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SPLIT RETURN OF SOLIDS TO COKER

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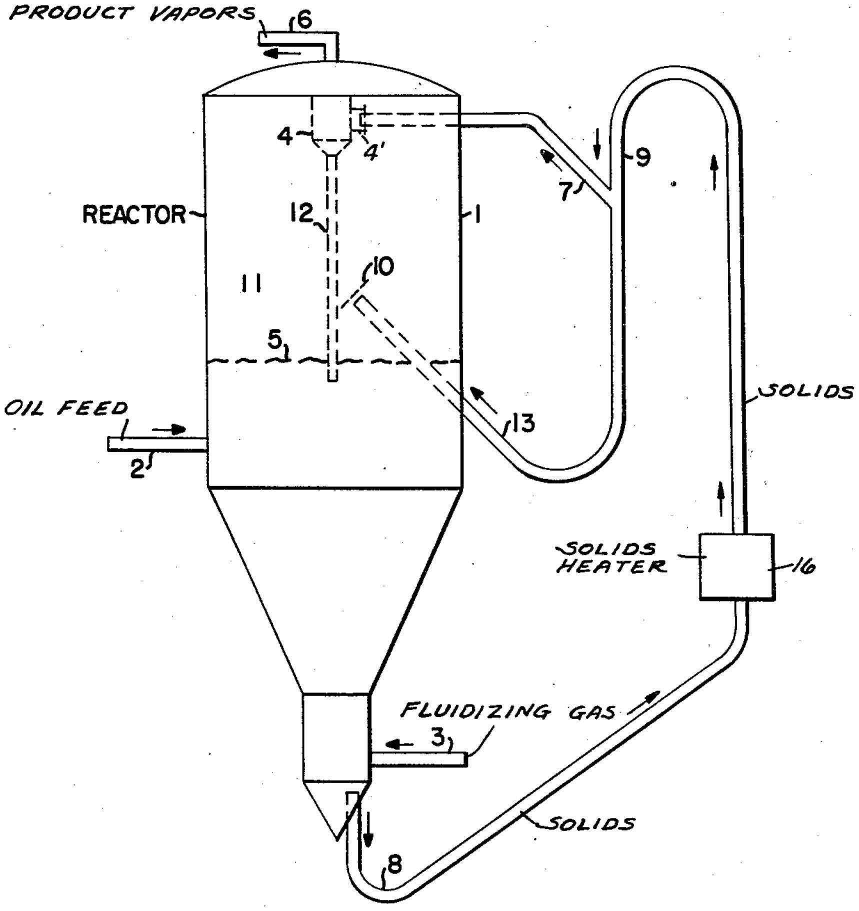

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SPLIT RETURN OF SOLIDS TO COKER

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The present invention is concerned with an improved method for carrying out hydrocarbon oil fluid coking reactions. More specifically it is concerned with a method of preventing coke deposition in the upper and lower portions of the disperse phase of the fluid coking reactor.

There has recently been developed an improved process known as the fluid coking process for the production of "fluid coke" and the thermal conversion of heavy hydrocarbon oils to lighter fractions, e.g., see U.S. Patents 2,735,439 and 2,735,806.

The fluid coking process unit consists basically of a reaction vessel or coker and a heater or burner vessel. In a typical operation the heavy oil to be processed is injected into the reaction vessel containing a dense, turbulent, fluidized bed of hot inert solid particles. A staged reactor can be employed. Uniform temperature exists in the coking bed. Uniform mixing in the bed results in virtually isothermal conditions and effects instantaneous distribution of the feed stock. In the reaction zone the feed stock is partially vaporized and partialy cracked. Effluent vapors are removed from the coking vessel and sent to a fractionator for the recovery of gas and light distillates therefrom. Any heavy bottoms is usually returned to the coking vessel. The coke produced in the process remains in the bed coated on the solid particles. Stripping steam is injected into the stripper to remove oil from the coke particles prior to the passage of the coke to the burner.

The heat for carrying out the endothermic coking reaction is generated in the burner or heater vessel, usually separate. At least a portion of coke is thus transferred from the reactor to the burner vessel, such as a fluid bed or transfer line burner, employing a standpipe and riser system; air being supplied to the riser for conveying the solids to the burner. Sufficient coke or added carbonaceous matter is burned in the burning vessel to bring the solids therein up to a temperature sufficient to maintain the system in heat balance. The burner solids are maintained at a higher temperature than the solids in the reactor. Coke, equivalent to about 5%, based on feed, is burned for this purpose. This may amount to approximately 15% to 30% of the coke made in the process. The net coke production, which represents the coke make less the coke burned, is withdrawn and thus at least a portion of the solids recycled to the coker.

Heavy hydrocarbon oil feeds suitable for the coking process include heavy crudes, atmospheric and vacuum bottoms from crude, pitch, asphalt, other heavy hydrocarbon petroleum residua or mixtures thereof. Typically such feeds can have an initial boiling point of about 700° F. or higher, an A.P.I. gravity of about 0° to 20°, and a Conradson carbon residue content of about 2 to 40 wt. percent. (As to Conradson carbon residue see A.S.T.M. Test D–189–41.)

It is preferred to operate with solids having a particle size ranging between 100 and 1000 microns in diameter with a preferred particle size range between 150 and

400 microns. Preferably not more than 5% has a particle size below about 75 microns, since small particles tend to agglomerate or are swept out of the system with the gases. While coke is the preferred particulate solid, other inert particulate solids such as spent catalyst, pumice, sand, kieselguhr, Carborundum and alumina can be employed.

In the operation of hydrocarbon oil fluid coking vessels 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 has therefore accordingly been necessary to inject solids into the upper portion of the disperse phase for their heating and scouring effect, e.g., see U.S. Patent 2,763,001. This solids injection has by itself been found not to overcome the problem.

This invention provides an improved method of overcoming these difficulties. The method comprises splitting the stream of hot solids being recycled from the extraneous coke heater to the reactor. A minor proportion of the solids is injected into the upper portion of the coker disperse phase adjacent to the cyclone. A major proportion of the recycled hot solids is injected into the lower portion of the disperse phase, a short distance above the level of the dense, turbulent, fluidized bed against a diffuser baffle. Further details follow.

The two important requirements are as follows:

(1) Some hot solids must be injected just above dense bed level in order to superheat the vapors rising from the dense bed. This protects the lower dilute phase zone from coke deposition. Injection of solids in the zone near the cyclones protects the cyclones, but not the lower dilute phase since the hot solids are swept into the cyclones.

(2) Control of the amount of disperse phase injection is necessary in order to prevent overheating and cracking of the product vapors. The temperature in the disperse phase above the dense bed is increased by 10° to 30° F., preferably 20° F. which accomplishes these purposes.

A minor proportion, i.e., about 5 to 15 wt. percent of the recycle solids are injected into the upper portion of the disperse phase adjacent to the cyclone. They also and preferably can be injected directly into the cyclone. A major proportion of the recycled hot solids, i.e., about 85 to 95 wt. percent, are injected into the lower portion of the disperse phase, shortly above the level of the dense bed.

Typical figures follow on commercial fluid cokers. The distance from the top of the dense bed to the cyclone inlets can be in the range of 15 to 20 feet. The "upper portion" would mean the zone around the cyclone inlets. The "lower portion" of the disperse phase means the zone from 0 to 2 feet above the dense bed. The amount of coke injected into the disperse phase is controlled by the bed level, which is not sharply defined, but is really a transition zone of one or two feet in width. By raising the bed "level," more of the incoming hot coke is held down in the dense phase and less is sprayed into the disperse phase.

The diffuser baffle is preferably integrally connected to the injection nozzle axially thereto. The diffuser baffle is designed to distribute the hot coke uniformly from a central location approximately at the vertical center line of the vessel and 0 to 2 feet above bed level.

This invention will be better understood by reference to an example and the flow diagram shown in the drawing.

In the drawing the numeral **1** is a coking vessel constructed of suitable materials for operation at 950° F. A bed of coke particles preheated to a sufficient temperature, e.g. 1125° F. to establish the required bed temperature of 950° F. is made up of suitable particles of 150 to 400 microns. The bed of solid particles reaches an upper level indicated by the numeral **5**. Above is disperse phase **11**. In a reactor of about 76 feet overall height the bed height is 54 feet and the disperse phase height is 22 feet. Cyclone **4** having an inlet 4′ is located at the upper portion of the disperse phase; several stages of cyclones can, of course, be used. The bed is fluidized by means of a gas such as stripping steam entering the vessel at the stripping portion near the bottom thereof via pipe **3**. The fluidizing gas plus vapors from the coking reaction pass upwardly through the vessel at a velocity of 1 ft./sec. establishing the solids at the indicated level. The fluidizing gas serves also to strip the vapors and gases from the coke which flows down through the vessel to the heater. A stream of solid particles is removed from the bottom portion of the coking vessel via line **8** and transferred to a heater **16**.

A reduced crude oil to be converted is introduced into the bed of hot coke particles via line **2**, but preferably at a plurality of points in the system. The oil upon contacting the hot particles undergoes decomposition and the vapors resulting therefrom assist in the fluidization of the solids in the bed and add to its general mobility and turbulent state. The product vapors leave through cyclone **4** and line **6**. The solids separated are returned to the bed through dipleg **12**.

Hot coke solids at a temperature of about 100° to 300° F. higher than the coker, e.g., 1125° F., are recycled from the heater **16** through line **9** or several lines. A minor proportion of these recycled solids, e.g., 10 wt. percent, are sent through line **7** to the upper portion of the disperse phase in the reactor **1** adjacent inlet **4′** of cyclone **4**. A major proportion or rest of the recycled hot solids, e.g. 90 wt. percent, is injected into the lower portion of the disperse phase through line **13**, a short distance above the level of the bed. The injected solids contact diffuser baffle **10** to effect better dispersion of the incoming hot coke and a more uniform dilute phase temperature. The amount of solids carried into the disperse phase can be controlled by raising or lowering the dense bed level relative to the hot coke inlet, thus controlling the degree of disperse phase superheat.

The advantages of this invention will be apparent to the skilled in the art. Coke deposition is prevented in both the upper and lower portions of the disperse phase of the fluid coker with the avoidance of overheating and cracking of product vapors.

The conditions usually encountered in a fluid coker for fuels are also listed below for completeness.

Conditions in fluid coker reactor

	Broad Range	Preferred Range
Temperature, ° F	850–1,200	900–1,000
Pressure, Atmospheres	1–10	1.5–2
Superficial Velocity of Fluidizing Gas, ft./sec	0.2–10	0.5–4
Coke Circulation (Solid/oil ratio)	2–30	7–15

Conditions in heater

	Broad Range	Preferred Range
Temperature, ° F	1,050–1,600	1,100–1,200
Superficial Velocity of Fluidizing Gas, ft./sec	1–5	2–4

It is to be understood that this invention is not limited to the specific examples which have been offered merely as illustrations and that modifications may be made without departing from the spirit of the invention.

What is claimed is:

1. In a process for coking a heavy hydrocarbon oil coking charge stock by contacting the charge stock at a coking temperature with a dense, turbulent, fluidized bed of inert particulate solids in a coking zone and having a superposed disperse phase thereabove, the oil being introduced directly into said fluidized bed and converted to product vapors and carbonaceous material which is continuously deposited on the inert solids in the coking zone; removing product vapors from the coking zone through a cyclone separating zone at the upper portion of the disperse phase; circulating at least a portion of the inert solids to an external heating zone to increase their temperature and recycling at least a portion of the heated solids to the coking zone to supply heat thereto, the improvement which comprises the steps of injecting a minor proportion of the recycled heated solids to the upper portion of the disperse phase adjacent the cyclone separating zone and injecting the rest of the recycled heated solids into the lower portion of the disperse phase, a short distance above the level of the dense, turbulent, fluidized bed against a diffuser baffle zone arranged substantially above the central portion of the dense fluidized bed to effect dispersion of the incoming heated solids in said dilute phase above the dense fluidized bed and to obtain a more uniform dilute phase temperature.

2. The process of claim 1 in which the minor proportion of the recycled heated solids is injected into the cyclone separating zone.

3. The process of claim 1 in which the minor proportion and the rest of the recycled heated solids are in the ranges of about 5 to 15 wt. percent and 85 to 95 wt. percent, respectively.

4. A process according to claim 1 wherein the minor proportion of the recycled heated solids is in an amount of about 10% of the recycled portion of the heated solids.

References Cited in the file of this patent

UNITED STATES PATENTS

2,763,601	Martin et al.	Sept. 18, 1956
2,779,719	Spitz et al.	Jan. 29, 1957
2,793,173	Fritz	May 21, 1957
2,824,046	Kimberlin	Feb. 18, 1958