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APPARATUS FOR TREATING CARBONACEOUS SOLIDS

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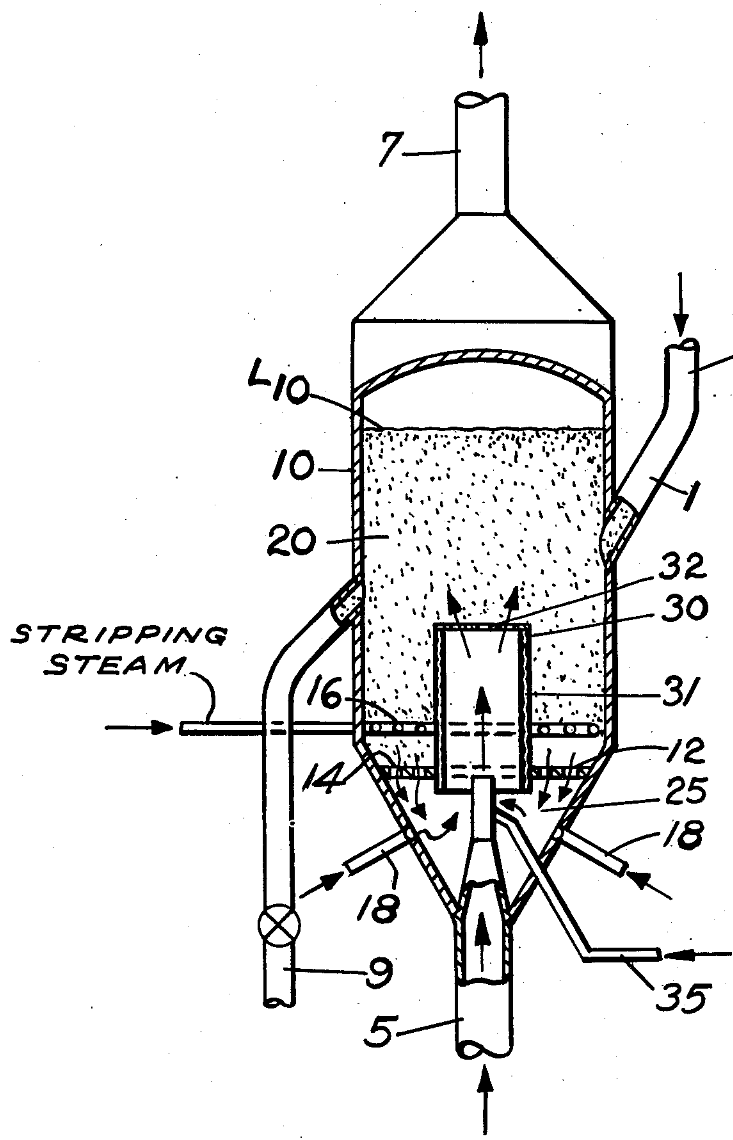

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APPARATUS FOR TREATING CARBONACEOUS SOLIDS

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2 Claims. (Cl. 48—62)

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The present invention relates to the conversion of carbonaceous solids into volatile products by carbonization and/or gasification with oxidizing gases and/or steam. More particularly, the invention is concerned with the pretreatment of carbonaceous solids such as all types of coal, lignite, cellulosic materials, including lignin, oil shale, tar sands, coke, oil coke, etc. which are to be converted into volatile products by carbonization and/or gasification or any other conversion process requiring a pretreated carbonaceous charge.

Heretofore, it has been customary to pretreat the carbonaceous charge for solid fuel conversion processes by preheating and, in some cases, by a limited oxidation at suitable temperatures preferably just below the point of beginning softening or volatilization of the charge. For instance, carbonization coal is usually preheated to temperatures varying from about 500° to about 1000° F. depending on the character of the coal and the conditions of the subsequent conversion process. The conventional method of generating and supplying this preheat to the coal involves the combustion of combustible gases with air in a separate heater and passage of the hot flue gases over the coal to be preheated.

In order to avoid losses of volatile coal constituents and to prevent baking and sticking of the coal in the preheating zone, the inlet temperature of the gas must not exceed about 1000°–1400° F. In addition, the specific heat of the flue gas is only a small fraction of that of the coal to be heated. As a result, the coal must be preheated to an undesirably high temperature and thereafter quenched to the desired temperature or vast amounts of flue gases are required to heat coal of atmospheric temperature up to a desirable preheating temperature of about 500°–700° F. However, even the use of an extremely large volume of heating gas of relatively low temperature necessarily entails an irregular distribution of the preheat throughout the coal charge. As the result of channelling effects and due to the low heat transfer coefficient of the solid charge, the coal first or most intimately contacted by the gas reaches a higher temperature than that contacted later or more incompletely. These conditions not only constitute a serious load on process economies but frequently cause even serious operational difficulties.

The present invention overcomes the aforementioned difficulties and affords various additional advantages. These advantages, the nature of the invention and the manner in which it is carried out will be fully understood from the following description thereof read with reference to the accompanying drawing.

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It is, therefore, the principal object of my invention to provide improved means for pretreating carbonaceous solids to be subjected to a conversion into volatile products at elevated temperatures.

Another object of my invention is to provide an improved method and apparatus for uniformly preheating carbonaceous solids to a definite desired temperature, preliminary to a high temperature treatment of said solids.

A more specific object of my invention is to provide improved means for pretreating, particularly preheating carbonizable solids at uniform temperature below the temperature of beginning softening and carbonization.

Other and more specific objects and advantages of my invention will appear hereinafter.

In accordance with my invention, the carbonaceous solids to be pretreated are maintained in the form of a dense turbulent bed of finely divided solids fluidized by an upwardly flowing gas and the heat required for the desired pretreatment is generated in a combustion zone surrounded by and in open communication with said bed so as to permit circulation of carbonaceous solids through said combination zone from and to said fluidized bed of solids and of combustion products from said combustion zone to said fluidized bed.

In this manner, the heat generated by the combustion is immediately transferred to a portion of the carbonaceous solids which serve as solid heat carrier of high specific heat thus reducing to a minimum the volume of hot flue gases required for pretreating. In addition, the excellent heat transfer and distribution characteristics of the dense turbulent fluidized bed of solids to be pretreated and the direct heat exchange between the combustion zone and the fluidized solids bed make it possible to maintain a temperature differential as low as about 100°–400° F. between the heat-generating combustion and the fluidized solids bed to be heated, resulting in the elimination of undesired high temperature side reactions. The pretreated carbonaceous solids are recovered in the form of fluidized or fluidizable solids and are, as such, particularly suitable as charge for conversion processes employing the fluid solids technique.

The combustion zone may be operated so as to generate merely the heat required for preheating. However, by a suitable choice of the temperature and size of the combustion zone, a suitable choice of the gases supplied to the combustion zone, and a proper control of the rate of circulation of carbonaceous solids through the combustion zone it may simultaneously serve to dehydrate, carbonize, gasify and/or mildly oxidize the carbonaceous solids passed therethrough.

The fuel burnt in the combustion zone preferably consists of combustible constituents of the carbonaceous solids circulated therethrough from the dense fluidized mass of solids to be pretreated. However, if it is desired to avoid a loss of combustible constituents of the solid carbonaceous charge, an extraneous fuel of lower ignition temperature such as a fuel gas or fuel oil may be charged to the combustion zone along with the air and/or oxygen supporting the combustion. If these fuels are added in theoretical or slight excess proportion to the oxygen supplied, little or no combustible constituents of the solid carbonaceous charge will be burnt and the latter will act mainly as a heat carrier.

Having set forth the general nature and objects, the invention will be best understood from the more detailed description hereinafter, in which reference will be made to the accompanying drawing which illustrates semi-diagrammatically a system suitable for carrying out a preferred modification of the present invention.

Referring now in detail to the drawing, the system shown therein essentially comprises a pretreating chamber 10 adapted for fluid solids operation and a vertical combustion zone 30. The function and cooperation of these elements will be explained hereinafter in connection with the preheating of a bituminous carbonization coal from substantially atmospheric temperature to about 600° F. to prepare it for subsequent low temperature carbonization at about 800° to 1200° F. It should be understood, however, that any other solid carbonaceous charge previously mentioned may be treated for the same or different purposes in a generally analogous manner.

In operation, finely divided bituminous carbonization coal having a volatile content of about 20 to 35%, a plasticizing temperature of about 700° F. and a temperature of incipient carbonization of about 750° F. is supplied through pipe 1 to pretreating chamber 10. The coal should have a fluidizable particle size which may fall within the broad range of about 50–400 mesh, 100–200 mesh being preferred, though larger sizes up to about ¼ in. may be used. Pipe 1 may be part of any conventional feeding device for fluidizable solids such as an aerated standpipe, pressurized feed hopper, mechanical conveyor or the like. The finely divided coal forms in chamber 10 a dense turbulent bed 20 of solids fluidized by upwardly flowing gases to resemble a boiling liquid having a well defined upper level L_{10} as will appear more clearly hereinafter.

Chamber 10 is equipped, in its lower portion, with a horizontal plate 12 provided with preferably adjustable orifices 14 which permit a controlled passage of finely divided coal from bed 20 to a point below the bottom of combustion zone 30. A fluidizing gas such as steam, flue gas, or the like is introduced into bed 20 through several, preferably annular, perforated tubes 16 located above and in close proximity to plate 12. The amount of fluidizing gas thus supplied is preferably so controlled that the gas has a linear velocity of about 0.3–3 ft., preferably about 1–2 ft. per second within bed 20 to convert the latter into the desired dense ebullient mass of solids. The fluidizing gas may simultaneously serve as a stripping agent to remove occluded undesirable gases from the solids to be passed to combustion zone 30 as will be presently explained.

Coal particles passing through orifices 14 in plate 12 into lower zone 25 of chamber 10 are aerated and kept in a mobile turbulent state by an aeration gas such as air, oxygen, steam, flue gas, or the like supplied through taps 18 at a linear velocity of about 0.3–3 ft. per second. The bulk of the air and/or oxygen required for combustion is introduced through line 5 directly into the lower, open end of combustion zone 30 at a relatively high superficial velocity of about 3–20 ft. per second, so as to establish an ejector effect at the bottom of zone 30, whereby coal particles are forced into and upwardly through combustion zone 30. The upper end of combustion zone 30 is preferably provided with a perforated cover plate 30 which permits the passage of solids and gaseous combustion products from combustion zone 32 into bed 20 while effectively preventing solids from entering the top of combustion zone 30.

The temperature of combustion zone 30 may be controlled by the oxygen content and linear velocity of the gas supplied through line 5, the latter determining in combination with the opening of orifices 14, the rate of fuel supply to zone 30. For the purpose of preheating coal bed 20 to about 600° F. the temperature in zone 30 is maintained at about 800°–1000° F. The amount of air required may vary within wide limits depending on the relative sizes of chamber 10 and zone 30, the character of the carbonaceous charge and the pretreatment desired. For the preheating of coal as indicated above in a system wherein the ratio of the diameters of chamber 10 and zone 30 falls within the approximate range of 2–10:1, about 0.1 to 5 cu. ft. of air supplied at a linear velocity of about 4–10 ft. per second in zone 30 is generally adequate to preheat 1 lb. of coal from about 60° to about 600° F. The solids-in-gas suspension within combustion zone 30 may have an apparent density of about 1 to 10 lbs. per cu. ft. as compared with a density of about 15 to 30 lbs. per cu. ft. of bed 20. At these conditions about 0.005 to 0.01 lbs. of combustible coal constituents are burnt in zone 30 per lb. of coal to be preheated.

A dilute suspension of solid combustion residue in flue gases passes through cover plate 32 at the temperature of combustion zone 30 and enters the fluidized bed 20 which absorbs the sensible heat of the combustion products uniformly through its entire mass to attain the desired uniform temperature of about 600° F. It should be understood that the pseudo-hydrostatic pressure generated by the fluidized solids column between plate 12 and the top of zone 30 must be great enough to overcome the flow resistance through orifices 14, combustion zone 30 and perforated plate 32. On the other hand, the length and cross-section of combustion zone 30 should only be fractions of those of chamber 10 so that the bulk of the treatment of carbonaceous charge takes place within bed 20. In general, the ratio of the heights of vessels 10 and 30 may be about 2–10:1, preferably about 8:1, and the ratio of their diameters about 2–10:1, preferably about 5:1.

Spent flue gases are withdrawn overhead from level L_{10} and passed through line 7 to the atmosphere or any desired use, such as heat recovery, aeration, etc., if desired, after separation and return to bed **20**, of entrained solids fines by means of a conventional gas-solids separation system including cyclones and/or electrical precipitators, or the like. Preheated fluidized coal is withdrawn from bed **20** through a conventional standpipe **9** or any other conventional conveying means for fluidized solids and passed substantially at the temperature of bed **20** to any subsequent processing stage such as carbonization, producer or water gas manufacture, etc.

If desired, an extraneous fuel, preferably a fuel gas or fuel oil may be introduced through line **35** into air pipe **5** at a point close to its entrance into combustion zone **30**. This extraneous fuel supply may be so controlled that it consumes substantially all of the oxygen available for combustion leaving the combustible constituents of the carbonaceous solids entering zone **30** unburnt.

It will be understood that the temperature levels at which zone **30** and bed **20** are operated may be substantially higher or lower than those indicated above. For example, zone **30** may be operated at about 400°–600° F. if mere dehydration of the coal in bed **20** at temperatures of 200°–300° F. is desired. On the other hand, the temperature of zone **30** may be raised to 1200°–1500° F. in order to cause carbonization of the carbonaceous charge in bed **20**, or to temperatures in the neighborhood of 2000° F. when it is desired to convert the solids of bed **20** into producer or water gas with the aid of air and/or steam supplied through pipes **16**. Bed **20** may also serve as a zone of mild oxidation at temperature conditions similar to those indicated above for preheating when a suitable amount of oxygen or air is added to the gas supplied through pipes **16**. In all these cases the temperature differential between zone **30** and bed **20** as well as the absolute temperature levels may be additionally controlled by choosing a suitable ratio of fresh carbonaceous solids feed to bed **20** to the combustion rate in zone **30**.

As previously indicated, zone **30** may also be operated as a conversion or treating zone proper such as a carbonization or gasification zone rather than as a mere heat-generating zone. For this purpose, the dimensions of zone **30** are increased in relation to chamber **10** and the linear velocity of the gases flowing through zone **30** is decreased so as to permit the treatment of a more substantial proportion of the total solids charge per unit of time at the conditions of zone **30**. For example, zone **30** may have about ½ the diameter and about ½ the height of chamber **10** and the linear gas velocity within zone **30** may be about 2–4 ft. per second as compared with a gas velocity of about 0.5–1.5 ft. per second in bed **20**, the relative and absolute temperatures in zone **30** and bed **20** being controlled by the supply of oxygen and, preferably, of extraneous fuel, in cooperation with a control of the ratio of fresh solids feed to bed **20** and zone **30**.

The temperature conditions and reactants required for these various conversions are those known in the art and need not be here specifically enumerated. However, it is noted that whenever a substantial amount of condensible volatile products such as tar is produced in zone **30** the vapors of such condensible products should be separated from entrained solids in conventional gas-solids separators, preferably at a temperature close to that of zone **30**, prior to the return of the solids to bed **20** in order to prevent condensation of tar or the like in bed **20**. Whenever zone **30** serves as a conversion zone, the carbonaceous charge is simultaneously dried and preheated and, if desired, mildly oxidized in bed **20**.

In some cases, it may be desirable to heat-insulate zone **30** as indicated at **31** in order to increase the temperature differential between zone **30** and bed **20**. This insulation is of particular value during the starting up period of the process which requires preheating of the fluids supplied through line **5** beyond the ignition temperature of the fuel used in zone **30**.

While I have shown combustion zone **30** as a vertical cylinder and this is the preferred embodiment of my invention, zone **30** may be arranged horizontally or it may have the shape of tube bundles or any other suitable shape without deviating from the spirit of my invention.

It will be understood that my process may be made fully continuous by continuously feeding and withdrawing carbonaceous solids through lines **1** and **9**, respectively, and continuously feeding fluids supporting the invention through line **5**.

My invention will be further illustrated by the following specific example.

Example

In order to preheat two tons per hour, of a bituminous coal of about ⅛ in. average particle size containing about 5% of water and having a plasticizing temperature of about 700° F. and an incipient carbonization temperature of about 750° F., from 60° F. to 600° F. the process of the invention may be carried out at the conditions given below.

Chamber **10**, total height—25 ft.
Chamber **10**, inner diameter—5 ft.
Zone **30**, total height—4 ft.
Zone **30**, inner diameter—1 ft.
Air feed rate—13,200 S. C. F./hr.
Linear gas velocity in zone **30**—10 ft./sec.
Bed density in zone **30**—1.5 lbs./C. F.
Aerating steam inlet temperature—300° F.
Aerating steam feed rate—1,380 lbs./hr.
Linear gas velocity in chamber **10**—1.25 ft./sec.
Bed density in bed **20**—20 lbs./C. F.
Solids circulation rate through zone **30**—7 tons/hr.
Temperature in zone **30**—900° F.
Coal burned—90–130 lbs./hr.

While the foregoing description and exemplary operations have served to illustrate specific applications and results of my invention, other modifications obvious to those skilled in the art are within the scope of my invention. Only such limitations should be imposed on the invention as are indicated in the appended claims.

The present application is a division of Serial No. 699,949 filed September 28, 1946, now Patent No. 2,582,710.

What is claimed is:

1. Apparatus for treating carbonaceous solids which comprises a vertical treating chamber, a horizontal plate in the lower portion of said chamber said plate being provided with orifices adapted to permit the passage of finely divided solids, a second vertical chamber of about ½–$\frac{1}{10}$ the height and ½–$\frac{1}{10}$ the diameter of said first named chamber, arranged within said first named chamber, the lower portion of said second chamber protruding through said plate and opening into the space of said first named chamber below said plate and the upper portion of said second chamber extending above said plate into said treating chamber and opening into said

treating chamber, means for passing a gas upwardly into the lower opening of said second chamber, means arranged above said plate for distributing a gas within said treating chamber above said plate, means for supplying a gas to said treating chamber in a lower portion of the space below said plate, means for supplying finely divided solids to said treating chamber, means for withdrawing finely divided solid from said treating chamber at a point above said plate and means for withdrawing gases carrying entrained solids from an upper portion of said treating chamber.

2. Apparatus as claimed in claim 1 wherein said orifices are adjustable.

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