

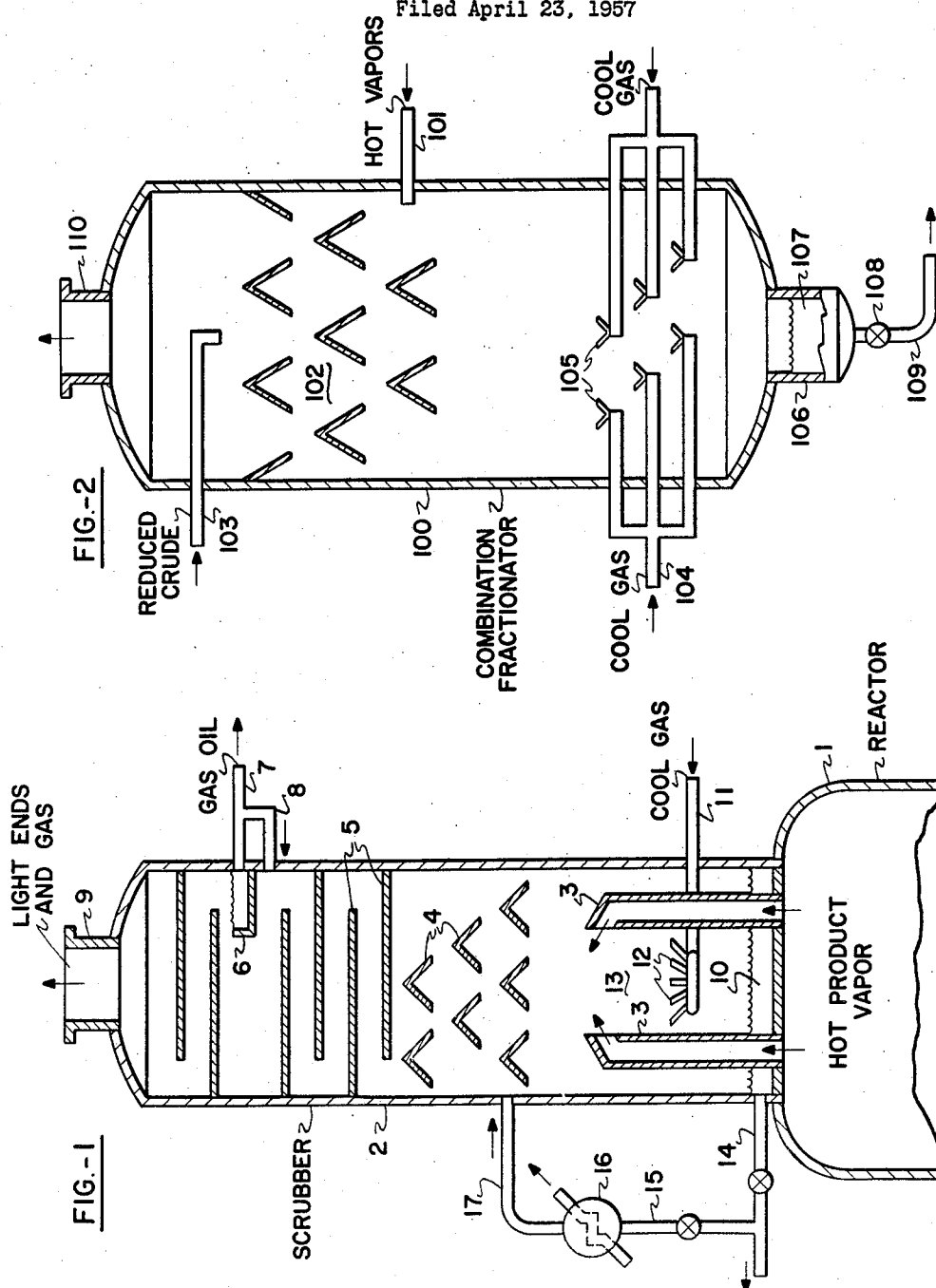
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RECOVERY OF GAS OIL FROM A FLUID COKER

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RECOVERY OF GAS OIL FROM A FLUID COKER

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5 Claims. (Cl. 208—100)

The present invention deals with a method and apparatus for improving the fractionation of desired materials from hydrocarbon vapors. More particularly, it is concerned with improving the recovery of gas oil fractions while simultaneously quenching heavy normally liquid materials.

In its broadest aspect, the present invention is applicable to any system employing a recovery step to fractionate hydrocarbons so as to recover particular constituents. Thus, it may be applied to conventional fractionating units, combination fractionators, vacuum pipe-stills, superposed scrubbers operating in conjunction with inert or catalytic reaction units, and the like. It is specifically advantageous in processes for the conversion of heavy hydrocarbon oils to lighter materials and substantial portions of gas oils, as for example, in the fluid bed coking process.

While the invention is not restricted to fluid coking of heavy oils, a brief description of this operation will be given for sake of emphasizing the considerable commercial advantages afforded by the present invention.

In this process, a heavy oil such as raw crude, vacuum bottoms or the like is introduced into a turbulent mass of inert solids, normally maintained at a temperature of 900–1200° F. While coke granules are preferred, other inert solids such as glass, ceramic beads, sand, etc. may be alternatively employed as the bed solids. Upon contact with the hot solids, the oil is converted to vaporous materials, and carbonaceous residue which deposits on the bed particles. Heat for the process is normally provided by passing contact solids to a combustion zone wherein oxidation of carbonaceous deposits thereon serves to heat the particles. Recirculation to the reaction bed provides necessary thermal energy for the conversion step.

The hot coker vapors, generally after a solids separation step, are then introduced into a fractionation tower, normally in the form of a superposed scrubbing unit in contiguous relation to the coking reactor itself. Conventionally, a shed section is provided above the point of product vapor introduction to the fractionator in order to encourage the rectification of upflowing vaporous reaction products and downcoming condensate, the condensate resulting from the natural tendency of the vapors to cool, and the recycling of externally cooled reflux materials. Gas oil product is withdrawn as a sidestream while naphtha, gas and light vapors are taken overhead. Heavy liquid ends are generally discharged from the bottom of the fractionator and at least a portion customarily recycled to the coking bed.

In the past, considerable difficulty has been encountered in obtaining desired yields of gas oil. An appreciable portion of the gas oil product is never fully recovered from the heavy liquid ends due to limitations in the fractionation system. It has been estimated that 30% of theoretical gas oil yield may be lost in this manner. Unrecovered coker gas oil represents a serious economic loss since it is a relatively high valued product which may

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be used as catalytic cracking or thermal cracking feed.

The gas oil yield is dependent in large measure upon the vapor temperature and gas oil partial pressure below and at the point of withdrawal from the system.

Maximum allowable vapor temperatures below the gas oil draw-off in a coker scrubber are limited by the maximum allowable liquid temperatures that can be tolerated before coking occurs. In an attempt to maintain tolerable temperature levels, heretofore, cool liquid bottoms have been returned to the scrubber. However, this method has several disadvantages. It tends to cause poor mass transfer from vapor to liquid in the shed section since the vapors are contacted with a recycled liquid rather than a fresh contacting medium. Concentration driving forces are thus relatively small. A high preponderance of heavy liquid ends further tends to promote coke formations. Additionally, extraneous equipment in the way of pumps, condensers and the like are necessary to recycle this liquid quenching agent.

The present invention sets forth means whereby not only is the temperature level of downcoming liquid ends controlled, but substantial additional benefits secured. In accordance with the present invention, a section of the fractionation vessel hereafter referred to as a mixing zone, is provided between the lowermost portion of the fractionator and the inlets of the hot, product vapors. A relatively cool gas is introduced into this mixing section, and serves to strip downcoming, counter-flowing liquids of gas oil while simultaneously acting as a quenching agent. The gas undergoes heating during its upward passage and enters the area of product vapor introduction substantially at the same temperature as the product materials. The thus preheated gas then serves to reduce the partial pressure of the gas oil, thereby improving the effectiveness of gas oil recovery. Gas oil cut point is increased and higher overall yields obtained.

It is readily apparent that the present invention has broad practicality, and may be employed in any hydrocarbon fractionation system where quenching, stripping and partial pressure reduction are desired.

The various aspects of the present invention will become more apparent in light of the following drawings, discussion, and accompanying examples.

Figure 1 illustrates its application in a fluid coking-scrubbing unit.

Figure 2 depicts a combination fractionator operating in accordance with the present invention.

Turning to Figure 1, there is shown one embodiment of the present invention, as applied to the heretofore described fluid bed coking of heavy hydrocarbon oils. The system essentially comprises a reactor vessel 1, only the upper portion of which is indicated, and scrubber-fractionator unit 2. Hot coker vapors at a temperature of about 975° F., pass upwardly from the reaction bed, through a dilute phase zone and then generally through a solids separation unit, not shown. Thereafter they are introduced into scrubber section 2 by one or more vapor conduits 3. It is generally preferred to introduce the vapors into the scrubber at an inclined angle so as to prevent backflow of liquid into the passageway. The hot vapors comprise cracked hydrocarbon products, relatively heavy volatilized fractions and fluidizing gases, such as steam, nitrogen or the like, employed to maintain the reaction bed in turbulent condition.

As in conventional practice, a shed section, containing disc and doughnut structures 4 or similar vapor-liquid contact promoting means, is provided above the feed vapor inlets to the scrubber. The vapors pass upwardly through the shed section and subsequent rectification plates 5, counter-current to downflowing liquid provided by the natural condensation of vapors, and ap-

appropriately introduced cool recycle materials, as is known in the art. Volatile fractions such as naphthas and lighter constituents are withdrawn overhead by passageway 9 and subjected to condensation, compressing, etc. to recover desired products.

In accordance with the present invention, a relatively cool gas is introduced into a mixing zone 13 located in the lower portion of the scrubber unit, below the hot vapor inlets. The cool gas is preferably at an initial temperature in the range of 60 to 300° F., although in practice it may be at any temperature lower than downflowing hydrocarbon liquid. In order to secure the beneficial partial pressure reduction features of the present invention, the cool gas should have an atmospheric boiling point of less than 300° F. preferably below 200° F. Put in other words, it should be sufficiently lower boiling than gas oil so as to appreciably depress its partial pressure. Thus materials suited for introduction are, among others, steam, nitrogen and C₄ and lighter hydrocarbon gases. Light hydrocarbons may be advantageously supplied by recycling a portion of the gases withdrawn overhead from the scrubber after subjecting them to sufficient cooling.

As shown, the cool gas is dispersed over the cross section of the scrubber by means of nozzle finger 12 or other appropriate gas injection means located on the terminal portion of cool gas inlet 11. In addition to, or instead of employing a nozzle structure, mixing section 13 may be adapted to contain bubble plates, disc and doughnuts, etc. for promoting the intermingling of up-flowing cool gas and downcoming liquid fractions.

Thus, the cool gas serves to quench the downcoming hydrocarbon liquid to a temperature of about 700° F., the liquid settling and accumulating to form bottoms holdup 10. Additionally, the gas acts as a stripping agent, recovering gas oil and similar valuable materials from the heavy liquid ends. During the course of its passage upwardly through the mixing section, the cool gas is preheated and is substantially at the temperature of the hot coker vapors, i.e. 700 to 800° F., by the time it reached the point of introduction of the product vapors. Thus, it does not appreciably cool incoming product vapors, nor cause carbon depositing condensation. Thereafter, the cool gas of the present invention serves as a gas oil partial pressure depressant. As will be appreciated by those in the art, decreased gas oil partial pressure results in an increased gas oil cut point with consequent increased yields of desired gas oil products. Generally, the gas oil partial pressure may be reduced by as much as .075 atm., cut points being thereby increased from approximately 1000° F. to 1050° F.

After passing through additional rectification configurations, gas oil, with a cut point in the neighborhood of 1050° F., is withdrawn from draw-off pan 6 by line 7. It may then be passed to storage, a catalytic cracking unit, or other processing. Customarily, a portion is recycled by line 8 back to this scrubbing unit as a rectification aid.

Bottom liquid is withdrawn by line 14. While the use of liquid quenching may be entirely eliminated in accordance with the present invention, the drawing depicts a highly flexible arrangement wherein a portion of the heavy liquid is passed by conduit 15 to cooling in condenser 16, whencefrom it is recycled through passageway 17 back into the shed section of the scrubber. Additional reflux and cooling may thus be supplied.

Figure 2 illustrates utilization of the present invention in a combination fractionator 100. As is conventional in such a unit, hot vaporous materials, such as the superheated vapors from a reformer, catalytic or inert reaction step, visbreaker, etc. are passed by line 101 into the shed section 102 of the fractionator, wherein they contact downcoming liquid oil supplied by the introduction of reduced crude through line 103. The vapors serve to heat the reduced crude, thus vaporizing

out desirable hydrocarbon fractions in gas oil or the like.

According to this invention, a cool gas of the type previously described is injected through line 104 and multiple dispersion means 105 into the fractionator below the hot vapor inlet. Downcoming liquid is thus simultaneously quenched and stripped as it descends to holdup section 106. Liquid in bottom reservoir 107 formed therein may be intermittently or continuously withdrawn through conduit 109 by suitable manipulation of valve 108.

The cool gas, continuously heated in its upward passage, contacts the feed vapors in section 102, thereafter serving to depress hydrocarbon partial pressure. Total gas effluent may be removed through passageway 110.

As previously noted, various structural aids for promoting rectification may be employed in the mixing zone between cold and hot vapor inlets.

The following table sets forth a compilation of pertinent conditions amenable for operating in accordance with the present invention.

Table I

	Broad Range	Preferred Range
Inlet temperature of hot vapors, ° F.....	500-1,800	900-1,200
Temperature range of downcoming liquid, ° F..	500-1,200	700-850
Maximum inlet temperature of cool gas, ° F....	700	300
Maximum atmospheric boiling point of cool gas, ° F.....	300	200

Thus, it is seen that by operating a hydrocarbon recovery system in accordance with this invention, downcoming liquid fractions are both quenched and stripped, and hydrocarbon partial pressure reduced thereby permitting increased cut points or yields. Particularly, gas oil recovery is substantially enhanced with a minimum of extraneous equipment or cumbersome procedures.

Having described the present invention, what is claimed is as follows:

1. A process for improving recovery of gas oil from hot vaporous cracked products comprising the effluent from a fluid coking reaction zone, which comprises passing such hot vaporous cracked products directly from said coking zone into a region above the bottom of a fractionating zone and above a mixing section therein for upward flow through said fractionating zone for contact with downflowing liquid hydrocarbons therein including condensate oil and for rectification of desired fractions, collecting a residual bottoms fraction in the bottom of said fractionating zone, removing uncondensed vapors and gases overhead from said fractionating zone, cooling the introduced vaporous cracked products with said downflowing liquid hydrocarbons and enhancing recovery of a gas oil hydrocarbon fraction by introducing above the level of said collected bottoms fraction a light hydrocarbon gas having an atmospheric boiling point of less than 200° F. and at a temperature below about 300° F. into said mixing section arranged in the bottom portion of said fractionating zone, contacting said relatively cool hydrocarbon gas with said downflowing liquid hydrocarbons in said mixing section so as to cool said downflowing liquid hydrocarbons and strip volatile material therefrom while heating said hydrocarbon gas to substantially the temperature of said vaporous cracked products by the time said hydrocarbon gas reaches the region of entrance of said vaporous cracked products to said fractionating zone, and contacting said thus heated hydrocarbon gas with said hot vaporous cracked products and said downflowing liquid hydrocarbons as said heated hydrocarbon gas passes upwardly through said fractionating zone to depress the hydrocarbon partial pressure of vaporous gas oil hydrocarbons passing up through said fractionating zone without condensing gas oil hydrocarbons to increase the recovery of a liquid gas oil fraction further up said fractionating zone, said hy-

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drocarbon gas being selected from the group consisting of C_4 and lighter hydrocarbon gases, and removing said liquid gas oil fraction from the upper portion of said fractionating zone.

2. A process for increasing the recovery of gas oil from hot vaporous cracked products comprising the effluent from a fluid coking reaction zone which comprises passing such hot vaporous cracked products directly from said coking zone into a region above the bottom of a fractionating zone and above a mixing section therein for upward flow through said fractionating zone for contact with downflowing liquid hydrocarbons therein including condensate oil and for rectification of desired fractions, collecting a residual bottoms fraction in the bottom of said fractionating zone, removing uncondensed vapors and gases overhead from said fractionating zone, cooling the introduced vaporous cracked products with downflowing liquid hydrocarbons and enhancing recovery of a gas oil hydrocarbon fraction by introducing above the level of said collected bottoms fraction light hydrocarbon gas having an atmospheric boiling point of less than 200° F. and having been cooled to a temperature in the range of 60° F. to 300° F. into said mixing section arranged in the bottom portion of said fractionating zone, contacting said relatively cool hydrocarbon gas with said downflowing liquid hydrocarbons in said mixing section so as to cool said downflowing liquid hydrocarbons and strip volatile material therefrom while heating said hydrocarbon gas to substantially the temperature of said vaporous cracked products by the time said hydrocarbon gas reaches the region of entrance of said vaporous cracked products to said fractionating zone, and contacting said thus heated upflowing hydrocarbon gas with said hot vaporous cracked products to depress the hydrocarbon partial pressure of vaporous gas oil hydrocarbons passing up through said fractionating zone

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without appreciably cooling said vaporous cracked vapors to increase the recovery of a liquid gas oil fraction further up said fractionating zone, said hydrocarbon gas having been recovered from said uncondensed vapors and gases passed overhead from said fractionating zone, and recovering an increased yield of said liquid gas oil fraction from an upper portion of said fractionating zone.

3. A process according to claim 2 wherein hydrocarbon oil feed is introduced into the upper portion of said fractionating zone for downward flow therethrough in countercurrent to upflowing vapors and gases to remove volatile components from said oil feed.

4. A process according to claim 1 wherein said hot vaporous cracked products introduced into said fractionating zone are at a temperature between about 700° F. and 800° F.

5. A process according to claim 2 wherein said hot vaporous cracked products introduced into said fractionating zone are at a temperature between about 700° F. and 800° F.

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