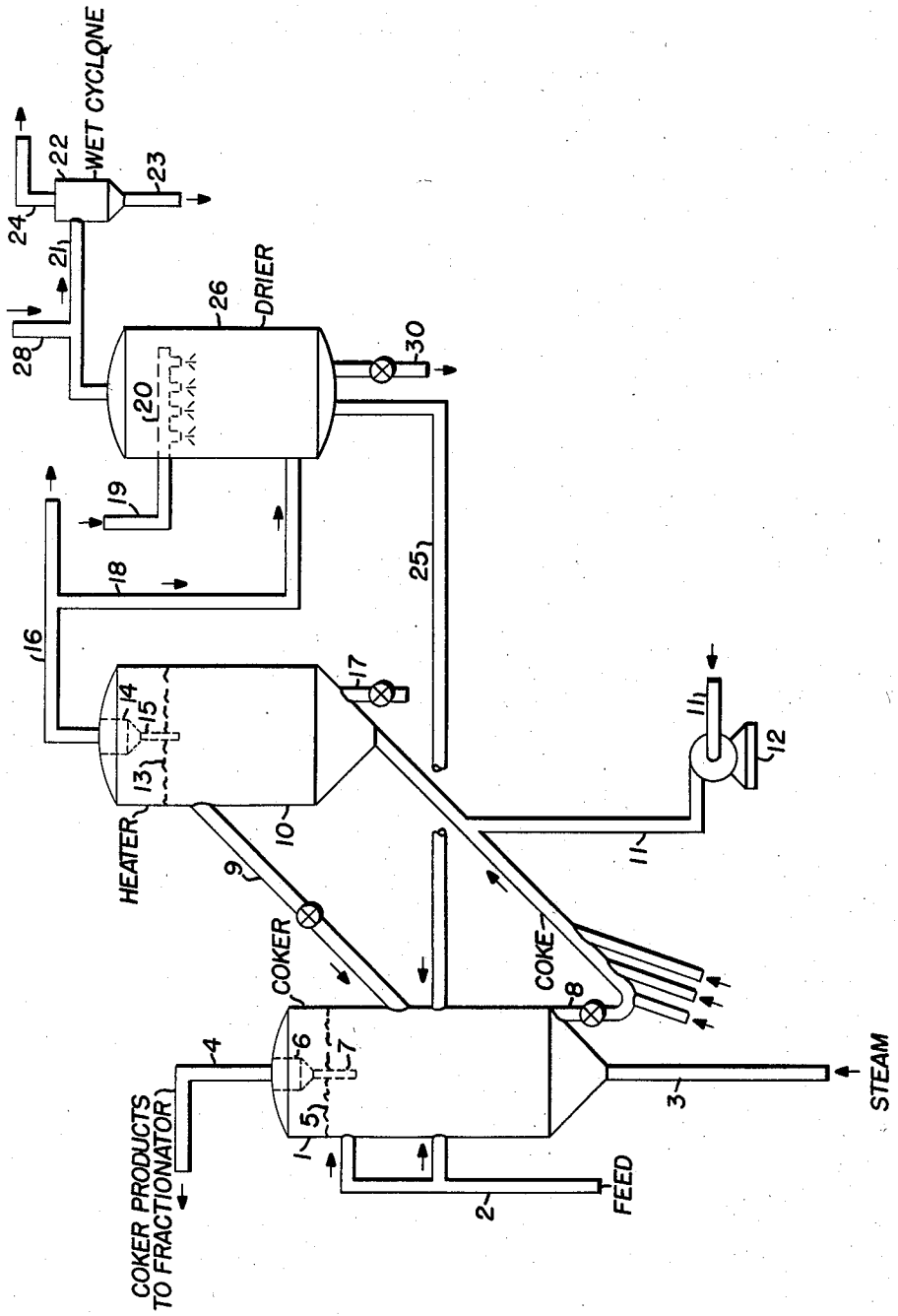
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FLUID COKING WITH PREPARATION OF SEED COKE

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FLUID COKING WITH PREPARATION OF SEED COKE

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This invention relates to improvements in the coking of heavy hydrocarbon oils where a coking charge stock is contacted at coking temperatures with coke particles maintained in the form of a dense turbulent fluidized bed. More particularly it relates to an integrated process of this nature wherein seed coke is prepared and utilized in the process.

There has recently been developed an improved process known as the fluid coking process. 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. 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. Product 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.

The heat for carrying out the endothermic coking reaction is generated in the burner vessel. A stream of coke is transferred from the reactor to the burner vessel employing a standpipe and riser system; air being supplied to the riser for conveying the solids to the burner. Sufficient coke or 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 amounts to approximately 15% to 30% of the coke made in the process. The unburned portion of the coke represents the net coke formed in the process. This coke is preferably withdrawn from the burner, normally cooled and sent to storage.

Heavy hydrocarbon oil feeds suitable for the coking process are heavy or reduced crudes, vacuum bottoms, pitch, asphalt, other heavy hydrocarbon residua or mixtures thereof. Typically, such feeds can have an initial boiling point of about 700° F., an A. P. I. gravity of about 0° to 20°, e. g., 1.9°, and a Conradson carbon residue content of about 5 to 40 wt. percent. (For Conradson carbon residue test see ASTM test D 189–52.)

It is preferred to operate with solids having an average 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.

A more complete description of this technique of fluid solids coking can be obtained by reference to copending application entitled, "Fluid Coking of Heavy Hydrocarbons and Apparatus Therefor," Serial No. 375,088, filed August 19, 1953, by Pfeiffer et al. The method of fluid solids circulation described above is well known in the prior art. Solids handling technique is described broadly in Packie Patent 2,589,124, issued March 11, 1952.

Because only a part of the coke deposited is burned to supply heat, the coke particles grow in size during the process, and must be withdrawn as product. In order to counteract the growth process and to maintain a constant particle size coke inventory, fine coke must be added continuously to serve as growth "seeds." The seeds required can be supplied either by grinding withdrawn coke in external equipment or by devices in the unit itself. The number of seed particles required is equal to the number of coke particles withdrawn as product. However, because the seed coke is much smaller in diameter than the average of the withdrawn coke, the weight of seed required is only a small percentage of the weight of coke withdrawn. For example, if the seed coke size is 100 microns, and the product coke averages 200 microns diameter, the weight of seeds required will be 12.5% of the weight of net product coke withdrawn. If 75 micron seed coke were used, the percentage would fall to slightly over 5 wt. percent on withdrawn coke. Seed coke particles typically have a size distribution predominantly of 75 to 150 microns in diameter.

Equipment, including grinding equipment, for making seed coke can increase the cost of a fluid coking unit by 10% or more. It is therefore desirable to be able to supply seed coke economically to the process.

This invention provides an improved integrated fluid coking process wherein seed coke is prepared and utilized therein. The method comprises broadly atomizing a heavy hydrocarbon oil in a drying zone and countercurrently contacting the small atomized oil droplets with hot flue gas from the coke heating or combustion zone. The size of the atomized oil droplets, and the velocity of the flue gas is controlled. This results in a product of dried coke seed particles which are then returned to the coking zone for utilization in the precess. Specific modifications are discussed in further detail hereafter.

This invention will be better understood by reference to an example in 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 fed to the bed at a sufficient temperature, e. g., 1125° F. to establish the required bed temperature of 950° F. is made up of suitable particles of 75 to 800 microns. The bed of solid particles reaches an upper level indicated by the numeral 5. The bed is fluidized by means of a gas such as steam entering the vessel at the bottom thereof via pipe 3. The fluidizing gas passes 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 from pipe 9 to pipe 8, as will be later related.

A reduced crude oil, to be converted having a Conradson carbon residue of 10 wt. percent, is preferably preheated to a temperaure not above its cracking temperature, e. g., 700° F. It is introduced into the bed of hot coke particles via line 2, 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 pass upwardly through the bed and are removed from the coking vessel via line 4 after passing through cyclone 6 from which solids are returned to the bed via dipleg 7.

A stream of solid particles is removed from the coking vessel via line 8 and transported with the assistance of air

or other free oxygen-containing gas into an external heating zone or burner vessel **10**. A transfer line heater could be used as an alternative. Air is supplied via line **11** with the assistance of pump **12**. In the burner a portion of the carbonaceous materials, e. g., coke or materials deposited thereon, is burned to raise the temperature to a point sufficient to supply the heat to the endothermic reaction occurring in the coking vessel **1**. The temperature of the burner solids is usually 100° F. to 300° F. higher than that of the solids in the coking vessel, e. g., 175° F. in this example. The bed of coke is fluidized in vessel **10** in much the same manner as the bed in vessel **1**. The solids are fluidized by the incoming air and resulting combustion gases and are maintained at a level indicated by the numeral **13**. Hot flue gases at a temperature of 1125° F. and containing CO_2, CO, N_2 and any unused O_2 leave the hot bed, pass through cyclone **14** and line **16**. Any entrained solids are returned to the bed via dip-pipe **15**. A portion of the hot solids are continually removed from burner **10** via line **9** and introduced into vessel **1** at one or more points in order to maintain heat balance in the system. Product coke is withdrawn through line **17**.

A high boiling oil, e. g., atmospheric or preferably vacuum residuum, asphalt, tar, etc., having a Conradson carbon residue of 30 wt. percent, first preheated to a temperature of 700° F. is fed through line **19** into nozzle spray head **20** located in an upper portion of drier **26**. The amount of oil fed will normally amount to about 10 volume percent of the oil feed to reactor **1**. The spray head converts the oil stream into droplets of a diameter such that the coke formed will be of the desired particle size. The drops can have a diameter in the range of 150 to 600 microns. These droplets are countercurrently contacted with hot flue gas at a temperature of 1125° F. taken from lines **16** and **18**. In some cases it will be desirable to heat the flue gas in line **18** to a higher temperature and this can be done by adding air and burning the CO content or extraneous feed in an auxiliary burner to increase the temperature to say 1500°–2500° F. Heat can later be recovered from the gases in a waste heat boiler. The droplets also scrub out fine coke particles from the flue gas and thus help in the problem of disposing of these fines. The flue gas is at a velocity of 1–4 ft./sec. This countercurrent contacting results in the conversion of the droplets to dry coke seed particles. These seed particles are then withdrawn from drier **26** through line **25** and returned to the bed **5** in coker **1**. A transporting gas such as steam may be used for this purpose. The withdrawn seed has an average diameter of about 75–150 microns.

Product gases consisting of flue gases and cracked oil products together with fine particles of coke and oil drops entrained out of spray drier **26** are withdrawn through line **21** into wet cyclone **22**. Preferably these gases are scrubbed by contacting with pitch feed added through line **28**. This scrubs the coke fines and small drops out of the gases. The scrubbing liquid is recovered in cyclone **22** and returned to the spray drier **26** via line **19**, or to coker **1** via line **2**. This also serves to preheat the heavy oil added via line **28**. The product gases are withdrawn overhead through line **24** from the wet cyclone and the liquid scrubbing oil slurry withdrawn through dipleg **23**. The pitch separated can be recycled back to line **19** for further atomization. It may be necessary to keep the wet cyclone hot so that the pitch will flow.

It will be noted that fine coke particles that would be too fine for use in the coker are recycled as a slurry to the spray drier until their size is increased to the desirable range. Similarly, oil spray which is too fine is so recycled, and only oil drops of optimum size are allowed to fall down into the hotter drying zone of vessel **26**. This effect can be regulated by means of the gas velocity in drier **26** according to well known laws. The spray may be formed by a nozzle, spinning disc or other conventional means.

Hot coke can be withdrawn from heater **10** as an additional heat transfer and drying medium to drier **26**. The hot coke from the heater is then preferably discharged in an annular curtain in the periphery of the drier and thus serves to maintain the proper temperature in the drier. The coarser coke particles then collect at the bottom of the drier and serve to even further dry the seed particles. It is not necessary to separate the seed particles, since the entire coke stream from drier **26** can be returned to the coker. In this case a relatively large amount of dry coke particles may entrain out of drier **26** depending on the gas velocity, in which case oil will not be added at **28** and cyclone **22** will operate dry instead of wet.

The feed to the coker and the drier can be the same. If two different types of heavy hydrocarbon oils are available, it is preferable to utilize the one of higher Conradson carbon as feed to the drier. Also it is advantageous to feed a slurry stream to drier **26**, as for example the heavy recycle from the coker fractionator.

Oil products in gases leaving line **24** may be recovered as desired. This recovery can be facilitated by recycling tail gas from the recovery system to the spray drier. Light hydrocarbons in the gas may serve as fuel for maintaining the proper drier temperature. If desired coke particles can be withdrawn from the spray drier via line **30** for other uses.

In order to express this information more fully the following conditions of operation of the various components are set forth below:

CONDITIONS IN FLUID COKER 1

	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	0.2–20	0.5–1.0
Average Size of Coke Particles, microns	100–1,000	150–400

CONDITIONS IN BURNER 10

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

CONDITIONS IN SPRAY DRIER 26

Temperature of Flue Gas, °F	1,000–2,500	1,200–2,000
Velocity of Flue Gas, ft./sec	0.5–8	1–4
Size of Feed Droplets Diameter, microns	100–1,000	150–600
Average Particle Size of Seed Coke Make, microns	50–300	75–150
Feed to Drier/Feed to Coker, Vol. Percent	5–30	7–15

The arrangement just described is highly flexible. It makes it possible to replace large product coke particles with an equivalent number of small "seed" particles at so constant and regular a rate as to keep the total number of particles, the particle size distribution, and the total solids inventory substantially constant at all times.

Other advantages of the process of this invention include savings in equipment and efficient heat balance.

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 which comprises the steps of contacting a heavy oil coking charge stock at a coking temperature with a body of coke particles maintained in the form of a dense turbulent fluidized bed in a reaction zone; removing product vapors from the reaction zone; circulating the coke through an extraneous heating zone, wherein a portion of the coke particles are burned, and sent back to the

reaction zone to supply heat thereto; the improvement which comprises atomizing a heavy hydrocarbon oil having a higher Conradson carbon residue than the charge stock and in an amount of from 7 to 15 volume percent based on the charge stock into a drying zone to produce small oil droplets having a diameter in the range of 150 to 600 microns; countercurrently contacting the atomized oil droplets with hot flue gas from the extraneous heating zone at a temperature in the range of 1000° to 2500° F. and having a velocity of 1 to 4 ft./sec. whereby coke seed particles having a diameter size distribution of predominantly 75 to 150 microns are formed; withdrawing the coke seed particles from the drying zone and sending the coke seed particles to the reaction zone.

2. The process of claim 1 including the additional step of withdrawing gas and entrained oil particles overhead from the drying zone; separating the oil from the gas and returning the oil as additional feed to the drying zone.

3. The process of claim 1 including the additional step of circulating a portion of the coke particles from the heating zone to the drying zone to supply additional heat thereto.

4. In a process for coking of a heavy hydrocarbon oil which comprises the steps of contacting a heavy oil coking charge stock at a coking temperature with a body of coke particles maintained in the form of a dense turbulent fluidized bed in a reaction zone; removing product vapors from the reaction zone; circulating the coke through an extraneous heating zone, wherein a portion of the coke particles are burned, and sent back to the reaction zone to supply heat thereto; the improvement which comprises atomizing a heavy hydrocarbon oil having a higher Conradson carbon residue than the charge to the reaction zone into a drying zone to produce small oil droplets having a diameter in the range of 150–600 microns; countercurrently contacting the atomized oil droplets with hot flue gas from the heating zone at a temperature in the range of 1200°–2000° F. and having a velocity in the range of 1–4 ft./sec. whereby fines are removed from the flue gas and coke seed particles having a diameter size distribution of predominantly 75–100 microns are formed; withdrawing gas, coke fines and entrained oil particles overhead from the drying zone; scrubbing this overhead fraction with additional higher Conradson carbon residue oil to scrub out the oil particles and fines, the volume percent of the total oil fed to the drying zone and for scrubbing to the oil charge to the reactor being in the range of 7–15 volume percent; separating resultant oil fines slurry from the gas; returning the oil slurry as additional feed to the drying zone; withdrawing the coke seed particles from the drying zone and sending them to the reaction zone.

References Cited in the file of this patent

UNITED STATES PATENTS

2,436,160	Blanding	Feb. 17, 1948
2,443,714	Arveson	June 22, 1948
2,598,058	Hunter	May 27, 1952
2,719,115	Russell	Sept. 27, 1955
2,742,403	Nicholson et al.	Apr. 17, 1956

FOREIGN PATENTS

1,057,092	France	Oct. 28, 1953