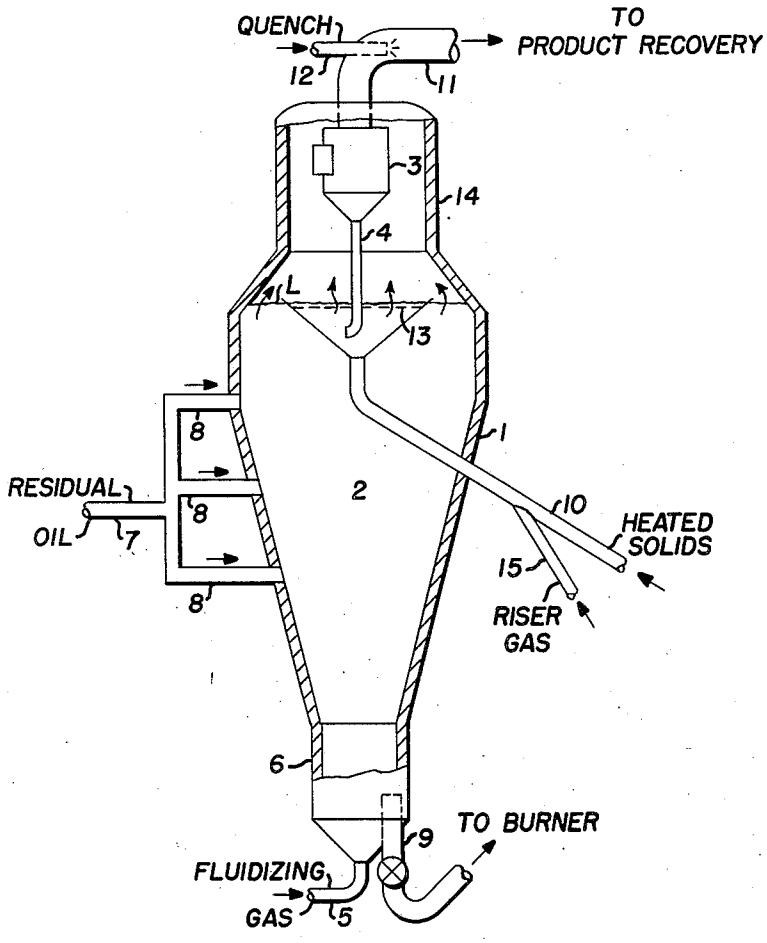
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PREVENTION OF COKE DEPOSITS IN FLUID COKERS

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PREVENTION OF COKE DEPOSITS IN FLUID COKERS

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The present invention relates to an improved hydrocarbon oil fluid coking vessel. In its more particular aspects, the invention is concerned with a method and arrangement of apparatus for preventing wall deposits of coke in a fluid coking vessel above the fluid bed.

The present invention pertains to hydrocarbon conversion processes wherein an oil is converted in a fluid coking zone containing a bed of fluidized particulate solids maintained at a coking temperature, wherein a portion of the particulate solids are circulated to an external heating zone and back by means of a conveying gas to maintain the coking temperature and wherein vaporous conversion products are withdrawn overhead from a disperse solids zone above the fluid bed. This invention proposes a method of preventing coke deposits in the disperse solids zone. The invention comprises introducing the freshly reheated solids into the coking zone at the interface of pseudo-liquid level of the fluid bed. This permits the conveying gas used to transport the solids to mix with the conversion products as they emerge from the fluid bed and not to be dissipated into the fluid bed itself.

By so admixing the conveying gas with the conversion products, the dew point of the conversion products is substantially lowered. This prevents partial condensation in the disperse phase of the heavier ends of the conversion products and consequently prevents coke deposition in this region.

In the operation of hydrocarbon oil fluid coking vessel, severe coke deposits have been experienced in the vapor phase section or disperse solids zone above the fluid bed. In some cases, these deposits have been so extensive as to render the equipment inoperable. It is believed that this coke is formed by condensation of the heaviest fraction or the heavy ends of the conversion products removed from the bed and that this condensed material polymerizes at the temperature of the reactor and forms coke. The overhead products leaving the fluid bed are substantially in equilibrium with the liquid film of oil undergoing pyrolysis on the individual coke particles. Any cooling in the disperse solids zone of the conversion products, either from heat loss from the reactor or from vapor phase cracking, serves to cause condensation of the heavy ends. This condensed material has a high Conradson carbon content and deposits on any surface or protrusions in the disperse phase and reacts to form coke. The upper part of a coking zone or reactor has a great propensity for the loss of heat which accounts for the troublesome coke deposits forming in this area.

It is the purpose of this invention to reduce or eliminate the deposition of coke in the disperse phase of a fluid coking reactor by a particular design of the reactor and by operating the coking process in harmony with this design.

Current fluid coking systems are of the two-vessel type wherein an oil is converted by contact with fluidized solids maintained at a coking temperature in one zone and solids are continuously circulated to an external heating zone, e. g., a burner vessel, and back to maintain the coking temperature. To effect circulation of the solids, it is customary to use standpipe and riser systems as illustrated in Packie patent U. S. 2,589,124. In such a standpipe and riser system, a conveying gas such as steam is used to dilute or decrease the density of the flowing solids in the riser portions.

According to this invention, the reheated solids from the external heating zone along with the necessary conveying gas are admitted to the coking zone at the level of the fluid bed. This permits the heated solids to fall into the fluid bed while the conveying gas, which may be present in substantial amounts, passes substantially immediately into the disperse solids zone of the reactor and serves to dilute the conversion products withdrawn overhead and to reduce the dew point of the products below the disperse solids zone temperature. This particular design also appreciably raises the temperature of the vapors in the disperse zone which further ameliorates the likelihood of condensation of the vapors. Thus any small temperature lowering in the disperse solids zone because of heat loss or vapor phase cracking is prevented from resulting in condensation by this invention.

In the prior fluid coking designs, the reheated solids were normally injected into some part of the fluid bed in such a manner that the conveying gas was mixed into the bed. The conveying gas that was removed with the overhead products was, therefore, a part of the vapors or gases that were in equilibrium with the liquid on the coke particles. Hence any reduction in the temperature of the overhead vapors resulted in partial condensation and coke deposition. In the present invention, the riser gas is mixed in the disperse solids zone with the product vapors. In this way the equilibrium within the bed is unchanged and the riser gas acts as a true diluent. With the amount of conveying gas normally used to circulate the reheated solids, this dilution effect of the conveying gas is sufficient in most cases to lower the dew point temperature by at least 7° to 10° F. Coking reactors are customarily insulated to an extent that heat losses are not sufficient to reduce the reactor disperse solids zone temperature by more than 10° F. and vapor residence time is so short that vapor phase cracking reactions do not reduce the temperature more than this 10° F., particularly in view of the large heat content of the solids entrained in the vaporous conversion products.

In a modification of this invention, the amount of riser gas used to circulate the solids is controlled, whereby the extent of entrainment of solids in the conversion products in the disperse solids zone can be controlled. It has been found necessary to have some entrainment of solids in conversion products emerge from the fluid bed as a further aid to eliminating coke depositions. The entrained solids help to uphold the temperature of the vapors, and exert a beneficial scrubbing action which removes incipient coke deposits that may form.

To further enhance the entrainment of solids it is also preferred in the design of this invention to return the solids separated from the conversion products to the terminal portion of the conduit supplying reheated coke to the vessel. These entrained solids recaptured from the vapors are relatively fine and by returning them to a point approximately at the inner face of the fluid bed, reentrainment of these fine solids is induced. It is desirable, however, to avoid an undue concentration of fines in the upper portion of the fluid coking bed, as these fines may contribute to wall deposits below the level of the bed. By the design of this invention, the entrained solids are supplied to the outlet of the heated coke return line in such a manner as to promote reentrainment while avoiding increasing the concentration of fines in the upper portion of the bed.

The following description of the attached drawing will emphasize the salient features of this invention. The drawing depicts schematically one embodiment of this invention wherein coke deposition in the disperse solids zone of a fluid coking zone is prevented or greatly minimized.

Referring particularly to the drawing, there is shown a coking vessel 1 containing a bed 2 of fluidized solids maintained at a coking temperature in the lower portion in a manner well known in the art. The fluid bed has an upper level L with a disperse solids zone thereabove. There is located in the disperse solids zone a cyclone separating system 3 with a dipleg 4 to return recovered solids to the fluid bed. This cyclone may, of course, comprise a multiplicity of individual units in parallel or in series and may be located exteriorally of vessel 1. To maintain the bed of solids in a fluid condition, a fluidizing gas, e. g., steam is admitted to the base of the vessel by line 5. In this particular design, this fluidizing gas serves first to strip the solids being removed from the vessel in stripping zone 6 and then passes upwardly at a velocity in the range of 0.5 to 4 ft./sec. fluidizing the solids in the bed.

Any suitable solid may be used in the practice of this invention such as sand, glass beads, spent catalyst and dried coke. It is preferred, however, to use particulate coke produced in the process having a size in the range of about 40 to 800 microns.

Any of the customary charging stocks such as vacuum residua, catalytic cycle oils, tars, asphalts, shale oils, coal tars, and including whole crudes are charged to the vessel by line 7 and injected into the vessel at a multiplicity of points by manifold system 8.

To heat the bed, solids are continuously withdrawn from the stripping section by standpipe 9 and are circulated to external heating means which may include a fluid bed burner, transfer line burner, shot heating system and other familiar heating means known by the art. Reheated solids are returned to the vessel by line 10. These reheated solids are circulated by a riser or conveying gas such as steam.

The oil when injected into the fluid bed contacts the solids therein which are at a temperature in the range of 900° to 1200° F. and undergoes pyrolysis evolving considerable quantities of relatively lighter hydrocarbon vapors and depositing carbonaceous residue or coke on the solids. The vapors so formed pass upwardly through the bed through the dispersed solids phase into cyclone 3 wherein entrained solids are removed. The vapors, relatively free from entrained solids, are removed from the cyclone by line 11 and are sent to further conventional processing or separating equipment. For example, the vapors can first be scrubbed to remove the heavy ends of the vapors and then fractionated to recover gas oils and naphthas. The naphthas may be reformed and the gas oils catalytically cracked to obtain a high quality gasoline product. The heavier ends initially scrubbed from the vapors can be recycled to the coking zone.

It is desirable to rapidly cool or quench the vapors to prevent undesirable secondary cracking reactions. For this purpose, a quench medium may be injected into the vapors as in the cyclone or as they emerge from the cyclone by line 12. This quench medium may comprise suitably cooled, liquids, solids or gases. For example, a recycled heavy oil having an initial temperature of about 500° F. may be used.

According to this invention, the freshly reheated solids in line 10 are introduced into vessel 1 at the level of the fluid bed whereby the conveying gas immediately mixes with the conversion products in the disperse solids zone without being appreciably mixed into the fluid bed. In the apparatus shown, conduit 10 terminates in an upwardly diverging conical frustrum placed immediately below fluid bed level L. Associated with this cone is a distributing grid 13 which uniformly distributes the material into the reactor and inhibits back flow of solids into conduit 10. This distributing grid may comprise perforated plates, bars, screening, and the like. Preferably, the level of the grid is slightly below the level L of the fluid bed. This prevents, somewhat, solids from line 10 from spewing up into the disperse solids zone, i. e., the solids of the fluid bed cause sufficient particle interference with the incoming solids as to prevent them from carrying or rising unduly far into the disperse solids zone. The level of the grid is not so far below the level L of the bed so as to permit any appreciable back mixing of the conveying gas into the bed for the reasons previously noted.

As previously pointed out, it is desirable to maintain some entrainment of solids in the gases withdrawn overhead. For this purpose, the upper portion 14 of the reactor is reduced in diameter or necked down whereby the velocities of the vapors are increased to about 3.5 to 6 ft./sec. This enhances entrainment. This particular shape of the disperse solids zone also causes the more efficient commingling of the conveying gas with the overhead products. To further induce entrainment and to control somewhat the entrainment, the amount of riser gas admitted with reheated solids in line 10 is regulated. Thus extra riser gas above the amount normally required to convey the solids can be admitted to conduit 10 by line 15, if so desired. This will increase the velocity of the gases in the disperse solids zone and consequently entrainment of solids therein. The relatively fine solids separated in cyclone 3 may be returned to the bottom portion of the fluid bed to prevent a concentration of fines in the upper portion of the bed. It is preferred, however, to introduce them into the terminal portion of conduit 10 by line 4 below the level of grid 13 as illustrated. By so connecting the dipleg with the reheated solids inlet, coke deposition on the bottom of dipleg is prevented. The plugging of the return solids dipleg has been another problem associated with fluid coking apparatus. In this manner, recirculation of the fine solids in the disperse solids zone is also brought about but backmixing of the lines is prevented by the conical frustrum on the solids riser 10. With the combination of means just described, efficient entrainment of solids can be secured to provide for satisfactory operation. In general, it is desirable to achieve entrainment rates better than 400 lbs. of solids/bbl. of residual oil injected into the reactor.

Example I

Referring to apparatus shown in the attached drawing, the reactor may contain 90 tons of coke of a particle size in the range of 40–800 microns at a temperature of 950° F. The diameter of the bed at level L may be 11 ft. 160 bbls./hr. of a residual oil may be introduced into the reactor, the residual oil having initial boiling point of 980° F., an API gravity of 2.0° and a Conradson carbon of 30 wt. percent. 10 lbs. of steam/lb. of residual oil may be introduced into the base of the reactor as fluidizing gas. The upper portion of the reactor in the area of the cyclone system may have a free cross-sectional area of 63.5 sq. ft.

Under these conditions, 66 wt. percent of the oil will be converted to vapors. The velocity of the vapors emerging from the fluid bed will be about 2.7 ft./sec. and the velocity of the vapors in the upper part of the disperse solids zone will be 4.0 ft./sec.

10 lbs. of solid/lb. of feed are circulated by conduit 9 to an external heating zone wherein the solids are heated to 1125° F. Reheated solids are returned to the coking zone by line 10 along with 0.2 cu. ft. (at reactor conditions) of conveying gas/lb. of solids circulated.

The conical terminal portion of conduit 10 has a diameter of 3.5 ft. and the grid 3 has a free area of 5.0 sq. ft. The grid is located 3 inches below the level L of the fluid bed. Under these conditions, the entrainment rate

is about 0.1 lb. of solids/cu. ft. of total reactor vapor of which 99% of the solids are separated in cyclone 3 and returned by dipleg 4.

Whereas the bed has a temperature of 950° F., the disperse phase has a temperature of about 960° F. Without the arrangement of this invention, the dew point of the vapors in the disperse solids zone would normally be about 950° F. and the temperature in the disperse solids zone about 945° F. By means of this invention, this dew point is lowered to about 940° F. whereby coke deposits are effectively prevented from forming.

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

What is claimed is:

1. In a hydrocarbon conversion process wherein an oil is converted in a fluid coking zone containing a bed of fluidized particulate solids maintained at a coking temperature, wherein a portion of said particulate solids is circulated to an external heating zone and back by means of a conveying gas to maintain said coking temperature, and wherein vaporous conversion products are withdrawn overhead, a method of preventing coke deposits in said fluid coking zone above the level of the fluid bed therein which comprises introducing freshly reheated solids into said coking zone at the level of said fluid bed whereby said conveying gas mixes with said conversion products without being appreciably mixed into said bed and serves to lower the dew point of said conversion products.

2. The method of claim 1 wherein the amount of said conveying gas entering with said reheated solids is regulated to control the amount of entrainment of solids in said conversion products.

3. The method of claim 1 wherein entrained solids separated from said conversion products are mixed with said reheated solids just before said reheated solids are discharged at said level.

4. The method of claim 1 wherein said conveying gas comprises steam.

5. An improved fluid coking process which comprises maintaining a fluidized bed of particulate solids at a coking temperature in a coking zone with a disperse solids zone thereabove, contacting an oil with said solids to produce vaporous conversion products and coke which is deposited on said solids, circulating a portion of said solids to an external heating zone, introducing reheated solids by means of a conveying gas from said heating zone upwardly into said fluidized bed immediately below the level of the bed whereby said conveying gas immediately enters said disperse solids zone while said reheated solids become a part of said fluidized bed, and withdrawing as product said vaporous conversion products diluted with said conveying gas overhead through a solids-separation zone wherein entrained solids are removed and returned to said fluidized bed.

6. In a hydrocarbon oil fluid coking vessel which comprises means for establishing and maintaining a fluid bed of particulate solids at a coking temperature in the lower portion thereof with a disperse solids zone thereabove, cyclone separating means in said disperse solids zone with a dependent dipleg and means for injecting liquid hydrocarbon oil into an intermediate portion of said fluid bed, the improvement which comprises inlet conduit means for admitting reheated particulate solids and conveying gas into said vessel, the terminus of said inlet conduit means defining the upper level of said fluid bed whereby coke deposits are prevented from forming in the upper portion of said vessel above said fluid bed.

7. The improvement of claim 6 wherein said dependent dipleg extends into said terminus.

8. The improvement of claim 6 wherein said terminus comprises an upwardly opening cone.

9. Apparatus for converting residual oils which comprises a vertically disposed vessel, a fluid bed of particulate solids in the lower portion thereof, means for introducing a residual oil into an intermediate portion of said fluid bed, means for withdrawing vaporous conversion products from the upper portion of said vessel, means for withdrawing particulate solids from said fluid bed and conduit means for introducing heated particulate solids and conveying gas into said vessel, said conduit means terminating at the level of said fluid bed.

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