United States Patent [19]

Molstedt

[11] **3,779,900**

[45] **Dec. 18, 1973**

[54] **PROCESS FOR FLUID COKING AND COKE GASIFICATION IN AN INTEGRATED SYSTEM**

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[22] Filed: **Nov. 30, 1971**

[21] Appl. No.: **205,775**

[52] **U.S. Cl.** .... **208/127,** 48/197 R, 48/206, 201/31, 201/38, 201/44

[51] **Int. Cl.** **C10g 9/32**

[58] **Field of Search** 208/127

[56] **References Cited**

UNITED STATES PATENTS

2,734,853	2/1956	Smith et al.	208/127
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Primary Examiner—Herbert Levine
Attorney—Leon Chasan et al.

[57] **ABSTRACT**

A method is provided for fluid coking and coke gasification in an integrated system. High temperature gases with entrained solids are delivered to a heating zone from the gasifier without the use of a cyclone, and mixed with either circulating coke from the reactor zone in a preferred embodiment, or with circulating coke from the heater zone in an alternative embodiment. The relatively cooler gaseous heater zone effluent is treated to separate gases and entrained solids.

6 Claims, 2 Drawing Figures

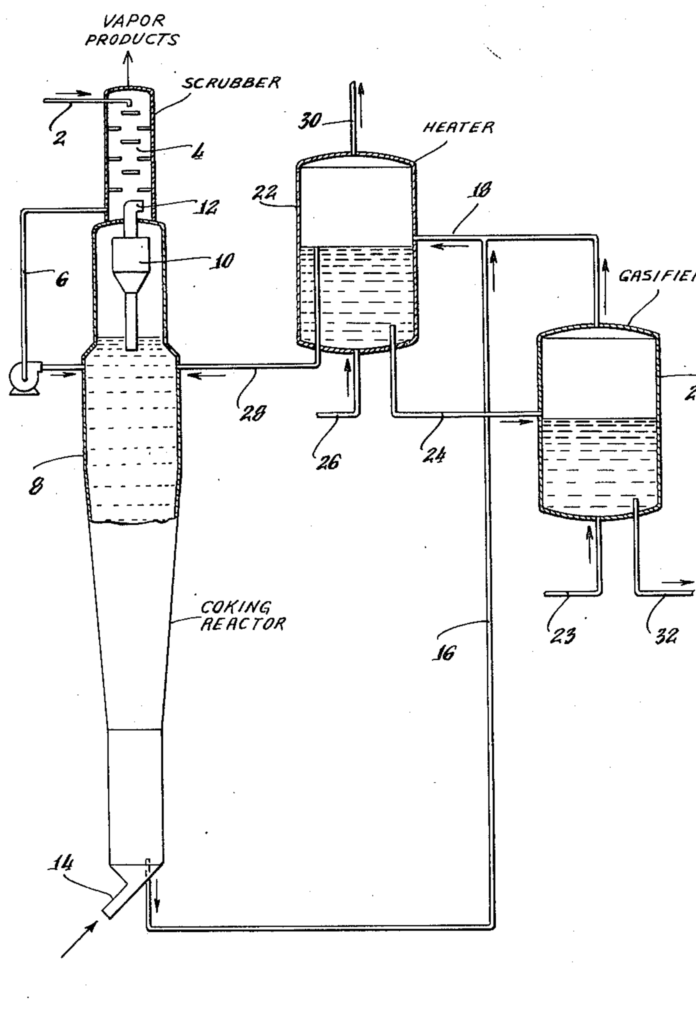


Fig. 1

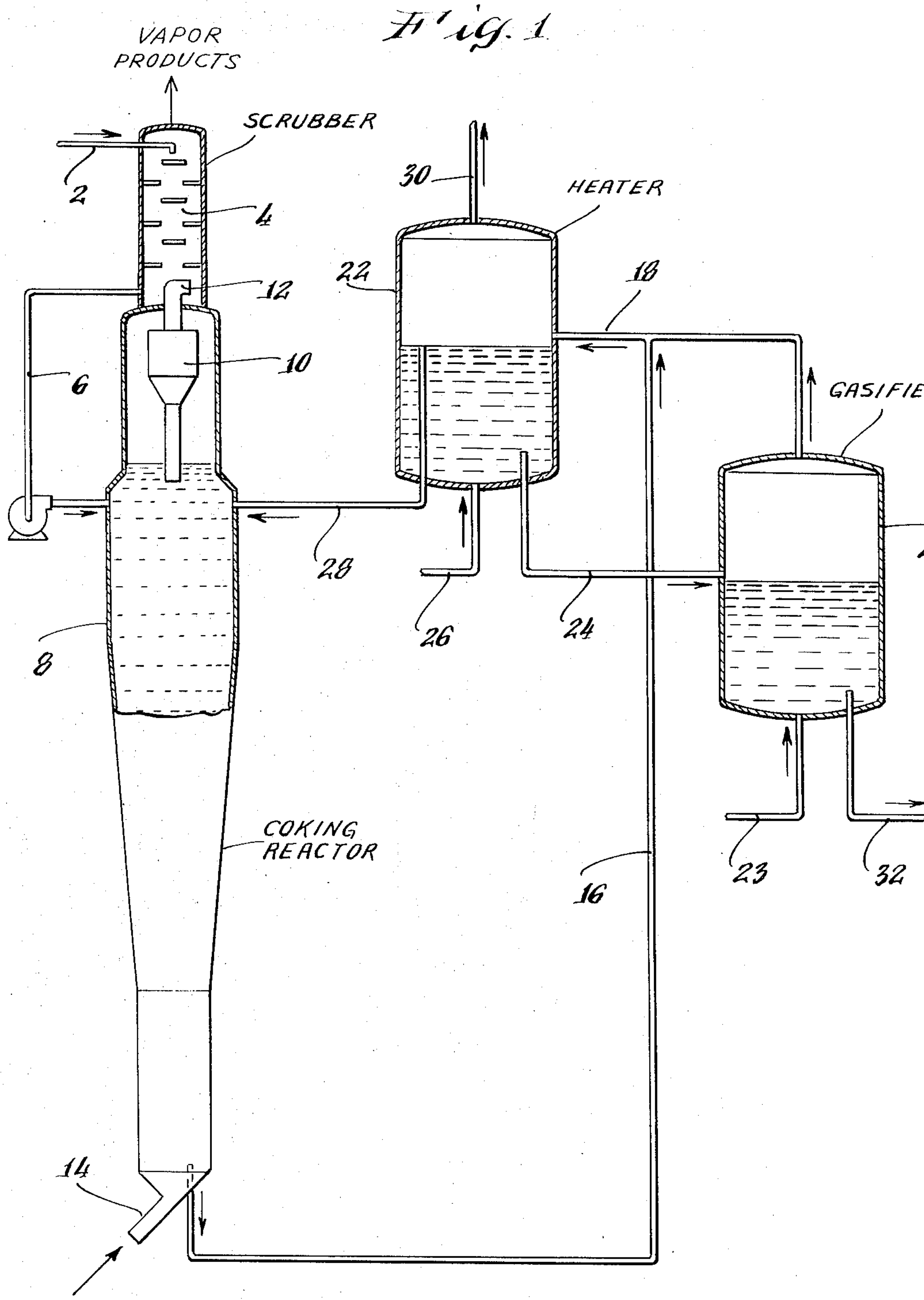
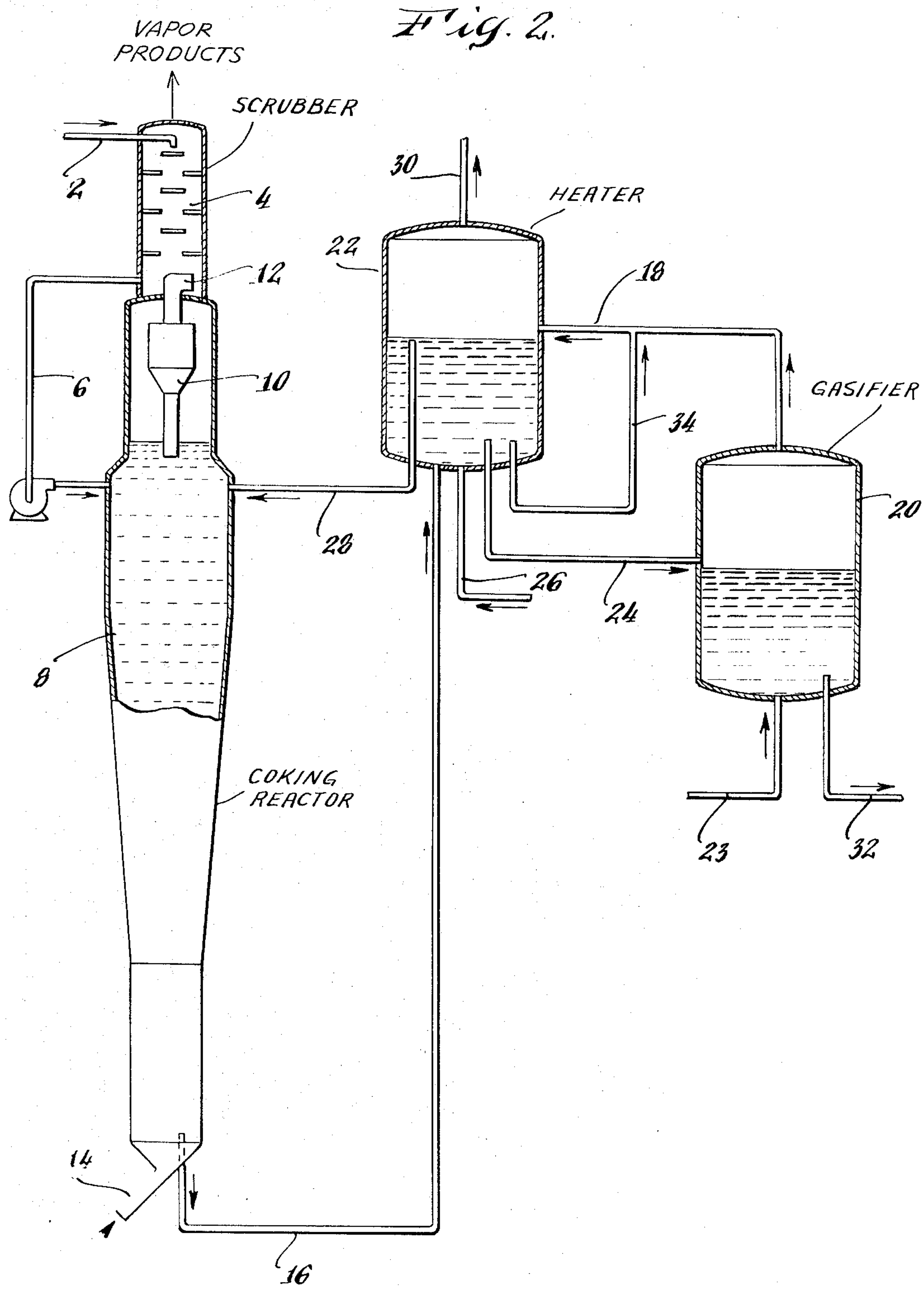

VAPOR PRODUCTS
SCRUBBER
2
4
12
10
6
8
HEATER
30
22
18
28
26
24
GASIFIER
20
23
32
16
COKING REACTOR
14

Fig. 2.


VAPOR PRODUCTS
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PROCESS FOR FLUID COKING AND COKE GASIFICATION IN AN INTEGRATED SYSTEM

This invention relates to a process for fluid coking and coke gasification in an integrated system.

Large quantities of residuum remain after distilling out naphtha, heating oil, and heavy gas oil from the crude. Residuum by itself is worth far less than the crude and must be treated or upgraded in some manner which is economically attractive. Fluid coking has provided an efficient, low-cost process to convert residuum into more valuable light products.

It has previously been found to be desirable to provide a burner or gasifier zone operated at temperatures of between 1,800° to 2,000° F. where coke and/or combustible gases are burned to supply heat required to sustain the coking reaction. The systems of U. S. Pat. No. 2,880,167 to C. N. Kimberlin, Jr. et al., and commonly owned copending U. S. application Ser. No. 17,802 filed Mar. 9, 1970, now U. S. Pat. No. 3,702,516, by E. C. Luckenbach are exemplary of systems employing such high temperature units. The products of such a high temperature zone are gases with entrained fine solids. Such prior art systems required the use of a high temperature cyclone to remove the entrained solids. However, high temperature cyclones are extremely costly because, although a satisfactory cyclone design for operation at 2,000° F. has been devised and demonstrated, the scale up to commercial size is not entirely predictable. Accordingly, it would be desirable to avoid the use of the high temperature gasifier cyclone.

A previous attempt to eliminate the cyclone, placed the heater unit directly above the gasifier in a completely integrated unit. The top of the gasifier was opened to permit the hot gases to rise directly through the bottom of the heater unit. This system, although near ideal in theory, was far less than ideal in practice because of the critical and complex integrating arrangement required. The gases from the gasifier plus other gases such as air or steam which were introduced into the heater were required to fluidize a bed of coke in the heater directly above the open bottom thereof. And, any fluctuation in gasifier operation would greatly affect the performance of the heater. Thus, costly, difficulty-designed equipment is required to approach desirable operation: (1) the top of the gasifier must be necked down by a critical amount, which must be critically related to (2) a conical bottom of the heater section, which must be critically related to (3) a properly designed disc and donut redistributor for passing the gases through an "egg crate" or other suitable type grid which supports the solids in the heater bed. These internals must be cooled by recirculation of solids from the heater bed through the egg crate baffle. Design and operability are quite problematical, largely as they relate to interactions between the two beds in terms such as the control of bed levels, control of solids recirculation to prevent excessive temperatures on the internals, etc.

The only previously known way to eliminate these problems was to completely separate the gasifier from the heater and operate them independently. However, two major disadvantages result; namely, (1) substantially higher cost, mainly due to the need for high temperature cyclones on the gasifier, which also entail serious design and maintenance problems, and (2) loss to

the fluid coking process of the recoverable heat in the 1,800° to 2,000° F. product gases from the gasifier.

Accordingly, it is an object of this invention to provide an improved process for fluid coking which avoids the use of a high temperature cyclone at the gasifier zone.

It is a further object of this invention to provide an improved process for fluid coking which avoids the use of a high temperature cyclone at the gasifier zone while avoiding the disadvantages attendant to a fully integrated system but retaining the principal advantages thereof.

These and other objects are achieved by providing an improved process for fluid coking in a system having a coking reactor zone which operates within the temperature range of 900° to 1,200° F., a heating zone which operates within the temperature range of 1,000° to 1,400° F., and a gasifier zone which operates within a temperature range of 1,300° to 2,500° F. comprising: admixing the hot gases including entrained solids issuing from the gasifier, with a relatively cooler stream of coke particles, whereby the coke particles are heated and the hot gases are cooled, conducting the resultant admixture into the heating zone; and exiting the gases from the heating zone along with any gases produced in the heating zone through a solids-gas separating zone wherein solid particles are recovered for re-use in the coker reactor. This invention thus provides a way of separating solids from a hot gasifier stream without the need of a gas-solids separator operating at high gasifier temperatures.

The present invention will become more apparent from the ensuing discussion with reference to the drawings wherein:

FIG. 1 is a flow diagram illustrating a preferred embodiment of this invention wherein hot gases plus any entrained solids are passed from the gasifier zone and mixed with relatively cooler coke from the coking reactor before passing the combined stream into the heater; and,

FIG. 2 is a flow diagram illustrating an alternative embodiment of this invention wherein hot gases plus any entrained solids from the gasifier zone are joined with a stream of relatively cooler coke particles from the heater zone before passing the combined stream into the heater zone.

The drawings are intended only to provide an understanding of the inventive features of this invention and are not intended to be comprehensive or limiting. Much detail as to conventional systems and equipment has been omitted to simplify the explanation. Like parts are designated by like numerals in all the various FIGS.

Referring now to FIG. 1, a carbonaceous material having a Conradson carbon of at least 15 percent, such as heavy residuum boiling at 1,050° F.+, or a coal char slurry, or tar sands oil is passed by line 2 into the top of scrubber 4 where it flows downwardly countercurrent to vaporous reaction products and collects in the bottom from where it is passed by line 6 to the upper portion of coking zone 8 onto a fluidized bed of solid particles, e.g., coke of 40 to 1,000 microns in size, maintained at a temperature of 900° to 1,200° F. and preferably 950° to 1,050° F. The reactor zone is maintained at a pressure of 5–50 psig., and preferably 7–30 psig. The contact of the heavy hydrocarbons in the feed and hot solid particulate material results in the heavy hydrocarbons being converted to coke and light hydrocarbons and gases which are removed overhead through cyclone **10** and exit line **12** into scrubber **4** where they are scrubbed by incoming feed. Steam, or other substantially inert fluidizing gas, is injected into the base of the vessel by line **14** and serves to fluidize the solids therein and also strips the solids in the lower portion of the reactor before they are removed therefrom via line **16.**

Very significant additional heating value is potentially available from the cracked products to be derived from the circulating coke stream entering the heater from the coking reactor. Some hydrocarbon vapors are not stripped away from the coke in passing through the stripper and are thereby passed into the heater system. In addition, there is an amount of heavy residual hydrocarbon material left on the coke issuing from the coking reactor. This material is subject to further cracking at the higher temperatures prevailing in the heater system. The main products of these two hydrocarbon sources are hydrogen, plus methane, and smaller amounts of other light hydrocarbons. In typical prior systems, these would become burned with air in the heater bed. However, with the embodiment shown in FIG. **1**, the coke plus the entrained hydrocarbons are passed from the coking reactor **8** via line **16** and into line **18** where they are heated in the absence of oxygen by the high temperature product gases from the gasifier **20.** Simultaneously, with the heating of the coke which would cause further cracking and release of entrained hydrocarbons, the hot product gases from the gasifier are cooled. The combined stream is then passed via line **18** into the heater **22** above or near the top of the heater bed, thus insuring full recovery of cracked products for inclusion into the total fuel gas being produced and eliminating the need for a high temperature cyclone to remove entrained solids from the gasifier product gases.

The product gases of the gasifier are produced by passing steam plus air or oxygen via line **23** to fluidize the bed of coke covered solid particles which are passed from heater **22** via line **24** to the gasifier **20.** The bed temperature in the gasifier is maintained at a temperature of between 1,300° to 2,500° F. and preferably 1,500° to 2,000° F. The pressure in the gasifier is maintained at between 5 to 50 psig and preferably between 10 to 35 psig.

A bed of coke covered solid particles is maintained in the heater at a temperature of between about 1,000° and 1,400° F. and preferably between 1,100° to 1,200° F. The pressure in the heater is maintained at about 5 to 50 psig and preferably from about 7 to 30 psig. Air or oxygen is fed into heater **22** via line **26** to fluidize the bed and to cause oxidation of the coke to heat the solid particles of the bed in heater **22.** A portion of the solid particles in the heater bed is transferred via line **28** to coking reactor **8** in amounts sufficient to supply the necessary heat for the endothermic coking reaction. The product gases from the heater and those from the gasifier which have been transferred to the heater via line **18** and cooled by mixture with the coke from line **16** are removed through cyclones (not shown) and exit line **30.** Solid coke particles fall back into the fluidized bed of heater **22.** Although the gases exiting line **30** contain a large percentage of relatively inert combustion gases, they still have a relatively high heating value and may be used for various purposes as is, or the more valuable hydrocarbons may be removed therefrom by procedures known to the art. Ash and any excess coke produced over that used may be purged from the system and the gasifier via line **32.**

The method illustrated by the embodiment of FIG. **1** is preferred because it most nearly approaches full utilization of all hydrocarbon gas products. Also, the embodiment of FIG. **1** recovers more of the heat from the high temperature gasifier product gases than does the embodiment of FIG. **2.** This is true, because coke from the reactor via line **16** is cooler than recirculated coke from the heater via line **24.** Thus the mixture in line **18** is somewhat cooler in the FIG. **1** embodiment than it is in the case of FIG. **2.** The alternative embodiment of FIG. **2** is essentially that as shown in FIG. **1** except that the coke from the coking reactor is passed by line **16** to the heater **22.** A portion of the coke is then withdrawn from the heater bed via line **34** which passes it into line **18** where it is admixed with the hot gases from the gasifier **20.** This combined stream is then passed by line **18** into heater **22** at or above the top of the bed. Passing this combined stream to the top of the bed as indicated, instead of passing it into the bed through the bottom of the heater, avoids preferential burning of any valuable hydrocarbon gases which may be present by the air or oxygen which is supplied to the heater via line **26.**

While the method of this invention provides for a well integrated system for efficient fluid coking, it also provides for a high degree of flexibility in operation. In either of the embodiments illustrated by FIGS. **1** and **2,** the fluid coking system can be operated with almost complete independence of the gasifier. In fact, as an extreme example, the gasifier can be shut down and the coker can function in normal fashion. By the same token, variability in the gasifier operation has a minor influence on the control and performance of the fluid coking system.

In a specific example of this invention, carrying out the method illustrated by the embodiment of FIG. **1,** 12,000 B/SD of 1,050° F.+ residuum having a Conradson carbon value of 21.8 weight percent is fed into a coking reactor containing a bed of fluidized coke particles maintained at a temperature of 975° F. The reactor is operated at a pressure of 20 psig. Steam is passed into the bottom of the reactor and stripper at a total rate of 555 pound moles per hour. The heater is operated at a temperature of 1,150° F. and a pressure of 19 psig. Air is passed into the bottom of the heater at a rate of 1,630 pound moles per hour. Coke is removed from heater **22** at a rate of 2,260 pounds per minute and is passed by line **24** to gasifier **20** which is maintained at a temperature of 1,800° F. and operated at a pressure of 22 psig. The coke in the gasifier bed is fluidized and partially oxidized by passing steam at a rate of 4,000 pounds per hour and air at a rate of 6,030 pound moles per hour through the bottom of the gasifier. Product gases exit the gasifier via line **18** at a rate of 8,100 pound moles per hour and carry with them entrained coke at a rate of 1,670 pounds per minute. This stream of hot gases and entrained coke is combined with coke from the coking reactor which is passed by line **16** into line **18** at a rate of 32,000 pounds per minute. This combined stream is then passed by line **18** to the top of the heater bed. The total product fuel gas from the heater is then separated from entrained solids by cyclones and is passed from the heater via line **30.** The results calculated for heating value in BTU's per hour of these heater product gases and is shown below in Table I.

TABLE I

Gasification Products only	300 million
Cracked Hydrocarbons from Circulating Coke	269 million
Total	569 million

Thus, it can be seen, as previously described, that the heater product gases produced in accordance with this invention, especially the embodiment illustrated by FIG. 1, have a very high heating value due in great measure to the avoidance of preferential burning of the cracked hydrocarbons and gasifier product gas via the air or oxygen introduced into the bottom of the heater. Table II below shows the losses that may be sustained if various intermediate percentages of the cracked products are allowed to be burned in the heater in a system which does not employ the method of the embodiment illustrated in FIG. 1.

TABLE II

	Approximate Heating Value BTU/SCF Gas	Loss In Heating Value, %
Total Gas Including All Cracked Hydrocarbons	150	—
Total Gas When Hydrocarbons Are Burned In Heater	—	—
1. If 50% are burned	115	24
2. If 75% are burned	97	35
3. If 100% are burned	79	47

Although, the method of the embodiment shown in FIG. 2 does not have the full sensible heat recovery advantage discussed above for the system of FIG. 1, it does avoid the preferential burning of the gasifier fuel gas which would occur if it were injected, along with air, into the bottom of the heater. Thus, it also recovers full fuel value of the combined gasifier product gas and cracked hydrocarbons.

While the process has been described with respect to the circulation of coke as the fluidized medium, it is to be understood that a captive bed of fluidized inert particles such as silica, alumina, zirconia, magnesia, alundum or mullite, or combinations thereof may be used. They may also be particles built up of vanadium, nickel, or other contaminants in the feed. The materials may be synthetically prepared or may be naturally occurring materials such as pumice, clay, kieselguhr, diatomaceous earth, bauxite and the like. This can be advantageous for systems in which substantial quantities of very fine (less than about 10 microns) particles of foreign solids are released in the gasifier such that very low velocities would be required in order to maintain a stable fluidized bed. Such a captive bed can be fluidized readily without significant entrainment of the captive bed particles at superficial velocities substantially higher than the entrainment velocity of fine particles released from the coke. A captive bed of this type provides a well mixed reaction zone in the gasifier in which the carbon can be burned and the foreign solids released without causing severe fluidization problems. Some equilibrium concentration of the fine particles is retained in the gasifier bed, thus providing sufficient residence time for complete gasification of the carbon before the bulk of the particles are entrained by the exit gases. This type of process would be preferable when processing feeds containing much higher solids than are normally present in petroleum residua, e.g., bitumen from coal, tar sands or shale which may contain 15–20 percent inert solids. The solids, such as fine sand, metal oxides, or the like, contained in the bitumen are released in the captive bed in the gasifier and, being smaller than coke, are more easily entrained out and carried upwardly through the heat exchange bed. Entrainment will also be high if the residuum fed to the unit has an unusually high Conradson carbon content, resulting in high coke yield.

The particle size should be adjusted to balance surface area required for good coking with high vessel velocities. A particularly desirable distribution of particle sizes is one in which the mix contains relatively dense small diameter particles and less dense large particles as described in Ser. No. 782,377 filed Dec. 9, 1968 by E. C. Luckenbach. The average particle size should be maintained between about 60 and 190 microns. Considerable fines will be entrained in the gasifier gases passed to heater **22** by line **18** due to the elimination of the cyclone at the gasifier zone. It has been found to be desirable to circulate them back to the coker reactor, from the heater zone, where the very finest would agglomerate on coarser particles and the rest would act as seed coke in maintaining particle size.

It will be obvious to those skilled in the art that various modifications and changes can be made without departing from the spirit and scope of the present invention, an outstanding feature of which is the cooling of the hot gasifier gases by a relatively cooler stream of coke particles which eleminates the need for a high temperature cyclone at the gasifier zone and increases the yield of usable product gases.

What is claimed is:

1. In an integrated fluid coking-gasification process, wherein fluidized particles circulate through a system comprising a coking zone containing a fluidized bed of solid particles maintained at a temperature of about 900°–1,200° F., and a heating zone containing a fluid bed of solid particles maintained at a temperature of about 1,000°–1,400° F., a steam gasification zone containing a fluid bed of solid particles maintained at a temperature between about 1,300°–2,500° F. to produce a gaseous effluent comprising hydrogen and carbon monoxide, the improvement which comprises combining the hot total gaseous effluent of said gasification zone including entrained solids with a relatively colder stream of coked solid particles, in the absence of oxygen, to preheat said coked solid particles and correspondingly cool said gasification effluent by heat exchange, passing the resulting combined stream into said heating zone above the fluid bed to heat said coked solid particles, removing at least a portion of the heating zone gaseous effluent containing entrained solids through a solids-gas separating zone and recovering a fuel gas comprising hydrogen and carbon monoxide from said separating zone.

2. The process of claim **1**, wherein said relatively cold stream of coked solids particles comprises coked solid particles withdrawn from said coking zone.

3. The process of claim **1**, wherein said relatively cold stream of coked solid particles comprises coked solid particles withdrawn from said heating zone.

4. The process of claim **1**, wherein said gasification zone temperature is maintained between 1,500°–2,000° F.

5. The process of claim **4**, wherein said coking zone temperature ranges from about 950°–1,050° F. and said heating zone temperature ranges from about 1,100–1,200° F.

6. In an integrated fluid coking-gasification process, wherein fluidized particles circulate through a system comprising a coking zone containing a fluidized bed of solid particles maintained at a temperature of about 900°–1,200° F., a heating zone containing a fluid bed of solid particles maintained at a temperature of about 1,000°–1,400° F., a steam gasification zone containing a fluid bed of solid particles maintained at a temperature between 1,300–2,500° F. to produce a gaseous effluent comprising hydrogen and carbon monoxide, the improvement which comprises combining the hot total gaseous effluent of the gasification zone, including entrained solids, with a relatively colder stream of coked solid particles withdrawn from said heating zone, in the absence of oxygen, passing the resulting combined stream into said heating zone above the fluid bed, removing at least a portion of the heating zone gaseous effluent containing entrained solids through a solids-gas separating zone and recovering a fuel gas comprising hydrogen and carbon monoxide from said separating zone.

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