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COMPLETE SPECIFICATION

Improvements in or relating to Method of and Apparatus for Gasifying Carbonaceous Solids

We, PITTSBURGH CONSOLIDATION COAL COMPANY, a corporation organised under the laws of the State of Pennsylvania, United States of America, of Koppers Building, Pittsburgh, Pennsylvania, United States of America, (Assignees of GEOFFREY EDWARD GORING), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the gasification of carbonaceous solids, and, more particularly, to method and apparatus for converting carbonaceous solids to a gas containing principally carbon monoxide and hydrogen.

It has hitherto been proposed to gasify finely divided carbonaceous solids in a single vessel by passing steam and a gas containing oxygen through a bed of the solids under fluidizing and reacting conditions. In such systems, the product gases are discharged from the gasification vessel at a high temperature, for example, 1700°—1900° F. and thus remove sensible heat from the system. They also contain entrained solid fines, which still possess a relatively high carbon content with consequent loss in carbon conversion. This loss of heat and carbon from the system is naturally undesirable because of its effect on the economics of the process through a lowered over-all thermal efficiency.

In accordance with the present invention, an improved system for gasifying carbonaceous solids is provided. Briefly this systsem comprises a combination of a moving but not fluidised bed of solids and a fluidized bed of solids. Fresh carbonaceous solids are fed upwardly as a moving bed which at the end of its upward travel is forced to overflow downwardly into a fluidized gasification zone. Gasification of the overflowing solids is carried out under fluidized conditions in the gasification zone by means of steam and a gas containing oxygen, both passing upwardly through said zone at reaction temperature. The effluent gases from the gasification zone, along with any entrained solids, are forced to pass downwardly through the upwardly moving bed of fresh solids, in countercurrent heat exchange relationship therewith. The hot gases serve to preheat the incoming solids, the maximum preheat temperature being reached at the point where the solids overflow into the fluidized gasification zone. By the time the gases are discharged from the bottom of the upwardly moving bed, the temperature of these effluent gases is substantially reduced. At the same time the entrained fines are separated from the effluent gases and deposited upon the fresh incoming solids and returned thereby to the fluidized gasification zone to be retreated.

For a better understanding of the invention, reference should be had to the following detailed description of a preferred embodiment and to the accompanying drawing in which is shown partly diagrammatically and partly in section, an apparatus adapted to carry out this preferred embodiment.

Referring to the drawing, numeral 10 designates a vertical substantially cylindrical vessel having side wall 12, top wall 14, and a bottom inverted cone-shaped section 15. The latter section is provided with an opening 16 at the apex of the cone through which fresh carbonaceous solids may be introduced. The introduction of these solids may be accomplished by the diagrammatically illustrated conventional feeding mechanism 17 such as an under feed stoker of the worm gear type supplied with solids by a conduit 18. The solids introduced through the opening 16 is forced upwardly by the stoker as a moving bed 19 into the interior of vessel 10, and form an annular solid bed surrounding a second vertical substantially cylindrical vessel 20 having side wall 22 and a bottom inverted cone-shaped section 24. This inner vessel 20 is supported within the vessel 10 by any suitable means (not shown) in spaced relationship to the side wall 12 of the latter vessel to permit the passage of the annular bed of solids 19.

The upwardly moving bed of fresh carbonaceous solids is forced to overflow at the top of vessel 10 into vessel 20 where the bed of the solids is maintained in a fluidized condition by means of a gaseous mixture of steam and an oxidizing gas such as oxygen which passes through a conduit 26 into the cone-shaped section 24 and up through a grid 28 disposed in the bottom of vessel 20. The velocity of the incoming gases required to maintain fluidization is well known to the art and is of the order of ½ to 2 feet per second. The amount of oxygen in the incoming gases is sufficient to elevate by combustion the temperature of the solids in the inner vessel to gasification temperatures, that is, preferably of the order of 1800°—2000° F.

The product effluent gases from the gasification vessel 20 are forced to pass downwardly through the upwardly moving annular bed of fresh carbonaceous solids. The hot gases contact the fresh feed in countercurrent relationship so that the maximum preheat temperature is effected at the point where the fresh solids overflow into the gasification zone. The gases themselves are cooled by passage down through the moving bed of solids 19 and are finally discharged from the system through conduit 30 at a relatively low temperature. During the downward passage of the gas through the upwardly moving bed of solids, the solids entrained in the gases are filtered out and picked up and returned to the gasification vessel. This is a desirable feature of the invention since it insures a substantially clean gas at the point of discharge and also increases the carbon conversion of the system since the fines contain a substantial amount of unconverted carbon. Ash is removed from the system as part of the continuous (or intermittent) bed solids draw-off taken through conduit 32 extending through the wall 12 of the outer vessel 10.

If desired the above described system may be operated under pressure. Because of the insulating barrier provided by the upwardly moving bed between the gasification zone and the walls of the outer vessel, less refractory is required as a liner for the outer walls, particularly near the bottom.

An example of the operation of the above described system in accordance with the invention as applied to the gasification of the carbonaceous residue known as char, obtained by the low temperature carbonization of coal is as follows. A finely divided char of 35 to 100 Tyler mesh size consist having the following composition is fed into the outer zone of vessel 10 which is maintained at a pressure of 20 atmospheres as the moving bed stream 19:—

Composition	Weight per cent
H	3.1
C	82.4
N	1.8
O	4.0
S	0.6
Ash	8.1

The rate of char feed is 7.36×10^{-2} lbs/ft² sec. This char overflows into the fluidized gasification zone contained in vessel 20 and maintained at 1900° F. Steam is fed to the latter zone at a rate of 3.11×10^{-3} lb. mols/ft² sec; and oxygen is fed to the same zone at a rate of 1.54×10^{-3} lb. mols/ft² sec. (In these feed rates, the area, ft², refers to that of the fluidized bed). With these conditions 199 lbs. of carbon in the char/ft² hr. are converted to a gas of the following composition:—

Product Gas	Mols/Mol C Fed
H_2	.611
H_2O	.195
CO	.769
CO_2	.154
CH_4	.006
O_2	.009
N_2	.002

The exit gas temperature is 1150° F.

In addition to the advantages previously described, namely, low sensible heat content of the product gas leaving the system by virtue of the counter current preheating of the solid feed; negligible entrainment loss by virtue of the filtering effect of the moving bed; and the insulating effect of the same moving bed, the following advantageous characteristics of the composite system described may be added: (1) high steam conversions due to the large bed heights that may be maintained at a high temperature in the inner gasification vessel; (2) high heat transfer rates at the point of oxygen injection into the inner vessel to permit high gasification rates without causing ash fusion. In short, this composite unit combines the advantages of the fixed bed and fluidized bed for the gasification of carbonaceous solids.

While we have shown as the preferred embodiment of the invention a system in which the gasification zone is completely surrounded by an annular stream of solids, it is to be understood that the invention is not so limited. The two beds of solids may be in separate vessels in side by side relationship or otherwise so long as the non-fluidized bed moves upwardly and overflows into the fluidized gasification zone, and the product gas and entrained fines passes in countercurrent relationship to the upwardly moving bed.

The above invention is applicable to the gasification of carbonaceous solids such as coal, oil shale, lignite, etc. A non-caking material is preferred; but a caking material may be used under non-agglomerating conditions. For example, a caking bituminous coal may be mixed with sufficient non-caking material, e.g., char to prevent agglomeration from taking place.

We have explained the principle, preferred construction, and mode of operation of the invention and have illustrated and described what we now consider to represents its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

What we claim is:—

1. The method of gasifying carbonaceous solids including passing steam and an oxidizing gas through a bed of the solids under fluidizing and reacting conditions which method comprises moving a bed of finely divided carbonaceous solids upwardly through a pretreating zone, forcing said bed to overflow downwardly into a gasification zone, passing said steam and a gas containing oxygen upwardly through the solids in said gasification zone, conducting the hot effluent gases and entrained solids from said gasification zone downwardly through said upwardly moving bed of carbonaceous solids in countercurrent relationship therewith, whereby said bed of solids is heated to an elevated temperature and the entrained solids in the effluent gases are separated therefrom and retained by said bed of solids, and recovering the effluent gases at the bottom of said upwardly moving bed of solids.

2. The method according to claim 1, in which the pretreating and gasification zones are maintained at superatmospheric pressures.

3. The method according to claim 1 or 2, in which the carbonaceous solids consist of finely divided char.

4. The method according to claim 1, 2 or 3, in which the gas containing oxygen is oxygen.

5. The method according to any of the preceding claims, in which the upwardly moving bed of carbonaceous solids comprises an annular stream of said solids which surrounds the gasification zone and is in heat exchange relation therewith.

6. Apparatus for gasifying carbonaceous solids by the method according to any of the preceding claims, comprising a vessel having openings only at the bottom thereof for introducing fresh solids and for withdrawing product gas therefrom, means associated with the bottom of said vessel for introducing a stream of finely divided solids into said vessel, a second vessel arranged entirely within said first vessel and having side and bottom walls spaced from the walls of said first vessel to permit the passage of solids therebetween, said second vessel communicating with the interior of said first vessel only through a top opening through which solids are adapted to overflow, means associated with said second vessel for introducing gaseous gasifying agents from outside said first vessel into said second vessel, means associated with said second vessel for discharging solid product therefrom to the exterior of said first vessel, and means associated with the bottom of said first vessel for discharging product gas therefrom.

7. The method of gasifying carbonaceous solids substantially as described with reference to the accompanying drawings.

8. Apparatus for gasifying carbonaceous solids constructed and adapted to be operated substantially as described and shown in the accompanying drawings.

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1 SHEET.

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