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(54) GASIFICATION OF SOLID CARBONACEOUS FUEL

(54) GAZEIFICATION DE CARBURANT SOLIDE CHARBONNEUX

(72) Inventors (Country):	**WILHELM GUMZ** (Not Available)
(73) Owners (Country):	**HYDROCARBON RESEARCH**
(71) Applicants (Country):	
(74) Agent:	
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ABSTRACT:

CLAIMS: Show all claims

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This invention relates to a process for the gasification of a solid carbonaceous fuel. The process of the invention is applicable to the gasification of coal, lignite, oil shale, and the like. It is particularly useful for the production of fuel gas from those carbonaceous materials which tend to agglomerate on heating.

The fluidized solids technique has been applied to processes for the gasification of carbonaceous materials. In such processes, small particles of the solid fuel are reacted with a gaseous reactant while the solid particles are maintained in a dense phase fluidized bed. Fluidization is effected by passing the reactant gases upwardly through a bed of the solid particles at a rate sufficient to agitate the particles but insufficient for entrainment of the average size particles from the bed. The resulting bed of solid particles presents the appearance of a boiling liquid. Dense phase fluidization is now fairly well known in the art.

Coal, for example, in ~~Agglomerate~~ particle form, may be subjected to gasification in a fluidized bed by reaction with an oxidizing gas. Some difficulty has been experienced in the gasification of coal due to the tendency of many grades of coal to form clinkers or agglomerate on heating. Some coals in particular, known as caking coals, have a tendency to become plastic or tacky on heating thereby causing agglomeration of the particles. These coals may be treated prior to gasification to prevent agglomeration. Such pretreatment may consist of heating the coal to drive off at least a portion of the volatilizable constituents therefrom, or partial preoxidation of the coal, usually with an oxygen-containing gas or nitric acid. An expedient which is used to some extent involves mixing fresh coal with coke, ash, or an inert material, such as sand, to prevent agglomeration of the raw coal particles.

The process of the present invention is particularly adaptable to the handling of caking coals and similar solid fuels without difficulty due to the agglomerating tendency of the material and generally without the necessity for preliminary treating.

In accordance with this invention, the solid carbonaceous fuel is comminuted to a particle size suitable for fluidization, suitably less than 1/4 inch in diameter, and preferably less than about 0.2 inch in diameter, and charged to a gasification zone into an agitated mass of particles of hot char, or residue, resulting from previous partial gasification of coal. The bed of solids in the gasification zone is fluidized by a stream of flue gas so that carbonization of the feed material in the resulting mixture takes place in a dense phase fluidized bed. Following charging of fresh coal and carbonization in a fluidized bed, fluidization of the bed of solids in the gasification reactor is discontinued and the bed permitted to settle. The settled bed generally occupies a volume approximately 1/3 the volume of the fluidized bed. Fuel gas is generated by the gasification of the particles in the settle bed by reaction with a stream of steam passed downwardly through the settled bed of heated particles. Oxygen-containing gas may optionally be supplied to the bed with the steam for the production of gas. Some agglomeration of the particles takes place during the gasification reaction. Following gasification in the settled bed, a stream of hot flue gases is again passed upwardly through the bed of particles at a velocity sufficient to cause fluidization of the bed. These hot gases also supply heat to the bed to make up for heat lost therefrom by the endothermic reaction between carbon and steam during gasification. As the bed is fluidized, any agglomerate particles or clinkers settle to the bottom of the bed and are withdrawn therefrom. At the same time, an additional quantity of fresh coal is fed into the fluidized bed, thus completing the gasification cycle.

The agglomerate particles removed from the gasification reactor are reacted with an oxygen-containing gas, suitably air, to supply heat in the process. During the fluidization, the stream of hot flue gases used for fluidization and for heating of the bed of solid particles in the gasifier is derived from the combustion of the agglomerate particles in a separate zone. When the particles in the gasification reactor are subjected to reaction with steam, the hot gases may be used to supply heat for the generation of steam or for other purposes.

An object of this invention is to provide an improved process for the gasification of a solid carbonaceous material. A further object is to provide such a process which is particularly applicable to the gasification of caking coal. Another object is to provide a process for the gasification of solid carbonaceous materials which tend to soften and agglomerate on heating. Other objects and advantages will be apparent from the following detailed description and the accompanying drawings.

Figure 1 of the drawings is a diagrammatic elevational view in cross-section of one form of apparatus suitable for carrying out the process of my invention.

Figure 2 is a diagrammatic elevational view, partly in cross-section, illustrating an arrangement of apparatus suitable for conducting the process of my invention under elevated pressure.

With reference to Figure 1 of the drawings, coal of small particle size is fed from a storage hopper 6 by a screw conveyor 7 into a gasification vessel 8. The gasification vessel 8 is provided with a tipping grate 9. When the grate 9 is opened, fairly large particles may drop through into the space below the grate. When it is closed, it permits gases to pass through but retains substantially all of the solid particles making up the charge in the gasification reactor. Grates of this type are known in the art and do not, per se, form a part of the present invention. Below grate 9, an outlet conduit 11 is provided for discharging gas from the gasification zone. A valve 12 closes the lower end of the gasification reaction vessel. When this valve is open it permits gases to enter the gasification reactor and also permits discharging solid particles from the gasification reactor, as will be described hereinafter. An inlet conduit 13 is provided at the upper end of vessel 8 for the introduction of a gasification reactant. Gases may also be discharged from the upper part of the vessel 8 through line 14. These gases may be cooled by a cooler 15 and may be treated in a separator 16, suitably of the cyclone type, for the removal of powdered solids entrained in the gases. The resulting gases are discharged through line 17.

Disposed below vessel 8 is a separate reaction zone 20. Communication may be established between the flue gas generation zone 20 and the vessel 8 by opening valve 12. This permits flue gases from the combustion of residue in zone 20 to pass into the gasification vessel 8. Alternatively, the gases from zone 20 may be passed to a furnace 21 by operation of valve 22.

The furnace 21 may contain a more or less conventional boiler comprising steam generation tubes 23, steam drum 24, and steam preheating coils 25. Steam may be withdrawn from or supplied to the system through line 26. A part or all of the steam introduced into vessel 8 through line 13 may be supplied from the steam boiler through line 27.

Air is supplied to the lower portion of zone 20 from a blower 31 through tuyers 32 for consumption of fuel therein. Ash is discharged from zone 20 through an outlet 33. Air from blower 31 may also be introduced through tuyers 34 into zone 20 above the level of the fuel therein, as illustrated in the drawings and, if desired, to an outlet 36 in the furnace 21.

Fines separated from the gas stream in separator 16 may be introduced through line 37 into zone 20. Additional fuel may be discharged, if necessary, from a storage bin 38 into zone 20 through line 39.

In operation, air is blown through tuyers 32 into the flue gas generation zone 20 consuming carbon from the fuel and producing hot producer gas. Additional air is introduced through tuyers 34 to burn the producer gas with a substantial excess of secondary air. The hot gases from zone 20 are introduced into vessel 8 below grate 9 by opening valve 12. Valve 22 is in closed position. Grate 9 is turned to open position to allow free entrance of the hot gases from zone 20, which fluidizes the fuel bed A_1, increasing its volume to about 2/3 the volume of vessel 8, as indicated by A_2. During this period, fresh coal is introduced to vessel 8 from hopper 6 by means of feeder 7. Gases discharged from vessel 8 through duct 14 are cooled by a cooler 15, suitably in the form of a waste boiler, and passed to cyclone separator 16 where fine particles are separated from the gases. The gases are discharged from the system through line 17. Fine particles separated from the gases are passed through line 37 to zone 20.

During the period in which gases are passed from zone 20 through the bed of fuel in vessel 8, agglomerate particles settle to the bottom of the fuel bed and escape from the bed through grate 9. These particles drop into zone 20 and provide a source of fuel for this portion of the process.

When the temperature of the fuel bed in vessel 8 is raised to the desired temperature, for example, 1,600°F. to 2,000°F., grate 9 and valve 12 are closed and valve 22 opened to permit the gases from zone 20 to pass into furnace 21. Air is continuously introduced into zone 20 to produce heat. This heat is now utilized in furnace 21 for the production of steam, as explained in more detail hereinafter.

Upon discontinuing the introduction of gas through valve 12, the fuel bed in vessel 8 settles above grate 9 to form a bed of relatively small volume, as indicated by A_1. Steam is now introduced into vessel 8 above the bed of fuel through line 13. The duct 14 is closed so that the steam passes down through the hot fuel bed generating fuel gas. The fuel gas leaves through grate 9, which is now in closed position, and is discharged from the vessel through line 11, which is now open.

When the fuel bed temperature drops to a temperature such that the rate of gas production falls off, for example, 1,500°F., the flow of steam through line 13 is discontinued, line 11 is closed, line 14 and valve 12 opened, valve 22 closed, and the cycle repeated.

While gas is being made in vessel 8 by reacting the fuel bed with steam, the hot gases produced in the gas production zone 20 are passed through valve 22 into furnace 21 to produce steam for the process. Steam may be generated in the boiler tubes 23 and this steam drawn from steam drum 24 through a superheating coil 25, also disposed in furnace 21. Steam from the superheater 25 may be passed through line 27 to supply steam to the gasification vessel 8 through line 13. Air is generally introduced through tuyere 34 above the bed in substantial excess to insure complete combustion of the gases from the fuel bed in zone 20. Alternatively, or additionally, air may be introduced directly into furnace 21 through inlet 36.

Instead of superheater tubes 25, a regeneration chamber with checker brickwork, not illustrated in the drawings, may be used for preheating steam, as is well known in the art. An alternative, though less desirable, procedure is the operation of the gas generation in vessel 8 as a fluidizing system. The downdraft-fixed bed operation and the fluidized bed operation may be used consecutively in the gas producing cycle.

Some of the advantages of the process of my invention as compared with usual water gas producers are: higher average bed temperatures, hence higher gas yields; less carbon dioxide; longer gasification periods; and less danger of damaging the grates. Unclassified, lower grade fuels may be used, which results in lower fuel cost and, consequently, lower gas cost. Furthermore, the system may be operated under high pressure.

Apparatus for operation under pressure is illustrated diagrammatically in Figure 2. In this case, the water gas generator 8 is designed for operation under pressure, for example, from 300 to 750 pounds per square inch gage. The flue gas generation zone 20 may be designed for operation at the same pressure or a lower pressure, e. g., atmospheric pressure. The two zones are connected by a pressure lock 40 provided with a valve 41 communicating with the lower part of vessel 8 and valve 42 communicating with the upper part of vessel 20.

Alternatively, the pressure lock 40 may be omitted and the pressure in vessel 20 increased to that in vessel 8 during the heating period and subsequently decreased to a lower pressure, for example, atmospheric pressure, for discharging the ash or slag for the vessel. Gas produced in vessel 20 during the make period in vessel 8 may be discharged through line 43 to a boiler or gas turbine.

In either of the modifications illustrated, it is preferable to operate gasification zone 20 at a temperature such that the ash is removed as a fluid slag.

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.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A cyclic process for the production of fuel gas from a solid carbonaceous fuel which comprises passing a gaseous reactant comprising steam downwardly through a bed of said solid fuel in particle form at gasification reaction temperature in a gas generation zone to produce a fuel gas comprising carbon monoxide and hydrogen as principal constituents, thereafter discontinuing the flow of said gaseous reactant through said bed, supplying heat to said bed by introducing a stream of hot flue gas at a temperature above said reaction temperature into the lower portion of said bed and passing the flue gas upwardly therethrough at a rate sufficient to maintain the solid particles in said bed in a state of dense phase fluidization whereby the larger particles gravitate to the lower portion of said bed, removing said larger particles from the lower portion of said bed, introducing fresh fuel into said bed during said fluidization, and thereafter discontinuing the flow of hot flue gas through said bed and again passing said gaseous reactant downwardly therethrough for the generation of fuel gas.

2. A process according to Claim 1 wherein the temperature of said bed is maintained within the range of 1500°F. to 2000°F.

3. A process according to Claim 1 wherein said larger particles removed from the lower portion of the bed are burned with air to supply said stream of hot flue gas.

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4. A process according to Claim 3 wherein fine particles entrained in the flue gas stream during fluidization are separated from said gas stream and burned with air together with said larger particles to supply said stream of hot flue gas.

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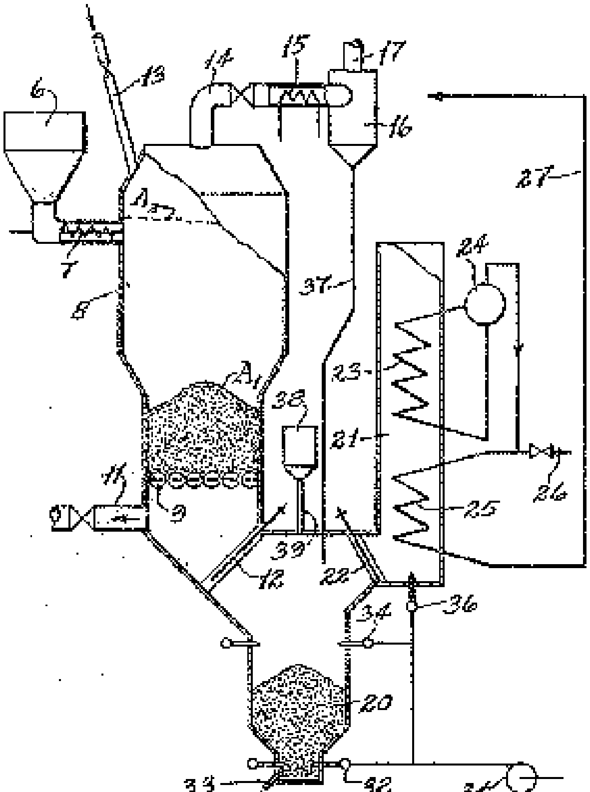

Fig.1.

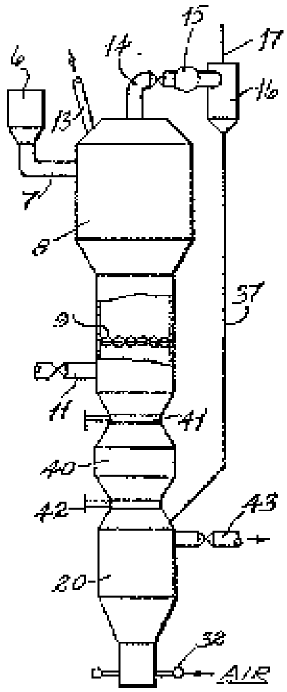

Fig.2.

INVENTOR

WILHELM GUMZ

PATENT AGENT

Smart & Biggar