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GASIFICATION OF CARBONACEOUS MATERIALS

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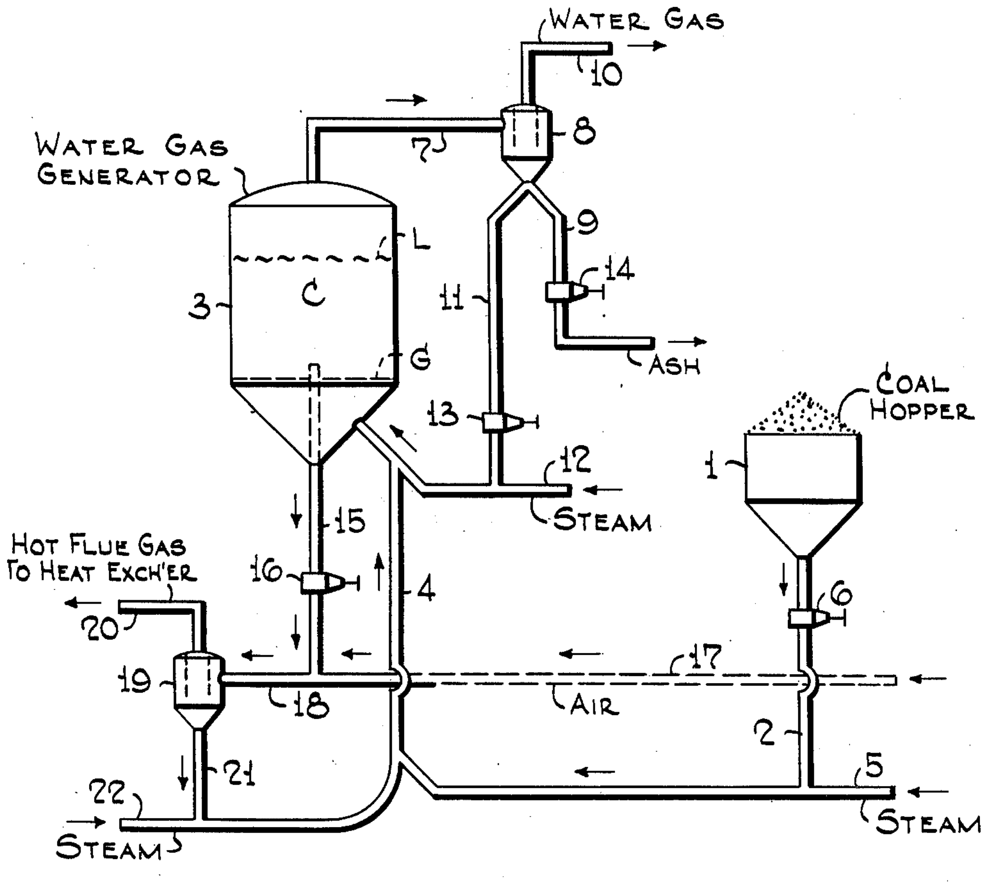

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GASIFICATION OF CARBONACEOUS MATERIALS

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7 Claims. (Cl. 48—206)

The present invention relates to conversions involving the gasification of carbonaceous materials. It is more particularly concerned with an improved process for maintaining the temperature in the conversion zone, such as a generator. In accordance with the present invention the temperature in the generator, as for example, a water gas generator, is maintained by withdrawing a portion of the carbonaceous material from the generator and passing it through a transfer line while in contact with air for a relatively short time period. By operating in this manner, a maximum production of carbon dioxide is secured as compared to carbon monoxide, resulting in the maximum production of heat, for the amount of carbonaceous material circulated.

It is well known in the art to treat carbonaceous materials such as coal with steam for the production of water gas. In this endothermic reaction, carbon reacts with steam to produce hydrogen and carbon monoxide. Problems encountered in a coal gasification reaction of this character are the coking of crushed coal or surplus coal fines, the generating of water gas from the coke with steam, and the supplying of heat for the water gas generation. It is with this last problem that this invention is particularly concerned.

In accordance with the invention the temperature in a gas-producing conversion zone such as a water gas generator is maintained by withdrawing a portion of the carbonaceous material from the generator, burning a portion of that withdrawn under conditions to produce the maximum amount of carbon dioxide and recycling the heated remainder to the generation zone. This is extremely desirable because in burning to carbon dioxide nearly three times as much heat is generated than when burning to carbon monoxide (94.0 vs. 26.4 kg.-cal./mol of carbon), thereby minimizing the amount of carbon and air required to generate a given amount of useful heat. Since the equilibrium in the presence of carbon very much favors formation of carbon monoxide at the temperatures at which the heat must be generated, this can be accomplished only by minimizing the opportunity for reaction between the gas and solid phases so as to discourage the slower secondary reaction, $C+CO_2 \rightarrow 2CO$, while permitting the much faster primary reaction, $C+O_2 \rightarrow CO_2$ to proceed.

The process of the invention may be readily understood by reference to the drawing illustrating one modification of the same. Carbonaceous material, as for example, coal or coke, is withdrawn from coal hopper 1 through line 2 and introduced into a water gas generator 3 by means of line 4. Steam is introduced into line 4 by means of line 5. The amount of coal or coke introduced into the water gas generator is controlled by means of slide valve 6.

In generator 3 there is shown a body of carbonaceous material indicated by the reference character C. This material is in the form of a dense fluidized mass having an upper level at L above which, separated by an interface, is a dilute phase. G represents a foraminous member such as a grid and the gasiform material from lines 4 and 12 entering the bottom of 3 pass through said foraminous member, which functions to afford good distribution of gasiform material entering the dense fluidized bed of carbonaceous material C.

The water gas generator is maintained at a pressure in the range from about atmospheric to 100 lbs./sq. in. ga. while the temperature is maintained in the range from about 1500° F. to 2100° F. The temperature is maintained in water gas generator 3 in a manner as hereinafter described. Reaction products are withdrawn overhead from generator 3 by means of line 7 and introduced into separation zone 8 wherein carbonaceous or ash products are separated and removed by means of line 9. The water gas reaction products are removed from the system by means of line 10 and handled in any desirable manner. It may be desirable to recycle ash products separated in zone 8 in which case these products are removed by means of line 11 and recycled to the generation zone 3. Sufficient and additional steam may be introduced by means of line 12. Slide valves 13 and 14 control the amount of ash passing through lines 11 and 9, respectively.

In accordance with the invention, carbonaceous materials are withdrawn from water gas generator zone 3 by means of line 15. The amount of carbonaceous materials withdrawn is controlled by means of slide valve 16. Air is introduced by means of line 17 and the air and carbonaceous materials pass through a relatively short line 18 in order that the time of contact between the carbonaceous materials and the air is relatively short. The reaction products are introduced into cyclone separation zone 19 in which the hot flue gas is separated and removed by means of line 20. These gases may be handled in any desirable manner, as for example, passed through heat exchangers. Unburned carbonaceous materials are separated in separation zone 19, withdrawn by means of line 21, steam added by means of line 22 and the heated carbonaceous materials then passed back to water gas generator zone 3 by means of line 4.

The process of the present invention may be widely varied. The invention may be adapted to any process wherein it is desirable to secure the maximum amount of heat by the burning of carbonaceous materials such as coal, coke, or the like. For example, heat may be supplied in accordance with the invention to such reactions as high and low temperature carbonization of carbonaceous solids, coking of hydrocarbonaceous materials particularly heavy hydrocarbonaceous residues including reduced crude, asphalt, pitch, or the like, and similar reactions. Of course in the case of starting materials which are liquid at the gasification conditions, suitable carrier solids such as coke, sand, pumice, etc. will be present in the gasification zone at least to start up the process, as it is well known in the art of fluid coking of such materials.

The invention, however, is particularly adapted to a water gas generator reaction in which it is desirable to maintain the temperature in the generator zone in a fixed range. In accordance with the present invention, coal or coke and air are contacted for a relatively short time period resulting in the maximum production of carbon dioxide and the minimum production of carbon monoxide. Thus, to maintain the temperature in the generator zone, it is possible to circulate a smaller amount of the carbonaceous material than would otherwise be the case if equilibrium would be reached between carbon dioxide and carbon monoxide.

The time of contact between the air and the carbonaceous material may be varied considerably. However, it is essential that the time of contact be less than five seconds, preferably less than one second. It is especially desirable to contact the air and coke for less than .7 second at a temperature in the range from about 1600° F. to 2200° F.

The present invention may be more fully understood by the following example illustrating modifications of the same.

Example

Various operations were conducted in which air and coke were contacted for the time periods shown. The results of these operations are as follows:

	Oper. 1	Oper. 2	Oper. 3	Oper. 4	Oper. 5
Time of contact (sec.)	.66	.56	.56	.53	10
Temperature, ° F	1,725	1,900	1,700	1,900	1,800
Flue Gas Analysis—mol percent:					
CO_2	18.3	14.4	18.2	16.3	3.6
CO	3.1	9.7	3.8	6.4	27.0
O_2	0.0	0.1	0.0	0.2	0.0
M_2	78.6	75.8	78.0	77.1	69.4
Percent CO_2 in $CO+CO_2$	86	60	83	72	12
Percent CO_2 in $CO+CO_2$ at equilibrium for $CO_2+\leftrightarrows 2CO$	1.5	0.25	2.8	0.25	0.50

From the above, it is readily apparent that by operating in accordance with the present invention, in this case, at times less than about one second, substantial improvements will be secured. For example, the percentage of CO_2 in the total carbon dioxide plus carbon monoxide varied from 60 to 86% when the time was 0.5–0.7 second whereas when a relatively long time of contact (10 seconds) was employed, the percentage of carbon dioxide as compared to carbon dioxide plus carbon monoxide was about 12. The numbers in the last line indicate the percent CO_2 in CO plus CO_2 which will result, for each of the temperatures, when long times for reaction are permitted.

This application is a continuation-in-part of our copending application Serial No. 663,230, filed April 18, 1946, now abandoned.

The process of the present invention is not to be limited by any theory as to mode of operation but only in and by the following claims in which it is desired to claim all novelty insofar as the prior art permits.

What is claimed is:

1. A process for forming a gaseous fuel from finely divided solid carbonaceous material, which comprises charging fresh powdered solid carbonaceous material to a gaseous fuel generation zone, charging steam to said generation zone where it contacts said charged carbonaceous material at temperatures within the range of from about 1500° F. to 2100° F., causing the steam to flow upwardly in said generation zone at a sufficiently low rate so as to cause the said carbonaceous material undergoing treatment to form a fluidized bed, withdrawing carbonaceous material from said generation zone, mixing the withdrawn carbonaceous material with an oxygen containing gas and causing the said carbonaceous material to undergo at least partial combustion to add heat to said carbonaceous material, while the said carbonaceous material is in the form of a confined stream in a zone of restricted cross-section, limiting the time period of combustion of said carbonaceous material within the limits of from about 0.5–0.7 second, separating the unburnt carbonaceous material from the resulting combustion fumes to prevent substantial reduction of the formed carbon dioxide and returning the thus heated carbonaceous material to the said generation zone for the purpose of supplying the heat necessary to support the gaseous fuel generation therein taking place.

2. The method of claim 1 in which the carbonaceous material withdrawn from the reaction zone is subjected to the influence of air for a sufficiently short period of time such that of the oxides of carbon contained in the combustion fumes, up to 86% is in the form of carbon dioxide.

3. A process for producing gasiform fuels from carbonaceous materials, which comprises charging fresh carbonaceous material to a gasification zone containing a dense turbulent bed of carbonaceous solids maintained at a gasification temperature and fluidized by upwardly flowing gases to resemble a boiling liquid, withdrawing carbonaceous solids from said zone, mixing the withdrawn carbonaceous solids with a free oxygen-containing gas and causing the said carbonaceous solids to undergo at least partial combustion to add heat to said carbonaceous solids, while the said carbonaceous solids are in the form of a confined stream in a zone of restricted

cross-section, limiting the residence time of said last-mentioned gas in contact with said carbonaceous solids to a period of less than about 0.7 second at a temperature higher than said gasification temperature, separating the unburned carbonaceous solids from the resulting combustion fumes to prevent substantial reduction of the formed carbon dioxide and returning the thus heated carbonaceous solids to the said zone for the purpose of supplying the heat necessary to support the gasification taking place therein.

4. The process of claim 3 in which said higher temperature is 1600° F.–2200° F.

5. A process for supplying heat to the conversion of carbonaceous materials, which comprises charging fresh carbonaceous material to a conversion zone containing a dense turbulent bed of carbonaceous solids maintained at a conversion temperature and fluidized by upwardly flowing gases to resemble a boiling liquid, withdrawing carbonaceous solids from said zone, mixing the withdrawn carbonaceous solids with a free oxygen-containing gas and causing the said carbonaceous solids to undergo at least partial combustion to add heat to said carbonaceous solids, while the said carbonaceous solids are in the form of a confined stream in a zone of restricted cross-section, limiting the residence time of said last-mentioned gas in contact with said carbonaceous solids to a period of less than 1 second at a temperature higher than said conversion temperature, separating the unburned carbonaceous solids from the resulting combustion fumes to prevent substantial reduction of the formed carbon dioxide and returning the thus heated carbonaceous solids to the said zone for the purpose of supplying the heat necessary to support the conversion taking place therein.

6. The process of claim 5 in which said period is less than 0.7 second.

7. The process of claim 6 in which said higher temperature is 1600° F.–2200° F.

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