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VAPOR PRESSURE CONTROL PROCESS FOR A BLENDED PRODUCT STREAM

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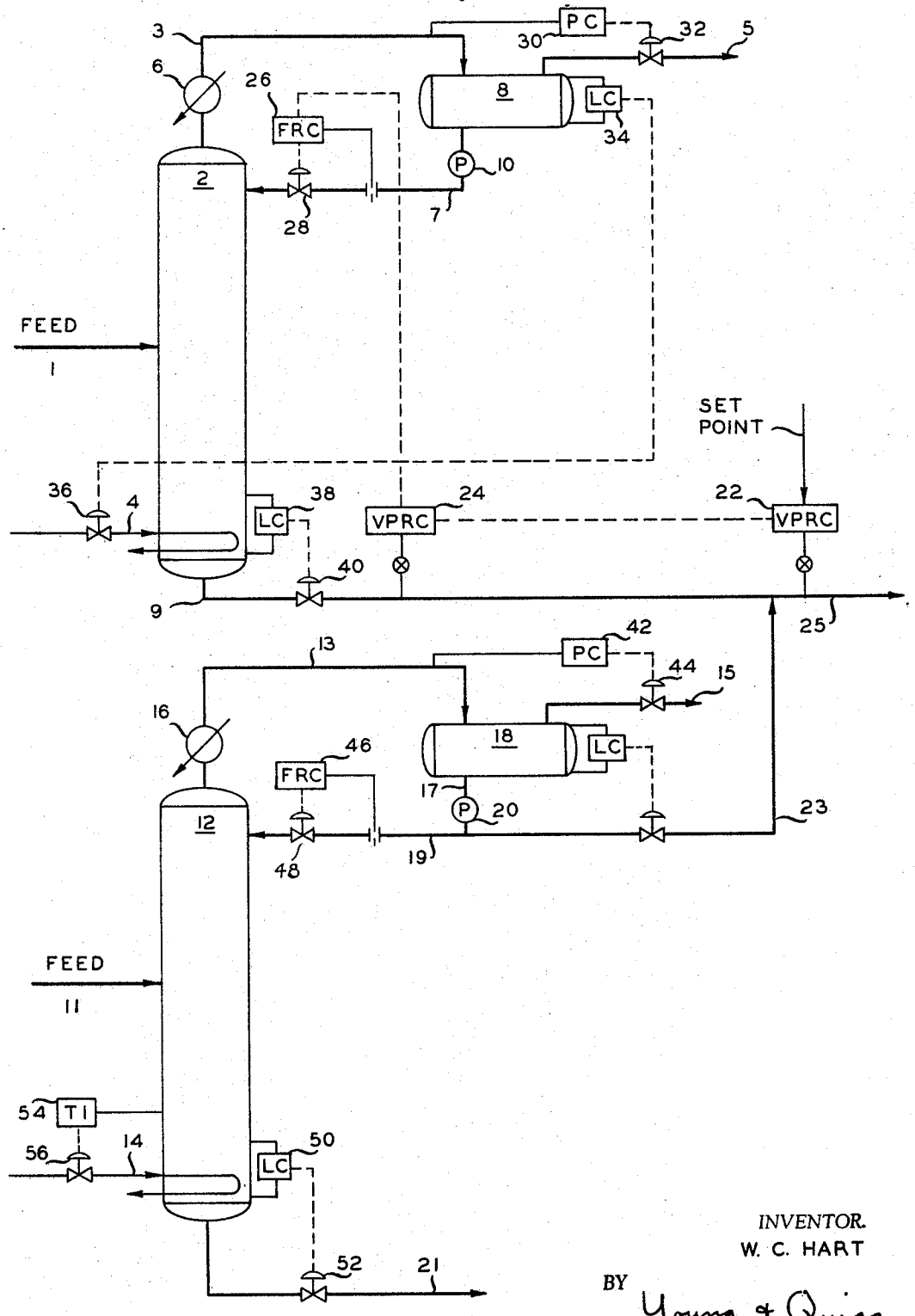

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VAPOR PRESSURE CONTROL PROCESS FOR A BLENDED PRODUCT STREAM

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ABSTRACT OF THE DISCLOSURE

Process and apparatus for continuously producing a product hydrocarbon stream **25** of predetermined constant vapor pressure by continuously blending a first hydrocarbon stream **23** of variable but lower vapor pressure with a second hydrocarbon stream **9** of controlled higher vapor pressure sufficient to maintain said product stream at said constant vapor pressure. Said second hydrocarbon stream is produced by a distillation column **2** having a feed inlet means **1**, a bottom product outlet for supplying said stream **9**, a variable temperature reboiler **4**, and an overhead vapor condenser and reflux accumulator **6**, **8**, said accumulator having a liquid level operated control **34** controlling at **36** the temperature of said reboiler, and having a reflux line **7** connected to said column and containing means **26**, **28** to control the rate of flow of reflux. The vapor pressure of said second hydrocarbon stream is controlled by a first vapor pressure controller **22** measuring the vapor pressure of the product stream relative to a setting of its desired vapor pressure and sending a first control signal to a second vapor pressure controller **24** which measures the vapor pressure of said second hydrocarbon stream relative to said first control signal and sends a second control signal to reset the reflux rate of said reflux control means, thereby adjusting the vapor pressure of said second hydrocarbon stream so as to maintain said product stream at a predetermined constant vapor pressure.

This invention relates to separation of fluid streams. In another aspect this invention relates to the production of fluid streams having predetermined volatilities. In another aspect this invention relates to the control of separation columns.

Much of the commercial demand for liquefied hydrocarbons, such as one containing mostly propane, requires that the hydrocarbons have a certain volatility. The volatility of a hydrocarbon stream varies depending upon the quantity of light and heavy fractions therein. Most generally, hydrocarbons are separated by fractionation, fractional distillation, distillation, and selective absorption. These separation processes do not produce a hydrocarbon fraction having a constant volatility because variations in the feed compositions change the quantities of the light and heavier components remaining with the desired hydrocarbon fraction. Rigid control of such separation processes may produce a pure desired hydrocarbon fraction; however, such stringent controls require loss of the desired fraction to be removed with the other fractions thereby reducing the quantity of production of the desired fraction and making such operation uneconomical. In the past, a hydrocarbon product having a predetermined vapor pressure has been obtained by blending low vapor pressure hydrocarbons and high vapor pressure hydrocarbons. This blending is accomplished by storing hydrocarbon streams in a surge tank and then blending other hydrocarbon streams thereto. This method is not desirable because it requires storage space, does not allow variation in the volatility of the hydrocarbons obtained, and is not operationally and economically efficient.

Accordingly, it is an object of this invention to produce a fluid stream having a predetermined volatility. It is another object of this invention to provide an improved method for blending fluid streams to obtain a fluid stream having a predetermined volatility. It is still another object of this invention to provide control of a separation column to obtain a product having a predetermined volatility. Still another object of this invention is to provide method and control for producing a hydrocarbon stream of varying volatility for blending with a hydrocarbon stream of varying volatility to produce a blend having a predetermined volatility.

In accordance with this invention a liquid product of a separation column is blended with a similar liquid product having a varying and lower volatility to produce a liquid product of predetermined volatility by controlling a process variable of the separation column in response to a volatility measurement of the blended stream to vary the volatility of the liquid produced to maintain a predetermined volatility of the blended stream.

Other objects and advantages of this invention will be apparent from the description and reference to the drawing, which shows a schematic flow diagram and apparatus suitable for practicing the invention.

Referring to the drawing, a mixed liquid feed, containing for example propane and lighter materials, is introduced into separation column **2** through conduit **1**. Heat is added to column **2** by reboiler inlet conduit **4** to effect the separation of ethane and lighter materials therefrom. The light materials vaporized in column **2** are removed therefrom as overhead through conduit **3**, passed through condenser **6** and into accumulator **8**. Noncondensible overhead product is removed from accumulator **8** through conduit **5**. Liquid is removed from accumulator **8** and returned to column **2**, as reflux, through line **7** and pump **10**. Liquid, containing mainly propane, is removed as bottoms product from column **2** through conduit **9**.

A mixed liquid feed, containing, for example, butane and lighter, is introduced to column **12** through conduit **11**. Heat is added to column **12** by reboiler inlet conduit **14** to effect the separation of propane and lighter materials therefrom. The light materials vaporized in column **12** are removed through conduit **13**, passed through condenser **16** and into accumulator **18**. Noncondensible gases are removed from accumulator **18** through conduit **15**. Liquid is removed from accumulator **18** through conduit **17** and pump **20**. A portion of the liquid from conduit **17** is returned to column **12**, as reflux, through conduit **19**. Liquid, containing mainly butane, is removed as bottoms product from column **12** through conduit **21**. The remainder of liquid in conduit **17** is passed through conduit **23**, combined with the liquid in conduit **9**, and passed through conduit **25** as product.

Vapor pressure recorder controller **22** is operatively connected through a transmitter to conduit **25**. Controller **22** compares the vapor pressure of the blended hydrocarbon stream with a set point value which is representative of a predetermined vapor pressure and transmits a corrective signal to vapor pressure recorder controller **24** operatively connected through a transmitter to conduit **9**. Controller **24** compares the vapor pressure of the hydrocarbon stream in conduit **9** with the correction signal from controller **22** and produces a control signal which is transmitted to flow recorder controller **26**, operatively connected to conduit **7**. Controller **26** compares the flow of reflux through conduit **7** with the corrective signal from controller **24** and produces a control signal which is transmitted to valve **28** in conduit **7**. The signal from controller **26** manipulates valve **28** to regulate the flow or reflux through conduit **7**, which varies the operation of column **2** to produce a liquid product having a volatility such that

the blended hydrocarbon streams will have the predetermined volatility.

Presure controller **30**, operatively connected to conduit **3**, produces a signal to manipulate valve **32** in conduit **5** for regulation of vapor removal therethrough. Liquid level controller **34**, operatively connected to accumulator **8**, produces a signal which manipulates valve **36** to regulate the flow of heating medium through reboiler inlet conduit **4**. Liquid level controller **38**, operatively connected to the lower portion of column **2**, produces a signal which manipulates valve **40** in conduit **9** for regulation of the bottoms product withdrawal from column **2**.

Pressure controller **42**, operatively connected to conduit **13**, produces a signal which manipulates valve **44** in conduit **15** for regulation of the venting therethrough. Flow recorder controller **46**, operatively connected to conduit **19**, produces a sign to manipulate valve **48** in conduit **19** for regulation of flow of reflux to column **12** therethrough. Liquid level controller **50**, operatively connected to the lower portion of column **12**, produces a signal to manipulate valve **52** in conduit **21** for regulation of the bottoms product withdrawal from column **12**. Temperature controller **54**, operatively connected to the lower portion of column **12**, produces a signal which manipulates valve **56** to regulate the flow of heating medium through reboiler inlet conduit **14**.

Controllers **22** and **24** can be any combination of sensing elements and devices for determining the vapor pressure of the liquid and converting such to a signal; either electrical, pneumatic, hydraulic, or mechanical; representative of such pressure which will be operative with the conventional recorder controllers and flow recorder controllers employed in the control system. One suitable apparatus for determining vapor pressure of a liquid is that described in U.S. Patent 3,037,375, which is incorporated by reference to this disclosure. The pressure measurement obtained therefrom is passed through a Bourdon tube for conversion to a signal operative with recorder controllers. The vapor pressure control may also be effected by analyzing the liquid streams for the concentration of light constituents therein and controlling the operation of the separation column in response thereto to maintain a predetermined concentration of light materials in the product stream which will give a desired vapor pressure of the blended product. Such component concentration analysis may be made by the well known chromatographic analyzers.

Example

A propane stream having approximately a vapor pressure of 200 p.s.i.g. is produced in accordance with this invention by operating column **2** as a deethanizer wherein 228,000 gallons per day of hydrocarbon feed at a temperature of 76° F. is charged through conduit **1**. Reflux at the rate of about 109,000 gallons per day at 49° F. is returned to the column through conduit **7**. A kettle product of about 90,000 gallons per day at 173° F. is removed from the column through conduit **9**. The top of the column operates at a temperature of about 70° F.

Column **12**, operating as a depropanizer, has a feed charge of 860,000 gallons per day at a temperature of 200° F. through conduit **11**. A reflux of 644,000 gallons per day at a temperature of 111° F. is returned to column **12** through conduit **19**. Overhead product of 167,000 gallons per day at 129° F. is passed through conduit **23** and combined with the product in conduit **9** to form a propane stream having the volatility of 200 p.s.i.g. in conduit **25**. A kettle product of 681,000 gallons per day at 260° F. is removed from column **12** through conduit **21**. The vapor pressure of the propane stream in conduit **23** is lower than that desired in conduit **25** whereas the vapor pressure of the propane stream in conduit **9** is greater than that desired in conduit **25**. When the vapor pressure of the propane in conduit **25** is below that of the predetermined value, controller **22**, operating in a cascade system with controller **24**, signals controller **26** to change the flow through conduit **7** by decreasing it to decrease the reflux rate in column **2** which raises the liquid level in accumulator **8**, causing liquid level control **34** to decrease the flow of heating fluid through valve **36** and reboiler **4** and allow more light material to pass through conduit **9**. Conversely, when the vapor pressure of the propane stream in conduit **25** is greater than the predetermined value, the control signal operates to increase the rate of flow through conduit **7** to column **2** which lowers the liquid level in accumulator **8**, causing liquid level control **34** to increase the flow of heating fluid through valve **36** and reboiler **4** and thereby decrease the quantity of light material passing through conduit **9**.

The compositions of the various streams used in the above example are listed below in table form in pound moles.

TABLE

Component	Column 2			Column 12			
	1	5	9	11	23	21	15.1
C_1 methane	10.1	10.1	------	1.1	------	------	1.2
C_2 ethane	65.9	56.6	9.3	10.9	10.7	------	
C_3 propane	185.2	21.7	163.5	578.8	511.2	67.6	------
iC_4 isobutane	4.0	.1	3.9	306.8	12.3	294.5	------
nC_4 normal butane	0.7	------	0.7	890.9	0.5	890.4	------
iC_5 isopentane	------	------	------	9.0	1.0	8.0	------
Total	265.9	88.5	177.4	1,797.5	535.7	1,260.5	1.3

From the above example it is apparent that this invention permits the separation columns to be operated at conditions to obtain the maximum amount of recovery of the desired hydrocarbon and still allow the recovered hydrocarbon stream to have a predetermined volatility.

This invention is applicable to all fluid streams where the volatility of same is to be maintained at a certain value. Most generally, such fluids will be hydrocarbons having from 2 to 4 carbon atoms per molecule.

Reasonable variations and modifications of this invention will be apparent to one skilled in the art without departing from the spirit and scope of this invention.

That which is claimed is:

1. Process for producing a product stream of constant volatility comprising:

blending a stream of higher vapor pressure with a stream of lower vapor pressure;

sensing the vapor pressure of said blended stream;

varying the reflux rate of a fractionating column producing said higher vapor pressure stream in response to said sensed vapor pressure whereby the vapor pressure of said higher vapor pressure stream is varied inversely with said sensed vapor pressure and said sensed vapor pressure is maintained constant.

2. Process for producing a product stream of constant volatility comprising:

blending a stream of higher vapor pressure with a stream of lower vapor pressure;

sensing the vapor pressure of said blended stream and generating a first signal representative of the difference between said sensed vapor pressure and a predetermined vapor pressure;

comparing said first signal with a second signal representative of the vapor pressure of said higher vapor pressure stream and generating a third signal representative of the difference therebetween;

varying the reflux rate of a fractionating column producing said higher vapor pressure stream in response to said third signal whereby the vapor pressure of said higher vapor pressure stream is increased responsive to a decrease in the vapor pressure of said blended stream and decreased responsive to an increase in the vapor pressure of said blended stream.

3. Process of claim 2 wherein said higher vapor pressure stream is produced from a distillation column below the level of reflux introduction.

4. Process of claim 3 wherein said lower vapor pressure stream is produced from a distillation colunm above the level of reflux introduction.

5. Process for producing a blended hydrocarbon stream of a predetermined vapor pressure comprising the steps of:

fractionating a first hydrocarbon feed stream to produce an overhead product of lower vapor pressure than said predetermined vapor pressure;

fractionating a second hydrocarbon feed stream in a column provided with a variable rate of reflux to produce a bottoms product having a vapor pressure higher than said predetermined vapor pressure, and measuring the vapor pressure thereof;

blending said overhead product and said bottoms product to form said blended hydrocarbon stream;

measuring the vapor pressure of said blended stream and generating a first control signal as a function of the differential between the vapor pressure of said blended stream and said predetermined vapor pressure;

generating a second control signal as a function of said first control signal and the measured vapor pressure of said bottoms product; and

controlling said rate of reflux responsive to said second control signal whereby the vapor pressure of said bottoms product is varied to maintain said predetermined vapor pressure in said blended stream.

6. Apparatus for producing a fluid of constant vapor pressure comprising:

a distillation column having reflux means to return overhead product stream to said column as reflux;

a first conduit adapted to withdraw a first fluid as a product of said distillation column;

a blending means adapted to blend a second fluid with said first fluid;

means for measuring the vapor pressure of said blended fluids and generating a signal responsive thereto; and

means for varying the rate of flow in said reflux means responsive to said signal.

7. Apparatus for continuously producing a blended hydrocarbon stream of predetermined vapor pressure which comprises in combination:

a distillation column having feed inlet means continuously introducing a hydrocarbon feed;

a variable temperature reboiler associated with the lower portion of said column;

an accumulator;

a first conduit having a condenser therein for passing and condensing vapor from said column to said accumulator;

a second conduit having a valve therein for passing liquid from said accumulator to said column as reflux;

a first control means operated by the liquid level of condensate in said accumulator to increase the variable temperature of said reboiler as said liquid level decreases and to decrease the variable temperature of said reboiler as said liquid level increases;

a third conduit for withdrawing liquid from said column;

a fourth conduit communicating with said third conduit for continuously adding a fluid having a varying volatility lower than desired;

a first vapor pressure controller means operatively connected to said third conduit downstream of said fourth conduit disposed to measure the vapor pressure therein relative to a set vapor pressure and to generate a first control signal which is a function of the difference between these pressures;

a second vapor pressure controller means operatively connected to said third conduit upstream of said fourth conduit disposed to measure the vapor pressure therein relative to said first signal and to generate a second control signal which is a function of the upstream vapor pressure and said first signal;

a first control communicating means disposed to communicate said first signal from said first to said second vapor pressure controller means;

a flow controller operatively connected to said valve in said second conduit to control flow of reflux liquid therethrough; and

a second control communicating means disposed to communicate said second signal from said second vapor pressure controller means to control said flow controller.

8. Apparatus for producing a blended hydrocarbon stream of predetermined volatility which comprises:

a distillation column having feed inlet means;

a reboiler associated with the lower portion of said column;

an accumulator;

a first conduit having a condenser therein for passing and condensing vapor from said column to said accumulator;

a second conduit having a valve therein for passing liquid from said accumulator to said column as reflux;

a third conduit for withdrawing liquid from said column;

a fourth conduit communicating with said third conduit for adding a fluid having a varying volatility lower than desired;

a first vapor pressure controller means operatively connected to said third conduit downstream of said fourth conduit;

a second vapor pressure recorder controller means operatively connected to said third conduit upstream of said fourth conduit;

a first control communicating means connecting said first and second vapor pressure recorder controller means;

a flow recorder controller operatively connected to said second conduit and valve therein; and

a second control communicating means connecting said second vapor pressure recorder controller means and said flow recorder controller.

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