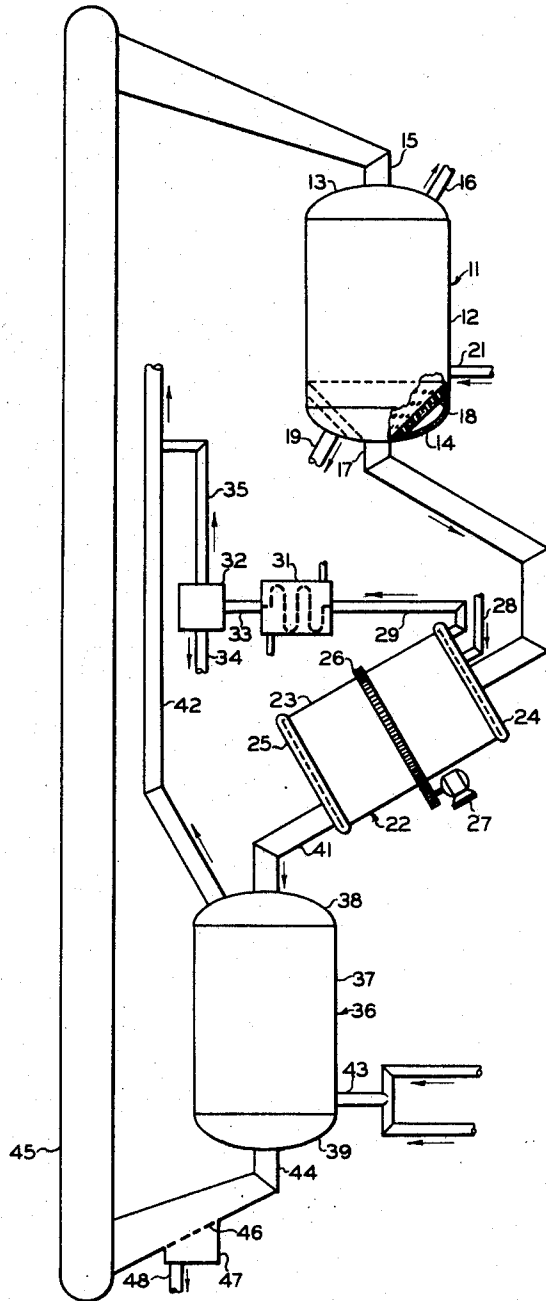


Nov. 17, 1953

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METHOD FOR GASIFYING COALS

Filed Sept. 12, 1949

2,659,668



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2,659,668

METHOD FOR GASIFYING COALS

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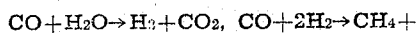
Application September 12, 1949, Serial No. 115,209

4 Claims. (Cl. 48—206)

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This invention relates to the gasification of organic solid materials. In one of its more specific aspects it relates to a method and apparatus for the gasification of coking and low ash-fusion-temperature coals.

The gasification of coal can be represented by the reaction between steam and carbon, i. e., $C + H_2O \rightarrow CO + H_2$. This reaction takes place at temperatures in the neighborhood of approximately 1200° F., but in commercial operation it is ordinarily desirable to use higher temperatures so as to obtain a more rapid rate of reaction. Other reactions also occur in the gasification of coal, such as



etc. The resulting gas, therefore, is a mixture of hydrogen, carbon monoxide, steam, carbon dioxide, and hydrocarbons. Hydrocarbons are also formed by thermally cracking the coal structure which is composed of complex molecules of primarily carbon and hydrogen. The net gasification reaction is endothermic and most commercial processes vary mainly in their means of introducing heat of reaction for the gasification process. Some conventional processes use internally fired retorts, others provide for periodically blasting the bed of coal with air, and others provide for continually introducing oxygen to make the net reaction exothermic, thus highly super-heating steam which is added.

In conventional operation the coal is introduced into a gasification reactor and is heated by one of the above means to the reaction temperature. As the coal is heated, a number of things may happen. At temperatures in the neighborhood of between 400° F. and 500° F., the coal starts to lose its volatile matter, the first released material being mainly loosely bound water. As the temperature is increased, more violent thermal decomposition occurs and hydrocarbon fragments are given off as volatile matter. Larger hydrocarbon fragments, resulting either from cracking or polymerization of smaller hydrocarbon fragments remain in the coal and exert a solvent action thereon. When this occurs the coal goes through a plastic or semi-fluid state. The temperature at which the coal is converted to a plastic or semi-fluid state depends upon the particular coal which is being reacted. With a bituminous coal a plastic or semi-fluid state is encountered at temperatures in the neighborhood of between 800° F. and 1000° F. Certain types of coals, such as lignitic coal and high rank anthracite coal, do not go through the plastic state.

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Coals which form a plastic state will, upon further heating, further decompose with the evolution of volatile matter and form a resulting solid coke residue.

Commercial gasification processes have heretofore utilized as a feed, coke and coals which do not pass through a plastic or semi-fluid state. Since these materials do not go through a plastic stage, no difficulty is encountered in the gasification thereof. A great deal of the coal which is available in the United States for gasification is of a coking variety, such as bituminous and sub-bituminous coals. When these coals are supplied to conventional commercial processes, considerable plugging difficulties are encountered in the feed entry and reaction chambers tend to become plugged because of caking on the walls of the chamber where the process utilizes a powdered coal as the feed and the formation of solid clinker-like plugs when the process utilizes a moving solid bed of coal. It has therefore been necessary, heretofore, to convert such coal to coke before supplying the material to a gasification system.

The present invention is devised to overcome the obstacles and difficulties described above which beset conventional gasification processes when utilizing coking and low ash-fusion-temperature coals. Broadly speaking, the invention comprises forming a coating of coke upon the surface of hot, small particles of solid heat exchange material. The coke encrusted solid heat exchange material is then passed to a gasification chamber wherein the coke encrusted solid heat exchange material is contacted with a mixture of steam and oxygen whereby the coke material is gasified. The solid heat exchange material is then removed from the gasification chamber and is heated once again for the purpose of supplying heat to coal which is mixed therewith so as to form a layer of coke on the particles of the solid heat exchange material.

An object of this invention is to provide improved means for gasifying organic solid materials. Another object of the invention is to provide an improved method for gasifying organic solid materials. Another object of the invention is to provide a method for gasifying low ash-fusion-temperature coals. Another object of the invention is to provide a method for gasifying organic solid materials and preventing the accumulation of coke on the walls of gasifying apparatus. Other and further objects and advantages of this invention will be apparent to those

skilled in the art upon study of the accompanying disclosure.

Solid heat exchange material which may be utilized in the gasification system of this invention may be generally termed "pebbles." The term "pebbles" as used herein denotes any substantially solid material of flowable size and form which has sufficient strength to withstand mechanical pressures and the temperatures encountered within the gasification system. These pebbles must be of such structure that they can carry large amounts of heat from one chamber to another without rapid deterioration or substantial breakage. Pebbles which may be satisfactorily used in this gasification system may be substantially spherical in shape and range from about $\frac{1}{8}$ inch to about 1 inch in diameter. The size of the pebbles which are used will generally be dependent upon the state of the organic solid material with which they are mixed. When the organic solid material is in a finely powdered state, the pebbles are preferably of a size within the range of from $\frac{1}{8}$ inch to $\frac{5}{8}$ inch in diameter. Materials which may be used singly or in combination in the formation of such pebbles include among others alumina, silicon carbide, periclase, beryllia, mullite, nickel, cobalt, copper, iron, magnesia, and zirconia.

More complete understanding of the invention will be obtained upon reference to the drawing which is a schematic representation of the device of this invention.

Referring particularly to the drawing, heating chamber 11 comprises a vertically disposed chamber 12 being closed at its upper and lower ends by closure members 13 and 14, respectively. Pebble inlet conduit 15 and effluent outlet conduit 16 are provided in closure member 13. Pebble outlet conduit 17 is disposed in closure chamber 14. Perforate pebble support member 18 extends upwardly and outwardly from the inlet end of conduit 17 to the walls of shell 12. Member 18 forms a false bottom in the bottom of chamber 11 and is perforate so as to permit drainage of liquid there-through, but so as to prevent the passage of pebbles therethrough. Liquid ash outlet conduit 19 is provided in closure member 14 below support member 18. Fluid heat exchange material inlet conduit 21 is provided in the wall of shell 12, preferably in the lower portion thereof but above the rim of support member 18.

Coking chamber 22 is a cylindrical shell 23 which is rotatably mounted at its ends in end closure members 24 and 25. Closure members 24 and 25 are maintained rigidly in place and permit shell 23 to rotate therein. Traction means, such as toothed member 26, is provided about the outer surface of shell 23 and is operatively connected to drive means, such as motor 27. Coking chamber 22 is inclined from the horizontal at an angle of between 1° and 30° . It is preferred that the angle of inclination be between 2° and 15° . Pebble outlet conduit 17 extends from the lower end of chamber 11 to the upper end of chamber 22 and forms a pebble inlet conduit for the latter chamber. Conduit 28 is provided in closure member 24 so as to provide inlet means for finely divided organic solid material.

Effluent outlet conduit 29 extends from closure member 24 to condensation chamber 31. Separation chamber 32 is connected to condensation chamber 31 by means of conduit 33. Condensate outlet conduit 34 extends from the bottom of separation chamber 32 and effluent outlet conduit 35 extends from the upper portion of separation

chamber 32. Gasification chamber 36 comprises shell 37 closed at its upper and lower ends by closure members 38 and 39, respectively. Pebble conduit 41 extends between closure member 25 at the lower end of coking chamber 22 and closure member 38 at the upper end of gasification chamber 36. Effluent outlet conduit 42 extends upwardly from closure member 38 and is connected to effluent outlet conduit 35 to form a common outlet conduit. The gasifying medium conduit 43 is provided in shell 37 adjacent its lower end. Pebble outlet conduit 44 is provided in closure member 39 and extends to elevator 45. Elevator 45 is connected at its upper end to pebble inlet conduit 15 of heating chamber 11. Screen member 46 is provided in the lower wall of a portion of pebble outlet conduit 44 and chamber 47 is provided below screen member 46. Solid ash outlet conduit 48 is provided in the bottom of chamber 47.

In the operation of the device disclosed above, solid heat exchange material is introduced to pebble heating chamber 11 and is heated to a temperature of at least 1200°F . The pebbles are preferably heated to a temperature within the range of between 1200°F and 2000°F . Heat is provided to the flowing bed of pebbles within chamber 11 by passing a fuel which may be a hydrocarbon liquid or gas into the chamber through inlet conduit 21. The fuel is burned on the surface of the pebbles, providing heat to the pebbles, and the resulting combustion gas is passed upwardly through the pebble bed and is removed from chamber 11 through effluent outlet conduit 16. This method of operation may be modified by passing a hot gas, such as hot combustion gas, into chamber 11 through inlet conduit 21 rather than supplying a fuel therethrough. The heated pebbles are removed from the lower portion of chamber 11 through pebble outlet conduit 17 and are supplied to the upper portion of coking chamber 22.

Powdered organic solid material, such as coking or low ash-fusion-temperature coal, is added to coking chamber 22 through inlet conduit 28. Shell 23 is rotated at a speed within the range of from 1 to 30 revolutions per minute, preferably at a speed of from 1 to 15 revolutions per minute, by the connection between motor 27 and traction member 26, or any other conventional drive means. The powdered organic solid is mixed with the heated pebbles and receives sufficient sensible heat from the pebbles to convert it to a coke layer upon the surface of the pebbles. Loosely bound water and any hydrocarbon material which is released is removed from chamber 22 through effluent outlet conduit 29. The effluent material is passed through condensation chamber 31 where it is cooled so as to condense the water. The materials are then passed into separation chamber 32 through conduit 33 and the condensed materials are separated from the uncondensed materials. The uncondensed hydrocarbon materials are removed through conduit 35 and the condensed materials are removed through conduit 34.

The speed at which shell 23 is rotated will depend generally upon the diameter of the shell. The rotation of shell 23 is supplied only for the purpose of insuring complete mixing of the heated solid heat exchange material and the powdered organic solid material. The inclination of chamber 22 from the horizontal is sufficient to insure flow of the coke covered solid heat exchange material from the lower end of chamber

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22 through conduit 41 into gasification chamber 36. The coated solid heat exchange material forms a flowing bed within chamber 36.

Oxygen and steam are supplied to the lower portion of chamber 36 through conduit 43 and is passed upwardly countercurrent the flow of the coated solid heat exchange material. The coke is gasified by the reaction with steam and the resulting gaseous materials are removed from chamber 36 through effluent outlet conduit 42. The hydrocarbons from conduit 35 are added to the gases in conduit 42 so as to enrich the gases therein. The cooled solid heat exchange material is removed from the bottom of chamber 36 through pebble outlet conduit 44 and passes over screen 46 to elevator 45. Any solid ash which has been separated from the surface of the solid heat exchange material is removed from the flowing mass of solid heat exchange material by allowing it to fall through screen 46 into chamber 47 from which it is removed through outlet conduit 48. The solid heat exchange material is elevated by elevator 45 to the upper portion of heating chamber 11. Any ash which remains on the surface of the solid heat exchange material is melted by the application of heat to that solid heat exchange material in heating chamber 11. The melted ash flows downwardly through the perforate support member 18 and is removed from the bottom of chamber 11 through melted ash outlet conduit 19.

The description of the method of this invention is clearly applicable to the operation of the apparatus which is shown in the drawing. The scope of the method of gasifying the coking variety of coals which is disclosed herein is believed to be broader than the specific apparatus herein disclosed. It should be noted that the device of this invention could be modified by providing another type of tumbler device which would insure complete mixing of the coal and heated pebbles, but the device would not necessarily have to be rotated axially. A separation means, such as screen 46 and chamber 47, could be provided in pebble outlet conduit 17 and pebble support member 18 would therefore not be required. It is very important, however, that the coke be gasified while coating the solid heat exchange material and that a minimum of grinding be obtained in drum 22. By passing the pebbles and coke to the gasification chamber without separation, a greater overall heat efficiency is obtained and producer gas of higher calorific value is obtained.

The upper surface of support member 18 is preferably formed as an inverted cone, the included angle within said cone being between 60° and 100°. A support member which has such a slope on its upper surface will direct pebbles through its central inlet and substantially prevent the accumulation of stagnant pebbles on its upper surface.

Inert gas, such as steam, may be supplied to

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pebble conduits 17 and 41 through conduits not shown. The inert gas will act as a choke means and will prevent effluent gas from passing from one chamber upwardly through conduits 17 and 41 to another chamber.

Various other modifications of the invention will be apparent to those skilled in the art upon study of the above disclosure. It is believed that such modifications are within the spirit and the scope of the disclosure.

I claim:

1. An improved method for gasifying organic material which comprises the steps of heating solid heat exchange material in a heating zone; gravitating said heated solid heat exchange material into a coking zone; continuously tumbling said heated solid heat exchange material in said coking zone while adding organic material thereto; decomposing said organic material to coke on the surface of said solid heat exchange material; gravitating said coke-covered solid heat exchange material into a gasification zone; passing steam and oxygen into contact with said coke-covered solid heat exchange material and gasifying said coked organic material; recovering resulting gaseous materials from said gasification zone; removing said solid heat exchange material from said gasification zone; and returning said solid heat exchange material to said heating zone.

2. The method of claim 1 wherein loose solid ash is separated from said coke covered solid heat exchange material after the gasification step but before the heating step.

3. The method of claim 1, wherein any solid ash remaining on said solid heat exchange material is melted in said heating zone; and separating resulting liquid ash from solid heat exchange material in said heating zone.

4. The process of claim 1 wherein said organic material is low ash-fusion-temperature coal; heating said solid heat exchange material in said heating zone to a temperature between 1200° F. and 2000° F.; and maintaining a ratio of the portion of said solid heat exchange material to said coal supplied to said coking zone within the range of from 1:1 to 10:1.

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