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PROCESS CONTROL FOR FRACTIONATION COLUMN

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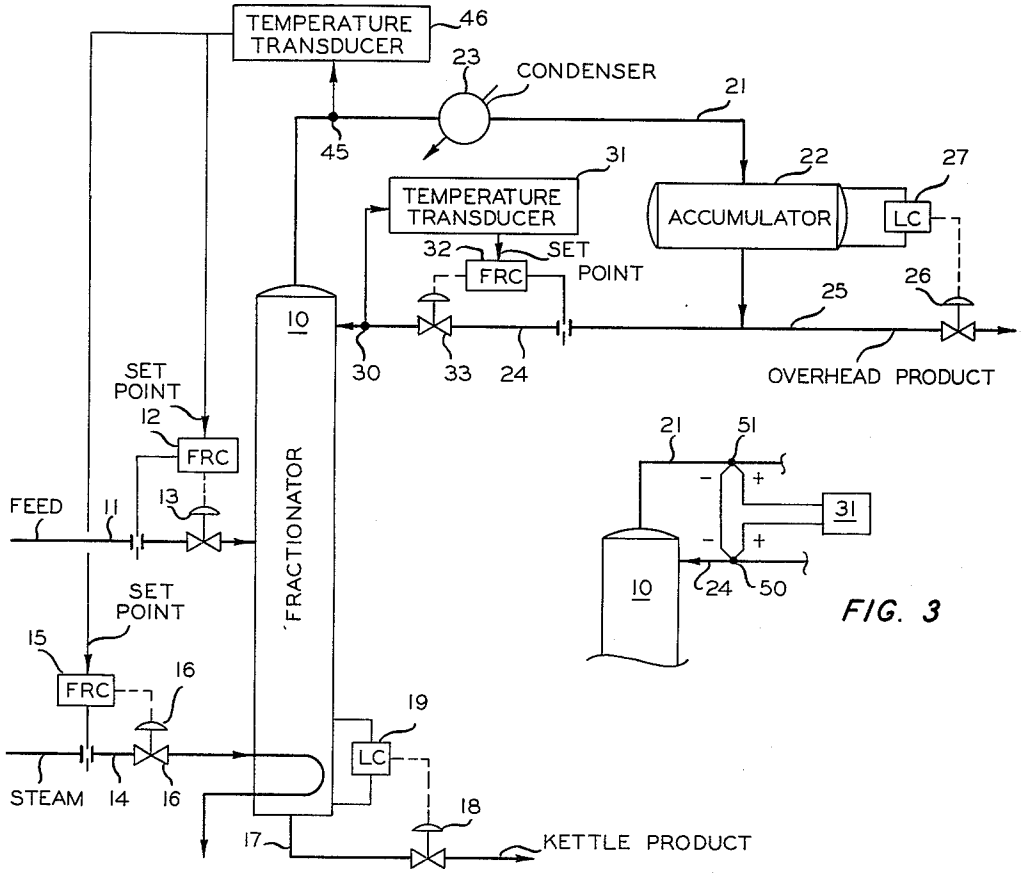


FIG. 1

FIG. 3

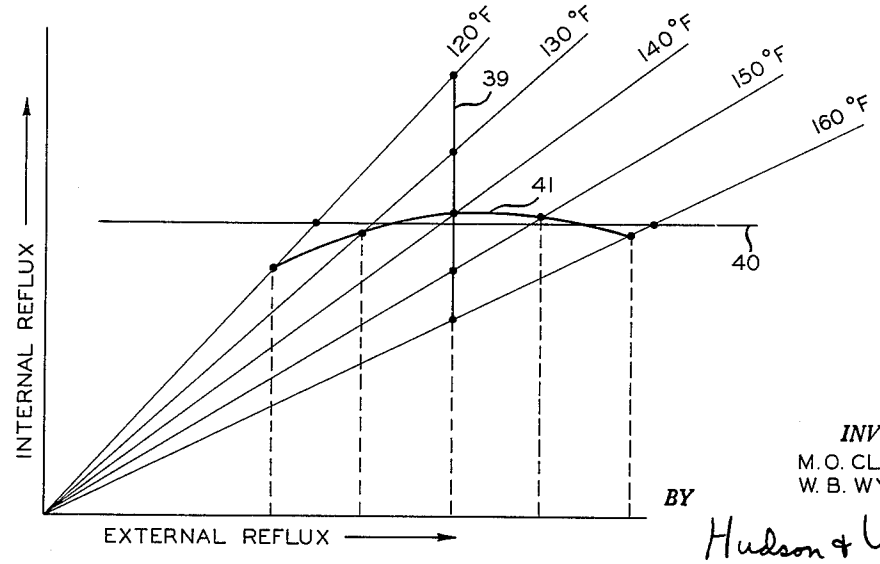


FIG. 2

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PROCESS CONTROL FOR FRACTIONATION COLUMN

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This invention relates to the control of fractionation processes.

In recent years an increasing use has been made of fan coolers for condensing overhead vapors from fractionation columns. However, this type of cooler has resulted in a rather serious operating problem because it is difficult to control the exact amount of cooling provided. Schemes such as fan speed control, variable pitch fan blade control and hot vapor bypass control have been employed in an attempt to solve this problem, but have not been entirely satisfactory. Sudden atmospheric temperature changes, as may occur during a rainstorm, result in the lowering of the reflux temperature. This causes an increase in the flow of liquid leaving the top tray of the column because more of the vapor which enters this tray is condensed. The result of this increased condensation is an increase in overhead product purity at the expense of a decreased overhead product rate.

With conventional control equipment, variations in temperature of the reflux of 10 to 30 degrees from the desired value are not uncommon. If the flow of external reflux to the column is maintained at a constant value, the flow of internal reflux within the column is changed by these temperature fluctuations. A sudden change in internal reflux can upset the operation of the column so that the liquid level in the kettle, the steam supply rate and the overhead vapor withdrawal rate fluctuate in cycles. Still greater changes in the amount of cooling of the overhead vapors must then be made and the cycling can increase in magnitude.

In order to eliminate these difficulties, a computer has recently been developed which calculates the internal reflux in the column from measurements of the flow of external reflux, the temperature of the external reflux returned to the column and the temperature of the overhead vapor removed from the column. This computer is described in ISA Journal, June 1959, Volume 6, No. 6, pages 34 to 39. The internal reflux R_i is defined by the following equation:

$$R_i = R(1 + K\Delta T)$$

where R is the rate of flow of the external reflux, K is the specific heat of the liquid on the top tray divided by the heat of vaporization of the liquid on this tray and ΔT is the difference between the temperature of the liquid on the tray (overhead vapor temperature) and the temperature of the external reflux returned to the column. In response to this computation, the flow of external reflux can be adjusted so as to maintain the computed internal reffux constant. It has been found that this type of control system greatly improves the stability of operation of fractionation columns.

In accordance with the present invention, a simplified control system is provided which is based on the principles of the internal reflux computer, but which does not require an actual computation of the internal reflux. The flow of external reflux to the column is regulated automatically in response to a measurement of the temperature of external reflux returned to the column. If the temperature of the external reflux should increase, for example, a greater amount of external reflux is returned to the column, whereas the external reflux flow is decreased if the measured temperature decreases. This control system provides improved fractionation column operation where the temperature of the external reflux is likely to fluctuate.

Accordingly, it is an object of this invention to provide improved apparatus for controlling the operation of fractionation columns by adjusting the flow of external reflux to compensate for temperature changes.

Another object is to provide a method of controlling fractionation columns in response to a measurement of the temperature of the external reflux returned to the column.

Other objects, advantages and features of the invention should become apparent from the following detailed description, taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a schematic representation of an embodiment of the control system of this invention.

FIGURE 2 is a graphical representation of the operation of the control method of this invention.

FIGURE 3 is a schematic representation of a second embodiment of the control system of this invention.

Referring now to the drawing in detail and to FIGURE 1 in particular, a feed stream of a fluid mixture to be separated is introduced into a fractionation column **10** through a conduit **11**. Conduit **11** is provided with a flow recorder-controller **12** which adjusts a valve **13** to maintain a predetermined rate of flow though conduit **11**. Heat is supplied to the lower region of column **10** by means of a conduit **14** which conveys steam or other heating material. A flow recorder-controller **15** adjusts a valve **16** to supply the heating material at a pretedetermined rate. A kettle product stream is withdrawn from the bottom of column **10** through a conduit **17** which has a control valve **18** therein. Valve **18** is regulated by a liquid level controller **19** so as to maintain a predetermined liquid level in the bottom of column **10**. Vapors are removed from the top of column **10** through a conduit **21** which communicates with an accumulator **22** through a condenser **23**. A portion of the condensate in accumulator **22** is returned to the top of column **10** as external reflux through a conduit **24**. The remainder of the condensate is removed as overhead product through a conduit **25** which has a control valve **26** therein. Valve **26** is adjusted by a liquid level controller **27** to maintain a predetermined level in accumulator **22**.

In accordance with the present invention, the temperature of the external reflux returned to column **10** is measured by a detecting element **30** which is connected to a temperature transducer **31**. Transducer **31** provides an output signal which is representative of the temperature of the external reflux. The flow of external reflux through conduit **24** initially is maintained at a predetermined value by means of a flow recorder-controller **32** which adjusts a valve **33**. This flow rate is set initially at a preselected value for a preselected external reflux temperature. If the measured reflux temperature should change from this preselected value, the output signal from

temperature transducer **31** adjusts the set point of flow recorder-controller **32** to change the rate of flow of external reflux.

In order to describe the operation of this invention, reference is made to a specific separation of a hydrocarbon mixture. The compositions and flow rates of the feed, overhead product and kettle product are set forth in the following table:

Component	Flows (gal./day)		
	Feed	Overhead	Kettle
2,2-dimethylbutane	15,362	15,362	----------
2,3-dimethylbutane	10,070	10,070	----------
2-methylpentane	31,917	31,917	----------
3-methylpentane	19,348	16,898	2,450
Normal hexane	50,591	8,193	42,398
Methylcyclopentane	19,094	2,902	16,192
2,2-dimethylpentane	2,334	----------	2,344
2,4-dimethylpentane	1,598	----------	1,598
Cyclohexane	39,628	----------	39,628
1,1-dimethylcyclopentane	1,918	----------	1,918

Under normal operating conditions, the kettle temperature is approximately 250° F. and the temperature at the top of the column is approximately 208° F. The temperature of the external reflux returned to the column is approximately 140° F. The flow of external reflux is approximately 784,400 gallons per day. The pressure at the top of column **10** is approximately 30 p.s.i.g., and the pressure in the kettle is approximately 40 p.s.i.g.

As previously mentioned, the temperature of the external reflux can fluctuate substantially during operation of the column. The method of control provided by this invention is illustrated schematically in FIGURE 2. This figure shows a plot of the internal reflux as a function of the external reflux for different temperatures of the external reflux. Vertical line **39** shows changes in internal reflux which result from changes in temperature of the external reflux where the external reflux rate is held constant. The horizontal line **40** represents the ideal control which shows changes of flow of external reflux which should be made in response to changes in reflux temperature to give a constant internal reflux rate. In actual practice, however, the response of control system of this invention is not exactly linear, but is more of the form of curve **41**. However, curve **41** is so nearly linear within the normal range of operation that satisfactory results are obtained.

The control system of FIGURE 1 can further be improved by adjusting the flow of either the feed to the column or the steam to the column in response ot a measurement of the temperature of the overhead vapor. In order to accomplish this result, a temperature detector **45** is disposed in conduit **21**. This detector is connected to a temperature transducer **46** which adjusts the set point of either flow recorder-controller **12** or flow recorder-controller **15**. Temperature transducer **46** adjusts the set points of one of these controllers in order to maintain the temperature of the overhead vapors at a constant value. If the temperature of these vapors should decrease, for example, additional steam is supplied to the column or less feed is supplied. Conversely, an increase in temperature results in a decrease in the flow of steam or a decrease in the flow of feed.

Another embodiment of the control system of this invention is illustrated in FIGURE 3. Temperature detectors **50** and **51** are positioned in respective conduits **24** and **21**. These two detectors, which can be thermocouples connected in opposition, are applied to transducer **31** so that an output signal is provided which is representative of the difference between the two temperatures.

This temperature differential signal is employed to reset flow recorder-controller **32**, but in an opposite manner. An increase in the temperature differential, for example, results in a lower reflux rate. Otherwise, the system of FIGURE 3 is identical to that of FIGURE 1.

In view of the foregoing description, it should be evident that a simplified fractionation column control system is provided in accordance with this invention. This system utilizes a minimum number of conventional components which are commercially available and provides stable column operation under many conditions. While the invention has been described in conjunction with present preferred embodiments, it should be evident that it is not limited thereto.

What is claimed is:

1. A fractionation system comprising a fractionation column, first conduit means communicating with said column to introduce a feed mixture, second conduit means communicating with a lower region of said column to withdraw a kettle product, an accumulator, a condenser, third conduit means communicating between an upper region of said column and said accumulator through said condenser, fourth conduit means communicating with said accumulator to remove an overhead product, fifth conduit means communicating between said accumulator and an upper region of said column to return liquid to said column as external reflux, first temperature sensing means disposed in said fifth conduit means adjacent said column, second temperature sensing means disposed in said third conduit means adjacent said column, means responsive to said first temperature sensing means to control the rate of flow through said fifth conduit means, and means responsive to said second temperature sensing means to control the rate of flow through said first conduit means.

2. In a fractionation process wherein a feed mixture of two or more components is directed to a fractionation zone, a vapor stream is removed from the top of said zone, said vapor stream is cooled to condense at least a part of same, and at least a part of the resulting condensate is returned to said zone as reflux; a control process which comprises continuously measuring the temperature of said reflux, adjusting the flow of said reflux solely in response to measured temperature changes by increasing the flow when the measured temperature increases and by decreasing the flow when the measured temperature decreases, continuously measuring the temperature of the vapor stream removed from the top of said zone, and adjusting the rate at which said feed mixture is supplied to said zone responsive to the measured temperature of said vapor stream so as to maintain the temperature of said vapor stream constant.

3. A fractionation system comprising a fractionation column, first conduit means communicating with said column to introduce a feed mixture, second conduit means communicating with a lower region of said column to withdraw a kettle product, an accumulator, a condenser, third conduit means communicating between an upper region of said column and said accumulator through said condenser, fourth conduit means communicating with said accumulator to remove an overhead product, fifth conduit means communicating between said accumulator and an upper region of said column to return liquid to said column as external reflux, first temperature sensing means disposed in said fifth conduit means adjacent said column, second temperature sensing means disposed in said third conduit means adjacent said column, means responsive solely to said first temperature sensing means to control the rate of flow through said fifth conduit means, and means responsive to said second temperature sensing means to control the rate of flow through said first conduit means.

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