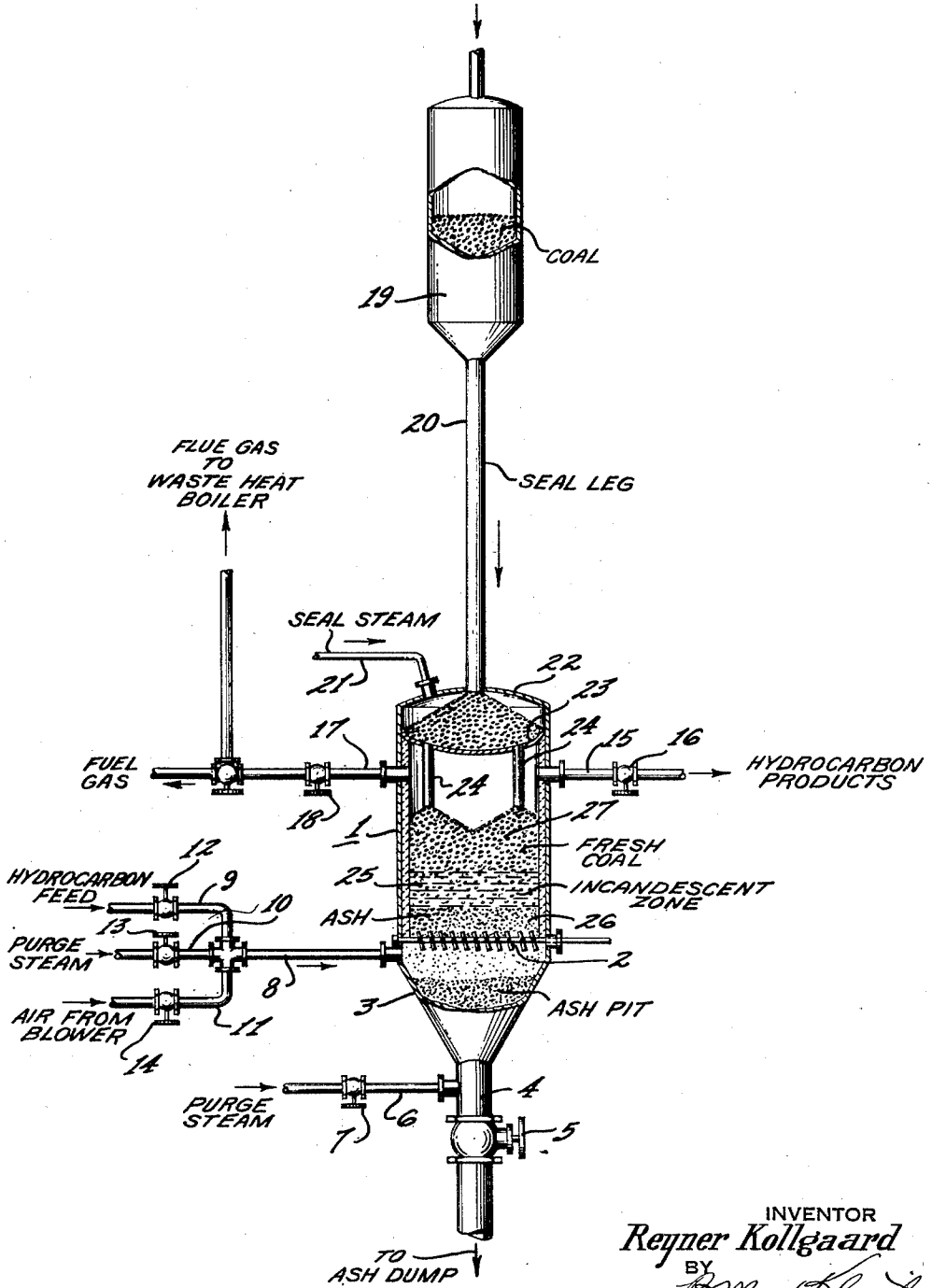
April 26, 1955 R. KOLLGAARD 2,707,148

PROCESS FOR PYROLYTIC CRACKING OF HYDROCARBONS AND GASIFICATION OF COAL

Filed Feb. 8, 1951



INVENTOR
Reyner Kollgaard
BY
ATTORNEY

United States Patent Office 2,707,148 Patented Apr. 26, 1955

2,707,148

PROCESS FOR PYROLYTIC CRACKING OF HYDROCARBONS AND GASIFICATION OF COAL

Reyner Kollgaard, Media, Pa., assignor to Houdry Process Corporation, Wilmington, Del., a corporation of Delaware

Application February 8, 1951, Serial No. 210,075

2 Claims. (Cl. 48—201)

This invention relates to a process for the pyrolytic cracking of hydrocarbons, combined with gasification of coal.

In pyrolytic non-catalytic cracking of hydrocarbons the heat required for cracking the hydrocarbons is generally produced by combustion of a portion of the hydrocarbons with air or the like, this portion of the hydrocarbon charge thus being lost for the production of gasoline or other cracking products desired.

It is an object of the invention to avoid such loss in hydrocarbon charge. It is another object of the invention, while avoiding such loss, to produce at the same time gaseous fuels as useful by-products of a combined pyrolytic cracking operation. Further objects and advantages of the invention will appear from the following specification and the claims.

According to the present invention the pyrolytic non-catalytic cracking of hydrocarbons is combined with gasification of coal in such a manner that on the one hand the heat required for cracking the hydrocarbons is furnished by burning the coal, while on the other hand water-gas is produced by treatment of the incandescent coal with steam. Preferably, this combined process is carried out in a semi-continuous system. For this purpose, fresh coal is passed through a combustion zone, ash being formed which is continuously or periodically removed. Air is blown into this zone to form an incandescent layer or zone and to burn the coal, followed by steam blown in for producing water-gas and for purging. Thereafter, a hydrocarbon feed is passed counter-currently through the incandescent bed to crack the hydrocarbons, until the temperature of the bed reaches a practical minimum. On raising the temperature again by air blowing, the cycle of operations is resumed and repeated.

The invention will be more clearly understood by the subsequent detailed description of an example of execution, in connection with the accompanying drawing.

The single figure of the drawing shows a somewhat diagrammatic view, partly in section, of an apparatus suitable for carrying out the new process.

A cylindrical vertically elongated refractory lined reaction chamber **1** is provided at its lower end with an ash removal grate **2**. Below the grate **2** the reaction chamber **1** ends in a funnel-shaped chamber **3** forming an ash pit. The funnel **3** ends in a solids-discharge pipe **4** provided with a valve **5** to control removal of the ashes. A pipe **6** is provided for steam to be blown into and through ash pit **3** controlled by a valve **7**.

A manifold **8** communicates with the ash pit **3** proximate to its upper end below grate **2**. Manifold **8** is connected with branch pipes **9**, **10** and **11**, which are adapted to be opened and closed by valves **12**, **13** and **14**, respectively, which may be suitably coupled with one another in such a manner that only one of them can be open at a time. Pipe **9** serves for introducing the hydrocarbon feed into the apparatus, pipe **10** for blowing steam to purge manifold **8** and pipe **11** for introducing air from a blower.

A pipe **15** near the upper end of reaction chamber **1**, provided with a control valve **16**, forms an outlet for the hydrocarbon cracking effluent, while another similarly arranged pipe **17**, controlled by valve **18**, forms an outlet for the flue and water-gas.

Coal is introduced into reaction chamber **1** by gravity from a funnel, or the like chamber **19** through a conduit **20**, forming a seal leg to prevent escape of vapors and

gases from chamber **1** to chamber **19**. A pipe **21** opening in the dome **22** of chamber **1** allows the introduction of seal steam into the top of this chamber above a partition **23**. The coal charge introduced through seal leg **20** gravitates from partition **23** through a number of vertical open pipes **24** circularly arranged at said partition **23** and depending from it into reaction chamber **1** to a level below the mouths of pipes **15** and **17**.

In a typical operation of the process according to the invention, the lower portion of reaction chamber **1** below the lower ends of pipes **24** is filled with coal from funnel **19** through seal leg **20** and pipes **24** while all valves **12**, **13**, **14** and **16** are closed and valve **18** only is open. Seal steam is then introduced through pipe **21** above partition **23**.

Ignition and combustion of the coal in chamber **1** can be started in any suitable manner, e. g. by means of gas burners (not shown) arranged above grate **2**, or by means of an electric heating device (not shown), which may be arranged correspondingly; or, if desired, by introducing pre-heated air through pipe **11**, said air being at a temperature high enough to ignite the coal. Such ignition will start, for example, at a temperature of at least about 800° F., depending on the type of coal employed. Once started, the whole process can be generally run automatically, without further requiring any interior heating devices or the like.

The combustion of the ignited coal in the incandescent zone **25** of reaction chamber **1** by air blown in through pipe **11** and valve **14** proceeds for a predetermined time, for example for 10 minutes, while valve **18** of pipe **17** is open to allow the gases of combustion to escape. The heat of these gases can be used for pre-heating the air to be blown into chamber **1** and/or the steam to be employed, or for heating a waste-heat boiler, and/or for pre-heating the hydrocarbon charge to be cracked. After initial start-up of the operation, producer gas formed by subsequent passage of air through reactor **1**, may be separately collected as a valuable by-product.

At the end of the coal combustion period, valve **14** is closed and valve **13** of pipe **10** is opened to purge manifold **8** by steam. After closing valve **13**, valve **7** of pipe **6** is opened to blow steam through ash pit **3**, upward through the ash layer **26** resting on grate **2**, and through the incandescent zone **25** above the ash layer **26**. The steam pre-heated by the hot ashes reacts with the glowing coal in zone **25** to produce water-gas which passes through the coal layer **27** and through pipe **17**, and can be utilized for any desired purpose, e. g. in part for heating coal to ignition in the reaction chamber of an identical apparatus operated in parallel, and/or for pre-heating the hydrocarbon feed.

When the water-gas producing period comes to an end after a predetermined time, say after 5 minutes, valves **7** and **18** of pipes **6** and **17** are closed, while valve **12** of pipe **9** and valve **16** of pipe **15** are opened. Hydrocarbons to be cracked are now passed from below grate **2**, if desired pre-heated by the flue gases of combustion or by the sensible heat of hot water-gas produced, through reaction chamber **1** and are cracked while passing the incandescent zone **25** under suitable cracking conditions, i. e. at a temperature of about 1000° to 1300° F. or more. While passing the zone **27** of fresh coal in reaction chamber **1**, the cracking effluent formed is cooled and said fresh coal is simultaneously preheated.

At the end of the cracking period, say after about 20 minutes, valve **12** of pipe **9** is closed again, while valves **7** and **13** of pipes **6** and **10** respectively, are re-opened to purge the apparatus by steam, say for about 5 minutes, and valve **16** is closed while valve **18** is opened during this period.

Thereafter, valves **7** and **13** are closed and the cycle resumed with opening valve **14** of pipe **11** to re-heat the hot coal in zone **25** of chamber **1** to incandescence by blowing air. Generally, no re-heating of the coal in this chamber by external heat will be required for this purpose, the temperature of the coal in zone **25** being still high enough at the end of the cracking period to effect its ignition and incandescence by the air-blowing. The air may, however, be preheated in the afore-mentioned manner, if desired. Ashes formed above grate **2** are discharged

to the pit 3 below, by actuating the grate in any suitable manner.

By arranging at least two identical apparatus of the described type parallel to each other and by suitably coupling them, care can be taken, that the cracking of hydrocarbons can proceed continuously without any interruptions, one of these parallel apparatus being switched, for example, for a 10 minutes' coal combustion period succeeding a 5 minutes' steam flush and followed by another 5 minutes' steam flush combined with water-gas production, while the other apparatus is switched for the pyrolytic cracking of hydrocarbon charge during 20 minutes, for example, and vice versa. On using three such apparatus coupled with one another and correctly predetermining the periods of combustion, repeated steam flushing, and cracking, care can be taken that the water-gas production, too, may go on continuously and without interruption.

Any suitable type of coal can be employed in the process, including hard and soft coal, as well as de-gasified coal, or coke.

Practically all kinds of hydrocarbons or hydrocarbon mixtures can be employed as the hydrocarbon charge material, such as normally gaseous hydrocarbons, gasolines, light and heavy gas-oil fractions, petroleum residua, and the like; also fractions containing or composed of tar, so far as they are sufficiently fluid or sufficiently fluidized or liquefied by pre-heating with the aid of the sensible heat of the flue-gases or the water-gas escaping through pipe 17, or in any other suitable manner.

The type of cracked products obtained will mainly depend on the type of hydrocarbon charge used and on the cracking conditions, particularly the temperature of the incandescent coal zone and the rate of flow of the hydrocarbon charge through this zone. Thus, gasoline, furnace oil, and the like can be produced and separated from the cracking effluent withdrawn from the reaction chamber.

Solid hydrocarbonaceous or carbonaceous deposits, called "coke," which in known processes are generally formed by pyrolytic cracking of hydrocarbons and/or tar, will not interfere in the present process. Any coke formed in the present process, will deposit on the coal in chamber 1 and will be burnt with this coal during a subsequent air-blowing or water-gas producing period. Besides, steam can also be admitted to reaction chamber 1 during the cracking periods, if so desired, in order to reduce coke formation in vapor-phase cracking of the hydrocarbons.

The cracking effluent or a portion thereof, can be recycled for further cracking, if so desired.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

1. A combination process for effecting successively the gasification of coal and the pyrolitic, non-catalytic cracking of hydrocarbons in the presence of said coal which comprises the steps of: maintaining a confined treating zone partially filled with a grid-supported bed of said coal including an upper region containing fresh coal, an intermediate region containing incandescent coal derived from the combustion of said coal in the presence of oxygen-containing gas, and a lower region containing coal ash resulting from said combustion, uniformly distributing fresh coal over the surface of said bed from a distributing zone maintained immediately above said treating zone, maintaining a continuous supply of fresh coal to said distributing zone from a supply zone located a substantial distance above said distributing zone, said fresh coal being conveyed between said supply and distributing zones as an elongated compact moving column forming a seal leg, removing coal ash from the bottom of said treating zone through said grid, the removal of said coal ash and the supply of said fresh coal being regulated to maintain a constant bed level within said treating zone, passing the coal ash discharged through said grid by free fall to the surface of a bed of coal ash partially filling a confined ash-receiving zone located directly beneath said treating zone, discharging coal ash from the bottom of said ash-receiving zone at a rate adapted to constantly maintain said bed of coal ash therein, the foregoing steps being simultaneously accompanied by the sequential steps of: passing oxygen-containing gas upwardly through said grid-supported bed under conditions suitable for effecting the combustion of said coad, and removing the gaseous combustion products collected in the upper region of said treating zone above said grid-supported bed; passing steam upwardly through said ash-receiving and treating zones to purge the same of said gaseous combustion products and to form water-gas while passing through said intermediate region, said water-gas being removed from said gas-collecting region of said treating zone; passing hydrocarbons upwardly through said treating zone to pyrolytically crack the hydrocarbons, and removing the gaseous cracking products separately from said gas-collecting region; again passing steam upwardly through said ash-receiving and treating zones to purge the same of said gaseous cracking products; and thereafter again passing oxygen-containing gas upwardly through said grid-supported bed to reheat said coal to the desired stage of incandescence in preparation for a repeated cycle of operation.

2. A process as defined in claim 1, including the step of continuously introducing seal steam into said distributing zone in an amount sufficient to prevent the migration of gaseous material from said treating zone into and through said elongated compact moving column.

References Cited in the file of this patent

UNITED STATES PATENTS

1,762,100	Odell	June 3, 1930
1,875,923	Harrison	Sept. 6, 1932
1,902,747	Yunker	Mar. 21, 1933
1,947,339	Galusha	Feb. 13, 1934
2,194,574	Snyder	Mar. 26, 1940
2,406,810	Day	Sept. 3, 1946
2,426,848	Tuttle	Sept. 2, 1947
2,445,328	Keith	July 20, 1948
2,514,371	Caldwell	July 11, 1950
2,547,015	Kirkbride	Apr. 3, 1951
2,561,419	Schutte	July 24, 1951
2,596,610	Shabaker	May 13, 1952