may enter the boiler feed line 18 through the inlet 20 at a temperature of 85°C. The water may be heated to approximately 115°C by the second heat exchanger 16, and from 115°C to approximately 132°C by the first heat exchanger 14. The energy meter 24 is capable of measuring the energy gained by the boiler feed water as it flows through the energy recovery unit. The energy meter comprises three main components, namely; a flow meter, a pair of temperature sensors and a display for displaying the energy gained. The temperature gauges 26, 32 measure the temperature of the boiler feed water as it enters and exits the energy recovery unit 10.

[0034] If necessary, the energy recovery unit 10 can be isolated, without affecting the running of the steam utilising system which it serves, by closing the isolation valves 28, 30 of the boiler feed line 18 and opening the isolation valve 58 of the bypass line 56. In this configuration the boiler feed water bypasses the first and second heat exchangers 14, 16 and therefore the feed water is not preheated. The flash vessel 12 can be inspected using an inspection hole 13.

[0035] The energy recovery unit recovers energy from both flash steam and condensate and uses this steam to pre-heat boiler feed water. As the boiler feed water is preheated, the energy demand of the boiler is reduced.

[0036] The flash steam and condensate energy recovery unit 10 is designed so as to utilise off-the-shelf components, so that the unit can be constructed at relatively low cost, and so that any component requiring replacement can be replaced rapidly and economically. In practice, it is expected that the cost of the condensate recovery unit will be covered, by the resulting energy savings, in less than two years of standard operation.

[0037] Locating first and second heat exchangers 14, 16 within a single vessel 12 reduces the overall size of the energy recovery unit when compared with prior art systems such as that disclosed in US 4878457.

[0038] By recovering substantially all waste heat held in the collected condensate, and returning it to the feed tank, the requirement for make-up water is significantly reduced. this also reduces the requirement for chemical additives that need to be added to any make-up water to maintain the required levels of chemicals in the boiler.

Claims

1. An energy recovery unit, comprising:

a vessel having a condensate inlet and a condensate outlet;
a fluid feed line defining a fluid path; and
first and second heat exchangers located within the vessel and arranged to transfer heat from flash vapour and condensate respectively, to fluid in the fluid feed line.

2. An energy recovery unit according to claim 1, wherein the first heat exchanger is located above the second heat exchanger in the vessel.

3. An energy recovery unit according to claim 1 or 2, wherein the first and/or second heat exchanger comprises a plurality of heat transfer fins in thermal contact with the fluid feed line.

4. An energy recovery unit according to claim 3, wherein the plurality of fins are stacked horizontally.

5. An energy recovery unit according to any preceding claim, wherein the condensate inlet is arranged to direct condensate towards the second heat exchanger.

6. An energy recovery unit according to any preceding claim, wherein the condensate outlet is located towards the bottom of the vessel.

7. An energy recovery unit according to any preceding claim, further comprising a second condensate outlet located above the condensate outlet.

8. An energy recovery unit according to any preceding claim, wherein a condensate outlet pipe connects the or each condensate outlet to a steam trap.

9. An energy recovery unit according to any preceding claim, further comprising a flash vapour outlet.

10. An energy recovery unit according to claim 9, wherein the flash vapour outlet is located towards the top of the vessel.

11. An energy recovery unit according to claim 9 or 10, wherein a flash vapour outlet pipe connects the flash vapour outlet to a pressure control valve.

12. An energy recovery unit according to any preceding claim, wherein the fluid feed line passes through the vessel.

13. An energy recovery unit according to claim 12, wherein the fluid feed path passes through the first and/or the second heat exchanger.

14. An energy recovery unit according to any preceding claim, wherein the fluid feed line is a boiler feed line.

15. A steam utilisation system including an energy recovery unit in accordance with any one of the preceding claims.

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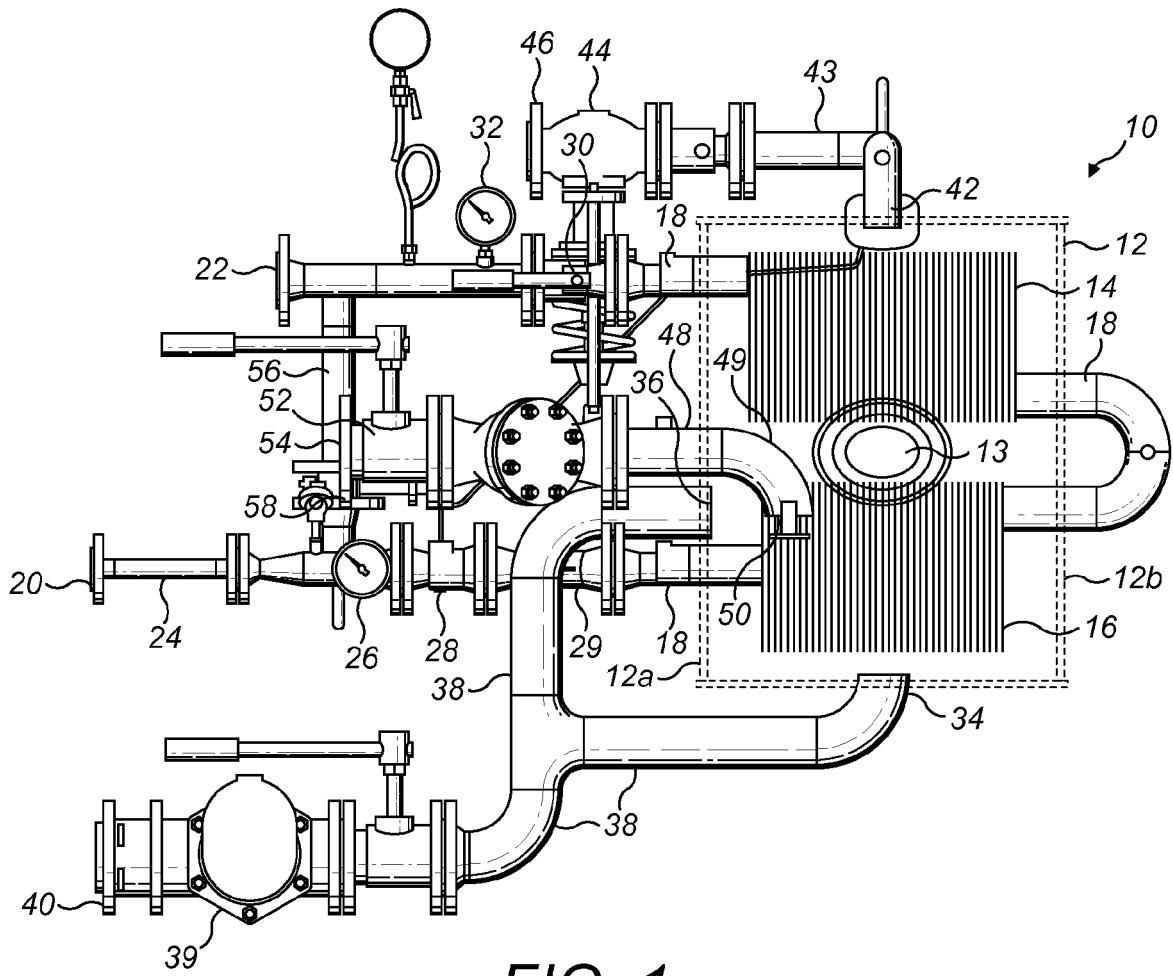


FIG. 1

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4878457 A [0003] [0037]