METHOD OF CONTROLLING SECONDARY CONDENSER DUTY

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ABSTRACT

A portion of the overhead vapor from a distillation column is used to heat a process stream. The temperature and flow rate of the stream out of a heat exchanger are controlled so that the vapor is condensed.
METHOD OF CONTROLLING SECONDARY CONDENSER DUTY

BACKGROUND OF THE INVENTION

[0001] 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.

[0002] 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.

[0003] A small amount of the overhead 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.

[0004] 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).

[0005] A portion 55 of the liquid propane stream 50 from the receiver 40 can be returned to the depropanizer 15.

[0006] The feed coming to the depropanizer is typically at a temperature of about -35°C. However, the temperature needs to be raised to at least about 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 deasphaltizer column.

SUMMARY OF THE INVENTION

[0007] 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.

[0008] 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 is introduced into the receiver and combined with the first portion of the condensed overhead stream to form a condensed liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is an illustration of one embodiment of a prior art depropanizer.
[0010] FIG. 2 is an illustration of one embodiment of the process of the present invention.
[0011] FIG. 3 is an illustration of another embodiment of the process of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0012] 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.

[0013] The first portion flowing to the first heat exchanger should be no more that about 50% of the total overhead vapor. The remaining portion of the overhead vapor, which is at least about 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.

[0014] 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.

[0015] 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 about 10 kPa (0.1 bar).

[0016] 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 about 1°C. less than the bubble point of the overhead vapor stream. It is desirable to minimize subcooling in order to maximize duty.

[0017] 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.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] The overhead vapor stream of two or more distillation columns can be combined, if desired.

[0024] 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.

[0025] 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 steam 190 is then sent to another process unit (not shown).

[0026] 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.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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 about 40°C to about 60°C. This overhead propane vapor stream is typically condensed at a temperature of about 50°C, with the temperature setpoint for the temperature controller being about 49°C when the receiver pressure is about 1.7 MPa (g) (about 17 bar (g)).

[0032] 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 about −35°C. The feed can be preheated using the present invention to a temperature in the range of about 0°C to about 54°C, or about 20°C to about 54°C. The feed stream should not be heated too high because of reactor requirements.

[0033] 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.

[0034] 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 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.

2. The process of claim 1 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.

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

4. The process of claim 1 further comprising introducing the condensed liquid from the receiver into a dehydrogenation reactor.

5. The process of claim 1 wherein the first heat exchanger is positioned above the receiver.

6. The process of claim 1 wherein the second heat exchanger is positioned below the receiver.

7. The process of claim 1 wherein the overhead stream comprises at least one C₂ to C₆ alkane.

8. The process of claim 1 wherein the process stream is a feed to the distillation column.

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

10. 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.

11. The process of claim 10 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.

12. The process of claim 11 wherein the predetermined temperature is at least 1°C. less than the bubble point.

13. The process of claim 10 further comprising introducing the condensed liquid from the receiver into the dehydrogenation reaction zone.

14. The process of claim 10 wherein the first heat exchanger is positioned above the receiver.

15. The process of claim 10 wherein the second heat exchanger is positioned below the receiver.

16. The process of claim 10 wherein the overhead stream comprises at least one C₂ to C₆ alkane.

17. The process of claim 1 wherein the process stream is the product stream.

18. The process of claim 17 wherein the overhead stream comprises propane and wherein the temperature of the product stream is increased to at least 0°C.