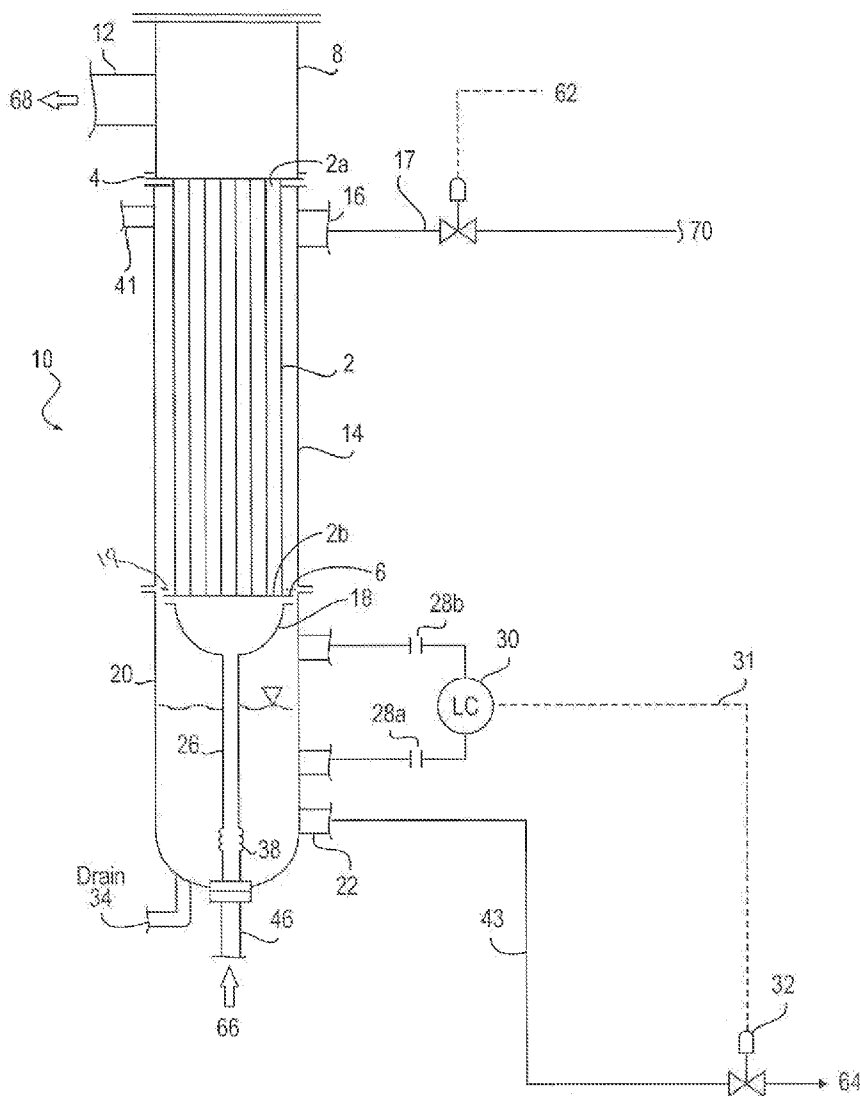




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Jackowski et al.(10) **Pub. No.: US 2014/0008034 A1**(43) **Pub. Date: Jan. 9, 2014**(54) **INTEGRATED THERMOSIPHON
REBOILER-CONDENSATE POT SYSTEM
AND PROCESS FOR USE THEREOF****Publication Classification**(51) **Int. Cl.**
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(US)(21) Appl. No.: **13/542,030**(22) Filed: **Jul. 5, 2012**(57) **ABSTRACT**

Disclosed is an integrated thermosiphon reboiler-condensate pot which integrates a condensate collection volume into a thermosiphon reboiler and avoids the need for an external condensate pot or steam trap. Also disclosed are a method for operating the integrated thermosiphon reboiler-condensate pot, a system including the integrated thermosiphon reboiler-condensate pot and a method for retrofitting an existing thermosiphon reboiler.



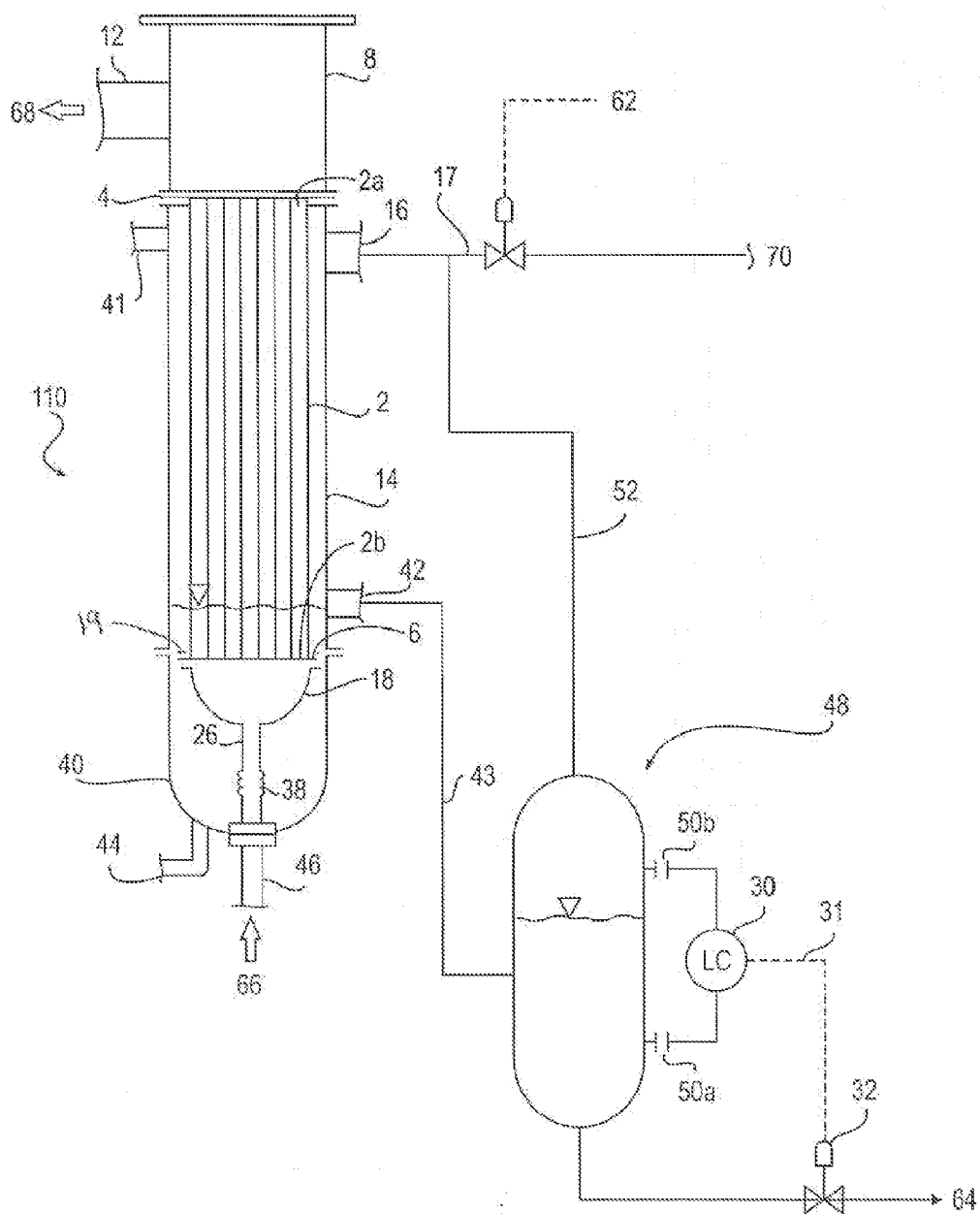


FIG. 1
(Prior Art)

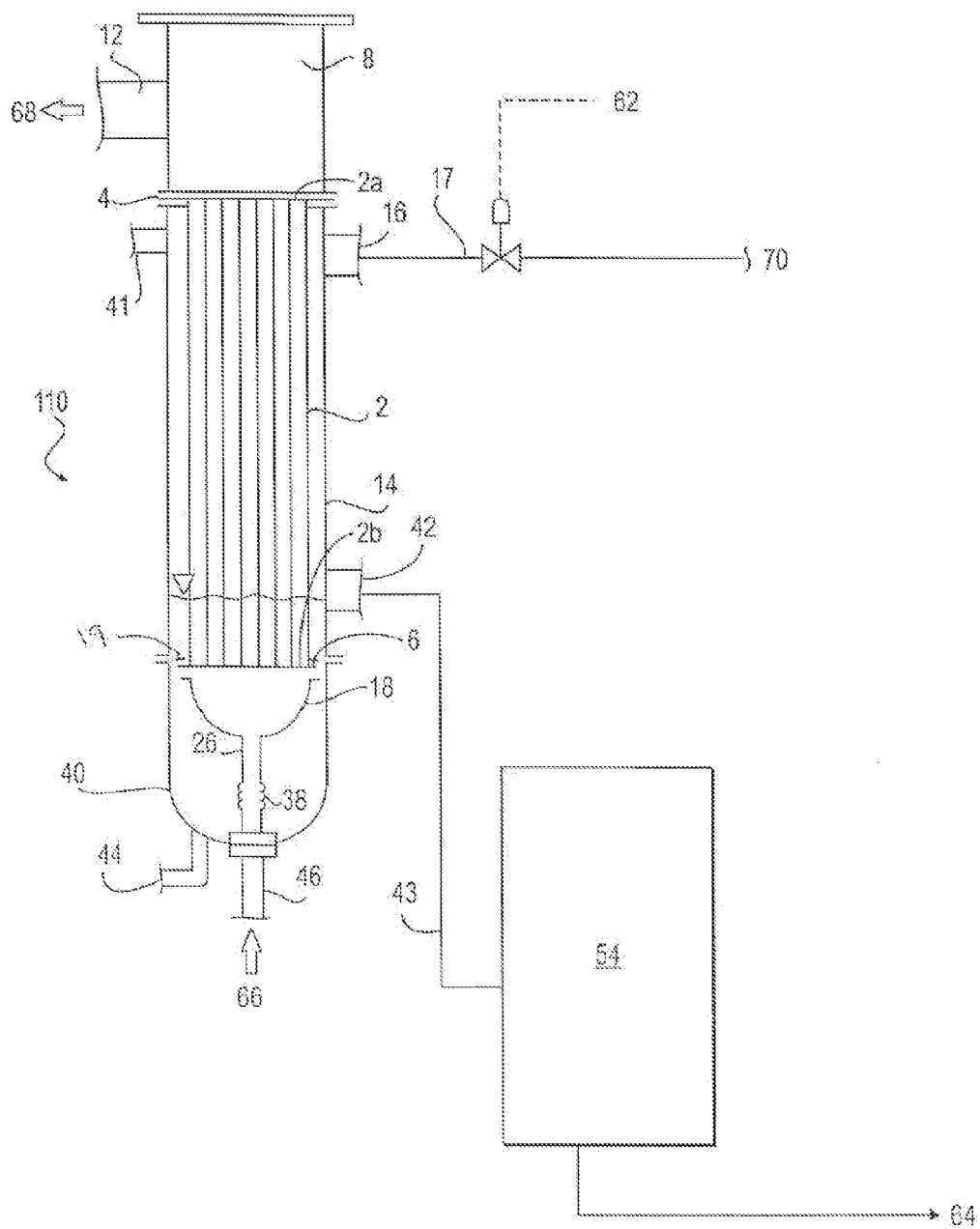


FIG. 2
(Prior Art)

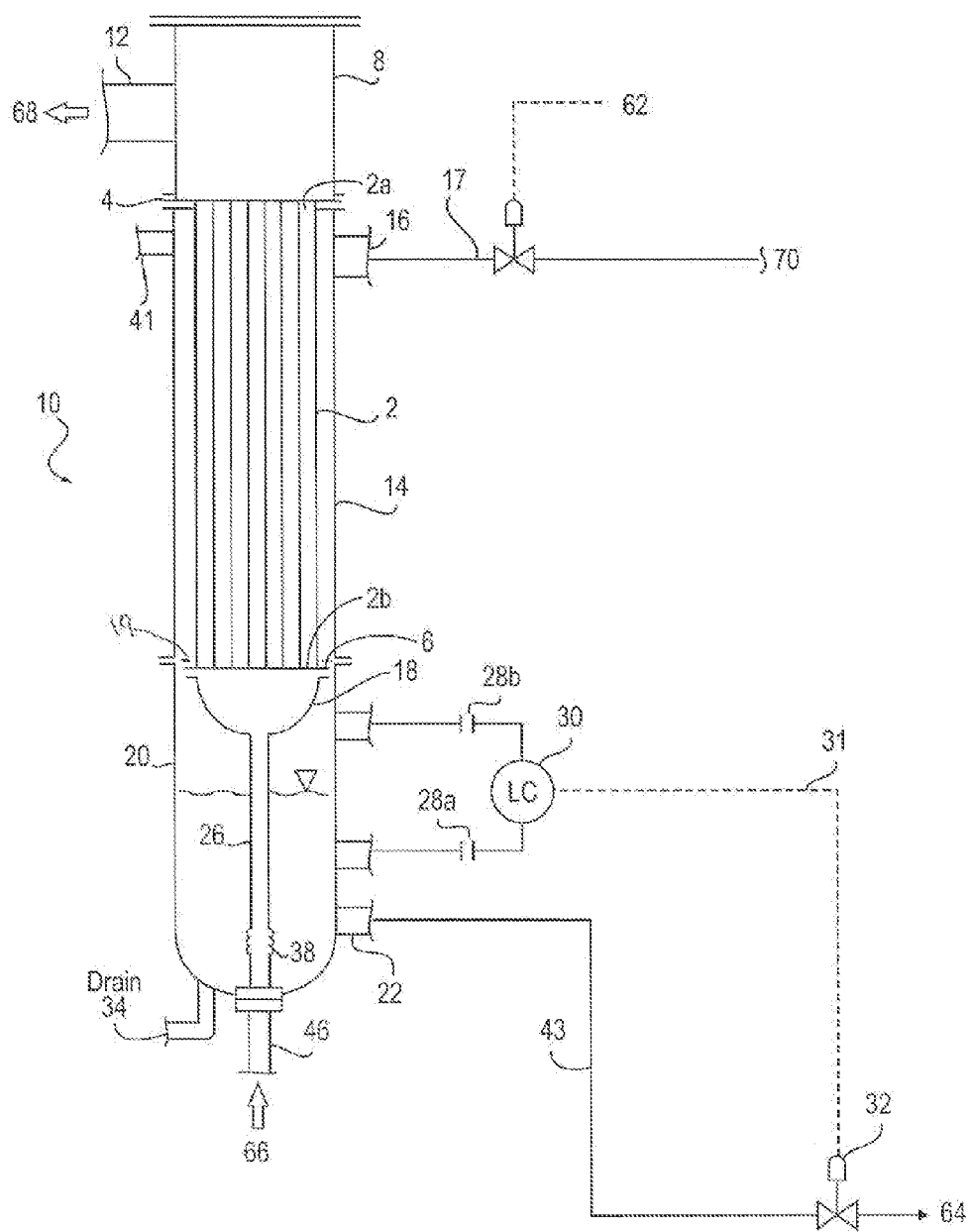


FIG. 3

INTEGRATED THERMOSIPHON REBOILER-CONDENSATE POT SYSTEM AND PROCESS FOR USE THEREOF

FIELD

[0001] The present disclosure relates to a thermosiphon reboiler such as the type used to provide heat to industrial distillation columns, and further relates to a thermosiphon reboiler having a means for collecting condensate.

BACKGROUND

[0002] Thermosiphon reboilers, also referred to as thermosiphon reboilers or calandrias, are commonly used as heat exchangers in industrial processes. Thermosiphon reboilers are commonly used to provide heat to distillation columns or reactors. For instance, thermosiphon reboilers are designed to receive a liquid stream from the column bottom. The liquid is heated to boiling whereupon lower density vapor is generated, rises and is returned to the distillation column to enhance separations within the distillation process. The rising of the vapor creates natural recirculation of the column bottoms from the column, through the reboiler and back to the column without the need for a mechanical pump. Known thermosiphon reboilers may be categorized as vertical or horizontal, and as once-through or recirculating. Steam is generally used as the heat transfer medium.

[0003] Condensate management systems typically used with thermosiphon reboilers include steam traps, flooding reboiler tubes with condensate and use of an external condensate pot. Known systems using steam traps, as depicted in FIG. 2, are commonly subject to failure of moving parts, and are therefore not considered reliable. Another example of a condensate control system used with thermosiphon reboilers is flooding reboiler tubes with condensate to control the reboiler duty by changing an acting surface area of the reboiler. Such systems commonly have reboiler tube failures at the tube-condensate interface. Yet another example of a condensate control system used with thermosiphon reboilers is an external condensate pot or pressure vessel with a balancing or equalizing line provided between the top of the condensate pot and the steam line, as depicted in FIG. 1. This is generally the most reliable of the known condensate control systems; however, such a system requires plot space for the condensate pot, balancing line and associated piping. Such space is not always available in a process plant.

[0004] There remains a need for a way to manage thermosiphon reboiler condensate which would avoid the aforementioned problems.

SUMMARY

[0005] In one aspect, an integrated thermosiphon reboiler-condensate pot is provided. The integrated thermosiphon reboiler-condensate pot includes a plurality of tubes configured to contain a process fluid to be heated, the tubes being supported between an upper tubesheet and a lower tubesheet, and a channel head adjacent and attached to the upper tubesheet such that the channel head and the upper tubesheet together define a channel volume in fluid communication with the tubes and having a two-phase (liquid and vapor) or vapor only outlet. The integrated thermosiphon reboiler-condensate pot further includes a shell defining a shell volume surrounding the plurality of tubes for containing a heating medium and having a heating medium inlet. The integrated

thermosiphon reboiler-condensate pot includes an integrated condensate pot-shell-cover attached to the shell and adjacent the lower tubesheet such that the integrated condensate pot-shell cover and lower tubesheet together define a condensate collection volume for collecting heating medium condensate from the shell volume and having a condensate outlet in fluid communication with the condensate collection volume and a process fluid inlet.

[0006] In another aspect, a method for operating the integrated thermosiphon reboiler-condensate pot to deliver a fluid mixture having a desired heat duty to a distillation column or reactor through the vapor outlet is provided.

[0007] In another aspect, a system is provided including the integrated thermosiphon reboiler-condensate pot and the distillation column or reactor, wherein the integrated thermosiphon reboiler-condensate pot is not connected to an external condensate pot or steam trap.

[0008] In yet another aspect, a method for retrofitting an existing thermosiphon reboiler is provided to result in the integrated thermosiphon reboiler-condensate pot.

DESCRIPTION OF THE DRAWINGS

[0009] These and other objects, features and advantages of the present invention will become better understood with reference to the following description, appended claims and accompanying drawings where:

[0010] FIG. 1 is a schematic diagram illustrating a thermosiphon reboiler with an associated external condensate pot according to the prior art.

[0011] FIG. 2 is a schematic diagram illustrating a thermosiphon reboiler with an associated steam trap according to the prior art.

[0012] FIG. 3 is a schematic diagram illustrating a thermosiphon reboiler with integrated condensate pot according to an exemplary embodiment.

DETAILED DESCRIPTION

[0013] A system including a thermosiphon reboiler 110 connected to an external condensate pot 48, according to the prior art, is shown in FIG. 1. The reboiler 110 includes a plurality of tubes 2 for containing a process fluid to be heated. The upper ends 2a of the tubes 2 are received and supported by apertures in an upper tubesheet 4, and the lower ends 2b of the tubes 2 are received and supported by apertures in a lower tubesheet 6. A shell 14 surrounds the plurality of tubes 2 and defines a shell volume there within in which is contained a heating medium for imparting heat to the plurality of tubes 2. The shell 14 includes a heating medium inlet 16 through which heating medium can be introduced to the shell volume. A heating medium line 17 delivers heating medium, e.g. steam, from a heating medium source 70 to the heating medium inlet 16. The system can be provided with a control valve 62 for controlling the delivery of heating medium to the heating medium inlet 16.

[0014] A channel head 8, also referred to as a head, is attached to the upper end of the shell 14. The channel head 8 is generally attached to the shell 14 by way of bolts (not shown) through flanges with the upper tubesheet 4 there between such that the channel head 8 and the upper tubesheet 4 together define a channel volume. Heated process fluid in the form of liquid and vapor or vapor only rises from the tubes 2 into the channel volume. An outlet 12 in the channel head 8 allows the liquid and vapor or vapor only 68 to be returned to

a column or reactor (not shown) to which the reboiler-condensate pot is connected. The head can be any known construction, e.g., a bonnet or channel type head.

[0015] A shell cover 40 is attached to the lower end of the shell 14. The shell cover 40 is generally attached to the shell 14 by way of bolts through flanges. The shell cover 40, the lower tubesheet 6, and the space between the lower tubesheet 6 and condensate outlet 42 define a condensate collection volume. During use, condensate from the shell volume collects in the condensate collection volume within the shell cover 40 and the space between the lower tubesheet 6 and condensate outlet 42. A condensate outlet 42 is installed typically in the shell 14. In some instances, the condensate outlet 42 may be installed in the shell cover 20 below the lower tubesheet 6. The condensate is sent to an external condensate pot 48 via line 43.

[0016] Condensate pot 48 is equipped with fluid detectors 50a and 50b connected with a level controller 30 for controlling the condensate level within the condensate pot 48 such that the level is maintained between 50a and 50b. The level controller 30 can be connected to a control valve 32 via a signal line 31 which can be used to control the condensate level in the condensate pot 48 and direct condensate to a condensate header 64. Reboiler-condensate pot pressure equalizing line 52 is often provided. As shown, this equalizing line 52 can be tied into the heating medium line 17. Alternatively, the equalizing line may be connected to the heating medium inlet 16 or the shell 14 directly.

[0017] A process fluid inlet 46 is provided in the shell cover 40 through which process fluid 66 is fed from the column or reactor to which the reboiler is connected. The process fluid inlet 46 is in fluid communication with a line, also referred to as process fluid conduit 26, running between the process fluid inlet 46 and the plurality of tubes 2.

[0018] The lower tubesheet 6 is attached to a floating head cover 18 (typically by bolting the floating head cover 18 to a ring flange 19) such that the floating head cover 18 and the lower tubesheet 6 together define a floating head volume in fluid communication with the plurality of tubes 2. The floating head cover 18 acts as a transition between the tubes 2 and the process fluid inlet 46, as channel head 8 acts as a transition between the tubes and outlet 12. The process fluid conduit 26 may include an expansion joint 38 which allows for relative movement due to thermal expansion of the shell 14 relative to the tubes 2 caused by the temperature difference between process fluid and heating medium. Alternatively, a tail pipe with a packing gland may be used in lieu of the expansion joint, as would be apparent to one skilled in the art.

[0019] The shell cover 40 can also include a drain 44 which can be used for draining condensate from the reboiler for the purposes of shutdown, cleaning and the like.

[0020] The reboiler also includes a vent 41 located in the shell 14 for venting vapor or non-condensable gases from the reboiler.

[0021] A similar system according to the prior art utilizing an external steam trap 54 in place of an external condensate pot 48 is shown in FIG. 2.

[0022] An integrated thermosiphon reboiler-condensate pot 10, also referred to interchangeably as the integrated reboiler-condensate pot and the reboiler-condensate pot, according to one embodiment, is shown in FIG. 3. Like reference numerals refer to like elements.

[0023] An integrated condensate pot-shell cover 20 is attached to the lower end of the shell 14. The integrated

condensate pot-shell cover 20 is generally attached to the shell 14 by way of bolts through flanges. The integrated condensate pot-shell cover 20 and the lower tubesheet 6 together define a condensate collection volume. During use, condensate from the shell volume collects in the condensate collection volume within the integrated condensate pot-shell cover 20. The integrated condensate pot-shell cover 20 acts as a condensate pot integrated with the reboiler. A condensate outlet 22 is provided in the integrated condensate pot-shell cover 20 through which condensate can be sent to a condensate header (not shown) where condensate is collected, and may be further used to generate steam. A process fluid inlet 46 is provided in the integrated condensate pot-shell cover 20 through which process fluid 66 is fed from the column or reactor to which the reboiler-condensate pot is connected. The process fluid inlet 46 is in fluid communication with a line, also referred to as the process fluid conduit 26, running between the process fluid inlet and the plurality of tubes 2.

[0024] In one embodiment, the lower tubesheet 6 is attached to a floating head cover 18 (typically by bolting the floating head cover 18 to a ring flange 19) such that the floating head cover 18 and the lower tubesheet 6 together define a floating head volume in fluid communication with the plurality of tubes 2. The process fluid conduit 26 may include an expansion joint 38 or a tail pipe as would be apparent to one skilled in the art.

[0025] In one embodiment, the integrated condensate pot-shell cover 20 is equipped with fluid detectors 28a and 28b connected with a controller 30 for controlling the condensate level within the condensate collection volume such that the level is maintained between 28a and 28b. The level controller 30 can be connected to a control valve 32 connected to the condensate outlet 22. The control valve 32 can be opened to reduce the condensate level in the condensate collection volume.

[0026] The integrated condensate pot-shell cover 20 of the integrated thermosiphon reboiler-condensate pot 10 can also include a drain 34 which can be used for draining condensate from the apparatus for the purposes of shutdown, cleaning and the like.

[0027] The integrated thermosiphon reboiler-condensate pot 10 also includes a vent 41 located in the shell 14 for venting vapor or non-condensable gases from the integrated thermosiphon reboiler-condensate pot.

[0028] The integrated thermosiphon reboiler-condensate pot can be either horizontally or vertically oriented. The integrated thermosiphon reboiler-condensate pot can be either a once-through type reboiler or a recirculating type reboiler.

[0029] In one embodiment, a method for operating the integrated thermosiphon reboiler-condensate pot 10 is provided. A process fluid, such as column bottoms, from a distillation column or reactor is fed to the process fluid inlet 46 of the integrated thermosiphon reboiler-condensate pot 10. The heating medium, such as steam or any other suitable heating medium, is fed through the heating medium inlet 16, thereby heating the process fluid in the plurality of tubes 2 to form a fluid mixture which results in a desired heat duty delivered to the column or reactor, such as a fluid mixture including vapor. The fluid mixture is delivered to the column or reactor through the outlet 12.

[0030] In one embodiment, a system is provided including the integrated thermosiphon reboiler-condensate pot 10 and a distillation column or reactor (not shown) without the need for an external condensate pot or steam trap connected to the

reboiler-condensate pot, with associated foundation, piping, and pressure equalizing line. Such a system offers advantages of reduced space requirements, lower capital cost by eliminating one vessel with foundation and piping, lower maintenance cost by eliminating a vessel, and greater simplicity and reliability.

[0031] According to the present disclosure, the column or reactor can be any equipment which a reboiler is known to supply, including, but not limited to, distillation columns, regenerators, evaporators, batch reactors, continuous stirred tank reactors, and the like. Exemplary distillation unit applications include, but are not limited to, crude stabilizers, naphtha stabilizers, naphtha splitters, de-ethanizers, de-butanizers, de-propanizers, de-pentanizers, amine regenerators, sour water strippers, hydrocracker fractionators, lube oil fractionators and styrene recovery columns.

[0032] In one embodiment, a method for retrofitting an existing, conventional thermosiphon reboiler connected to an external condensate pot or steam trap is provided. In this method, the external condensate pot or steam trap is disconnected from the reboiler, as well as any lines associated with the external condensate pot or steam trap. The shell cover of the existing reboiler is then detached from the shell of the thermosiphon reboiler, and replaced with an integrated condensate pot-shell cover as described above such that the integrated condensate pot-shell cover and lower tubesheet together define a condensate collection volume for collecting condensate.

[0033] Where permitted, all publications, patents and patent applications cited in this application are herein incorporated by reference in their entirety; to the extent such disclosure is not inconsistent with the present invention.

[0034] Unless otherwise specified, the recitation of a genus of elements, materials or other components, from which an individual component or mixture of components can be selected, is intended to include all possible sub-generic combinations of the listed components and mixtures thereof. Also, “comprise,” “include” and its variants, are intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that may also be useful in the materials, compositions, methods and systems of this invention.

[0035] From the above description, those skilled in the art will perceive improvements, changes and modifications, which are intended to be covered by the appended claims.

What is claimed is:

1. An integrated thermosiphon reboiler-condensate pot, comprising:

- a. a plurality of tubes having upper ends and lower ends, the tubes configured to contain a process fluid;
- b. an upper tubesheet having a plurality of apertures to receive the upper ends of the plurality of tubes;
- c. a lower tubesheet having a plurality of apertures to receive the lower ends of the plurality of tubes;
- d. a channel head adjacent and attached to the upper tubesheet such that the channel head and the upper tubesheet together define a channel volume in fluid communication with the tubes and having a vapor outlet;
- e. a shell defining a shell volume surrounding the plurality of tubes for containing a heating medium and having a heating medium inlet in fluid communication with the shell volume;
- f. a floating head cover adjacent and attached to the lower tubesheet such that the floating head cover and the lower

tubesheet together define a floating head volume in fluid communication with the tubes;

- g. an integrated condensate pot-shell cover attached to the shell wherein the integrated condensate pot-shell cover and lower tubesheet together define a condensate collection volume for collecting heating medium condensate from the shell volume, the integrated condensate pot-shell cover having a condensate outlet in fluid communication with the condensate collection volume and a process fluid inlet in fluid communication with the floating head volume; and
 - h. a process fluid conduit providing fluid communication between the process fluid inlet and the floating head volume.
2. The integrated thermosiphon reboiler-condensate pot of claim 1, wherein the integrated condensate pot-shell cover further comprises fluid detectors in communication with a controller for controlling the condensate level within the condensate collection volume.
3. The integrated thermosiphon reboiler-condensate pot of claim 1, wherein the process fluid conduit providing fluid communication between the process fluid inlet and the floating head volume includes an expansion joint or tail pipe.
4. The integrated thermosiphon reboiler-condensate pot of claim 1, wherein the integrated thermosiphon reboiler-condensate pot is vertically oriented.
5. The integrated thermosiphon reboiler-condensate pot of claim 1, wherein the integrated thermosiphon reboiler-condensate pot is one of a once-through type reboiler and a recirculating type reboiler.
6. A method for operating a thermosiphon reboiler comprising:
- a. feeding a process fluid from a distillation column or reactor to the process fluid inlet of the integrated thermosiphon reboiler-condensate pot of claim 1;
 - b. operating the integrated thermosiphon reboiler-condensate pot to heat the process fluid within the plurality of tubes to provide a fluid mixture which results in a desired heat duty delivered to the column or reactor; and
 - c. delivering the fluid mixture to the distillation column or reactor through the vapor outlet.
7. A system for supplying heat to a distillation column or reactor, the system comprising:
- a. a distillation column or reactor; and
 - b. the integrated thermosiphon reboiler-condensate pot of claim 1 wherein the process fluid inlet of the integrated thermosiphon reboiler-condensate pot is in fluid communication with a process fluid stream inlet from the distillation column or reactor and the vapor outlet of the integrated thermosiphon reboiler-condensate pot is in fluid communication with a process fluid stream inlet to the distillation column or reactor; wherein the integrated thermosiphon reboiler-condensate pot is not connected to an external condensate pot or steam trap.
8. A method for retrofitting an existing thermosiphon reboiler having an existing shell cover attached to a shell containing a shell volume and adjacent a lower tubesheet in which the shell cover is connected to an external condensate pot or steam trap, comprising:
- a. disconnecting the external condensate pot or steam trap from the thermosiphon reboiler;
 - b. disconnecting any lines associated with external condensate pot or steam trap;

- c. detaching the existing shell cover from the shell of the thermosiphon reboiler; and
- d. attaching an integrated condensate pot-shell cover to the shell adjacent the lower tubesheet such that the integrated condensate pot-shell cover and lower tubesheet together define a condensate collection volume for collecting heating medium condensate from the shell volume wherein the integrated condensate pot-shell cover has a condensate outlet in fluid communication with the condensate collection volume and a process fluid inlet.

9. The method of claim 8, wherein the integrated condensate pot-shell cover further comprises fluid detectors in communication with a controller for controlling the condensate level within the condensate collection volume.

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