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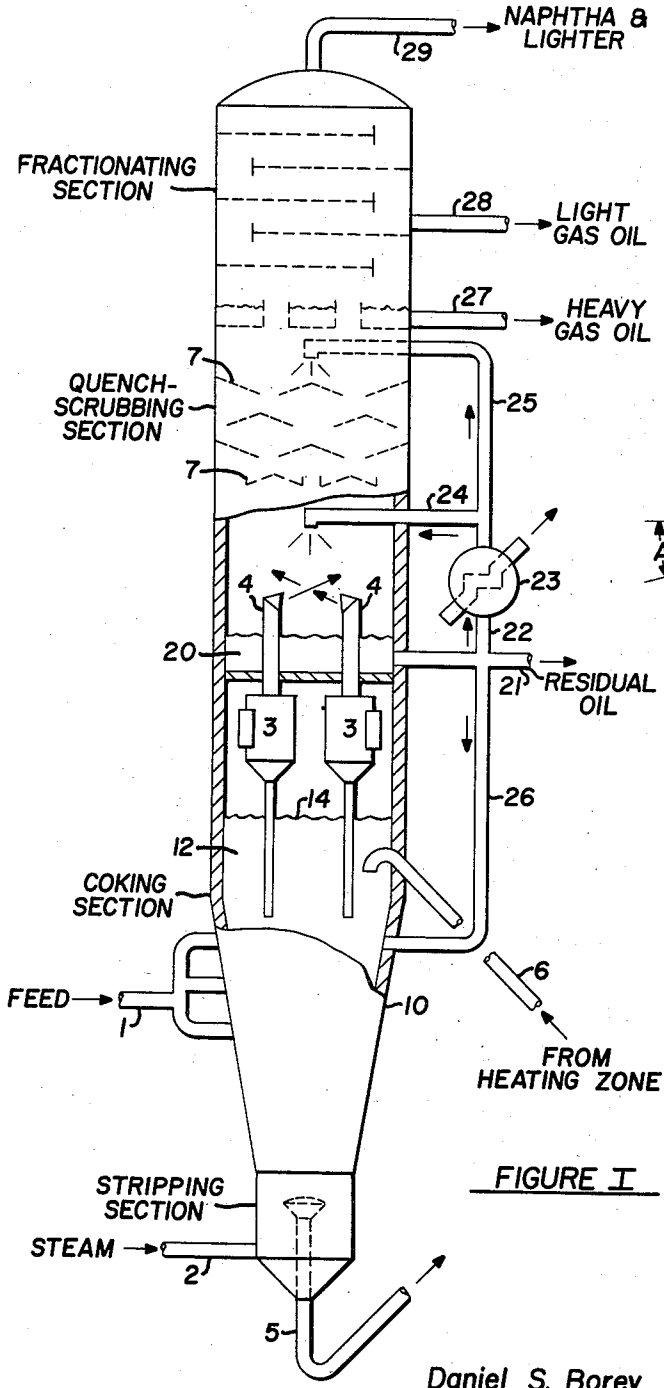

FIGURE I

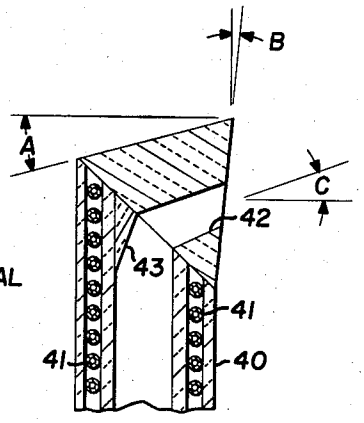

FIGURE II

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QUENCH NOZZLE FOR FLUID COKER REACTOR VAPORS

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This invention relates to a method and apparatus for quenching high temperature hydrocarbon vapors that have a propensity for forming coke deposits. More particularly, this invention relates to an improved fluid coking process wherein provision is made for quenching and scrubbing the conversion products while avoiding coke deposits.

Briefly, this invention proposes a quench nozzle for introducing high temperature hydrocarbon vapors, particularly those from a fluid coking process, into the lower portion of a quench-scrubbing zone at a high velocity and at an angle whereby coking of or in the quench nozzle is effectively prevented. The quench nozzle comprises an insulated vertical riser extending through the bottom portion of the scrubbing zone and through the reservoir of liquid oil usually contained therein, and terminating in an inclined converging insulated nozzle, integral with the vertical riser, for discharging vapors at a high velocity into the scrubbing zone.

The fluid coking process has recently been introduced into the petroleum industry. In this coking process, a heavy oil, usually a residual oil, is converted by contact with high temperature particulate solids maintained as a fluid bed in a coking or reaction zone. Upon contact with the solids, the heavy oil is converted to vaporous conversion products and coke which is deposited on the solids. The solids used are usually coke particles produced by the process having a size in the range of about 20 to 1000 microns. Other solids, either catalytic or non-catalyic, may be used however, such as sand, spent catalyst, kieselguhr and the like. To maintain the coking temperature at about 900° to 1200° F., a portion of the fluidized solids bed is continuously circulated to an external heating zone and back. This external heating zone customarily comprises a fluid bed burner wherein the carbon containing solids are partially burnt and heated to a temperature 100° to 400° above the coking temperature, but may comprise other suitable means of heating, including transfer line burners and gravitating bed burners.

The vaporous conversion products are withdrawn overhead from the fluid coking bed, have entrained solids removed, and then are cooled and separated as by fractionation to recover the desired product fractions. A cyclone separation system comprising a plurality of cyclone units either in parallel or series located within the reactor is customarily used to separate entrained solids from the conversion products before they are cooled. The cyclone system may be located externally over the coking reactor.

Because of the coke forming propensity of the vapors, it is usually desired to have the passageway for conveying the vapors to the zone where they are cooled as short as possible. To this end, the quench-scrubbing zone in one design has been mounted or superposed on the coker. This quench-scrubbing zone comprises a lower zone relatively unobstructed with internals and an upper portion

with liquid vapor contacting means, e.g., disc and doughnut baffles, and means for spraying a cool scrubbing oil over the contacting means. The conversion products from the coking zone are introduced into the lower portion of the quench-scrubbing zone, contact the scrubbing oil and are rapidly cooled to below coke forming temperatures, i.e., below about 800° F. The scrubbed conversion products are then fractionated. In some designs, the fractionation section is further superposed on the scrubbing zone to obtain an integral structure.

In commercial operations, trouble has been experienced in introducing the high temperature conversion products into the quench-scrubbing zone. The vapors partially condense and form deposits in the conduits conveying the vapors to and into the scrubbing zone, and scrubbing liquid falls into the outlet of the vapor conveying conduits and forms coke. These coke deposits have been so severe as to render the equipment inoperable.

Although a coking process is designed for one set of conditions, it will be apparent to those skilled in the art that in many cases the equipment must operate at less than design capacity. At low capacities, the velocity of the vapors discharging into the scrubbing zone may be so low as not to prevent entrance of the scrubbing liquid into the conduit, even though the conduits have originally been designed to maintain discharge velocities in the nature of 150 feet per second to avoid this.

It also has been found that the internals in the scrubbing zone that are not washed with liquid readily receive coke deposits when vapors impinge thereon without having first been cooled. Such deposits, although perhaps not rendering the equipment inoperable per se, drop off, fall to the base of the scrubbing zone and plug up the liquid circulation lines thereby causing inoperability.

This invention is addressed to these specific problems and other similar problems occurring in fluid coking operations, and proposes a particular solution therefor, as will appear from the following description of the drawings attached to and forming a part of this specification.

Figure 1 of the drawing depicts an integrated fluid coking arrangement modified in accordance with the teachings of this invention. Although an integral design is shown, it is to be understood that each of the zones may be contained in separate vessels with suitable connecting conduits therebetween.

Figure 2 of the drawing shows an enlarged vertical section view of the quench nozzle of this invention.

In brief compass, this invention proposes an improvement of a fluid coking process wherein a hydrocarbon oil is converted to vaporous conversion products in a coking zone by contact with high temperature fluidized solids, wherein said vaporous conversion products are withdrawn overhead after having entrained solids removed and are immediately quenched in vapor phase in a scrubbing zone with cool heavy quench oil, and wherein a body of liquid oil is maintained in the lower portion of the scrubbing zone. The improvement comprises passing the vaporous conversion products from the coking zone upwardly into the lower portion of the scrubbing zone through an insulated passageway extending through the body of liquid oil and thence discharging the vapors through an inclined insulated converging nozzle at a velocity in the range of 100 to 250 ft. per second at an angle of 20° to 60° from the horizontal whereby the operability and flexibility of the coking process is greatly improved.

More particularly, this invention proposes apparatus for quenching high temperature hydrocarbon vapors which have coke forming propensities. The apparatus comprises a quench vessel, a vertically disposed insulated conduit projecting into the lower portion for admitting

vapors thereto, the insulated conduit terminating in an inclined converging nozzle or deflecting cap having a free vapor passageway 15 to 40% that of the insulated conduit, and adapted to introduce the vapors into the quench vessel at a velocity in the range of 100 to 250 ft. per second and at an angle of 20° to 60° from the horizontal, the inclined converging nozzle terminating in a planar surface downwardly inclined more than 3° from the vertical.

The quench vessel, more particularly described, contains vapor-liquid contacting means, means for introducing cool quench oil into the upper portion thereof, means for withdrawing liquid from the lower portion thereof and means for withdrawing quenched vapors from the top portion.

Referring now to Figure 1, the reference character **10** designates a reactor or coking zone combined with a superposed product quench and fractionation system. The coking zone contains a dense turbulent fluidized bed **12** of finely divided inert particles, preferably particulate coke produced in the process. The dense bed **12** has a level indicated at **14** with dilute or disperse phase thereabove. The inert solids of the fluidized bed **12** have a particle size between about 20 and 1000 microns, preferably between about 40 and 400 microns. The fluidized bed is maintained at a temperature between about 850° and 1600° F., preferably between about 900° to 1100° F.

The preheated oil feed to be converted is introduced directly into the dense fluidized highly turbulent bed **12** in the reactor at a plurality of points via line **1**. The oil feed is preferably preheated in any suitable manner as by heat exchange with product streams, etc., to a temperature between about 600° and 800° F. before being introduced into reactor **10**. The oil feed comprises, preferably, a residual petroleum oil such as tar, pitch, crude residuum, heavy bottoms or other similar hydrocarbon stocks having an A.P.I. gravity between about −10 and 20°, a Conradson carbon between about 5 and 50 weight percent and an initial boiling point between about 850° and 1200° F. Steam or other substantially inert gas may be introduced at one or more points **2** to strip the coke of adhering hydrocarbons before it is circulated to be reheated and to assist in maintaining the bed in a fluidized condition.

The fluidized bed **12** is maintained as such by the upflowing hydrocarbon gas and vapors formed by the coking of the oil feed and by the steam added to the process. The superficial velocity of the gases and vapors passing upwardly through the bed **12** is between about 0.5 and 4 ft./sec. when using finely divided coke of about 40 to 400 microns, and at a superficial velocity of about 1 to 2 feet per second, the density of the fluidized bed will be about 40 lbs. per cu. ft. but may vary between about 15 and 60 lbs. per cut. ft. depending on the gas velocity selected and the particular particle size range.

Coke particles are withdrawn downwardly from dense bed **12** through the stripping zone at the base of the coking vessel by line **5** and circulated to an external heating zone to be reheated to a temperature of 100° to 400° F., above the coking temperature. Heated coke particles are circulated from the heating zone and reintroduced into the coking zone via line **6** to maintain the coking temperature.

Vaporous products of coking leave the bed **12** and pass overhead through a cyclone system **3** arranged in the top interior of reactor **10**. The vaporous reaction products leaving the coking zone contain entrained solids and cyclones **3** or other gas-solid separating devices are used to separate or recover the entrained solids and return them to the dense fluidized bed through suitable diplegs. More than one cyclone in stages may be used and the cyclone may be arranged externally of reactor **10**. The vapors continue upwardly through quench nozzles **4** designed according to this invention into the combination tower wherein they are initially quenched to a temperature in the range of 600° to 900° F. by a cool reflux stream of oil. This quenching removes from the vapors heavy ends containing catalyst contaminants and refractory constituents.

The quench or scrubbing oil and condensed heavy ends collect in liquid oil reservoir **20** at the base of the scrubbing zone. A portion of this condensed oil may be withdrawn as product via line **21** if desired, but preferably, a portion, circulated by line **22**, is cooled in heat exchanger **23** and the cool oil then injected into the scrubbing zone via lines **24** and **25**, and sprayed over vapor-liquid contacting means **7**. The remainder of the oil is recycled via line **26** to the coking zone for further treatment. The scrubbed vapors continue upwardly through the tower wherein intermediate boiling range fractions are condensed. Thus, a heavy gas oil may be removed by line **27** and a light gas oil by line **28**. The remaining uncondensed material, including naphtha and lighter, is removed from the top of the tower by line **29** and further treated as desired. To effect staged heat removal, portions of the product streams may be cooled and refluxed to the tower as is conventional.

In past operations, difficulty has been experienced in introducing the high temperature conversion products from the disperse phase of the coking zone into the quench zone. Coke deposits form in the vertical risers passing the conversion products from the reactor cyclones up through the reservoir of liquid in the bottom of the quench zone. Also, when the high temperature vapors impinge upon the internals of the scrubbing zone and the surfaces are not adequately washed with liquid, severe coke deposits will form.

According to this invention a specially designed quench nozzle **4** is used to introduce vapors from the reactor cyclone into the scrubbing zone in such a manner as to avoid coke deposits in the vertical riser from the cyclone, to prevent impingement of the vapors on unwashed surfaces in the scrubber, and to provide efficient mixing between the scrubbing or quench oil and the vapors. This nozzle design is more fully shown in Figure 2.

The important features of this quench nozzle include:

(1) The use of an inclined converging cylindrical nozzle on the vertical vapor riser to increase the velocity of the conversion products above 100 feet per second. The high velocity achieved by this nozzle breaks any coke deposits loose that may form in the nozzle and provides for violent mixing between the scrubbing oil and the vapors.

(2) Because the nozzle is set at an angle, the vapors are forced to travel transversely through the tower and have a longer path of flow before contacting wall surfaces. They are directed against vertical walls that are well washed with liquid. This prevents contact of the vapors with the under-surfaces of the vapor-liquid contacting baffles in the scrubber which may not be washed with liquid.

(3) The vertical riser and nozzle are well insulated to prevent heat loss and to prevent coking of the liquid in contact with the vertical riser. The vertical riser and inclined conversion nozzle may be heated as by steam coils or electrical heating elements to further off-set heat losses.

(4) In a preferred design, the discharge end of the converging nozzle ends in a planar surface that slants more than 3°. This prevents liquid from falling into the nozzle, particularly at low reactor feed rates when the velocity in the nozzle may not be sufficient to positively prevent entrance of liquid. Because the nozzle terminates in a planar surface, inspirating of liquid into the discharged vapors is prevented. Such inspiration has been found to cause coke deposits.

Figure 2 more particularly shows this arrangement. A portion **40** of the vertical riser containing the vapors discharged from the cyclone is shown. The vapors pass through this portion at a velocity in the range of 40 to

75 feet per second. The walls of the vertical riser are well insulated and may be further heated by steam coils **41**, placed within the insulation. The vapors are deflected into an inclined converging nozzle **42**. In this particular example, a flat baffle plate **43** is inserted in the vertical vapor passageway to smoothly direct the vapor flow. The top surface of nozzle **42** is inclined (angle A) more than 10° to provide liquid run-off. The planar terminal portion of the nozzle is inclined (angle B) more than 3° from the vertical to prevent downflowing liquid from entering the nozzle. The nozzle, for best operation, directs the vapors into the scrubbing zone at an angle (angle C) in the range of 20° to 60° from the horizontal. The width of the annular planar surface around the nozzle discharge must be 0.5 to 1.0 times the diameter of the discharge nozzle, but not less than 6", to effectively prevent inspiration of liquid into the high velocity vapors. The nozzle is sized so that in normal operation the vapors have a discharge velocity in the range of 150 to 200 feet per second. This is sufficient to blow out any liquid that may enter the nozzle and to break loose any coke deposits that may form.

In normal operation, the lower portion of the scrubbing zone is filled with a very fine violently agitated hydrocarbon mist. At low velocities, however, the scrubbing oil may descend in the region of the nozzles as discrete large size liquid droplets. Thus, at capacity operation, high velocities prevent entrance of mist into the nozzle and at low capacity operation of the coker, the inclination of the discharge face prevents entry of descending liquid droplets. It can be appreciated that this particular nozzle design gives flexibility to the coking process.

When more than one quench nozzle is used to introduce the coker vapors into the quench zone, for example, when four are used, the inclined converging nozzles are arranged to direct the vapors tangentially about a horizontal section of the scrubbing zone, rather than through the vertical center line. This will promote further agitation and mixing of the scrubbing oil and vapors.

Table I presents a specific example of this invention. The example is based on coking a vacuum flashed residuum having a 950° F. initial boiling point, a 0.2° A.P.I. gravity, a 30.2 wt. percent Conradson carbon, and a 4.1 wt. percent sulfur content, and all of 1015° F.+ product (0.3 lb./lb. fresh feed) is recycled to extinction.

Table I

	Example
Pressure, @ cyclone inlet, p.s.i.	11.0.
Temperature of coking bed, °F.	990.
Feed rate, w./hr./w.	0.7.
Solids circulation rate, lbs./lb. feed	8.6.
Fluidizing steam, wt. percent feed	14.7.
Conversion to 1015° F., products	70.7.
Vapor velocity @ quench nozzle outlet, ft./sec.	190.
Pressure drop through cyclones and quench nozzles, p.s.i.	0.93.
Vapor temperature in scrubbing zone, °F.	990—bottom, 650—top.
Liquid temperature in scrubbing zone, °F.	725—bottom, 500—top.
Liquid quench used, lbs./actual cu. ft. vapors	0.11.
Number of cyclones and quench nozzles	2.
Cyclone rating, cu. ft. min. at 0.11 lb./cu. ft. initial solids loading	6000/cyclone.
Internal diameter of vertical quench nozzle riser, inches	18.
Outlet diameter of quench nozzle, inches	12.

Table I—Continued

	Example
Angle A	15°.
Angle B	5°.
Angle C	35°.

Having described this invention, what is sought to be protected by Letters Patent is succinctly set forth in the following claims.

What is claimed is:

1. In a fluid coking process wherein a hydrocarbon oil is converted to vaporous conversion products in a coking zone by contact with high temperature fluidized solids, wherein said vaporous conversion products are withdrawn overhead after having entrained solids removed and are immediately quenched in a scrubbing zone with a cooled heavy oil, and wherein a body of liquid oil is maintained in the lower portion of said scrubbing zone, the improvement which comprises passing said vaporous conversion products from said coking zone upwardly into the lower portion of said scrubbing zone through an insulated passageway extending through said body of liquid oil, thence discharging said vapors through an inclined converging nozzle at a velocity in the range of 100 to 250 ft./sec. and an angle of 20° to 60° from the horizontal, whereby the operability and flexibility of said process is improved.

2. In a fluid coking system wherein a hydrocarbon oil is converted to vapors in a coking vessel by contact with high temperature fluidized solids contained therein and wherein said vapors are withdrawn overhead after having entrained solids removed and are rapidly and immediately quenched with a cool oil in a quench vessel, an improved quench nozzle for admitting said vapors at high velocity into said quench zone which comprises an insulated substantially vertical conduit projecting into the lower portion of said quench zone, said insulated conduit terminating into an integrated deflecting cap adapted to discharge the vapors therefrom at an angle of 20° to 60° from the horizontal and sized to discharge the vapors at a velocity in the range of 100 to 250 ft./sec., said deflecting cap having a free vapor passageway 15 to 40% of the vapor passageway of said insulated conduit.

3. The improvement of claim 2 wherein said deflecting cap terminates in a planar face inclined downwardly towards said insulated conduit more than 3° from the vertical.

4. Apparatus for quenching high temperature hydrocarbon vapors having coke forming propensities which comprises a vertical disposed insulated conduit projecting into the lower portion of a quench vessel for admitting said vapors thereto, said quench vessel having a vapor-liquid contacting member above the area of vapor introduction, said conduit upwardly terminating in an inclined converging nozzle having a vapor passageway 15 to 40% of the area of the vapor passageway of said insulated conduit, said inclined converging nozzle being adapted to introduce said vapors into said quench vessel at a velocity in the range of 100 to 250° F., per second and at an angle of 20 to 60° from the horizontal and terminating in a planar surface downwardly inclined more than 3° from the vertical.

5. Apparatus for converting hydrocarbon oils which comprises a vertically elongated reaction vessel, a fluid bed of high temperature particulate solids therein, a scrubbing vessel superposed on said reaction vessel, said scrubbing vessel having a vapor-liquid contacting member positioned therein, means for injecting oil into said bed to form vaporous conversion products, means for withdrawing overhead said conversion products and removing entrained solids therefrom and means for upwardly introducing said conversion products into the lower portion of said scrubbing vessel, said last named means comprising a vertically elongated conduit upward-

ly terminating in an inclined converging nozzle, said nozzle being adapted to discharge the conversion products at a velocity in the range of 100 to 250 ft./sec. and at an angle of 20 to 60° from the horizontal.

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