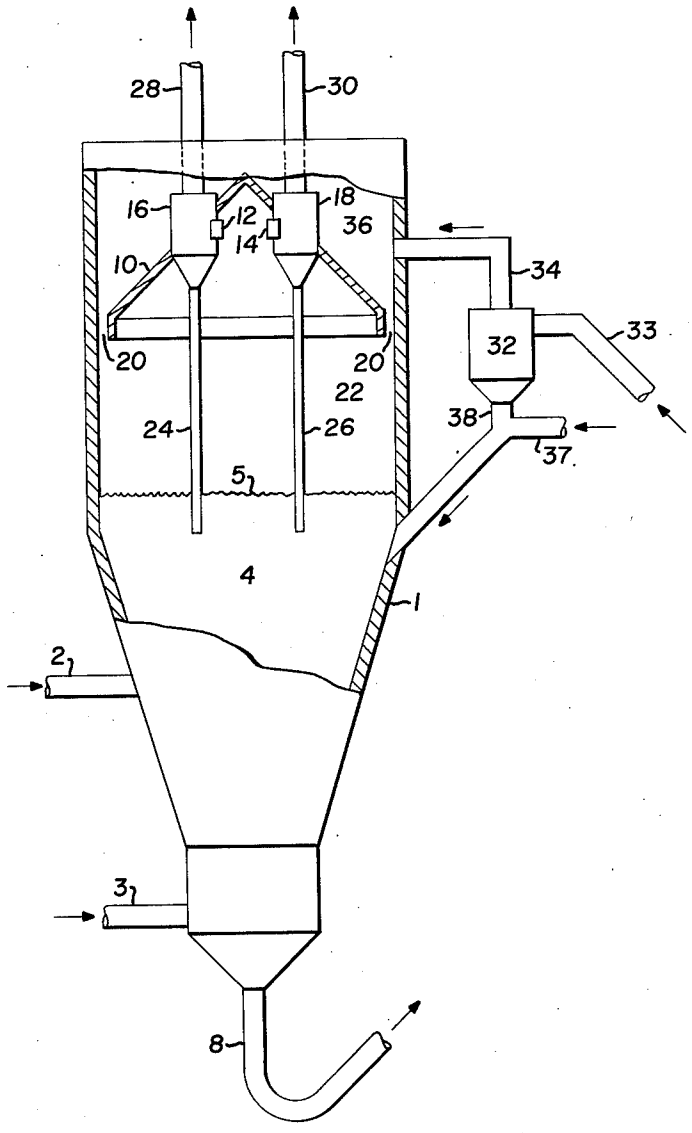
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PREVENTION OF COKE FORMATION IN UPPER PORTION OF FLUID COKER

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PREVENTION OF COKE FORMATION IN UPPER PORTION OF FLUID 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 proposes a method for reducing coke deposition in the upper portions of fluidized solids reactors, particularly in reactors wherein heavy residual oils are processed.

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 allowed cases Serial No. 433,913, filed June 2, 1954, and Serial No. 431,412, filed May 21, 1954.

The fluid coking 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, preferably coke particles, but sand or spent catalyst can be employed. A transfer line or staged reactors 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 partially 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 vessel, usually but not necessarily separate. A stream of coke is thus transferred from the reactor to the burner vessel, such as a transfer line or fluid bed burner, employing a standpipe and riser system; steam usually 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. About 5% of coke, based on the 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.

Heavy hydrocarbon oil feeds suitable for the coking process include heavy crudes, atmospheric and vacuum bottoms, 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 50 and 1000 microns in diameter with a preferred particle size range between 70 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 solids such as spent catalyst, pumice, sand, kieselguhr, Carborundum, and alumina can be employed.

Several problems have been encountered in the development of this type of coking process. One problem in particular is the building up of coke deposits on the confines of the vapor space above the fluidized bed in the reactor. These deposits can cause the pressure drop through the coker and overhead lines to increase to such an extent as to require the coker to be shut down periodically and cleaned out.

As the vapors leaving the coking bed are at or near their dew or condensation point, they will readily condense, particularly in areas of stagnation. This condensation is aided by endothermic cracking reactions occurring in the vapor phase. It has been found that if this condensation of the coker vapors is on surfaces having a temperature of about 700° to 1000° F., severe coke deposition occurs.

In a fluid coking process the conversion products are removed overhead through cyclones located in the upper portion of the reactor. By the nature of the equipment, stagnant areas, i. e., areas having little or no vapor velocity, exist in the uppermost portion of the reactor around the cyclone separation system. The high temperature conversion products driven into these stagnant areas will remain resident there for a time sufficient to permit appreciable cooling and perhaps more cracking and condensation to occur. Thus vapors in areas of stagnation readily deposit coke on the surrounding equipment surfaces.

The present invention provides an improved method of overcoming these difficulties. The method comprises providing a sealed zone in the upper portion of a coker through the utilization of a conical imperforate baffle. The aerated hot coke solids are treated in a vapor solids separating device external to the coking reactor. The hot inert aerating gas together with fine coke particles are separated from the coarser hot coke particles. The fines together with the hot inert gas are injected into the sealed zone at a pressure sufficient for sealing the latter, and the fines are then sent into the disperse phase of the coking zone. The coarse separated hot coke particles are preferably then injected into the dense turbulent fluidized bed.

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, e. g., 975° 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, e. g., 150 to 400 microns in diameter. The bed 4 of solid particles reaches an upper level indicated by the numeral 5. 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, e. g. 1 ft./sec. establishing the solids at the indicated level. The fluidizing gas serves also to strip the vapors and gases from the hot coke from the heater which flows down through the vessel. A stream of solid particles is removed from the coking vessel via line 8 and transferred to the heater not shown.

A reduced crude oil to be converted is introduced into the bed of hot coke particles via line 2, perferably 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.

In the upper portion of coker reactor **1** there is welded a radially spaced converging or conical imperforate baffle **10**. This baffle extends from the sides of the coking vessel above the bed level as shown to the inlets **12** and **14** of cyclones **16** and **18**. It thus encloses the cyclone inlets and defines a confined passage for vapors to these inlets. The baffle also forms a confined annulus **20** which terminates above the bed level. The baffle is tapered from 40° to 70° from the horizontal so that its sides are steeper than the angle of repose of the fluid coke. The baffle unit is so designed as to have minimum clearance around the cyclones passing therethrough, sufficient to permit differences in expansion of the equipment. The baffle unit is sufficiently tight to prevent the flow of product vapors into the chamber **36** above. The width of the annular portion **20** is such that the pressure in the chamber **36** is maintained about 2 to 7 p. s. i. greater than the pressure in the disperse phase **22** of the reactor. The conversion products pass through the disperse phase **22** of the reactor carrying some entrained solids to a plurality of cyclones, two shown here, **16** and **18**. Entrained solids are removed from the vapors and returned to the fluid bed via diplegs **24** and **26**. The vapors now substantially free of solids are then removed from the vessel via lines **28** and **30** and may be processed as desired such as quenched, fractionated, etc.

Hot coke solids from the burner, aerated by an inert gas, such as steam or light hydrocarbons, enter from the coke burner, not shown, through line **33**. The hot coke particles together with the aerating gas are sent into an external vapor-solids separating device, e. g., a cyclone **32**. In cyclone **32** the hot aerating gas stream together with the fine coke particles, i. e., those having a diameter of less than about 100 microns are removed through line **34** and injected into sealed zone **36** in the upper portion of a coker as shown and above the baffle **10**. The steam and fine solids at the temperature of 1125° F. are above the dew point of the vaporous products. In this way the surface of the baffle coming in contact with the conversion products is maintained above the condensation temperature. Coke deposition on the surfaces is greatly inhibited. Without this arrangement coke deposition would occur in the upper portion of the reactor sufficient to cause blocking of inlets **12** and **14**. The pressure of the aerating gas stream is 7 to 15 p. s. i. g., sufficient to seal the zone **36** and to carry the fine coke particles down through annulus **20** into the disperse phase **22** of the coking zone. The steam and fines then enter the regular circulation system. The separated coarse coke solids are sent via line **38** into the dense turbulent fluidized bed **4**.

By way of example the dense fluidized bed **4** contains 70 tons of coke particles. Pitch is introduced through nozzles **2** at a rate of 4000 barrels per day. Steam is introduced through injectors **3** at a rate of 3000 to 8000 pounds per hour. Coke at 1125° F. from the burner flows at a rate of 8000 to 9000 pounds per minute to the external cyclone **32** via line **33** along with 2000 to 3000 pounds per hour of carrying steam. The steam/coke mixture enters the cyclone **32** at a velocity of 20 to 60 feet per second, preferably at 45 to 55 feet per second. Over 90 weight percent, and usually 98 to 99.5%, of the coke entering the cyclone **32** is separated from the steam and returned via standpipe **38** to the dense fluidized bed **4** of the coker reactor **1**. If necessary, steam could be added via line **37** to the standpipe **38** in order to maintain the flowing coke at a density of 40 to 50 pounds per cubic foot.

Virtually all of the steam and the finer particles of coke not collected in cyclone **32** flows via line **34** to the sealed zone **36** above the baffle **10**. The high temperature, i. e., about 1125° F., of the steam heats the zone **36** and the baffle **10** so as to keep the baffle above the temperature of the disperse phase **22**. In this way, no cool surface is in the path of the product vapors flowing toward the inlets **12** and **14** of the internal cyclone **16** and **18**. As the steam and fine coke particles enter the zone **36**, their velocity is reduced and most of the coke particles settle onto the sloping baffle **10** and slide toward the annular gap **20**. The steam leaves the zone **36** through the annulus **20**. The pressure exerted by the steam is reduced from 12 p. s. i. g., to 10 p. s. i. g., in flowing through the narrow annulus **20**. The high velocity of the steam when passing through the annulus **20** serves to sweep the coke particles from the edge of baffle **10** into the disperse phase **22** of the reactor and also to prevent product vapors from entering the zone **36** above the baffle **10**.

The advantages of this invention will be apparent to those skilled in the art. The expense of superheating steam by a conventional steam superheating coil is avoided. Since the steam is heated by contact with the hot coke stream, savings in equipment and ease of processing are substantial. Overhead coking is avoided along with consequent shutdowns of the unit.

Without this invention, it is necessary to supply superheated steam to the sealed zone **36** from a separate source, usually a superheating coil submerged in the dense fluidized bed of the burner vessel (not shown). This superheated steam is conventionally transported to the sealed chamber **36** via an alloy pipe covered with the maximum practical thickness of insulation so as to minimize heat losses from the steam. This conventional system is subject to some difficulty in operation: the desired amount of superheat is difficult to achieve and maintenance of the steam coil in the burner vessel has been costly. With this conventional system, it has been necessary to supply safety valves or other devices to prevent excessive pressures from occurring in chamber **36** in the event that annulus **20** should become plugged by coke deposition or other means. With this invention, safety valves or other pressure relieving devices can be eliminated because the steam pressure can never greatly exceed the pressure in the disperse phase **22** of the reactor vessel **1**. The steam is already at a moderately low pressure in the line **33** from the burner vessel and is not in a closed system as in the conventional superheated steam system. A high differential pressure cannot be maintained between the chamber **36** and the disperse phase **22**, because it would tend to correct itself via the cyclone overhead line **34**, the cyclone **32**, and the standpipe **38**. The elimination of the separate superheated steam system reduces the complexity of the burner vessel, eliminates the safety valve system, reduces the investment cost appreciably, reduces the size of the subsequent fractionating equipment and steam condensing equipment, and reduces the quantity and cost of steam supplied to the process.

It is preferred in the process of this invention to have cyclone **32** external of the vessel, although it can be positioned internally. This invention is also applicable to the hot coke line utilized for scouring of the cyclones themselves so as to prevent coke deposition.

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	1–3	1.3–2
Superficial Velocity of Fluidizing Gas, Ft./sec	0.2–6	0.5–4
Coke Circulation (Solids/Oil Ratio)	2–30	7–20

CONDITIONS IN BURNER

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. A system for coking heavy hydrocarbon oil feeds comprising a reactor; means for introducing feed into said reactor; means for introducing particles into said reactor; means for fluidizing the particles in said reactor; in an upper portion of said reactor an upwardly converging, imperforate baffle radially spaced from the inner wall of said reactor and forming an upwardly converging, confined passage for hydrocarbon vapors to the inlet of a cyclone enclosed by said baffle and an annular section opening into a lower portion of said reactor; vapor-solids separating means external of said reactor; conduit means for introducing hot gases and solids into said external vapor-solids separating means; conduit means for transporting gases and fine solids from said vapor-solids separating means into the said reactor above the baffle and conduit means for transporting coarse solids from said vapor-solids separating means to a lower portion of said reactor below the baffle.

2. The system of claim 1 in which said vapor-solids separating means is a cyclone.

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