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(54) Title: METHOD OF CONTROLLING SECONDARY CONDENSER DUTY

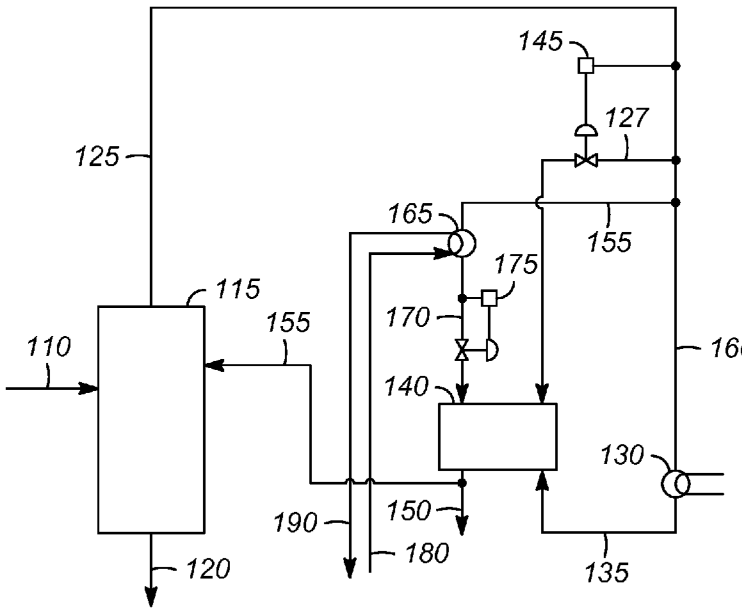

FIG. 2

(57) Abstract: A process for condensing an overhead vapor stream from a distillation column is described. The overhead stream is divided into two portions. The flow rate of the first portion from the first heat exchanger is controlled. The first portion of the overhead stream is introduced into a first heat exchanger to exchange heat with a process stream. The first portion of the condensed overhead stream is introduced into a receiver. The second portion of the overhead stream is introduced into a second heat exchanger to reduce the temperature to condense the second portion. The second portion is introduced into the receiver and combined with the first portion of the condensed overhead stream to form a condensed liquid.

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METHOD OF CONTROLLING SECONDARY CONDENSER DUTY

STATEMENT OF PRIORITY

This application claims priority to U.S. Application No. 13/836,119 which was filed March 15, 2013, the contents of which are hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

Dehydrogenation process units often include fractionators and other process equipment. A feed rich in the desired alkane can be separated in a distillation column into an overhead containing the desired alkane and a bottoms stream containing heavier hydrocarbons. The overhead vapor is condensed and sent to the dehydrogenation unit for conversion to the alkene.

For example, in a propylene plant, a feed 10 rich in propane is sent to a depropanizer 15, as shown in Fig. 1. The feed 10 is separated into a bottoms stream 20 containing butanes and heavier hydrocarbons and an overhead stream 25 containing propane. The overhead stream 25 is sent to a condenser 30 where the overhead stream 25 is condensed into a liquid propane stream 35 which is sent to a receiver 40.

A small amount of the overheard vapor stream 25, hot vapor bypass stream 27, is sent directly to the receiver 40 where it is condensed on the vessel wall and on the subcooled liquid surface in the receiver 40.

The process typically utilizes a single condenser 30, which is positioned at or below the level of the receiver 40 The condenser 30 typically uses water for cooling. The flow rate to the receiver 40 is controlled by a pressure controller 45 which measures the pressure of the overhead stream 25. The liquid propane stream 50 from the receiver 40 is sent to the dehydrogenation reactor (not shown).

A portion 55 of the liquid propane stream 50 from the receiver 40 can be returned to the depropanizer 15.

The feed coming to the depropanizer is typically at a temperature of -35°C. However, the temperature needs to be raised to at least 0°C so that the temperature is appropriate for the feed guard beds for the depropanizer. This is typically done using an available process stream, such as the overhead vapor from a deethanizer column.

SUMMARY OF THE INVENTION

One aspect of the invention is a process for condensing an overhead vapor stream from a distillation column. In one embodiment, the process includes dividing the overhead stream into two portions. The first portion of the overhead stream is introduced into a first heat exchanger to exchange heat with a process stream thereby increasing a temperature of the process stream and reducing the temperature of the first portion of the overhead stream to condense the first portion of the overhead stream. The flow rate of the first portion of the condensed overhead stream from the first heat exchanger is controlled. The first portion of the condensed overhead stream is introduced into a receiver. The second portion of the overhead stream is introduced into a second heat exchanger to reduce a temperature of the second portion of the overhead stream to condense the second portion of the overhead stream. The second portion of the condensed overhead stream is introduced into the receiver and combined with the first portion of the condensed overhead stream to form a condensed liquid.

Another aspect of the invention is a separation process. In one embodiment, the process includes separating a product stream in a distillation column into a liquid bottoms stream and an overhead vapor stream. The overhead stream is divided into two portions. The first portion of the overhead stream is introduced into a first heat exchanger to exchange heat with a process stream thereby increasing a temperature of the process stream and reducing the temperature of the first portion of the overhead stream to condense the first portion of the overhead stream. The flow rate of the first portion of the condensed overhead stream from the first heat exchanger is controlled. The first portion of the condensed overhead stream is introduced into a receiver. The second portion of the overhead stream is introduced into a second heat exchanger to reduce a temperature of the second portion of the overhead stream to condense the second portion of the overhead stream. The second portion of the condensed overhead stream into the receiver is introduced and combined with the first portion of the condensed overhead stream to form a condensed liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an illustration of one embodiment of a prior art depropanizer.

Fig. 2 is an illustration of one embodiment of the process of the present invention.

Fig. 3 is an illustration of another embodiment of the process of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A portion of the overhead vapor from a distillation column can be used to heat a process stream while condensing the portion of the overhead vapor stream to a liquid. The overhead vapor stream from the distillation column is split into two portions. The first portion flows to a first heat exchanger positioned above the receiver for the condensed vapor, while the second portion flows to the heat exchanger of the prior art system, which is positioned at the level of or lower than the receiver.

The first portion flowing to the first heat exchanger should be no more that 80% of the total overhead vapor. The remaining portion of the overhead vapor, which is at least 20% of the total overhead vapor, goes to the second heat exchanger. Putting the two heat exchangers in parallel allows for a lower pressure differential between the pressure at the top of the column and the pressure of the receiver.

The additional heat exchanger provides the energy needed to heat the process stream. In addition, the presence of the additional heat exchanger reduces the amount of cooling water used in the other heat exchanger.

The elevation of the first heat exchanger positioned above the receiver ensures that there is sufficient pressure drop for the control valve in the rundown line between the first heat exchanger and the receiver. The pressure drop is typically at least 10 kPa (0.1 bar).

There is a temperature controller in the rundown line which controls a valve in the line. Desirably, the set point of the temperature controller is set to ensure total condensation of the portion of the overhead vapor stream used to heat the process stream. It can be set for a small amount of subcooling, if desired. The temperature is typically at least 1°C less than the bubble point of the overhead vapor stream. It is desirable to minimize subcooling in order to maximize duty.

The temperature of the liquid at the outlet of the elevated heat exchanger is measured, and the flow rate of the liquid from the heat exchanger is controlled by the valve so that all of the overhead vapor stream into the heat exchanger is condensed. The system is designed to obtain the maximum duty while still ensuring that total condensation of the overhead vapor occurs. The normal column pressure control system can function in its usual manner without hydraulic or other control problems.

The second portion of the overhead vapor stream is cooled in a second heat exchanger with cooling water, as in the prior art. The cooled liquid from the second heat exchanger is also sent to the receiver. The duty of the second heat exchanger is adjusted to pressure control the distillation column. If the required duty is too small control of the column pressure will be difficult.

The second heat exchanger is typically at the level of the receiver or lower. The higher the second heat exchanger is, the lower the pressure drop will be across the hot vapor bypass valve. Positioning the second heat exchanger lower than the receiver ensure a pressure drop across the hot bypass valve.

The hot vapor by-pass flow is adjusted to regulate the liquid accumulation in the second heat exchanger. Liquid retention reduces the heat transfer coefficient and the temperature difference.

The process can be used to heat any process stream which needs to its temperature raised, such as for example, preheating boiler feed water, and the like. In one embodiment, the distillation column overhead is used to heat the feed to the distillation column.

The process can be used with any distillation column[s] in which condensation of the overhead vapor stream is to occur (desirably total condensation), such as for example, depropanizers, naptha splitters, xylene splitters, and the like. Desirably, the overhead vapor stream is completely condensed. The presence of only liquid in the run down line from the first heat exchanger makes the pressure values easier to determine, simplifying selection of appropriate control valves. However, in some situations, partial condensation may be acceptable.

The overhead vapor stream of two or more distillation columns can be combined, if desired.

Fig. 2 illustrates one embodiment of the present invention. The feed 110 to the distillation column 115 is separated into bottoms stream 120 and overhead vapor stream 125. The overhead vapor stream 125 is divided into two portions 155 and 160. The second portion of the overhead vapor stream 160 is sent to heat exchanger 130 where it is cooled with cooling water. The condensed liquid 135 is sent to receiver 140. Hot vapor bypass 127 goes directly to the receiver 140 where it is condensed on the vessel wall and the subcooled liquid surface.

The first portion of the overhead vapor stream 155 flows to a heat exchanger 165. The first portion of the overhead vapor stream 155 is cooled and condensed through heat exchange with process stream 180. The preheated process stream 190 is then sent to another process unit (not shown).

The cooled liquid 170 is sent to the receiver 140. There is a temperature controller 175 between the heat exchanger 165 and the receiver 140. The temperature of the condensed vapor is measured, and the flow rate to the receiver is controlled to ensure that all of the vapor has been condensed in the heat exchanger 165. The condensed liquid 150 from the receiver 140 is sent for processing in a dehydrogenation unit (not shown), and a portion 155 can be returned to the distillation column 115.

Another embodiment is illustrated in Fig. 3. In this embodiment, the process stream to be heated is the feed stream to the distillation column. The feed 210 to the distillation column 215 is separated into bottoms stream 220 and overhead vapor stream 225. The overhead vapor stream 225 is divided into two portions 255 and 260. The second portion of the overhead vapor stream 260 is sent to heat exchanger 230 where it is cooled with cooling water. The condensed liquid 235 is sent to receiver 240. Hot bypass vapor 227 goes directly to the receiver 240 where it is condensed on the vessel walls and on the surface of the subcooled liquid.

The first portion of the overhead vapor stream 255 flows to a heat exchanger 265. The first portion of the overhead vapor stream 255 is cooled and condensed through heat exchange with the feed 205. The preheated feed 210 is then sent to the distillation column 215. The preheated feed 210 can be sent to various other pretreatment units, such as guard beds to remove impurities (not shown), before being introduced into distillation column 215.

The cooled liquid 270 is sent to the receiver 240. There is a temperature controller 275 between the heat exchanger 265 and the receiver 240. The temperature of the condensed vapor is measured, and the flow rate to the receiver is controlled to ensure that all of the vapor has been condensed in the heat exchanger 265. The condensed liquid 250 from the receiver 240 is sent for processing in a process unit, such as a dehydrogenator (not shown). A portion 255 of the condensed liquid 250 from the receiver 240 is returned to the distillation column 215.

In some embodiments, the present invention could be used to provide all of the heating for the process stream. In other embodiments, it might be used to provide only a portion of the heating, with the remainder of the heating being provided in another manner.

Where the overhead vapor stream being used to heat the process stream is the overhead vapor stream from a depropanizer, the overhead vapor stream is propane typically at a temperature in the range of 40°C to 60°C. This overhead propane vapor stream is typically condensed at a temperature of 50°C, with the temperature setpoint for the temperature controller being 49°C when the receiver pressure is 1.7 MPa (g) (17 bar (g)).

Where the stream being heated is the feed to a depropanizer column, and the feed is coming from storage, it is typically at a temperature of -35°C. The feed can be preheated using the present invention to a temperature in the range of 0°C to 54°C, or 20°C to 54°C. The feed stream should not be heated too high because of treater requirements.

When using other overhead vapor streams and process streams to be heated, one of ordinary skill in the art will be able to determine the appropriate amount of cooling and heating for the overhead stream and process stream.

SPECIFIC EMBODIMENTS

While the following is described in conjunction with specific embodiments, it will be understood that this description is intended to illustrate and not limit the scope of the preceding description and the appended claims.

A first embodiment of the invention is a process for condensing an overhead vapor stream from a distillation column comprising dividing the overhead stream into two portions; introducing the first portion of the overhead stream into a first heat exchanger to exchange heat with a process stream thereby increasing a temperature of the process stream and reducing the temperature of the first portion of the overhead stream to condense the first portion of the overhead stream; controlling a flow rate of the first portion of the condensed overhead stream from the first heat exchanger; introducing the first portion of the condensed overhead stream into a receiver; introducing the second portion of the overhead stream into a second heat exchanger to reduce a temperature of the second portion of the overhead stream to condense the second portion of the overhead stream; and introducing the second portion of the condensed overhead stream into the receiver and combining it with the first portion of the condensed overhead stream to form a condensed liquid. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein controlling the flow rate of the first portion of the condensed stream comprises measuring a temperature of the first portion of the condensed overhead stream; reducing the flow rate if the temperature of the first portion of the condensed overhead stream is above a predetermined temperature, wherein the predetermined temperature is below a dew point for the overhead vapor stream; and increasing the flow rate if the temperature of the first portion of the condensed overhead stream is below the predetermined temperature. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the predetermined temperature is at least 1°C less than a bubble point of the first portion of the overhead stream. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph further comprising introducing the condensed liquid from the receiver into a dehydrogenation reactor. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the first heat exchanger is positioned above the receiver. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the second heat exchanger is positioned below the receiver. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the overhead stream comprises at least one C2 to C6 alkane. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the process stream is a feed to the distillation column. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the overhead stream comprises propane and wherein the temperature of the feed to the distillation column is increased to at least 0 °C.

A second embodiment of the invention is a separation process comprising separating a product stream in a distillation column into a liquid bottoms stream and an overhead vapor stream; dividing the overhead stream into two portions; introducing the first portion of the overhead stream into a first heat exchanger to exchange heat with a process stream thereby increasing a temperature of the process stream and reducing the temperature of the first portion of the overhead stream to condense the first portion of the overhead stream; controlling a flow rate of the first portion of the condensed overhead stream from the first heat exchanger; introducing the first portion of the condensed overhead stream into a receiver; introducing the second portion of the overhead stream into a second heat exchanger to reduce a temperature of the second portion of the overhead stream to condense the second portion of the overhead stream; and introducing the second portion of the condensed overhead stream into the receiver and combining it with the first portion of the condensed overhead stream to form a condensed liquid. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein controlling the flow rate of the first portion of the condensed stream comprises measuring a temperature of the first portion of the condensed overhead stream; reducing the flow rate if the temperature of the first portion of the condensed overhead stream is above a predetermined temperature, wherein the predetermined temperature is below a dew point for the overhead vapor stream; increasing the flow rate if the temperature of the first portion of the condensed overhead stream is below the predetermined temperature. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the predetermined temperature is at least 1°C less than the bubble point. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph further comprising introducing the condensed liquid from the receiver into the dehydrogenation reaction zone. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the first heat exchanger is positioned above the receiver. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the second heat exchanger is positioned below the receiver. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the overhead stream comprises at least one C2 to C6 alkane. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph- wherein the process stream is the product stream. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the overhead stream comprises propane and wherein the temperature of the product stream is increased to at least 0 °C.

While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention. It being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A process for condensing an overhead vapor stream (125) from a distillation column (115) comprising:

dividing the overhead stream (125) into two portions (155, 160);

introducing the first portion (155) of the overhead stream (125) into a first heat exchanger (165) to exchange heat with a process stream (180) thereby increasing a temperature of the process stream (180) and reducing the temperature of the first portion (155) of the overhead stream (125) to condense the first portion (155) of the overhead stream (125);

controlling (175) a flow rate of the first portion of the condensed overhead stream (1770) from the first heat exchanger (165);

introducing the first portion of the condensed overhead stream (170) into a receiver (140);

introducing the second portion (160) of the overhead stream (125) into a second heat exchanger (130) to reduce a temperature of the second portion (160) of the overhead stream (125) to condense the second portion of the overhead stream (135); and

introducing the second portion of the condensed overhead stream (135) into the receiver (140) and combining it with the first portion of the condensed overhead stream (170) to form a condensed liquid.

2. The process of claim 1 wherein controlling (175) the flow rate of the first portion of the condensed stream comprises:

measuring a temperature of the first portion of the condensed overhead stream (170);

reducing the flow rate if the temperature of the first portion of the condensed overhead stream (170) is above a predetermined temperature, wherein the predetermined temperature is below a dew point for the overhead vapor stream (125) ; and increasing the flow rate if the temperature of the first portion of the condensed overhead stream (170) is below the predetermined temperature.

3. The process of claim 2 wherein the predetermined temperature is at least 1°C less than a bubble point of the first portion (155) of the overhead stream (125).

4. The process of any of claims 1-3 further comprising introducing the condensed liquid from the receiver (140) into a dehydrogenation reactor.

5. The process of any of claims 1-3 wherein the first heat exchanger (165) is positioned above the receiver (140).

6. The process of any of claims 1-3 wherein the second heat exchanger (130) is positioned below the receiver (140).

7. The process of any of claims 1-3 wherein the overhead stream (125) comprises at least one C_2 to C_6 alkane.

8. The process of any of claims 1-3 wherein the process stream (205) is a feed (210) to the distillation column (215).

9. The process of claim 8 wherein the overhead stream (225) comprises propane and wherein the temperature of the feed (210) to the distillation column (215) is increased to at least 0 °C.

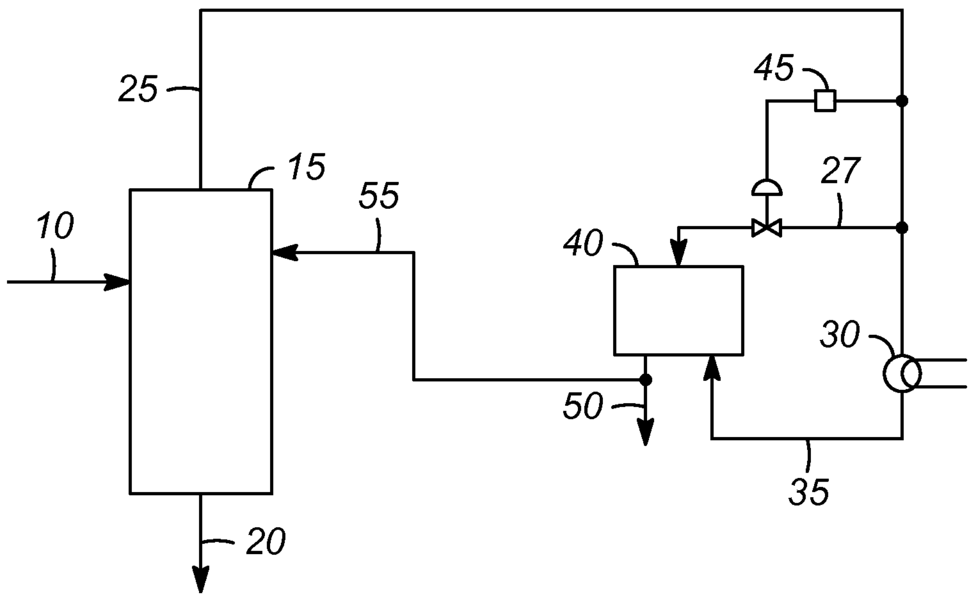
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FIG. 1

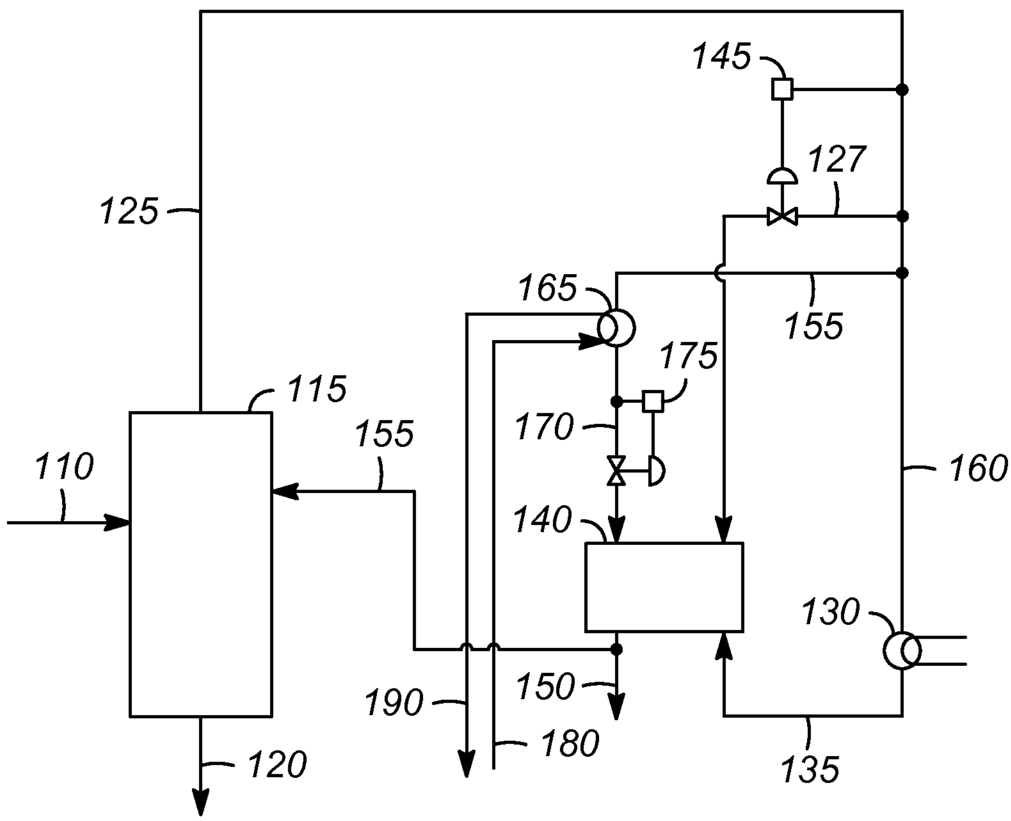
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FIG. 2

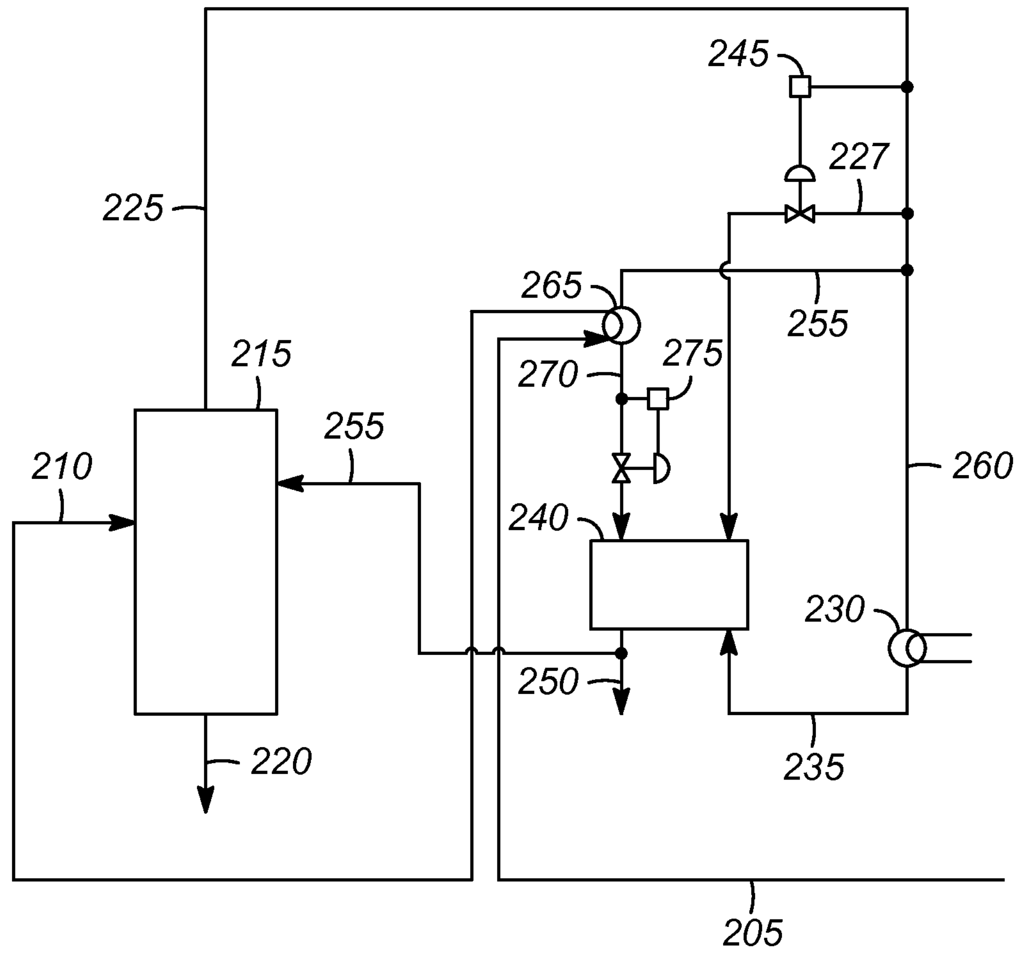
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FIG. 3

INTERNATIONAL SEARCH REPORT	International application No. PCT/US 2014/018144

A. CLASSIFICATION OF SUBJECT MATTER

C07C 7/04 (2006.01)

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)

C07C 7/04

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)

RUPAT BD, PAJ, Espacenet, USPTO DB, EAPATIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5435436 A (DAVID B. MANLEY et al.) 25.07.1995, fig. 1, claims, col. 3, line 34 - col. 5, line 39, col. 7, lines 19-26	1, 4-9 2-3
Y	STICHLMAIR, Johann. Distillation and Rectification. Universitat Gesamthochschule Essen, Essen, Federal Rebublic of Germany, 2005, pp.5-7, DOI: 10.1002/14356007.b03_04 In book: Ullmann's Encyclopedia of Industrial Chemistry	2-3

☐ Further documents are listed in the continuation of Box C.　　☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 May 2014 (28.05.2014)	24 July 2014 (24.07.2014)

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