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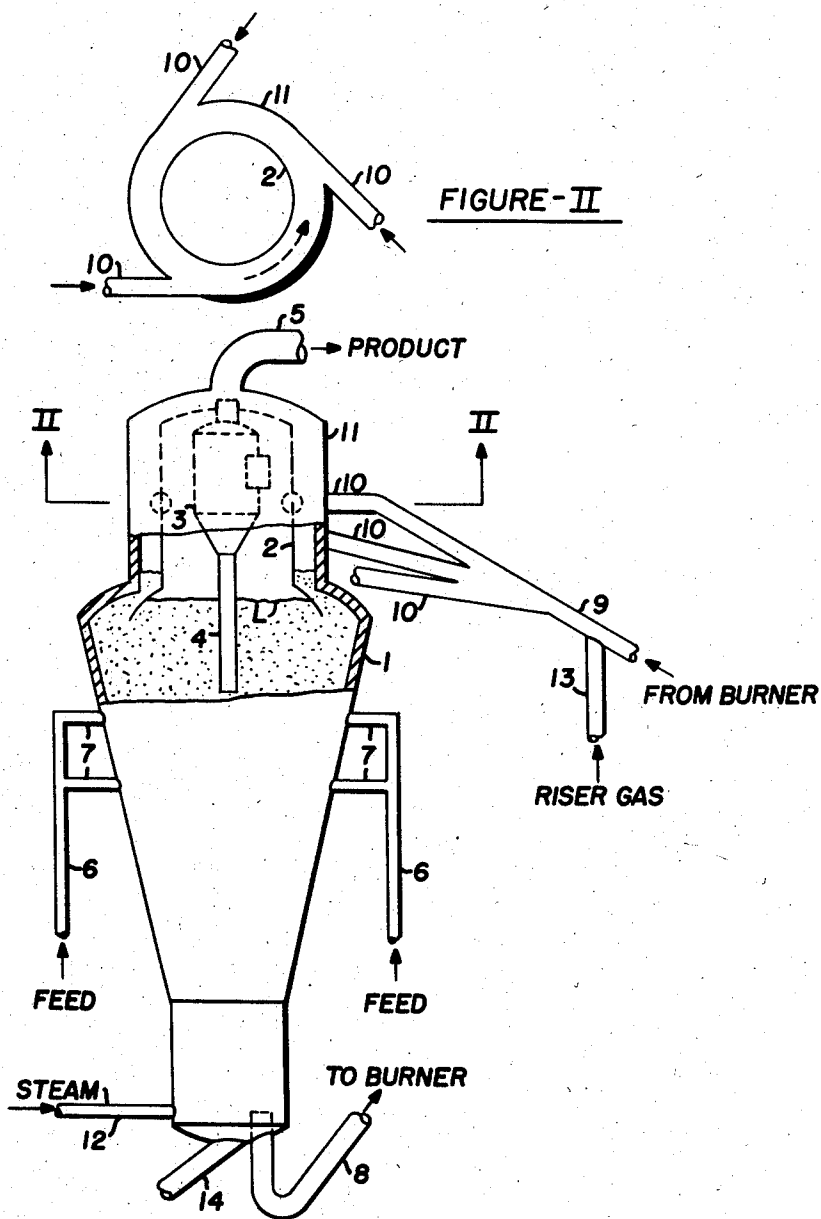


FIGURE - I

FIGURE - II

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FLUID COKING REACTOR AND PROCESS

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7 Claims. (Cl. 208—157)

This invention relates to the upgrading of heavy hydrocarbon oils by pyrolysis. Specifically this invention pertains to an improvement of a reactor wherein oils in the nature of petroleum residua are coked by contact with high temperature fluidized particulate solids.

Recently it has been proposed to coke heavy residuum oils by injecting them into a coking vessel containing a fluidized bed of high temperature finely divided solids, e.g., coke, and sand and the like. In the coking vessel, the oil undergoes pyrolysis in the fluidized bed, evolving lighter hydrocarbons and depositing carbonaceous residue on the solid particles. The necessary heat for the thermolysis is supplied by circulating a stream of the fluidized solids through an external heater and back to the coking vessel. The solids, which have had carbon deposited on them during the coking, are partially combusted in the heater. It can be seen that this technique of fluidized coking offers a great advantage over the delayed coking process in that the operation is continuous. This fluid coking process is more fully presented by co-pending application, titled, "Fluid Coking of Heavy Hydrocarbons and Apparatus Therefor," S.N. 375,088, filed August 19, 1953, by Pfeiffer et al.

Serious problems, however, have been encountered in the development of this type of coking. One particular problem is the building up of coke deposits on the confines of the vapor space above the fluidized bed and in lines removing the hot vapors from the coking vessel. It has been found that the high boiling constituents in the hot coker vapors will readily condense and that if this condensation is on surfaces having a temperature of about 700° to 1000° F., severe coking will occur with consequent fouling and plugging of the equipment. This coke deposition has been inhibited somewhat in prior fluid coking processes by providing for entrainment and carry over of solid particles from the fluid bed. This has been accomplished by increasing the velocity of the gases in the dilute phase above the fluidized solids bed (by decreasing the reactor cross-sectional diameter at this point) or by causing the internal solids-gas separator or cyclone to operate inefficiently, as by aerating the cyclone dipleg. The entrained particles help uphold the temperature of the vapors, scour attendant surfaces, thereby removing carbon deposits, and provide surfaces upon which condensing vapors are absorbed. This method, however, has not been entirely satisfactory. Larger amounts of fluidizing gas have to be used to cause the entrainment and this undesirably dilutes the vapors and increases the size and complexity of subsequent fractionating and separating equipment. Good control of the amount of entrainment has been difficult to achieve by the methods previously suggested. Large quantities of a diluent gas may be added to the vapors in the diluent phase above the fluid solids bed to prevent condensation of the hydrocarbon vapors but this requires additional heating and compressing capacity for the diluent besides increasing the load on subsequent separation equipment.

This invention is concerned primarily with this prob-

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lem of coke deposition. It is an object of this invention to provide an improved fluid coking process and apparatus which successfully overcomes this and other problems. Other objects and advantages will appear more clearly in the following description in which the attached drawings, forming a part of this specification, are discussed in detail.

Figure 1 of the drawings discloses one embodiment of the invention incorporated into a conventional fluidized solids bed, hydrocarbon oil coking vessel. Figure 2 is a sectional view of the apparatus of Figure 1 taken along line II—II of Figure 1. Figure 3 is second embodiment of the invention.

Generally, the objects of this invention are attained by placing a concentric baffle in the upper or dispersed phase zone of a fluid coking reactor radially spaced from the internal reactor wall and extending downwardly below the pseudo-liquid level of the fluidized bed. Hot solids, returning from an external combustion zone or burner, are injected tangentially into the annulus formed by the baffle and the outer vessel walls. In this manner an internal conduit of reduced diameter is formed through which a major portion of the hot effluent coker vapors pass. The hot tangentially injected solids, which have a temperature of about 1000°–1500° F., maintain the temperature of the baffle above the condensation point of the vapors and thereby coke deposition in this zone is prevented. Tangential injection of the heated solids is used not only to distribute the solids throughout the annulus, but also to accomplish centrifugal solids-gas separation in that zone.

This arrangement has several decided advantages aside from preventing coke deposition. The most obvious is the combination of the solids separator and the top section of the reactor whereby a vessel of substantially constant external diameter can be formed which would lower fabrication and construction costs in commercial units. Another very definite advantage is that this design reduces the cross-sectional area of the passageway for the product vapors. This tends to keep coke entrainment reasonably high without excessively high fluidizing gas rates in the dense bed and reduces vapor holding time thereby minimizing vapor phase cracking.

Referring now to the drawings, a simplified cross-sectional view is presented of a coking vessel 1 in Figure 1. The lower portion of the vessel is of reduced diameter and serves as a stripping section. The middle portion is conically shaped in order that the velocity of the uprising gases will be substantially constant. The upper portion is of reduced diameter to increase the velocity of the uprising gases and contains a baffle 2 constructed to achieve the objects of this invention.

A heavy hydrocarbon oil such as 12.9% West Texas vacuum residuum along with recycled bottoms from the coker effluent fractionator is introduced into the coker from manifolds 6 by lines 7 at a rate of 0.1 to 3 weight of oil per weight of solids in the fluid bed. To avoid bogging and agglomeration of the bed, it is preferred that the feed be sprayed or injected into the bed at a multiplicity of points both circumferentially and vertically. In the hot fluid bed, the oil is converted at a temperature of 900° to 1200° F., preferably 950° F., to carbonaceous residue which is deposited on the fluidized solids and hot hydrocarbon vapors. The vapors pass upwardly, with some entrainment, past the pseudo-liquid level of the bed 1 to a gas-solids separator, e.g. a cyclone 3, where a portion or substantially all of the entrained solids are removed and returned to the bed by line 4. Inclined baffles, vanes or the like may be satisfactorily used in place of the cyclone in some applications. Product vapors are removed from the coker by line 5 and trans-

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ferred to subsequent operations such as fractionation or quenching, not shown.

Fluidizing gas, e.g. steam, is admitted at a plurality of points in the lower portion of the coker, one of which is shown as line 12. This gas will amount to about 5 to 30 weight percent of the liquid hydrocarbon feed and serves not only to maintain the fluidity of the solids bed, but also to strip the particulate solids of hydrocarbon vapors before they are transferred to the combustion zone by line 8.

Normally coke will be produced in excess of that required to supply heat for the thermolysis and this excess is removed by line 14 as product. There will also be removed by this line particles that have increased in size by reason of the carbon deposition, or because of agglomeration of the particles, to the extent of being unfluidizable.

A portion of the bed is continuously removed by line 8 and transferred to a combustion zone, not shown. This zone can be one of several types. A vessel containing a fluidized bed of the solids, fluidized by air to support combustion, is preferred but a gravitating bed, a transfer line burner or other combustion equipment would suffice. A portion of the carbon deposited on the solids in the coking zone is burnt off in the combustion zone, raising the temperature of the remaining particles to a temperature of 1000° to 1500° F., preferably 1100° to 1300° F. The hot solids are returned to the coker by line 9. This method of combustion of carbon-containing solids and of transferring solids between zones is well known per se and, therefore, an elaborate description has not been made of these techniques.

For this example, the returned solids are shown as being tangentially injected at a plurality of points, e.g. 3, at the top of the reactor. Whether one point of injection or more is used will depend upon the equipment design, e.g., the diameter of the top of the coker, amount of solids circulation, and the radial depth of the annulus. As depicted, the returned hot solids in line 9 are divided into 3 streams by lines 10 and tangentially introduced into the annulus (see Figure 2) formed by baffle 2 and vessel wall 11. The conveying gas separates from the heated solids and this separation is aided by the centrifugal force created by the tangential injection of the solids. The hot solids move downwardly and enter the conical section or main fluid bed and the conveying gas passes through line 5 with the product vapors.

It is customary in normal coking operations to admit a conveying or aerating gas, generally steam, to the upwardly flowing solids in the transfer lines at one or more points. Line 13 admits such a conveying gas to transfer line 9. By judicious control of the amount of gas admitted, it is possible to control the amount of entrained solid carried over in line 5. By the design of this invention, the hot solids from the burner, which are at a higher temperature than the main fluid bed, are preferentially entrained. Because of the higher temperature of the entrained solids in the method of this invention, a lesser amount of solids are needed than in the conventional operation to prevent coking of the transfer lines of the hot coker vapors. The vapors are maintained above their condensation or dew point by the solids and consequently coking is greatly inhibited.

Thus, it can be seen, that by this invention, a major portion of the hot coker gases are made to pass through the central conduit formed by the baffle and the surfaces of the baffle are maintained above the dew point of the vapors. By this means, coke deposition on the reaction vessel walls is prevented. Because the vapors pass through the narrow passageway formed by the baffle, vapor residence time is held to a minimum. Further, because hot solids from the burner are preferentially entrained and because the amount of solids entrainment is

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easily controlled, coke deposition in vapors handling lines leading from the coker is inhibited.

The coking operation is usually carried out at relatively low pressure, such as from 0 to 50 pounds per square inch gauge. It is preferred to operate at a vapor outlet pressure sufficient to force the vapors through subsequent fractionating and separating equipment.

Figure 3 illustrates another form of a coking reactor 51 having a baffle 54 designed according to this invention. The main difference between this design and that of Figure 1 is that the coker vapor-solids separator or cyclone 56 is external from the coker 51. Briefly, feed is conveyed to the reactor by line 52 and injected at a plurality of points by lines 53. Fluidizing and stripping stream is admitted at a plurality of points in the lower portion of the reactor by lines 62. Product coke is removed by line 61 at the base of the reactor. The hot coker vapors pass upwardly through the conduit formed by baffle 54 and are removed from the coking vessel by line 55 to cyclone 56. Here entrained solids are removed and returned to the main fluid bed by line 58. The vapors are taken from the cyclone by line 57 to further processing, not shown. It is to be understood that the cyclone 56 can be so operated to permit solids carry over into line 56 and subsequent equipment. One method for controlling this entrainment is to pass gas into standpipe 58 by line 65. As before mentioned, this solids entrainment may be desired in order that the solids may maintain the temperature of vapors, scour attendant surfaces and provide surfaces for coke deposition.

Particulate carbon containing solids are removed by line 59 and transferred to a combustion zone, previously described in connection with Figure 1. The heated solids are returned from the combustion zone by line 60 and tangentially introduced into the annulus formed by interior baffle 54 in the upper portion of the reactor.

A variation is shown by the drawing in that the "riser" or conveying gas of the circulated solids is not used to control the amount of hot solids entrainment. Instead a gas, for example steam, is admitted to the lower portion of the annulus by lines 63. By controlling the amount of gas admitted, the amount of entrainment of solids is readily controlled.

It will be apparent to those skilled in the art that this invention is capable of various modifications and applications. Consequently, the invention is not to be limited by the above description, but only by the following claims.

What is claimed is:

1. A process for the conversion of heavy hydrocarbon oils, which comprises injecting a multiplicity of streams of said heavy oil into an enlarged circular coking vessel containing a body of finely divided solids having a pseudo-liquid level at the upper portion of said vessel, circulating said solids to an external heating zone, circulating heated solids from said heating zone to said coking vessel, tangentially injecting said heated solids into an annulus in the upper portion of said vessel above the level of said body of solids to maintain said vessel at a coking temperature between 900° and 1200° F., said annulus being formed by an internal concentric baffle radially spaced from the internal wall of said upper portion of said circular coking vessel, said baffle extending downwardly below said pseudo-liquid level and forming a centrally located conduit, passing gaseous material upwardly through said coking vessel at a velocity sufficient to maintain said body of solids in a dense turbulent fluidized state, maintaining said oil within said coking vessel for a period sufficient to convert the same into vapors and coke, and withdrawing vapors so formed from the top of said vessel through said centrally located conduit.

2. An apparatus for the conversion of heavy hydrocarbon oils comprising an enlarged circular coking vessel adapted to contain therein a dense turbulent bed of fluidized solids having a pseudo-liquid level near the upper portion of said vessel, a plurality of nozzles passing

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through the walls of said vessel, means for introducing said oils through said nozzles, a dense turbulent body of fluidized solids within said vessel having an internal concentric baffle in the upper portion of said vessel radially spaced from the internal wall of said coking vessel to form an annulus, extending downwardly below the upper portion of said vessel and below said pseudo-liquid level and forming a centrally located passageway for upwardly moving vapors, the bottom terminal cross section of said baffle being of greater area than the upper portions of said concentric baffle so as to reduce vapor residence time, means for circulating a stream of solids from said coking vessel to an external heating zone, conduit means for circulating heated solids from said zone to the upper portion of said vessel and for tangentially introducing said heated solids into said annulus whereby the walls of said passageway are maintained at a temperature above the dew point of said vapors and an outlet conduit for said vapors at the top of said vessel communicating with said annulus and said passageway.

3. The apparatus of claim 2 comprising in addition thereto conduit means for admitting gas to the lower portion of said annulus.

4. The apparatus of claim 2 wherein said heated solids are tangentially introduced into said annulus at a plurality of points.

5. The apparatus of claim 2 comprising in addition thereto gas-solids separating means located in said centrally located passageway for the purpose of removing entrained solids from said vapors.

6. An improved fluid coking process which comprises maintaining a dense turbulent bed of fluidized particulate solids at a coking temperature in a coking zone of circular

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cross-section, injecting a heavy hydrocarbon oil into said bed to form vapors and coke which is deposited on said solids, withdrawing overhead said vapors through a confined passageway of reduced diameter, said confined passageway forming with the confines of the upper portion of said coking zone an annular passageway extending into said bed, circulating a portion of said bed to an external heating zone, tangentially introducing heated solids from said heating zone along with conveying gas into said annular passageway whereby the walls of said confined passageway are maintained above the dewpoint of said vapors, passing heated solids from said annular passageway to said bed, and passing said conveying gas upwardly through said annular passageway, and mixing thereafter gases from said annular passageway with said vapors withdrawn overhead.

7. The process of claim 6 wherein heated solids are entrained from said annular passageway and commingled with said vapors withdrawn overhead.

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