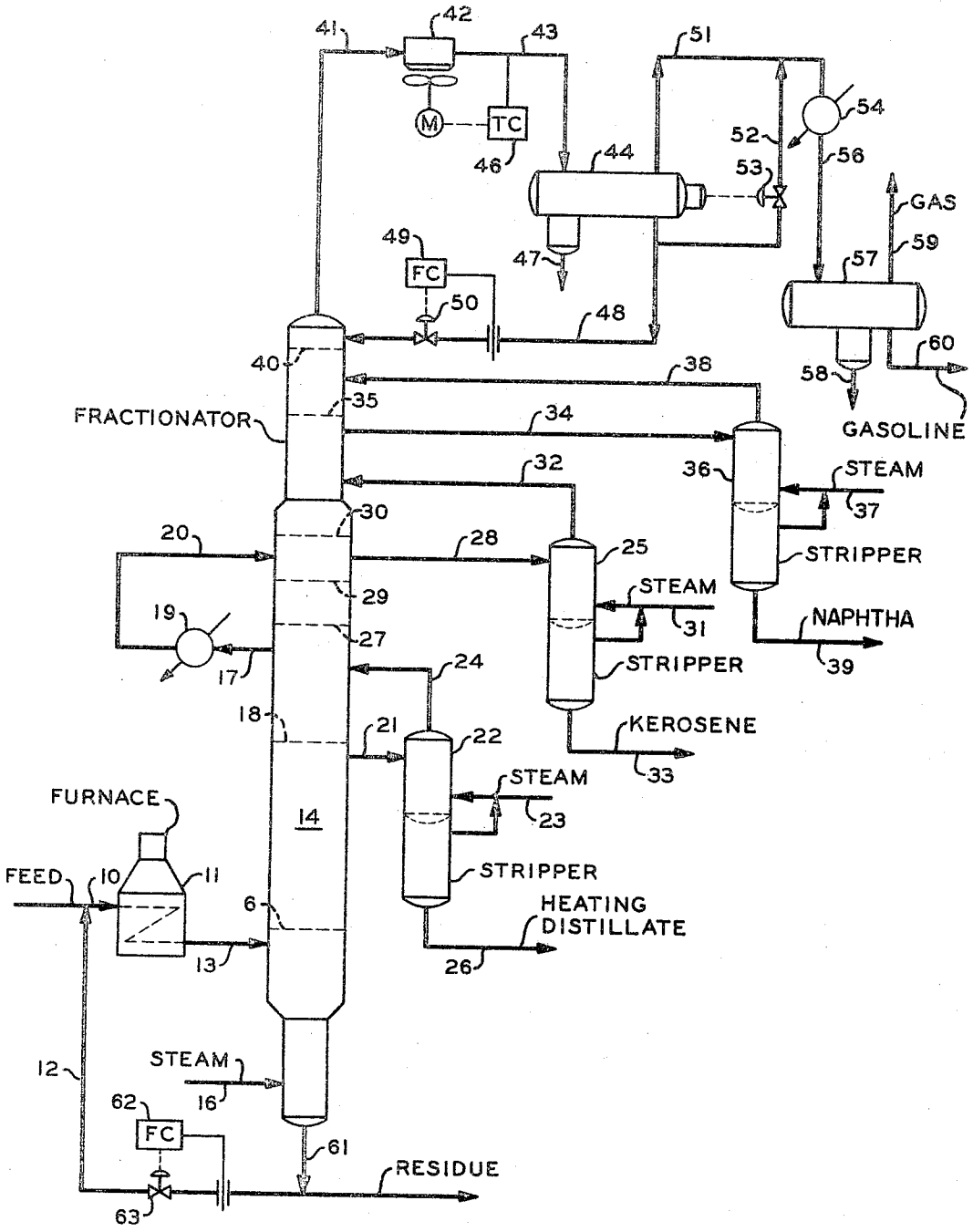
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CONTROLLING REFLUX IN A DISTILLATION PROCESS

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CONTROLLING REFLUX IN A DISTILLATION PROCESS

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This invention relates to a distillation process and apparatus therefor. In another aspect, this invention relates to a distillation process and apparatus therefor wherein an overhead vapor withdrawn from the distillation zone is partially condensed, a portion of the condensed vapor is recycled to the distillation zone as reflux, and the remainder of the overhead vapor in combination with the remainder of the condensed overhead vapor is passed to a second condensing zone wherein condensation of the overhead vapor is completed.

In a conventional distillation process, a feed is passed to a distillation column wherein a portion of the feed is vaporized and withdrawn from the top of the distillation column. The withdrawn vaporized fraction is condensed and a portion of the condensed overhead fraction is recycled to the distillation column as reflux. The cooling energy required to condense the overhead fraction is high and is a substantial portion of the distillation process cost. Therefore, a substantial reduction in the cost of the cooling energy required to condense the overhead fraction would result in a substantial reduction in distillation process costs.

Accordingly, an object of my invention is to provide an improved distillation process and apparatus therefor.

Another object of my invention is to provide a distillation process and apparatus therefor wherein the cooling energy required to condense an overhead vaporous fraction is minimized.

Other objects, advantages and features of my invention will be readily apparent to those skilled in the art from the following description, the drawing and appended claims.

By my invention, I have provided a distillation process and apparatus therefor wherein an overhead product vaporous stream is only partially condensed in a first condensation stage, at least a portion of the resultant condensed fraction is recycled to the distillation zone as reflux, and the remainder of the condensed portion in combination with the remainder of the overhead product vaporous fraction is passed to a second condensation stage wherein condensation of the overhead product vaporous fraction is completed at a lower temperature than the first condensation stage.

My invention results in a substantial saving in distillation process costs. For example, assume that the temperature of a multi-component vaporous fraction withdrawn from a distillation zone requiring reflux must be cooled to a temperature t_1 to effect substantial condensation of the vaporous fraction. Let it further be assumed that by cooling the vaporous fraction to a higher temperature t_2 that sufficient condensed liquid is obtained at a proper temperature to reflux the distillation zone. Separating the refluxed portion from the remainder of the vaporous fraction prior to completing the condensation of the vaporous fraction by cooling to the lower temperature t_1 results in a savings in cooling energy equivalent to the cooling energy required to cool the reflux portion from t_2 to t_1.

An additional advantage of the invention is that by cooling the vaporous fraction to the substantially higher temperature t_2, only the heavier components of the vaporous fraction are recycled to the distillation zone as reflux. This results in a substantial increase in the absorption effect of the reflux liquid, thereby substantially increasing

the effectiveness of the reflux stream and the over-all effectiveness of the distillation process.

The drawing is a schematic representation of one embodiment of the invention.

The invention is broadly applicable to distillation processes generally wherein a vaporous multi-component fraction is withdrawn from the distillation zone and a condensed portion of the vaporous multi-component fraction is recycled to the distillation zone as reflux. Although not to be limited thereto, the invention will hereinafter be described as applied to the distillation of a hydrocarbon distillate feed.

Referring to the drawing and using a specific example to illustrate the process, a hydrocarbon distillate fraction having an API gravity of 45.9 is passed at the rate of 28,122 barrels per stream day (b.p.s.d.) via conduit means **10** to a furnace **11**. The distillate feed is combined with a recycle stream, hereinafter described, passed to conduit means **10** via conduit means **12**, said recycle stream having an API gravity of 37.4, and passed to conduit means **10** at the rate of 1,000 b.p.s.d. The pressure of the combined mixture passed to furnace **11** is 135 p.s.i.g. Within furnace **11**, the feed mixture is vaporized and an effluent vaporous mixture at a temperature of 650° F. and a pressure of 30 p.s.i.g. is passed from furnace **11** via conduit means **13** to fractionator **14**.

Fractionator **14** can comprise a 10.5-foot diameter upper section 22 feet in length, a 12.5-foot diameter intermediate section 58 feet in length, and a 4-foot diameter bottoms stripper lower section 18 feet in length. As illustrated, the feed to fractionator **14** is introduced into fractionator **14** below the 6th tray. Fractionator **14** can contain perforated trays, bubble cap trays, plate trays, or other means for effecting intimate contact between countercurrent flowing liquid and vaporous streams. As illustrated, fractionator **14** contains 40 perforated tray members. Steam at 250 p.s.i.g. is introduced into fractionator **14** via conduit means **16** at the rate of 3,150 pounds per hour. Fractionator **14** is operated at a bottom temperature of 550° F., a top temperature of 353° F. and a top pressure of 21 p.s.i.g.

A side reflux stream at a temperature of 528° F. is withdrawn from the 27th tray via conduit means **17**, cooled to a temperature of 380° F. by means of a conventional heat exchange means **19**, and recycled to the 29th tray of fractionator **14** via conduit means **20**. A product liquid side stream is withdrawn from tray **18** of fractionator **14** via conduit means **21** and passed to a stripper **22**. Within stripper **22**, the side stream is contacted with 250 p.s.i.g. steam passed to stripper **22** via conduit means **23** at the rate of 2,240 pounds per hour. A vaporous stream is withdrawn from stripper **22** via conduit means **24** and recycled to fractionator **14**. Heating distillate having an A.P.I. gravity of 39.1 is withdrawn from stripper **22** via conduit means **26** at the rate of 6,384 b.p.s.d.

A second product liquid side stream is withdrawn from the 30th tray of fractionator **14** via conduit means **28** and passed to a stripper **25**. Within stripper **25**, the side stream is contacted with 250 p.s.i.g. steam passed to stripper **25** via conduit means **31** at the rate of 8,800 pounds per hour. A vaporous stream is withdrawn from stripper **25** via conduit means **32** and recycled to fractionator **14**. A kerosene product stream having an A.P.I. gravity of 45.2 is withdrawn from stripper **25** via conduit means **33** at the rate of 16,703 b.p.s.d.

A third product liquid side stream is withdrawn from the 35th tray of fractionator **14** via conduit means **34** and passed to a stripper **36**. Within stripper **36**, the product side stream is contacted with 250 p.s.i.g. steam passed to stripper **36** via conduit means **37** at the rate of 1,500 pounds per hour. A vaporous stream is withdrawn

from stripper **36** via conduit means **38** and recycled to fractionator **14**. A naphtha product stream having an A.P.I. gravity of 52.1 is withdrawn from stripper **36** via conduit means **39** at the rate of 2,839 b.p.s.d.

A vaporous overhead fraction is withdrawn from fractionator **14** via conduit means **41** and passed to a conventional means for partially condensing the overhead fraction such as an air fin cooler **42**. A vapor-liquid effluent mixture is passed from air fin cooler **42** via conduit means **43** to an accumulator **44**. A temperature of 170° F. and a pressure of 18 p.s.i.g. is maintained within accumulator **44**. The temperature of the effluent mixture withdrawn from air fin cooler **42** is controlled by a conventional temperature controller **46** which transmits a signal to the fan (and controls the pitch of the blades, motor speed, or position of louvers) of air fin cooler **42** responsive to the temperature measurement and a set point representative of the desired effluent temperature.

Condensed water is withdrawn from the water leg of accumulator **44** via conduit means **47**. A liquid reflux stream is withdrawn from accumulator **44** via conduit means **48** and passed to the 40th tray of fractionator **14** as reflux. The rate of flow of reflux liquid through conduit **48** is controlled by a conventional flow controller **49** further opening and closing valve **50** responsive to a flow measurement in conduit **48**.

The remainder of the condensed hydrocarbon liquid within accumulator **44** is withdrawn from accumulator **44** via conduit means **48** and combined with the vaporous stream withdrawn from accumulator **44** via conduit means **51**. That portion of the hydrocarbon liquid combined with the vaporous stream in conduit **51** is passed from accumulator **44** via conduit means **48** and conduit means **52** to conduit **51**. The rate of flow of liquid through conduit means **52** is controlled responsive to a liquid level measurement within accumulator **44**. Responsive to the liquid level measurement, valve **53** is further opened or closed, thereby manipulating the rate of flow of hydrocarbon liquid through conduit **52** to conduit **51**. The combined vapor-liquid mixture in conduit means **51** is passed to a conventional heat exchange means **54** wherein the mixture is cooled to a temperature of 100° F.

The cooled vapor **51** and the cooled liquid **52** (higher temperature level) from the first stage cooling (liquid and vapor being in equilibrium) are recombined and are charged to heat exchanger (condenser) **54** for second stage cooling of the admixture to a lower temperature level. By adding the liquid back to the vapor at this locus, we effect a rapid movement of the body of the flowing fluid over the solid cooling surfaces in the exchange **54**, which greatly reduces the boundary resistance of the film between the fluid and the solid heat exchange surface by reducing the thickness of the insulating film (thermal resistance) of the fluid, and thereby increases the rate of heat exchange (cooling) for a given capacity of heat exchange apparatus (condenser).

An effluent vapor-liquid mixture is passed from heat exchange means **54** via conduit means **56** to accumulator **57**. Condensed water is withdrawn from the water leg of accumulator **57** via conduit means **58**. Accumulator **57** is maintained at 100° F. and at a pressure of 15 p.s.i.g. Uncondensed vapors are withdrawn from accumulator **57** via conduit means **59** (on accumulator **57** pressure control, not shown). A gasoline product fraction is withdrawn from accumulator **57** (on accumulator **57** level control, not shown) via conduit means **60**, said gasoline product fraction having an A.P.I. gravity of 64.4 and is withdrawn from accumulator **57** at the rate of 540 b.p.s.d.

Generally, although not to be limited thereto, the vapor-liquid mixture passed to the second condensation zone (heat exchange means **54**) is cooled in the second condensation zone sufficiently to condense all the constituents of the said vapor-liquid feed mixture that are normally liquid and desired in this gasoline fraction.

Strippers **22**, **25**, and **36** are combination steam strippers and vacuum strippers, the products being first steam stripped and then vacuum stripped as shown.

A residual fraction is withdrawn from fractionator **14** via conduit means **61**. The residual fraction withdrawn from fractionator **61** has an A.P.I. gravity of 37.4 and is passed (on level control, not shown) to storage at the rate of 1,116 b.p.s.d. As previously noted, a portion of the residue fraction (1,000 b.p.s.d.) is recycled at 550° F. via conduit means **12** to feed conduit **10**. The rate of flow of the recycle residue fraction is controlled by a conventional flow controller **62** further opening and closing valve **63** responsive to a rate of flow measurement in conduit **12** and a set point representative of the desired recycled flow rate.

As will be evident to those skilled in the art, various modifications of this invention can be made, or followed, in the light of the foregoing disclosure, without departing from the spirit or scope thereof.

I claim:

1. A method of controlling the reflux to a fractionation zone of the heavier constituents in a vaporous water-hydrocarbon stream from said fractionation zone comprising: (a) cooling said vaporous water-hydrocarbon to a first temperature so that water and at least a portion of the heavier hydrocarbons in said vaporous stream are condensed to thereby form a first liquid vapor stream; (b) passing said first liquid-vapor stream to a first accumulation zone being maintained at a temperature at or below said first temperature; (c) withdrawing condensed water from said first accumulation zone; (d) passing a stream of the condensed heavier hydrocarbons from said first accumulation zone to the top of said fractionation zone as reflux at a predetermined flow rate; (e) removing the vapor from said first accumulation zone; (f) removing a second stream of condensed heavier hydrocarbons from said first accumulation zone in response to liquid level control therein and combining said second stream of condensed heavier hydrocarbons as a liquid with said vapor from said first accumulation zone to form a second liquid vapor stream which stream is at a temperature no higher than said first temperature; (g) cooling said second liquid vapor stream to a second temperature lower than said first temperature so that at least a portion of the vapor in said second liquid vapor stream is condensed to form a third liquid vapor stream; (h) passing said third liquid vapor stream to a second accumulation zone; (i) withdrawing liquid hydrocarbon product from said second accumulation zone; (j) withdrawing condensed water from said second accumulation zone; (k) withdrawing vapor from said second accumulation zone.

2. A method of claim **1** wherein said liquid product stream withdrawn from said second accumulation zone is a liquid gasoline product fraction.

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