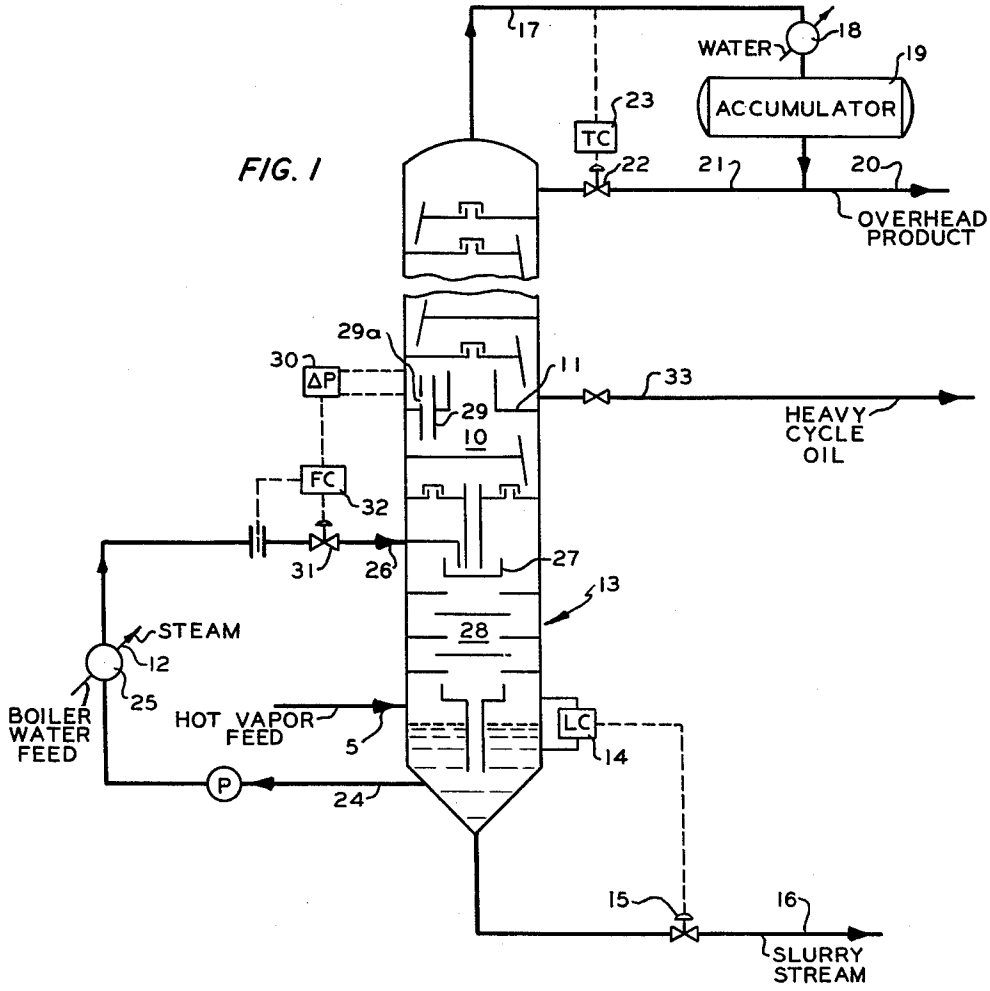
June 9, 1964 K. A. HARPER 3,136,706

OPTIMUM FRACTIONATION AND STEAM PRODUCTION

Filed June 20, 1960

FIG. 1



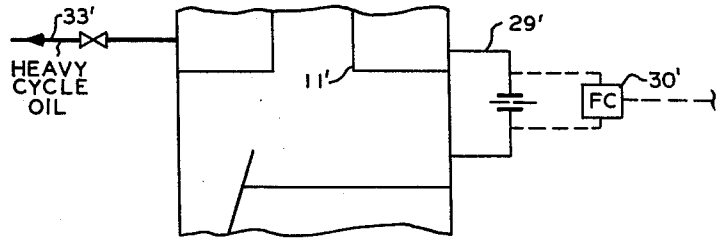


FIG. 2

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OPTIMUM FRACTIONATION AND STEAM PRODUCTION

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This invention relates to optimum fractionation and steam production. In one of its aspects, the invention relates to a fractionation apparatus. In another of its aspects, the invention relates to a fractionation operation. In a more specific aspect of the invention, it relates to the operation of a fractionation zone in which hot vapors fed thereto are fractionated and from which hot condensate is cycled through a heat exchanger adapted to produce steam or to heat some other fluid and back to the fractionation zone at a point above the vapor feed wherein the rate of cycling of said hot liquid is controlled to a maximum permissible consistent with a desired minimum of reflux flowing down to the fractionation zone toward said point at which said liquid is returned to said zone. In another of its aspects, the invention relates to a fractionation apparatus which is provided with means for cycling hot liquid from its bottom to an intermediate point thereof by way of a heat exchanger in which steam, say, can be produced, means for refluxing the top of the fractionator, means for sensing flow of reflux down the fractionator toward the point at which hot cycled liquid is returned and means operatively connected with said means for sensing flow of reflux and a means for controlling hot, heat exchanged liquid returned to said fractionator to control the flow of hot liquid through the heat exchanger and back to the fractionator to a maximum consistent with a desired minimum flow of reflux down through the fractionation apparatus. In a more specific aspect, vapors leaving the fractionation apparatus are refluxed responsive to their temperature to maintain their temperature at a constant desired value. In a still more specific aspect, bottoms are drawn from the fractionator as product from the operation responsive to a liquid level control.

In one embodiment of the invention, the flow of reflux downwardly through the fractionation apparatus toward the point at which hot, heat exchanged liquid is returned is sensed by means of a differential pressure sensing means. In another aspect, this flow is sensed by a flow measuring or sensing means.

The invention is particularly applicable to the fractionation of catalytic cracking product vapors, especially vapors obtained from a so-called fluidized or fluid catalytic cracking operation, for reasons which are apparent from this disclosure.

It has now occurred to me that the fractionation of hot vapors, the production of, say, product steam, and the reduction of cooling water required to condense and to cool overhead vapors to provide product and reflux to said fractionation can be neatly accomplished by cycling fractionator bottoms through a heat exchanger through which water is passed to produce steam and back to the fractionator and controlling the rate of cycling of the hot liquid to maintain it at a maximum responsive to flow of reflux flowing downwardly in the fractionator toward the point of return of cycled hot liquid consistent with a minimum of downwardly flowing reflux being provided while refluxing the top of the fractionator responsive to the temperature of the overhead vapors to maintain these at a desired value.

An object of this invention is to provide an improved fractionation method. Another object of the invention

is to provide an improved fractionation means. A further object of the invention is to provide a vapor fractionating method and means wherein maximum product steam can be produced from heat contained in the bottoms in said fractionator while maintaining a desired minimum flow of reflux down said fractionator and refluxing the top of said fractionator responsive to the temperature of vapors therein.

Other aspects, objects, and the several advantages of the invention are apparent from a study of this disclosure, the drawing, and the appended claims.

According to the present invention, flow of hot liquid from the bottom of a fractionator through a heat exchanger is controlled to a maximum responsive to downflow of reflux in a fractionator tower to maintain the downflow of said reflux at a desired minimum while refluxing the top of the fractionator. In a specific embodiment of the invention, the top of the fractionator is refluxed responsive to the temperature of the vapors there existing to maintain this temperature at a constant desired value.

Still further according to the invention, there are provided method and means for washing the bottom of a fractionator into which hot vapor feed containing unavoidably entrained particulate catalyst from a catalytic cracking operation is fed to ensure by said washing that there will be formed a sufficient slurry of said particles so that the slurry can be drawn off and returned to the cracking reactor or to some other desired place in the plant.

In FIGURE 1, there is shown diagrammatically an apparatus according to the invention. In FIGURE 2, there is shown a portion of FIGURE 1 illustrating a different means for sensing downflowing reflux in the tower as will be described in detail below.

The fluidized catalytic conversion of hydrocarbons is well known. In such a conversion, a hydrocarbon oil is contacted with a hot fresh or regenerated catalyst mass which travels essentially as a fluid because it is fluidized with a fluidizing vapor, usually the fluidizing vapor is the hydrocarbon to be converted. After a suitable period of contact of the hydrocarbon with the finely subdivided fluidized catalyst particles, there is performed a separation, usually with the aid of a cyclone or equivalent apparatus, the fluidized particles are stripped of residual hydrocarbons, regenerated and reused. There is entrained unavoidably in the separated hydrocarbon vapors some of the finely divided catalyst. This catalyst accumulates in a fractionator in which the vapors are condensed and fractionated. The slurry of hydrocarbon liquid and finely divided catalyst is usually accumulated and returned to the reactor. It is essential to maintain good flow conditions in the bottom portion of the fractionator. To this end, there is usually cycled from the bottom of the fractionator some of the liquid to a tray or plate somewhat above the bottom of the fractionator to ensure a washing down of any solid particles tending to separate out on the trays.

Referring now to FIGURE 1 of the drawing, hot vapor feed **5** at about 900° F., resulting from the contacting of a hydrocarbon oil such as a heavy gas oil with a cracking catalyst essentially consisting of silica-alumina, enters the bottom section of tower **13**, just above the liquid therein. The liquid level in this embodiment is controlled by liquid level controller **14**, actuating valve **15** in bottoms or slurry draw-off pipe **16**. Th overhead vapors **17** are condensed in **18**, passed to accumulator **19**, product being removed by **20**. External reflux **21** is controlled by valve **22** in response to the temperature of the overhead vapors **17** sensed through temperature controller **23**. Hot liquid **24** from the lower section of **13** is cooled in heat exchange

zone 25 wherein boiler water is converted into product steam 12. The cooled liquid hydrocarbon 26 is returned to tower 13 into the pan tray 27, affording the downward flowing liquid for the disc-doughnut tray zone 28 in tower 13, said liquid countercurrently contacting hot vapors flowing upwardly through zone 28. The quantity of cooled hydrocarbon 26 is controlled in response to the flow of liquid down the tower above zone 10. FIGURE 1 shows in tray 11 downcomer 29 with a machined orifice 29A therein and a differential pressure cell 30, one tap at said orifice and one tap above the liquid on the tray; the signal from 30 actuates control of valve 31 in line 26 via flow controller 32. Heavy cycle oil product can be withdrawn by 33. The complete tower is not shown above the heavy cycle oil draw-off, usually there being other trays and other side draw-offs, e.g., light cycle oil in most operations.

The quantity of steam 12 produced in 25 is in proportion to the liquid flow through 25, and hence line 26. It is desired that steam production 12 be at the maximum possible.

The quantity of liquid flowing downwardly in zone 10 is in inverse proportion to the flow of cooled hydrocarbon 26 into tower 13. That is, as reflux in 29, for example, tries to decrease to below the desired minimum, this lower flow value actuates a closing down on valve 31 to decrease the quantity of cooled hydrocarbon flowing via line 26, allowing more vapor (and heat) to go up the tower. The tower top temperature then tries to rise, but unit 23 effects a further opening on valve 22 in the external reflux line 21 to maintain the preset tower top temperature, increasing the top liquid external reflux, and hence increasing the liquid downflow in downcomer 29 into zone 10. As the flow in 26 decreases, less steam is produced; however, my system affords production of the minimum flow of liquid via 29 and the maximum possible steam 12 production, as is desired.

Referring now to FIGURE 2, downflowing liquid passes by pipe 29' having flow controller 30' thereon, to control the flow of cooled hydrocarbon 26 to the tower.

It will be seen that by maintaining reflux 26 as high as possible, maximum steam, which is an asset, can be produced and the top reflux can be maintained at a minimum while the desired quantity of liquid will be available to wash zone 10 as desired to avoid undesired deposition of any solid particles. It is also seen that by operating according to the invention, while the maximum steam is being obtained, cooling water use which is a liability is kept at a minimum.

Typical-Operation

		Lbs./hr.	B/D
Feed (5), at 900° F		[1] 180,000	
Bottoms (16), at 675° F			200
Overhead (20), at 100° F		[2] 138,000	
Cycle oils yield			1,000
Reflux (21), at 100° F			7,780
Cooled hydrocarbon (26), at 450° F		375,000	
Boiler water feed to (25)		30,000	
Steam (12), at 370° F		30,000	
Cooling water to (18), at 90° F			[3] 152,300
Vessel conditions:			
Tower temperatures:			
Top, ° F	275		
Bottom, ° F	675		
Tower pressure, p.s.i.g	14		
Accumulator:			
Temp., ° F	100		
Pressure, p.s.i.g	10		

[1] Includes 15,000 lbs./ hr. steam.
[2] Includes 15,000 lbs./ hr. steam condensate to be phase separated.
[3] Cooling water in at 90° F., out at 110° F.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, the drawing, and the appended claims to the invention the essence of which is that flow through a heat exchanger producing steam from heat contained in bottoms of a fractionator is maintained at a maximum by rendering said flow responsive to reflux flowing in a fractionation zone, preferably while maintaining the overhead vapors at a desired temperature by refluxing the same responsive to their temperature substantially as set forth and described herein.

I claim:

1. In the fractionation of a hot vapor containing feed, the steps comprising feeding a hot vapor containing feed to a fractionation zone near one end thereof, removing liquid from said end of said zone, passing said liquid through a heat extraction zone to extract heat from said liquid, returning to the fractionation zone at a point thereof intermediate the vapor containing feed point and the other end of said fractionation zone as an intermediate reflux therefor liquid from which heat has been extracted in said extraction zone, introducing reflux into said fractionation zone at said other end of said fractionation zone, sensing flow of reflux passing a point in said fractionation zone intermediate the point at which said intermediate reflux is introduced and the introduction of reflux to said other end of said fractionation zone, controlling the rate of flow of said liquid from said end of said fractionation zone to, through, and back from said heat extraction zone and adjusting said rate of flow responsive to said sensed flow of reflux passing said point in said fractionation zone.

2. A fractionation operation according to claim 1 wherein the reflux to said other end of said fractionation zone is controlled responsive to the temperature at said other end of said fractionation zone and wherein just sufficient desired reflux is caused to pass to said other end of said fractionation zone by controlling the flow of said liquid from said end of said fractionation zone to, through, and back from said heat extraction zone responsive to said sensed flow of reflux passing said point in a manner to maintain said sensed flow of reflux passing said point at a minimum.

3. An operation according to claim 1 wherein the hot vapor containing feed is obtained from a conversion operation in which a hydrocarbon is converted and wherein the desired product formed by extracting heat from said liquid in said heat extraction zone is product steam.

4. A method for fractionating a hot vapor containing feed and for obtaining a maximum output of product steam employing heat from said feed while keeping at a minimum cooling water required to adequately provide reflux for a fractionation zone which comprises feeding said vapor to a substantially vertical fractionation zone at a point thereof above the bottom end of said zone, withdrawing from the botton end of said zone at least a portion of the liquid therein collecting, passing said liquid into indirect heat exchange with water in a heat exchange zone, thus generating steam as a product of the operation, then returning thus cooled liquid to said fractionation zone at a point above the vapor feed thereto as intermediate reflux therefor, introducing reflux to the top portion of said fractionation zone, sensing reflux passing downwardly through said fractionation zone at a point above the introduction of said intermediate reflux thereto and controlling the introduction of said intermediate reflux to said fractionation zone responsive to the rate of flow of sensed reflux passing downwardly through said zone to maintainin the flow of said sensed reflux downwardly through said fractionation zone at a minimum.

5. A method according to claim 4 wherein the top portion of said fractionation zone is refluxed responsive to the temperature in said top portion of said zone to maintain the temperature in said top portion of said zone at a predetermiend desired value.

6. Apparatus for fractionating a hot vapor comprising a fractionation vessel, means at one end of said vessel for withdrawing hot liquid therefrom, means for passing said hot liquid into heat exchange with a fluid it is desired to heat, means for returning now cooled, hot fluid to said vessel at a point removed from said end of said vessel, means for introducing a hot vapor to

said vessel intermediate said end of said vessel and said point removed from said end of said vessel, means, upon said means to return now cooled, hot liquid, to control the rate of flow of hot liquid from said vessel to and through said means for passing said hot liquid into heat exchange and back to said vessel, means for introducing reflux into the other end of said vessel, means at a place intermediate said other end of said vessel and said point removed from said end of said vessel to sense reflux passing past said place and means operatively connected to said means at a place and said means upon said means to return now cooled, hot liquid to control the rate of flow of hot liquid from said vessel to and through said means for passing said hot liquid into heat exchange and back to said vessel adapted and arranged to control the rate of flow of the liquid from the vessel through the heat exchange zone and back to said vessel to a maximum while maintaining reflux flowing past said place at a minimum desired value.

7. Apparatus according to claim 6 wherein the other end of said vessel is refluxed to maintain a constant desired temperature therein.

8. Apparatus for fractionation comprising a substantially vertical vessel, a liquid draw-off at the bottom portion of said vessel, a hot vapor feed pipe near the bottom of said vessel, a heat exchanger through which a fluid to be indirectly heated can be passed, a liquid draw-off also at the bottom portion of said vessel communicating with said heat exchanger, a pipe for returning liquid from said heat exchanger to above said hot vapor feed pipe to said vessel, a flow control flow valve on said pipe, an overhead vapor pipe for removing vapors from the top end of said vessel, a condenser and an accumulator in communication with said vapor pipe to condense and acumulate a portion of overhead as reflux from said vessel, a pipe for removing condensate from said accumulator as a product of the operation and a pipe for returning condensate as reflux to the top of said vessel, a valve on the last-mentioned pipe to control the flow of reflux to the top of said vessel, temperature sensing means for sensing the temperature of overhead vapors, means responsive to the sensed temperature of the overhead vapors to control said valve and therefore the reflux to said vessel, means at a place on said vessel between the points at which liquid is returned from said heat exchanger to said vessel and the point at which reflux is fed to the top of said vessel to sense the flow of reflux downwardly in said vessel past said place and means operatively connected to said means sensing the flow of reflux downwardly in said vessel past said place and to said flow control flow valve to set its operation responsive to a desired minimum flow of reflux past said place.

9. Apparatus according to claim 8 wherein a liquid level in the bottom of said vessel is controlled by a liquid level controller controlling a valve on the first mentioned liquid draw-off at the bottom portion of said vessel.

10. A method for producing a maximum quantity of a heated stream employing heat contained in a vaporous feed which comprises passing said feed into a fractionation zone near one end thereof, removing liquid from said end of said zone, passing said liquid into indirect contact with said stream to extract heat from said liquid, returning to the fractionation zone at a point thereof intermediate the vapor containing feed point and the other end of said fractionation zone as an intermediate reflux therefor liquid from which heat has been extracted in said extraction zone, refluxing said fractionation zone at said other end of said fractionation zone, sensing flow of reflux passing a point in said fractionation zone intermediate the point at which said intermediate reflux is introduced and the introduction of reflux to said other end of said fractionation zone, controlling the rate of flow of said liquid from said end of said fractionation zone to, through, and back from said heat extraction zone and adjusting said rate of flow responsive to said sensed flow of reflux passing said point in said fractionation zone.

11. In the fractionation of a hot vapor containing feed, the steps comprising feeding a hot vapor containing feed to a fractionation zone near one end thereof, removing liquid from said end of said zone, passing said liquid through a heat extraction zone to extract heat from said liquid, returning to the fractionation zone at a point thereof intermediate the vapor containing feed point and the other end of said fractionation zone, as an intermediate reflux therefor, liquid from which heat has been extracted in said extraction zone, introducing reflux into said fractionation zone at said other end of said fractionation zone, flowing reflux, passing a point in said fractionation zone intermediate the point at which said intermediate reflux is introduced and the introduction of reflux to said other end of said fractionation zone, into a reflux collection zone and therein collecting a layer of reflux, draining reflux from said layer of reflux in said collection zone through a zone of restricted flow below the surface of said layer of reflux, measuring a first pressure at a point above the surface of said layer of reflux and a second pressure at said zone of restricted flow and controlling the rate of flow of said liquid from said end of said fractionation zone to, through, and back from said heat extraction zone and adjusting said rate of flow responsive to the differential of said first and second pressures.

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