Dec. 13, 1960 B. I. SMITH ET AL 2,964,464

INTEGRATED COKING AND CALCINING PROCESS

Filed March 17, 1959 2 Sheets-Sheet 1

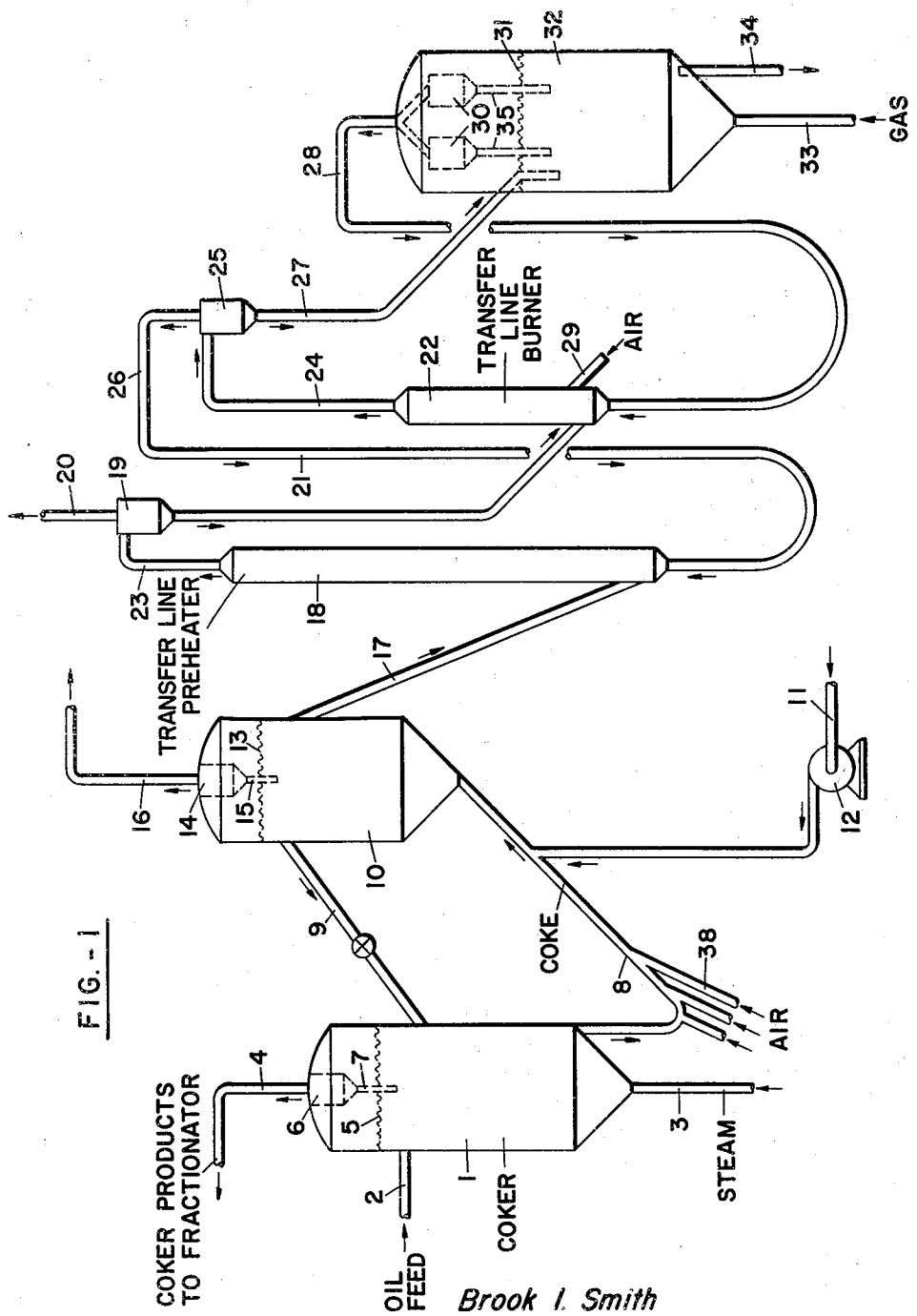

FIG. - 1

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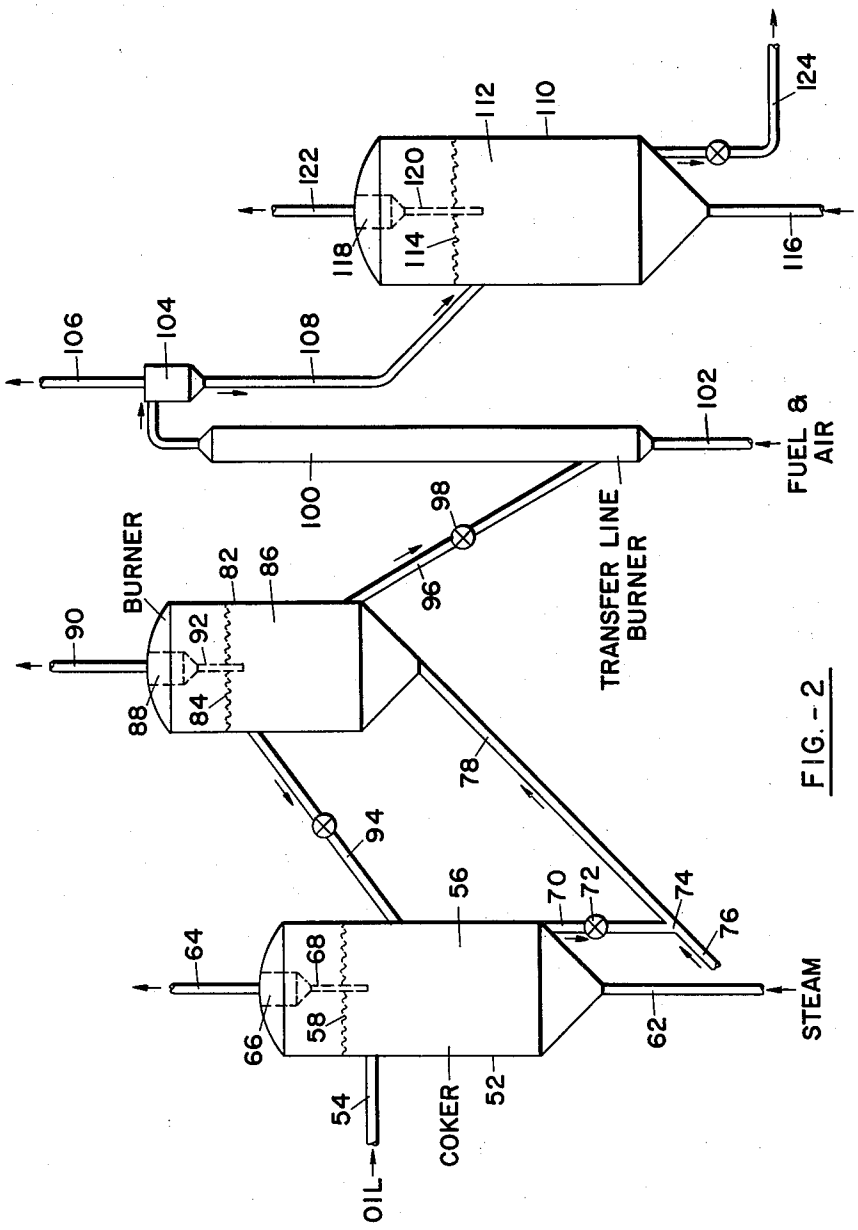

FIG. - 2

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United States Patent Office 2,964,464 Patented Dec. 13, 1960

2,964,464

INTEGRATED COKING AND CALCINING PROCESS

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Filed Mar. 17, 1959, Ser. No. 800,036

15 Claims. (Cl. 208—127)

This invention relates to a novel integrated coke calcining process. More particularly it relates to an integrated coke calcining process wherein the coke is heated at a high velocity for a short contact time in the form of one or more confined streams prior to the calcining operation.

In the coking of heavy hydrocarbon oils such as heavy crudes, atmospheric and vacuum still crude residua, tars, pitches, etc., either for the production of fuel products, such as gasoline and gas oils, or for the production of chemical raw materials, such as aromatics and olefins, one of the major by-products is petroleum coke. 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°, e.g. 1.9°, and a Conradson carbon content of about 5 to 40 wt. percent, e.g. 30 wt. percent. The amount of coke formed depends on the character of the materials being processed and to some extent upon the coking conditions. In the case of high Conradson carbon stock, such as residuum from Hawkins crude, the coke yield can be 20 weight percent or higher on the residuum. Other stocks have been found wherein the yield can be as high as 35 weight percent.

Since the value of the coke as fuel alone detracts from a coking process, more attractive uses for the coke have been sought. One of the major uses to which the coke has been put has been the manufacture of electrodes therefrom. Carbon electrodes find their major use in the electrical refining of alumina to produce aluminum metal. For this purpose, petroleum coke, because of its low ash content, is preferred to metallurgical coke.

Green (uncalcined) petroleum coke contains volatile matter which must be removed before the material is suitable for electrode purposes. This removal is accomplished by calcining the coke at a high temperature. This is done commercially at temperatures of 1800° F. to 2400° F. in rotary kilns, vertical retorts, ovens, and the like. The calcining operation reduces the volatile content of coke to 0.5% or lower of the final product, raises its true density and reduces the electrical resistivity of the coke to about 0.0015 ohm inches or lower.

The petroleum coke used today is largely from "delayed" coking plants. In general, and perhaps universally so, the "green" coke is calcined elsewhere than at the site of the coking plant. This is a wasteful practice from the standpoint of unnecessary coke handling and also because of the heat wasted.

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 burner vessel. In a typical operation the heavy oil to be processed is injected into the reaction vessel containing a fluidized bed of inert solid particles, preferably coke particles, maintained at a temperature in the range of 850° F. to 1200° F., and preferably at 900° F. to 1100° F. for the production of fuels, or at a higher temperature, e.g. 1200° F. to 1600° F. for the production of chemicals, i.e., aromatics and olefins. Uniform temperature exists in the fluidized coking bed. Uniform mixing in the fluidized bed results in virtually isothermic conditions and effects instant 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 thereof.

The heat for carrying out the endothermic coking reaction is generated in the burner vessel. A stream of coke or coke-coated solid inert particles, if the latter are used, 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 with an oxygen containing gas 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 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. The coke normally contains about 86% to 94% carbon, 1.5% to 2% hydrogen, 0.5% to 7.5% sulfur, 0.6% to 1.5% volatile matter at 1100° F., up to 6% volatile matter at 950° C., and approximately 0.5% to 3.0% ash at 1100° F.

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., now U.S. Patent No. 2,881,130, granted April 7, 1959. The method of fluid solids circulation described above is well known in the prior art. This solids handling technique is described in greater detail in Packie Patent 2,589,124, issued March 11, 1952.

This invention provides an improved method for calcining of a coke in a fluidized coke process. The method in one form comprises treating a stream of hot coke particles from the coking process, without substantial cooling for short periods of time and at high velocities while in the form of a confined elongated stream, i.e. a conduit, by a burning stream of combustible gases and oxygen containing gases under conditions so as to minimize the reduction of carbon dioxide to carbon monoxide. The thus heated coke is then sent, without substantial cooling, to a fluidized calcining operation wherein it is subjected to high temperature soaking in order to remove volatile material therefrom, to increase its true density, and to lower its electrical resistivity. This method provides extremely efficient utilization of the heat and fuel components evolved and in addition minimizes coke loss due to the reduction of carbon dioxide to carbon monoxide. In another form of the invention extraneous fuel is added to the transfer line burner.

In the drawing:

Fig. 1 represents one form of apparatus adapted to practice the present invention; and

Fig. 2 represents a modification of the invention utilizing a transfer line burner for heating the coke particles being passed to the calcination zone.

In Fig. 1 of the drawing 1 is a coking vessel constructed of suitable materials for operation at 1000° F. A bed of coke particles preheated to a sufficient temperature, e.g. 1200° F. to establish the required bed temperature of 1000° F. is made up of suitable particles in the range of about 70 to 600 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 superficial velocity of 2 ft. per second establishing the solids at the indicated level. The fluidizing gas serves also to strip vapors and gases from the coke which flows down into the vessel via pipe 9 as will be later described.

Oil to be converted is preferably preheated to a temperature not above its cracking temperature, e.g. 600° 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 or J-bend 8 and transported with the assistance of air or other free oxygen containing gas from lines 38 into burner vessel 10. Secondary air is supplied via line 11 with the assistance of pump 12. In the burner vessel a combustible gas, e.g., carbon monoxide and/or 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. 1200° F. in this example. The bed of coke is in a dense turbulent fluidized condition in burner vessel 10 in much the same manner as the bed in coking 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. Combustion gases leave the hot bed, pass through one or more cyclones 14 and are vented via 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 valved line 9 and introduced into vessel 1 at one or more points in order to maintain heat balance in the system.

The net make coke, in whole or in part, is removed from the burner via line 17 without substantial cooling and introduced into a transfer line preheater conduit 18. This transfer line preheater 18 typically has the following dimensions for a plant processing 1000 tons a day of green coke, 4 feet inside diameter and 20 feet long. The coke actually could also be withdrawn to the preheater from coker vessel 1. The coked particles are preheated to a temperature of 1500° F. by hot CO_2 containing flue gases essentially free of CO from line 26. Coke is transported through the transfer line preheater at high velocity, e.g., 50 feet per second so that the contact time is 0.4 second. The transported preheated coke and flue gas is carried by line 23 to cyclone separator 19. Flue gases are discharged through line 20, and may be passed through a waste heat boiler for further utilization of heat before discharge to the atmosphere or to a stack.

The preheated coke is then passed through line 21 to conduit 22, a transfer line burner, which typically or in one form has the following dimensions, e.g., 4 feet inside diameter and 10 feet long. Flue gas containing as the combustible component carbon monoxide but substantially no carbon dioxide is introduced from line 28 into transfer line burner 22. Secondary air is introduced into transfer line burner 22 through line 29. The preheated coke is thus heated at high velocity by the burning stream of flue gas and air or other oxygen containing gas. The temperature of the coke is raised to about 2200° F., its velocity in the transfer line burner is about 60 feet per second, and the gas residence time is about 0.2 second. For calcination the temperature of the coke particles need be raised only above about 1800° F. The time-temperature relationship in the transfer line burner is controlled to selectively burn the carbon monoxide to carbon dioxide and not to burn additional coke to carbon monoxide. The air or other oxygen containing gas for carbon monoxide combustion is introduced into the dispersed phase of the coke and flue gas. It is preferably not added to the hot carbon monoxide containing flue gas excepting in the presence of coke because of the excessive flame temperature which would result.

The coke and carbon dioxide containing flue gases are sent through line 24 into cyclone 25 or other solid vapor separating device. The hot flue gases are sent at a temperature of 2200° F. through line 26 to transfer line preheater 18. The heated coke at a temperature of about 2200° F. is discharged through line 27 into calciner or calcining vessel 32.

Calciner or calcining vessel 32, operating at a somewhat higher temperature, e.g., 2400° F., than the entering coke, has a fluid bed level as shown 31. The coke is heated to this temperature by burning some coke to CO with air or other oxygen containing gas which also acts as the fluidizing medium. The primary air enters the bottom portion of the calcining vessel 32 through line 33. The amount of coke to be burned in calcining vessel 32, is determined by the fuel requirements for the system on the basis of finally converting to CO_2 all of the coke which is burned and with the flue gas finally discharged from the system at the minimum temperature commensurate with the coke feed temperature. Natural gas, fuel oil or low cost fuel components can be used to supplant part or all of the coke burned and may be added to air in line 33.

The coke is retained in the calciner or soaker 32 for about 20 minutes, or up to 2 hours, or as long as necessary to reduce the volatile content at 950° C. to 0.3% weight or less and to increase the real density to the maximum obtainable. Preferably the soaking vessel is provided with horizontal or vertical baffles to minimize bypassing. The calcining vessel or soaker can be operated batchwise, using more than one vessel if desired. Instead of a fluid bed of coke particles in the calcining vessel 32, a downwardly moving compact bed of coke particles may be used. The product coke withdrawn from the soaker through line 34 can be cooled by indirect heat exchange in a waste heat boiler or it can be cooled by water quenching or by any other suitable means. The product vapors containing CO but no CO_2 pass upwardly through the bed and are removed from the calciner via line 28 after passing through cyclone 30 from which solids are returned to the bed via diplegs 35. The calcining vessel 32 may be maintained at a temperature between about 1800° F. and 2800° F. The higher temperatures are used, above about 2200° F. when it is desired to reduce the sulfur in the coke and produce a low sulfur coke product.

Although Fig. 1 of the drawings shows the preheating and heating stages as requiring separate transfer line units, the two phases can be arranged within a single transfer line so long as the principle of countercurrent staging of the coke and hot flue gas is applied. Also more than one preheating stage can be used if so desired to further reduce the temperature of the flue gas leaving the system.

An alternative method of operating, utilizing transfer line burners under conditions so controlled as to minimize reduction of CO_2 to CO is as follows:

Fluid coke from a fluid coke burner at 1000° F. to 1600° F. enters a transfer line burner immediately after the required amount of fuel (gas or oil) and air, thereby heating the coke to a temperature of 2300°–2600° F., preferably 2400°–2500° F., with residence time during heating held to 0.1 to 1 second in order to minimize reduction of CO_2 to CO. The transfer line heater effluent discharges into a cyclone for separation of the hot coke

from the combustion gases. The latter can be passed through a waste heat boiler or through a heat exchanger to preheat the air for combustion or it may be otherwise utilized to recover its sensible heat content.

Separated coke then enters the calcining vessel where it is treated in the manner discussed above except for the fact that no burning takes place in the calcining vessel since an inert gas such as hydrogen, nitrogen, etc. is used as the fluidizing gas. In a further modification of this design the quenching technique can be used to cool fluidizing gases from the fluid bed calcining vessel before they reach the cyclone. If this vessel is fluidized at a suitably low velocity, however, e.g., less than 0.8 ft./sec. with most coke size distributions, loss of solids in the gas directly from the bed is insignificant, and no cyclone need be used.

In Fig. 2, the reference character **52** designates a vertically arranged cylindrical fluid coking vessel into which heavy hydrocarbon or residual oil is fed through line **54**. The hydrocarbon oil is of the type above described. The oil feed is injected into the fluidized bed **56** of inert solid particles such as coke particles maintained at a temperature between about 850° F. and 1200° F. and preferably between about 900° F. and 1100° F. for the production of fuels, or at a higher temperature between about 1200° F. and 1600° F. for the production of chemicals such as aromatic hydrocarbon compounds and olefins. Because of the dense turbulent fluidized bed of coke particles, extremely good mixing of the hydrocarbon oil and coke particles results in the fluidized bed and the temperature is substantially uniform throughout the fluidized coking bed.

The fluidized bed **56** has a level indicated at **58**. The oil feed is preferably introduced into the fluidized bed of hot solids **56** at a plurality of points and this admixture heats and vaporizes some of the oil. The vaporized oil functions as a fluidizing vapor or gas during its passage upward through the coking vessel **52**. In addition, fluidizing gas is introduced into the bottom of the vessel **52** through line **62** and the fluidizing gases pass upwardly through the vessel **52** at a superficial velocity between about 0.2 and 5.0 feet per second, preferably 0.5 to 2 feet per second. The heavy hydrocarbon oil to be cracked is preferably preheated to a temperature below its cracking temperature, that is, about 500° F.–650° F. and then introduced through line **54** into the fluidized bed **56**. The heavy oil upon contacting the hot solid particles undergoes vaporization and decomposition and the vapors 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 fluidized bed **56** and are removed from the coking vessel **52** through line **64** after passing through cyclone separator means **66** from which separated solids are returned to the fluidized bed **56** through dipleg **68**.

A stream of solid particles is removed from the fluidized bed **56** in the coking vessel **52** through standpipe **70** provided with a control valve **72** for controlling the rate of withdrawal of solid particles from the coking vessel **52**. J-bend **74** is provided at the lower end of the standpipe **70** and air or other free oxygen containing gas is introduced through one or more lines **76** into the bottom of the J-bend **74** for producing a less dense suspension which is then passed upwardly through inclined line **78** into the bottom portion of a cylindrical vertically arranged burner vessel **82**. As in Fig. 1, additional air may be introduced into the line **78** leading to the burner vessel **82**.

In the burner vessel **82** a portion of the coke produced in the coking vessel **52** is burned to raise the temperature of the solid particles sufficiently to supply heat for the endothermic cracking reaction occurring in the coking vessel **52** when the solid particles are recycled to the coking vessel. The temperature of the solids in the burner vessel **82** is usually 100° F. to 300° F. higher than that of the solids in the coking vessel **52**. For example, the temperature of the solids in the burner vessel **82** for fuels manufacture may be between about 1000° F. and 1200° F. The bed of coke or other solid particles is fluidized in the burner vessel **82** by upflowing air and resulting combustion gases and the dense fluidized turbulent bed has a level indicated at **84**.

Combustion gases leave the dense turbulent bed **86** and pass through one or more cyclones **88** arranged at the top of and inside the burner vessel **82**. The combustion gases are vented through line **90**. Solids separated in the cyclone separator **88** are returned to the dense fluidized bed **86** through dipleg **92**. A portion of the hot solids is continually removed from the burner vessel **82** through valved line **94** and introduced into the coking vessel **52** at one or more points in order to supply heat to the coking reaction in the vessel **52**. Line **94** is shown as leading downwardly and, if desired, fluidizing gas may be introduced into line **94** to maintain the stream of solids passing through the line **94** in a fluidized condition.

The net make coke, in whole or in part, is removed from the burner vessel **82** through line **96** which is provided with a valve **98** for controlling the rate of withdrawal of solids from the burner vessel **82**. The line **96** is shown inclined downwardly and may also be provided with fluidizing lines for the introduction of gas to maintain the solids in fluidized condition in line **96**. The hot solids from line **96** at a temperature between about 1000° F. and 1200° F. are introduced into the lower portion of a transfer line burner conduit **100** which is shown as vertically arranged. Fuel such as combustible gas and air are introduced into the bottom portion of the transfer line burner **100** through line **102**. The combustible fuel for burner **100** may be selected from natural gas, refinery gas, light hydrocarbon oils, such as kerosene, fuel oil, etc.

The transfer line burner **100** in one example for a plant processing 1000 tons a day of green coke will have an inside diameter of about 4 feet and have a length of about 10 feet. The hot suspended solids and gaseous material pass upwardly through the transfer line burner **100** at a velocity between about 20 and 120 feet per second. During its passage through the transfer line burner **100**, the coke particles have their temperature raised to a calcining temperature between about 1800° F. and 2800° F. The temperature in the lower range of about 1800° F. is used to remove volatile material from the coke particles, to increase the density and electrical conductivity of the coke particles, whereas the higher temperature above about 2200° F. are used when it is desired to reduce the sulfur in the coke particles and produce a low sulfur coke product.

The velocity in the specific transfer line burner **100** above described is about 60 feet per second and the gas residence time is about 0.2 second. The time-temperature relationship in the transfer line burner is controlled to burn introduced fuels selectively to carbon dioxide and not to burn additional coke to carbon monoxide.

The hot coke and carbon dioxide containing flue gases are passed overhead into cyclone separator **104** and the separated hot flue gases leave the cyclone separator through **106** and may be passed through a waste heat boiler or the like to recover heat therefrom. The separated hot coke particles at a temperature above about 1800° F., say up to about 2200° F., are passed through line **108** into a vertically arranged cylindrical calcining vessel **110** containing a dense fluidized bed of solids **112** having a level indicated at **114**. The calcining vessel **110** is maintained at a temperature above about 1800° F., say up to about 2200° F. In this form of the invention an inert gas such as nitrogen, H_2 etc. is used as the fluidized gas, preferably at a low superficial velocity, and is introduced through bottom line **116** of the calcining vessel **110** for upward passage therethrough to maintain

the solids undergoing calcination in a dense fluidized condition.

Gases passing overhead are passed through one or more cyclone separators **118** and separated solids are returned to the fluidized bed **112** through dipleg **120**. The separated hot gases are passed overhead through line **122** and may be passed through a waste heat boiler or the like to recover heat therefrom.

The coke particles are maintained in the calcining or soaking vessel **110** for a time between about 5 minutes and 8 hours and the temperature is maintained between about 1800° F. and 2700° F. In the calcination zone or vessel **110** the volatile content of the coke at 950° C. is reduced to about 0.3% by weight or less and the real density of the coke is increased. Product coke is withdrawn from the lower portion of the calcination vessel **110** through valved line **124** and can be cooled by indirect heat exchange in a waste heat boiler or it can be cooled by water quenching or by any other suitable means. The product vapors which contain sulfur in various combinations and forms pass upwardly through the fluidized bed **112** and are withdrawn overhead through line **122**.

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

CONDITIONS IN FLUID COKERS 1 AND 52

	Broad Range	Preferred Range
Temperature, ° F.	850–1,600	900–1,100
Pressure, p.s.i.g.	0–50	5–15
Superficial Velocity of Fluidizing Gas, ft./sec.	0.2–5	0.5–3

CONDITIONS IN BURNERS 10 AND 82

Superficial Velocity of Fluidizing Gas, ft./sec.	0.2–5	0.5–3
Temperature, ° F.	1,000–1,800	1,050–1,300

CONDITIONS IN TRANSFER LINE PREHEATER 18

Temperature, ° F.	1,200–1,900	1,300–1,600
Pressure, p.s.i.g.	0–50	5–15
Superficial Velocity of Fluidizing Gas, ft./sec.	20–120	40–80
Contact Time, sec.	0.1–2.0	0.2–1

CONDITIONS IN TRANSFER LINE BURNERS 22 AND 100

Temperature, ° F.	1,800–2,500	2,100–2,300
Pressure, p.s.i.g.	0–50	5–15
Superficial Velocity of Fluidizing Gas, ft./sec.	20–120	40–80
Contact Time, sec.	0.05–1	0.1–0.5

CONDITIONS IN CALCINERS 32 AND 110

Residence Time, mins./hrs.	5–8	30–2
Temperature,	2,000–2,700	2,200–2,500
Gas Velocity, ft./sec.	0.2–5	0.8
Pressure, p.s.i.g.	0–50	5–15

Product coke can be activated by combustion in the soaker, and extraneous steam can be added to improve the quality. The coke may then be used for treating products from the coking process. For example, the coker naphtha and/or gas oil can be contacted with the activated coke at 700°–1000° F. to improve its quality or remove sulfur or contaminants, or the light hydrocarbons can be contacted with the coke plus air to remove sulfur.

The advantages of this process reside in the most efficient utilization of heat evolved and the minimizing of coke loss due to reduction of carbon dioxide.

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

This case is filed as a continuation-in-part of Smith et al. patent application Serial No. 417,749, filed March 22, 1954, now abandoned.

What is claimed is:

1. An integrated coking and calcining process which comprises the steps of coking a heavy hydrocarbon oil by contacting the same with hot coke particles in a coking zone wherein the oil is converted to product vapors and carbonaceous solids are deposited on the coke particles, removing product vapors from the coking zone, burning a portion of coke particles removed from the coking zone in a separate first burning zone containing a dense fluidized bed of coke particles to increase the temperature of said fluidized particles, returning a portion of the heated coke particles from the burning zone to the coking zone, passing at high velocity a separated confined stream of coke particles without substantial cooling from the first burning zone through a transfer line burning zone, the stream of coke particles being further heated by a high velocity burning stream of combustible gas and oxygen-containing gas introduced at the inlet of said transfer line burning zone so as to minimize reduction of carbon dioxide to carbon monoxide and burning of the coke, separating the thus heated coke from the resultant carbon dioxide containing flue gas, passing the coke to a calcining zone; maintaining the coke particles in the calcining zone at a temperature in the range of 2000° F. to 2700° F. for from 5 minutes to 8 hours and removing calcined coke from the calcining zone.

2. An integrated coking and calcining process which comprises the steps of coking a heavy hydrocarbon oil by contacting the same with hot coke particles in a coking zone at a temperature in the range of 850° F. to 1200° F. wherein the oil is converted to product vapors and carbonaceous solids are deposited on the coke particles, removing product vapors from the coking zone, burning a portion of coke particles removed from the coking zone in a separate first burning zone containing a dense fluidized turbulent bed of coke particles to increase the temperature of said fluidized particles to a temperature in the range of 100° to 300° F. higher than that in the coking zone, returning a portion of the heated coke particles from the burning zone to the coking zone, passing at high velocity a separated confined stream of coke particles without substantial cooling from said first burning zone through a transfer line burning zone so that the stream of coke particles is further heated to a calcining temperature at least as high as 1800° F. by a high velocity burning stream of combustible material and oxygen-containing gas introduced into the inlet of said transfer line burning zone with a residence time of about 0.1 to 1 second so as to minimize burning of the coke particles and to selectively burn to carbon dioxide, separating the thus heated coke particles from the resultant carbon dioxide containing flue gas, passing the coke particles to a calcining zone, maintaining and soaking the coke particles fluidized by an added inert fluidizing gas in the calcining zone at a calcining temperature in the range of about 1800° F. to 2700° F. for from about 5 minutes to about 8 hours and then removing calcined coke particles from said calcining zone.

3. An integrated coking and calcining process which comprises the steps of coking a heavy residual hydrocarbon oil by contacting the residual oil with fluidized hot coke particles maintained as a dense fluidized turbulent mass in a coking zone wherein the oil is converted to product vapors and carbonaceous solids are deposited on the coke particles, removing product vapors from the coking zone, burning a portion of coke particles removed from the coking zone in a separate first burning zone to increase the temperature of said fluidized particles, returning a portion of the heated coke particles from the burning zone to the coking zone to supply heat thereto, passing at high velocity a separated confined stream of coke particles without substantial cooling from said first

burning zone through a transfer line burning zone so that the stream of coke particles is further heated to a calcination temperature by a high velocity burning stream of combustible material and oxygen-containing gas introduced into the inlet of said transfer line burning zone and with a short residence time so as to minimize burning of the coke particles, and selectively burn to carbon dioxide, separating the thus heated coke from the resultant carbon dioxide containing flue gas, passing the coke particles to a calcining zone, maintaining and soaking the coke particles in said calcining zone as a moving bed and at a temperature in the range of about 1800° F. to 2700° F. for from about 5 minutes to about 8 hours, introducing a gas into the bottom portion of said calcining zone for upward passage therethrough, and then removing calcined coke particles from said calcining zone.

4. An integrated coking and calcining process which comprises the steps of coking a heavy hydrocarbon oil by contacting the same with fluidized dense turbulent bed of hot coke particles in a coking zone wherein the oil is converted to product vapors and carbonaceous solids are deposited on the coke particles, removing product vapors from the coking zone, burning a portion of coke particles removed from the coking zone in a separate burning zone to increase the temperature of said fluidized particles, returning a portion of the heated coke particles from the burning zone to the coking zone to supply heat thereto, passing at high velocity a stream of hot coke particles withdrawn from the process upwardly through a vertically arranged transfer line heating zone so that the stream of hot coke particles are further heated by a high velocity burning stream of combustible gas introduced into the inlet of said transfer line burning zone and oxygen-containing gas so as to selectively burn to carbon dioxide and to minimize burning of the coke particles, separating the thus heated coke particles from the resultant carbon dioxide containing flue gas, passing the thus heated coke particles to a calcining zone containing a dense bed of coke particles, maintaining the coke particles in said dense bed in said calcining zone at a calcining temperature in the range between about 1800° F. and 2700° F. for from about 5 minutes to about 8 hours and then removing calcined coke particles from said calcining zone.

5. An integrated coking and calcining process which comprises the steps of coking a residual hydrocarbon oil by contacting the residual oil with a dense turbulent bed of fluidized hot coke particles in a coking zone wherein the oil is converted to product vapors and carbonaceous solids are deposited on the coke particles, removing product vapors from said coking zone, burning a portion of coke particles removed from said coking zone in a dense fluidized turbulent bed of coke particles in a separate first burning zone to increase the temperature of said fluidized particles, returning a portion of the heated coke particles from said burning zone to said coking zone to supply heat thereto, passing at high velocity a stream of hot coke particles from said burning zone upwardly through a vertically arranged transfer line burning zone, introducing extraneous fuel and air into the bottom portion of said transfer line burning zone so that the stream of hot coke particles is further heated by an upwardly flowing high velocity burning stream of combustible fuel and air so as to selectively burn to carbon dioxide and to minimize burning of the coke particles, separating the thus heated coke particles from the resultant carbon dioxide containing flue gas, passing the thus heated coke particles to a calcining zone containing a bed of coke particles, maintaining the coke particles in said calcining zone at a temperature in the range between about 1800° F. and 2700° F. for from about 5 minutes to about 8 hours and then removing calcined coke particles from said calcining zone.

6. A process according to claim 5 wherein said bed of coke particles in said calcining zone is a dense fluidized turbulent bed and an inert fluidizing gas is introduced into the bottom of said calcining zone for upward passage therethrough.

7. Process for calcining hot petroleum coke particles which comprises the steps of passing at high velocity of 20 to 120 feet per second a confined stream of said hot coke particles without substantial cooling through a transfer line preheating zone, the stream of hot coke particles having its temperature raised to a temperature in the range of 1200° to 1900° F. by hot carbon dioxide containing flue gas from a sebsequent high velocity transfer line burning zone, separating the preheated coke particles from the flue gas, passing the preheated coke at high velocity through the transfer line burning zone where it is heated to a temperature in the range of 1800° to 2500° F., a higher temperature than in the preheating step by a burning stream of flue gas, the combustible component of which consists essentially of carbon monoxide from a subsequent calcining zone, and oxygen-containing gas introduced thereto, the burning being substantially limited by a residence time in the range of 0.05 to 1 second to the selective combustion of the carbon monoxide to carbon dioxide without burning of the coke, separating the heated coke from the resultant carbon dioxide flue gas, passing the coke to a calcining zone, heating the coke maintained in a fluidized state in the calcining zone to a higher temperature than in the transfer line burning zone, one in the range of 2000° F. to 2700° F. for from 5 minutes to 8 hours to burn a portion thereof to carbon monoxide with a free oxygen-containing gas introduced thereto, removing calcined coke from the calcining zone and introducing the carbon monoxide-containing gas into the transfer line burning zone.

8. An integrated coking and calcining process which comprises the steps of coking a heavy hydrocarbon oil by contacting the same with fluidized hot coke particles in a coking zone wherein the oil is converted to product vapors and carbonaceous solids are deposited on the coke particles, removing product vapors from the coking zone, burning a portion of the coke particles removed from the coking zone with an oxygen-containing gas in a separate burning zone to increase the temperature of said fluidized particles, returning a portion of the heated coke particles from the burning zone to the coking zone, withdrawing coke particles from the burning zone and passing said particles as a separate confined stream and at a velocity of 20 to 120 feet per second through a transfer line preheating zone, the stream of coke particles being directly preheated to a temperature of 1200° F. to 1900° F. by hot carbon dioxide-containing flue gas from a subsequent transfer line burning zone, separating the preheated coke particles from the flue gas, passing the preheated coke at high velocity through the transfer line burning zone where it is further heated to a temperature in the range of 1800° to 2500° F. by a burning stream of flue gas the combustible component of which consists essentially of carbon monoxide, from a subsequent calcining zone and oxygen containing gas introduced thereto, the burning being substantially limited by a residence time in the range of 0.05 to 1 second to the selective combustion of the carbon monoxide to carbon dioxide without burning of the coke, separating the heated coke from the resultant carbon dioxide rich flue gas, passing the coke to a calcining zone, heating the coke maintained in a fluidized state in the calcining zone to a temperature in the range of 2000° F. to 2700° F. for from 5 minutes to 8 hours to burn a portion thereof to carbon monoxide with a free oxygen-containing gas introduced thereto, removing calcined coke from the calcining zone and introducing the carbon monoxide-containing gas into the transfer line burning zone.

9. The process of claim 8 in which the coke particles are preheated to a temperature in the range of 1300° F.–1600° F. in an interval of from 0.2 to 1 second in the transfer line preheating zone.

10. The process of claim 9 in which the coke particles are heated to a temperature in the range of 2100° F.–2300° F. in an interval of from 0.1–0.5 second in the transfer line burning zone.

11. The process of claim 8 in which extraneous fuel is fed to the calcining step to supplant coke burned.

12. Process for calcining hot petroleum coke particles which comprises the steps of passing at high velocity of 20 to 120 feet per second a confined stream of said hot coke particles without substantial cooling through a transfer line preheating zone, the stream of hot coke particles having its temperature raised to a temperature in the range of 1200° to 1900° F. by hot carbon dioxide containing flue gas from a subsequent high velocity transfer line burning zone, separating the preheated coke particles from the flue gas, passing the preheated coke at high velocity through the transfer line burning zone where it is heated to a temperature in the range of 1800° to 2500° F., a higher temperature than in the preheating step by a burning stream of flue gas, the combustible component of which consists essentially of carbon monoxide from a subsequent calcining zone, and oxygen-containing gas introduced thereto, the burning being substantially limited by a residence time in the range of 0.05 to 1 second to the selective combustion of the carbon monoxide to carbon dioxide without substantial burning of the coke, separating the heated coke from the resultant carbon dioxide flue gas, passing the coke to a calcining zone, heating the coke maintained as a moving bed in the calcining zone to a higher temperature than in the transfer line burning step and in the range of 1800° F. to 2700° F. for from 5 minutes to 8 hours to burn a portion thereof to carbon monoxide with a free oxygen-containing gas introduced thereto, removing calcined coke from the calcining zone and introducing the carbon monoxide-containing gas into the transfer line burning zone.

13. An integrated coking and calcining process which comprises the steps of coking a heavy hydrocarbon oil by contacting the same with fluidized hot coke particles in a coking zone wherein the oil is converted to product vapors and carbonaceous solids are deposited on the coke particles, removing product vapors from the coking zone, burning a portion of the coke particles removed from the coking zone with an oxygen-containing gas in a separate burning zone to increase the temperature of said fluidized particles, returning a portion of the heated coke particles from the burning zone to the coking zone, withdrawing coke particles from the burning zone and passing said particles as a separate confined stream and at a velocity of 20 to 120 feet per second through a transfer line preheating zone, the stream of coke particles being directly preheated to a temperature of 1200° F. to 1900° F. by hot carbon dioxide-containing flue gas from a subsequent transfer line burning zone, separating the preheated coke particles from the flue gas, passing the preheated coke at high velocity through the transfer line burning zone where it is further heated to a temperature in the range of 1800° to 2500° F. by a burning stream of flue gas the combustible component of which consists essentially of carbon monoxide from a subsequent calcining zone and oxygen containing gas introduced thereto, the burning being substantially limited by a residence time in the range of 0.05 to 1 second to the selective combustion of the carbon monoxide to carbon dioxide without burning of the coke, separating the heated coke from the resultant carbon dioxide rich flue gas, passing the coke to a calcining zone, heating the coke maintained as a moving bed in the calcining zone to a temperature in the range of 1800° F. to 2700° F. for at least 5 minutes to burn a portion thereof to carbon monoxide with a free oxygen-containing gas introduced thereto, removing calcined coke from the calcining zone and introducing the carbon monoxide-containing gas into the transfer line burning zone.

14. A process according to claim 5 wherein said coke particles are heated to about 1800° F. and are resident in said transfer line burner for about 0.1 to 1.0 second.

15. A process according to claim 5 wherein an inert gas is passed up through said bed of coke particles in said calcining zone.

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