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PROCESS AND APPARATUS FOR CONTROLLING THE VAPOR PRESSURE OF THE FEED IN A DISTILLATION OPERATION

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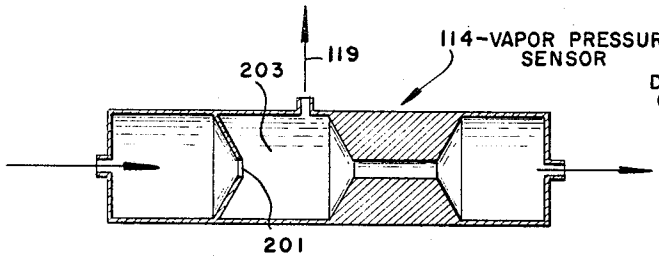


FIG. 2.

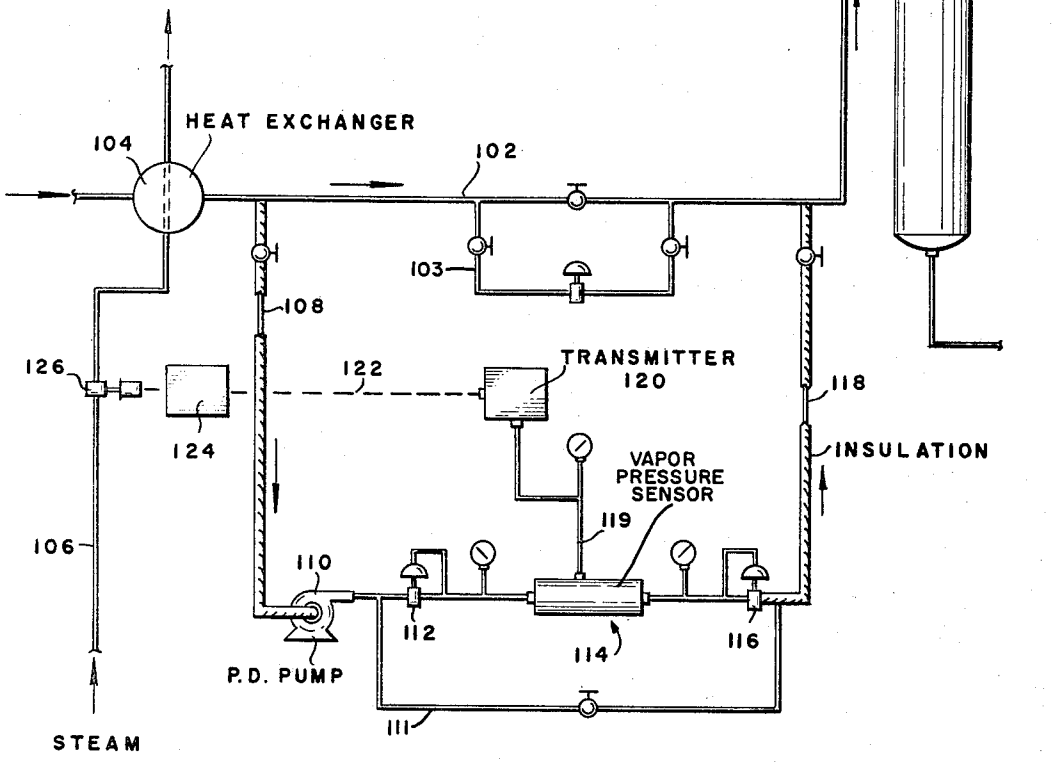


FIG. 1.

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PROCESS AND APPARATUS FOR CONTROLLING THE VAPOR PRESSURE OF THE FEED IN A DISTILLATION OPERATION

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ABSTRACT OF THE DISCLOSURE

The conditions on a feed tray of a fractionating column are dependent upon the vapor pressure of the liquid feed introduced thereon. The present invention provides a method and apparatus whereby the actual vapor pressure of the feed stream is sensed and the desired vapor pressure is controlled as a function of the sensed vapor pressure by changing the heat input into the feed stream. The process and apparatus are particularly applicable to the fractionation of hydrocarbon liquids.

The present invention is related to a system for controlling the conditions of a feed stream to be introduced into the fractionating column on a feed tray. More particularly, the present invention is directed to a process and apparatus whereby the vapor pressure of the feed stream being introduced onto the feed tray of a fractionating column may be directly controlled. In its most specific aspects, the present invention is directed to the control of the vapor pressure of a liquid hydrocarbon stream having a variable composition by sensing the vapor pressure of the feed stream, obtaining a signal directly proportional to the vapor pressure, and controlling the heat input into said feed stream in accordance with said signal. The present invention is particularly suited, although not limited, to those fractionation systems wherein the feed enthalpy constitutes an appreciable portion of the total heat input to the fractionation column.

As currently operated, fractionating towers receive a continuous liquid feed stream onto a feed tray. The vapor pressure of the liquid feed is a prime variable since it is a measure of the enthalpy of the feed and the percent of feed which is flashed on the feed tray. In current practice, the temperature of the liquid feed into the fractionating tower is the primary control variable since the temperature is a parameter of the vapor pressure where the feed composition remains constant. When the feed composition, however, varies over a period of time, the temperature is not a reliable parameter of the vapor pressure because as the feed composition changes, the vapor pressure of each constituent at the given temperature will have a different weighted effect.

Thus, it is seen that if possible, it is better to measure the primary variable (vapor pressure) directly instead of inferentially, and to control that variable with a signal derived from that direct measurement. The vapor pressure can be controlled by changing the temperature, since the vapor pressure is temperature dependent. Thus, by directly measuring the vapor pressure and changing the heat input into the feed stream, the vapor pressure itself may be varied to meet suitable conditions; that is, the vapor pressure can be adjusted to control the enthalpy of the feed and to flash the desired percentage of the components upon introduction into the tower at the feed tray.

The present invention can better be understood by reference to the drawings wherein:

FIG. 1 is a flow sheet depicting the present invention; and

FIG. 2 is a detailed drawing of the vapor pressure sensor.

Referring now to FIG. 1, wherein a preferred embodiment of the present invention is schematically shown, a fractionating tower **100** is shown to be provided with a liquid feed conduit **102** having a heat exchanger **104** interposed therein. The liquid hydrocarbon stream being introduced by way of line **102** is heated in the exchanger **104** by steam provided through line **106**. In order to control the vapor pressure of the feed stream, a sample stream is withdrawn by way of line **108** which is completely insulated to insure the determination of vapor pressure at the temperature prevailing within the feed line **102**. The sample stream is passed through a positive displacement pump **110**, pressure controller **112**, vapor pressure sensing means **114**, and back pressure control valve **116**, and may be returned by way of line **118** into the feed line **102**. In the event that the sample stream is returned to the feed line **102**, it is preferred that the return line **118** be fully insulated.

The sample stream is subjected to a pressure drop within the vapor pressure sensing device **114** so that a portion of the liquid will vaporize at the temperature obtaining in line **102**. This vaporized hydrocarbon exerts a pressure which is sensed by the vapor pressure transmitter **120**, and a signal proportional to the sensed vapor pressure is transmitted by way of line **122** to a control means **124**, which operates valve **126** regulating the amount of steam introduced into the heat exchanger **104**. The vapor pressure transmitter **120** can be any of a number of commercially available instruments designed for that purpose, such as a Type 611 GM Pressure Transmitter manufactured by The Foxboro Company. Thus, it is seen that the vapor pressure of the feed stream upon introduction into the fractionating column is directly controlled in response to the sensed vapor pressure of the heated liquid hydrocarbon feed stream.

The sensing of the vapor pressure within the sample stream is obtained at a controlled pressure drop. As one example, the back pressure valve **116** is set at 130 p.s.i.g., and pressure control valve **112** is set at 400 p.s.i.g. so that the pressure drop across the sensing means **114** is maintained at about 270 p.s.i.g., as compared to a pressure in line **102** of about 110 p.s.i.g. The pressure within the sensing means **114** cannot drop below the vapor pressure of the hydrocarbon at the temperature being sensed, since the loss in energy would be reflected only by an increase in the amount of hydrocarbon vapor being formed.

As seen by reference to FIG. 2, the sensing means **114** is essentially a specially designed jet pump. The velocity of this sample stream is increased at the nozzle **201** of the jet pump, reducing the pressure in the mixing section **203** of the device to a pressure low enough to initiate vaporization of the sample. The vapor pressure sensed through conduit **119** will correlate with the true or ASTM vapor pressures. An exemplary device which can be employed is the Knust Vapor Pressure Analyzer Model HP–1. This model, in contrast to the vapor pressure analyzer commonly employed, does not include means for heating the sample stream, since it is imperative in the present service that the sample stream be maintained at essentially the same temperature as that prevailing in the main liquid hydrocarbon feed line **102**.

The back pressure regulator **116** and the pressure controller **112** serve to maintain a constant stream velocity of the sample at the nozzle and mixing chamber of the vessel sensing device. By utilizing these pressure regulator means, the input pressure may rise higher and the back pressure may fall lower than the preset pressures with no appreciable effect on the vapor pressure measurement within the sensing means **114**.

As exemplary of the problems which face the refiner in fractionating liquid hydrocarbon streams of varying compositions, the following example is presented.

EXAMPLE 1

In a light ends fractionation unit, a feed stream obtained from an alkylation plant is fractionated within a column. This feed stream may vary in its composition within the ranges shown below in Table I.

TABLE I

Composition 1

Component:	Mole percent liquid
Propane	4
Isobutane	71
Normal butane	8
Pentanes	2
C_{6+}	15

Composition 2

Component:	Mole percent liquid
Propane	2
Isobutane	53
Normal butane	7
Pentanes	8
C_{6+}	30

Within the range of this change in composition, the temperature for maintaining a desired vapor pressure of 120 p.s.i. upon the feed tray may range from 150° F. to 175° F. Since the change in composition can occur over a cycle as short as several hours, it is obvious that a continuous system for sampling and directly measuring and controlling the vapor pressure is highly desirable.

By operating with the control system of the present invention, it has been found that vapor pressure on the feed tray can be maintained at 120 p.s.i., plus or minus 3 p.s.i.

Having disclosed our invention in detail, and having presented a preferred embodiment thereof, what is desired to be covered by Letters Patent should be limited not by the specific examples herein given, but rather only by the appended claims.

We claim:

1. Apparatus comprising

a fractionating column having a feed tray,

means for introducing a liquid feed stream onto said feed tray, comprising

conduit means communicating with said feed tray,

heat exchange means interposed in said conduit means,

vapor pressure sensing means comprising a jet pump having a nozzle, a mixing section adjacent thereto, and a conduit communicating with the mixing section through which vapor pressure can be sensed,

slip stream conduit means communicating with said liquid feed conduit means and adapted for passing a sample stream through said vapor pressure sensing means,

means for obtaining a signal directly proportional to the sensed vapor pressure of said slip stream,

and means responsive to the generated signal for varying the heat input into said heat exchanger.

2. A method of controlling the fractional distillation of a liquid stream of varying composition which comprises

continuously indirectly heating said liquid stream to increase the temperature and vapor pressure thereof,

continuously sensing directly the vapor pressure of said liquid stream after it has been heated, obtaining a signal proportional to the sensed vapor pressure,

controlling the vapor pressure in response to said signal by varying the heat input indirectly transferred into said liquid stream, and

introducing said heated liquid stream onto the feed tray of a fractionating column.

3. A method of controlling the fractional distillation of a liquid hydrocarbon stream of varying compositions which comprises

continuously indirectly heating said liquid hydrocarbon stream to increase the temperature and vapor pressure thereof,

withdrawing a sample stream from said heated liquid hydrocarbon stream,

reducing the pressure in said sample stream by an amount sufficient to allow vaporization of a portion of said sample stream,

sensing directly the vapor pressure of said vaporized portion,

obtaining a signal proportional to the sensed vapor pressure,

controlling the vapor pressure of said liquid hydrocarbon stream in response to said signal by varying the heat input indirectly transferred into said liquid hydrocarbon stream,

and introducing said heated hydrocarbon stream onto the feed tray of a fractionating column.

4. A method in accordance with claim 3 wherein the vaporization of a portion of said sample stream is accomplished by passing a constant volume of said sample stream through a jet pump at a controlled pressure drop, and the vapor pressure is sensed within said jet pump.

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