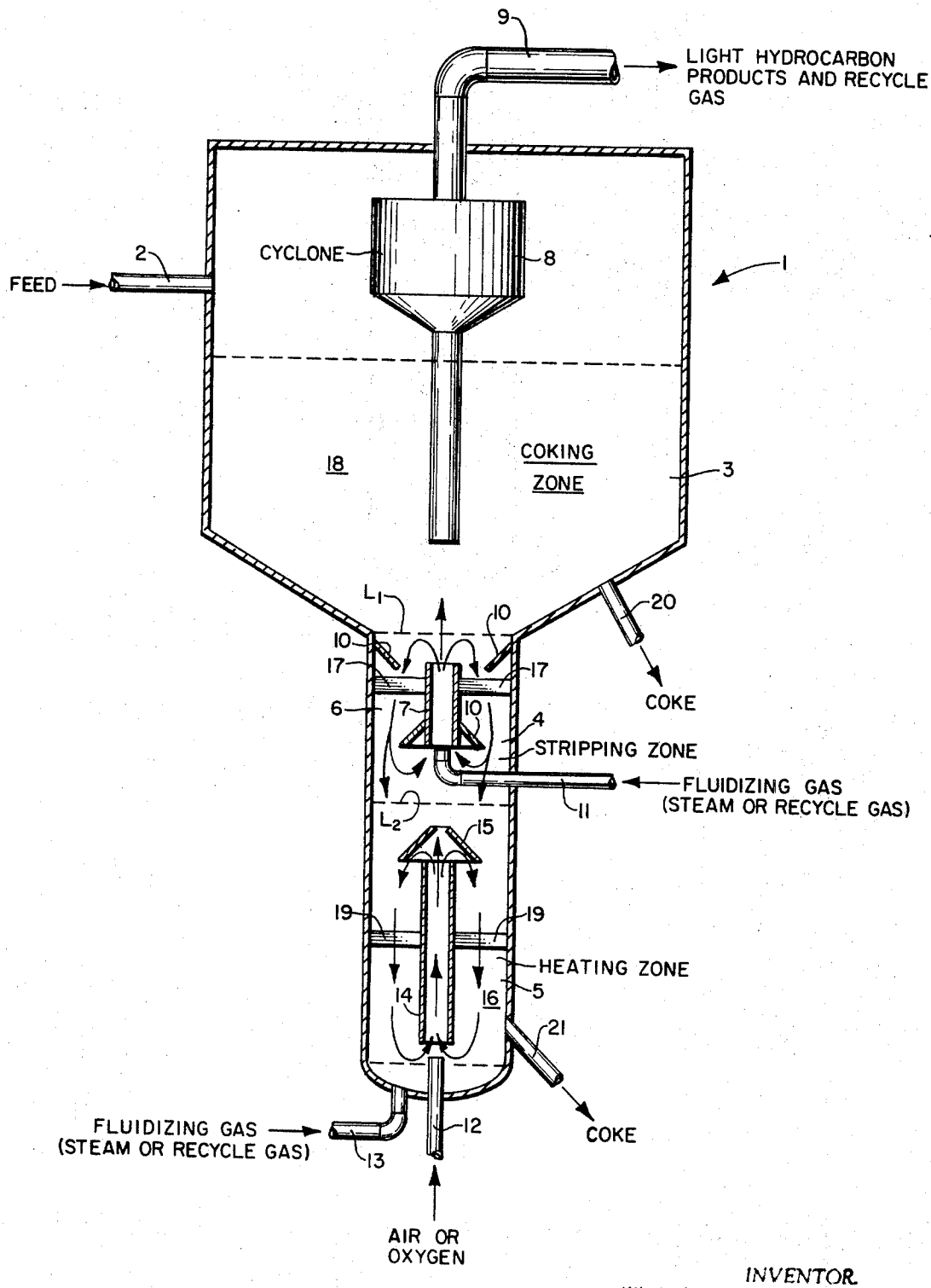
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PROCESS FOR COKING HEAVY HYDROCARBONS IN A SINGLE VESSEL

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PROCESS FOR COKING HEAVY HYDROCARBONS IN A SINGLE VESSEL

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ABSTRACT OF THE DISCLOSURE

Process for producing coke and gaseous hydrocarbons wherein heavy carbonaceous material is fed into a coking zone which is heated by hot gases from a gasifying zone and by hot particles from a stripping zone.

BACKGROUND OF THE INVENTION

This invention relates to the art of producing coke from heavy carbonaceous materials and, in particular, by the use of a single reaction vessel wherein is included a fluid bed which is heated by hot gases from a gasifying zone, and particulate coke solids from a stripping zone.

It is well known in the art that coke may be produced in a fluid bed reactor. In these earlier fluid coking systems two separate vessels were used, one to produce coke and a second to provide the heat needed in the first vessel. However, such a system did not provide for as efficient heat exchange as would be desirable. Also, such two-vessel systems require a larger capital outlay since two separate vessels along with complicated solids transfer lines had to be constructed. In order to increase the heat exchange efficiency and lower the capital expenditure cost, various single vessel systems were designed wherein all of the heat required for the coking process could be generated in the same vessel. Typical of the single vessel system designs is U.S. Pat. 2,445,328. Although this and similar designs improved on the heat exchange and capital outlay problems, many new difficulties were created making such a design impractical in industrial use. A major problem is that the valuable light hydrocarbons produced in the coking zone were burned in the heating zone of the reactor. Thus, the valuable light hydrocarbon byproducts could not be recovered. Moreover, the flow rate of particles is difficult to control in such a design without operating at high temperatures. Further, the openings which separate the coking zone from the heating zone become plugged by the hot particles from the reactor. This resulted in an expensive complete shutdown of the coking system and a difficult unplugging task. In addition, fluidization was made more difficult due to the fact that the smaller fluid bed particles, in particular if they are coke particles, are indiscriminately burned along with the larger particles in the heating or gasification zone.

It is accordingly the primary objective of this invention to alleviate these and other prior art problems. In particular, it is an object of this invention to provide a process for producing coke which does not burn the valuable light hydrocarbons also produced.

Another object of this invention is to provide a process operated within a single vessel to produce coke and valuable light hydrocarbon products.

A still further object of this invention is to provide a process operated in a single vessel which will not become plugged and require an expensive shutdown.

Still another object is to provide a process for producing coke in a single vessel reactor wherein the larger fluid bed particles are selectively burned in the heating zone.

Other objects and advantages of this invention will be apparent from the ensuing description and claims read in conjunction with the accompanying drawing.

SUMMARY OF THE INVENTION

It has been found that the above and other objects can be achieved by employing the process of this invention. Accordingly, heavy hydrocarbon material is introduced into a fluid bed coking zone which is located in the upper portion of a single vessel reactor. Within this fluid bed coke is produced which can then be withdrawn from the zone by ample means. Light hydrocarbon products are also produced in the coking zone. These light hydrocarbon products, attached to the particles comprising the fluid bed, are prevented from entering the heating zone located in the lower portion of the single vessel reactor by a stripping zone located between the coking zone and the lower heating zone. The light hydrocarbon materials, attached to the particles, are held in the stripping zone by a baffle-draft tube design located within the stripping zone for a period of time sufficient for the fluidizing gases introduced into the stripping zone and the gases produced in a lower heating zone to remove the light hydrocarbon material from the inert particles and to carry these light hydrocarbon materials through the coking zone so that they may be recovered overhead.

The residence time of the light hydrocarbon material attached to the particles, within the stripping zone, is determined by the amount of light hydrocarbon material desired to be removed from the inert particles. This residence time can be controlled by the depth of the stripping zone bed and by the spacing of the baffles, but primarily by the rate at which the fluidizing gas is introduced into the bottom portion of the draft tube located in the stripping zone. By introducing the fluidizing gas to the bottom portion of the draft tube, a circulation flow path is set up within the stripping zone. This flow path acts as a resistance to particles from the coking bed entering into the heating bed. Only when the particles from the coking bed have entered the circulation flow path to the stripping zone can they finally be introduced into the heating zone. Therefore, by controlling the circulation rate, the residence time within the stripping zone can also be controlled. If the rate of introducing the fluidizing gas is increased, the circulation of the particles within the stripping zone will also increase thus decreasing the residence time within the stripping zone. Likewise, if the rate of introducing the fluidizing gas within the stripping zone is decreased, the rate of circulation within the stripping zone will also decrease, thus increasing the residence time within the stripping zone. The circulation within the stripping zone can also be controlled by the spacing of baffles within the stripping zone. If the baffles are so positioned so as to restrict the flow within the stripping zone, the residence time within the stripping zone will necessarily increase.

The above baffle-draft tube design also allows one to control the size of particles entering into the heating zone. By reducing the circulation rate of the particles within the stripping zone, larger particles, due to gravitational effects, are more likely to enter the heating zone than are the lighter, smaller particles within the stripping zone. The size of particles entering the heating zone can also be controlled to a much lesser degree by the spacings of the baffles within the stripping zone. This can be done by controlling the angle and distances between baffles within the stripping zone.

In a preferred embodiment of this invention, the heating zone is also provided with a draft tube and means for introducing a fluidizing gas at the bottom of the heating zone. The second draft tube will also aid in the control of the circulation of hot particles from the heating zone

to the stripping zone. A circulation path can also be set up within the heating zone.

BRIEF REFERENCE TO THE DRAWING

The attached drawing illustrates a cross-sectional view of a suitable apparatus for carrying out a preferred embodiment of the process of this invention.

PREFERRED EMBODIMENT OF THE INVENTION

Referring to the figure, generally, there is shown a coking vessel **1** wherein is included a coking zone **3**, a stripping zone **4**, and a heating zone **5**. These zones are situated so as to allow direct interchange of particles between the coking zone and the stripping zone, and between the stripping zone and the heating zone.

A heavy hydrocarbonaceous material is introduced into coking zone **3** located within the upper portion of coking vessel **1** by line **2**. Preferably, the feed will have a Conradson carbon number greater than 5 and an initial boiling point greater than 700° F. This would include such heavy hydrocarbonaceous material as crude oil, shale oil, heavy residua from a fractionator, atmospheric and crude vacuum bottoms, pitch, asphalt, other heavy hydrocarbon petroleum residua or mixtures thereof.

The feed introduced into coking zone **3** is contacted with a fluidized bed of solid particles maintained at a temperature between 800°–1100° F., preferably about 950–1000° F. The bed is maintained in a fluidized state primarily by gases introduced to vessel **1** by lines **11**, **12**, and **13**. Also, gases which are produced by various reactions within stripping zone **4** and heating zone **5** aid in maintaining the coking zone bed in a fluidized state. Because the coke produced in coking zone **3** is formed by coating the fluid bed particles comprising the coking bed, it is preferable that these particles be of small size so as to provide more surface area for the coke to form on. Coke particles have a size in the range of aout 40–1000 microns are therefore preferred.

Because the production of coke and gaseous products is an endothermic reaction, heat must continuously be supplied to coking zone bed **18**. All the heat required to maintain coking zone bed **18** at a temperature between 800°–1100° F. can be supplied by the gases produced primarily in heating zone **5** and secondarily in stripping zone **4**, and by the interchange of solid particles between coking zone **3** and stripping zone **4** at level L_1. If desired, although not required for the operability of the process, additional heat may be furnished, if desired, by introducing hot coke particles, from a separate heating vessel although this is not necessary. The coke that is produced can be removed from coking zone **3** by line **20**.

Preferably, stripping zone bed **6** is of the same material as coking zone bed **18**, i.e., coke particles having a size in the range of 40–1000 microns. It is operated at a temperature greater than coking zone **3**, but less than heating zone **5**, generally, between 1000° and 1350° F., but preferably between 1050° and 1150° F. As in coking bed **18**, stripping zone bed **6** is maintained in a fluidized state by gases introduced in coking vessel **1** by lines **11**, **12**, and **13**. Also, the gases produced within stripping zone **4** and heating zone **5** aid in maintaining stripping zone bed **6** in a fluidized state. Located within stripping zone **4** is draft tube **7** connected to coking vessel **1** by support rods **17**. In a preferred embodiment of the invention, baffles **10** are located within stripping zone **4** and attached to the outside walls of draft tube **7** or the inside wall of coking vessel **1** adjacent to draft tube **7**, or attached to both, so as to aid in the control of circulation of coke particles and improve stripping within stripping zone **4**.

Steam or recycle gas is introduced to the bottom of draft tube **7** by line **11**. This steam or recycle gas forces the coke particles containing light hydrocarbon material up draft tube **7** during which time the light hydrocarbon materials are removed from the coke particles. The coke particles which reach the top of draft tube **7** enter into coking zone **3** or they are recirculated down the side of draft tube **7**, thus setting up a circulation path, as shown in FIG. 1, of coke particles within stripping zone **4**. These coke particles, which have now been removed of any light hydrocarbon material attached to them, are circulated to the bottom of draft tube **7** where they may again be circulated up the draft tube or they may enter heating zone **5**. The rate of circulation will be determined by the amount of time which is required to remove the light hydrocarbon materials from the coke particles. This residence time is controlled primarily by the rate at which the steam or recycle gas is introduced by line **11**. Preferably, the steam or recycle gas rate will be between 0.05 and 1.0 cu. ft./lb. of coke circulated resulting in an average coke holding time between 20 and 120 seconds.

Many important functions are performed by stripping zone **4**. The more important of these is to provide the heat requirement necessary in coking zone **3** and to prevent desirable light hydrocarbon products attached to the coke particles from being burned in heating zone **5**. Most of the heat required in coking zone **3** is provided by direct interchange of the hot coke particles from stripping zone **4** with the cooler coke particles of coking zone **3**. The remaining portion of the heat required in coking zone **3** is provided by the hot gaseous products produced in heating zone **5** and stripping zone **4** which pass upward in the coking zone **3**. This is beneficial in that less coke is required to be burned in heating zone **5** than if the heat transferred by the gases could not be utilized. In this connection, if one desires to produce coke, it is preferred that recycle gas rather than steam be introduced in heating zone **5** by line **13**. When recycle gas is introduced in heating zone **5** by line **13**, the H_2 and CH_x in the recycle gas would react with the air or oxygen or oxygen-containing gas introduced by line **12** according to the following reactions:

(1) $$H_2+\tfrac{1}{2}O_2 \rightleftharpoons H_2O$$

(2) $$CH_x+\left(1+\frac{X}{4}\right)O_2 \rightleftharpoons CO_2+\frac{X}{2}H_2O$$

On the other hand, if steam is introduced by line **11** and **13**, it may react with the coke within coking vessel **1** to produce H_2 and CO as follows:

(3) $$H_2O+C \rightleftharpoons H_2+CO$$

Thus, part of the coke produced will be used up in reaction with the steam, resulting in less net coke produced than when recycle gas is used.

Another important function of the stripping zone is to prevent the light hydrocarbon material from being introduced into the heating zone where it would be burned. This is accomplished by passing fluidizing gases, such as steam or recycle gas, through the coke particles covered with a light hydrocarbon material so as to strip these light hydrocarbon materials from the coke particles and carry them through the coking zone **3** and out of coking vessel **1** by line **9**. To insure that the light hydrocarbon materials are stripped from the coke particles in stripping zone **4** it is necessary that the residence time of the coke particles within stripping zone **4** be long enough to allow complete stripping. According to the present invention, the residence time in stripping zone **4** is controlled by setting up a circulation flow path for the coke particles within stripping zone **4**. This is accomplished by passing steam or recycle gas through draft tube **7**, thus forcing coke particles within stripping zone **4** up draft tube **7** and into contact with coking zone bed **18**. Some of the coke particles will enter coking zone bed **18**, but others will be returned down the side of draft tube **7** as shown by the arrows in FIG. 1. When the coke particles reach the bottom of stripping zone **4**, they are met by hot coke particles from heating zone **5** at level L_2. Some of the coke particles from stripping zone **4** will enter in the heating zone **5** while others will be recirculated up draft tube **7** along with hot coke particles

from heating zone 5. The rate at which the coke particles circulate within stripping zone 4 depends largely upon the rate at which the steam or recycle gas is introduced to the bottom of draft tube 7 by line 11. If the rate of introducing the steam or recycle gas is increased, then the circulation of the coke particles within stripping zone 4 will also increase, thus decreasing the residence time of the coke particles within stripping zone 4. On the other hand, if the rate of introducing the steam or recycle gas is decreased, then the residence time will be increased. In this process a residence time of 20–120 seconds would be sufficient to remove most of the valuable light hydrocarbons from the coke particles. The rate of circulation within stripping zone 4 can also be controlled by the positioning of baffles 10 located on the outside wall of draft tube 7 and the inside wall of stripping zone 4. If these baffles are positioned so as to inhibit the flow of circulation, this will result in an increase in the residence time of the coke particles within stripping zone 4. Also, the position of baffles 10 can be used to control the particle size of coke particles that flow through heating zone 4. It is understood that the residence time can also be increased by lengthening the depth of stripping zone 6.

Another function of stripping zone 4 is to prevent the smaller coke particles from entering heating zone 5 where they would be burned. This is desirable since the coke is produced in coking zone 3 by forming on the coke particles that comprise coking zone bed 18. If the coking bed particles are small, then there is more surface area for the coke to form on. Therefore, it is beneficial to maintain the coke particles relatively small. Also, maintaining the beds in a fluidized state will be much easier if the average coke particle size can be reduced. This is accomplished by stripping zone 4 through the control of the circulation rate. If the circulation rate within the stripping zone is reduced, then there will be greater probability for the larger coke particles to enter heating zone 5 due to gravitational considerations. This is because the larger and thus heavier coke particles would be more difficult to maintain in a fluidized state and would therefore tend to settle toward the bottom of coking vessel 1.

The heat requirements for the process are supplied primarily by circulation of hot coke particles from heating zone bed 16 and from the hot gases produced in heating zone 5. Oxygen or other oxygen-containing gases, such as air, are introduced by line 12 to the bottom of heating zone 5, along with the fluidizing gas, such as steam or recycle gas. In the preferred design, heating zone 5 would be equipped with draft tube 14 connected by supporting rod 19 to coking vessel 1. The oxygen or other oxygen-containing gases will flow up draft tube 14 in a similar manner as the steam or recycle gases flow up draft tube 7 within stripping zone 4. The coke particles, when contacted by the oxygen or oxygen-containing gases within draft tube 14 result in heat-producing reactions. By controlling the rate by which the oxygen-containing gases are introduced, the temperature in heating zone 5 can be maintained between 1300° and 2000° F., preferably between 1500° and 1600° F. This will require a gas flow rate of between 0.5 and 5.0 moles of oxygen per barrel of residuum feed. In order to control the rate at which the hot coke particles flow from heating zone 5 to stripping zone 4, baffle 15 can be placed above draft tube 14. If desired, coke may be removed from heating zone 5 by line 22.

The hot gases produced within heating zone 5, and particularly within draft tube 14, rise and enter first stripping zone 4 where they may undergo further reactions and where they import a portion of their heat to bed 6, next they enter coking zone 3 where again they may react with the coke in bed 18 and where they impart a portion of their heat to said bed, and finally the gases are recovered in line 9 after they have passed through cyclone 8. A typical recycle gas composition from line 9 after removing valuable hydrocarbons when air is introduced to gasifying zone 5 by line 12 would be:

	Mole percent
CH_X	11.4
H_2	3.2
H_2O	2.9
CO	10.7
CO_2	10.7
N_2	60.2
H_2S	0.9

and when oxygen is introduced by line 12:

	Mole percent
CH_X	26.9
H_2	10.0
H_2O	2.9
CO	37.5
CO_2	18.8
N_2	1.8
H_2S	2.1

These gases may then be recycled, or they may be used as fuel.

The nature of the present invention, having now been fully described and illustrated, what is claimed as new, useful and unobvious and desired to be secured by Letters Patent is:

1. A process for producing coke and light hydrocarbon material which comprises: introducing a heavy hydrocarbon material to a single vessel reactor comprising an upper portion that is maintained at coking temperatures, an intermediate portion that is maintained at temperatures in excess of said coking temperatures, and a lower portion that is maintained at a temperature in excess of the temperatures maintained in the intermediate portion, contacting said hydrocarbon material with a fluid bed of particles maintained in said upper portion thereby forming coke and light hydrocarbon material, at least a portion of said light hydrocarbon material being associated with said coke, passing said coke and associated light hydrocarbon material to said intermediate portion, circulating said coke within said intermediate portion and releasing hydrocarbon material from said coke by passing a portion of said coke and associated light hydrocarbon material and a hot fluidizing gas through a draft tube assembly positioned within said intermediate portion, said coke being maintained in said intermediate portion for a period of time sufficient for gravitational forces to selectively pass the larger particles of said coke to said lower portion.

2. The process of claim 1, wherein said coke is maintained in said intermediate portion on the average for about 20 seconds to about 120 seconds.

3. The process of claim 1, wherein a major portion of said fluidizing gas is a stream of recycle gases.

4. The process of claim 1, wherein said lower portion of the reactor is operated at temperatures above 1300° F.

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