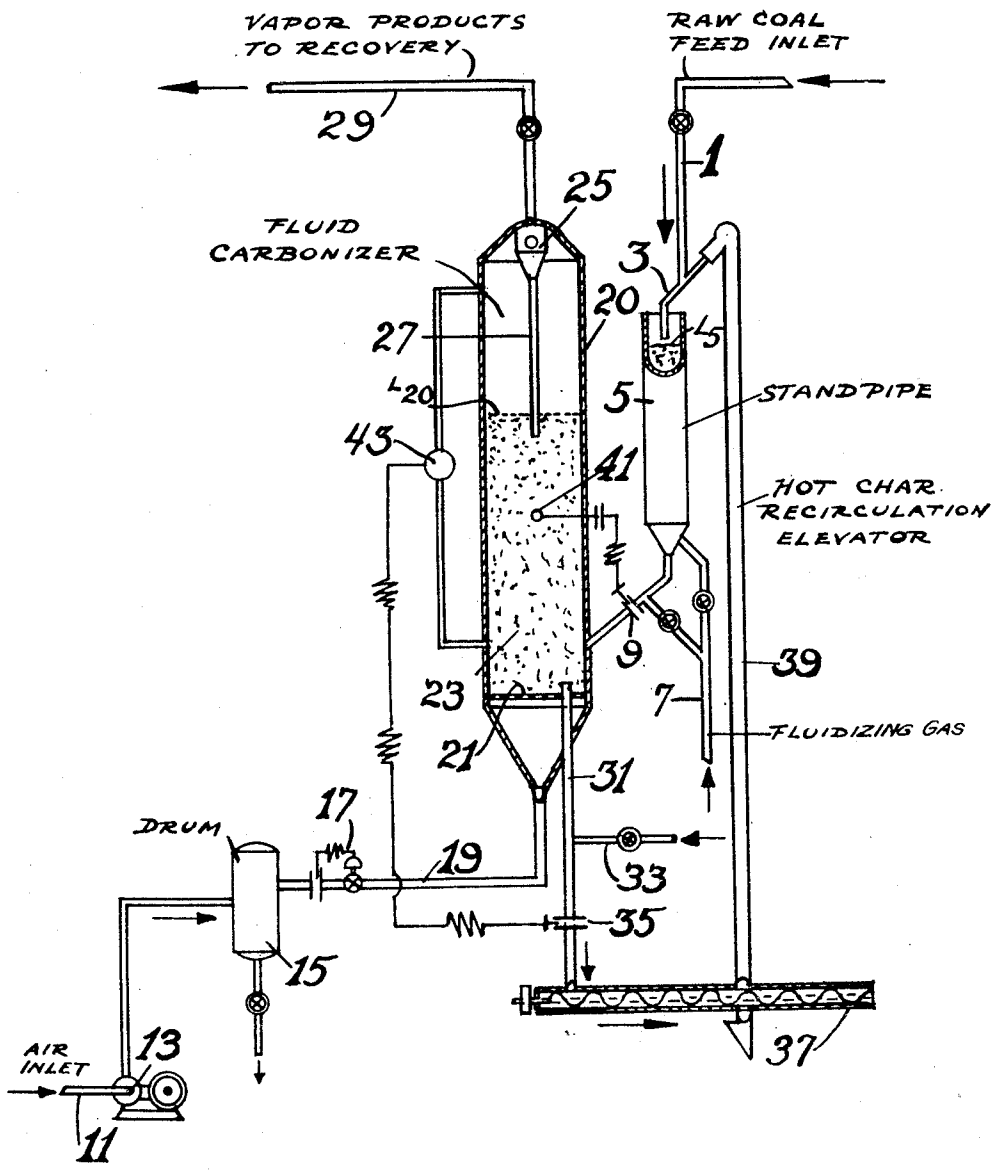
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METHOD FOR FLUIDIZED LOW-TEMPERATURE CARBONIZATION OF COAL

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Karl J. Nelson Inventor

By P. J. Whelan Attorney

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METHOD FOR FLUIDIZED LOW-TEMPERATURE CARBONIZATION OF COAL

Karl J. Nelson, Cranford, N. J., assignor to Standard Oil Development Company, a corporation of Delaware

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4 Claims. (Cl. 202—6)

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The present invention relates to the handling of carbonaceous solids. More particularly, the invention is concerned with the treatment of finely divided carbonaceous solids such as all types of coal, brown coal, lignite, oil shale, tar sands, asphalt, cellulosic materials including lignin, etc., employing the so-called fluid solids technique.

Heretofore, solid carbonaceous materials of the type mentioned above have been normally treated at elevated temperatures in fixed bed operation to form liquid and gaseous fuels such as light oils, tars, coal gas, producer gas and water gas. However, these processes involve either discontinuous operation or inefficient conversion of the available carbon into heat and volatile fuels.

The processes may be made fully continuous by employing the fluid solids technique in which the reactions take place in a dense fluidized bed of finely divided solids maintained in a turbulent ebullient state by means of fluidizing gases. This technique has highly desirable additional advantages including greatly improved heat distribution and efficiency of solids utilization.

However, difficulties have been encountered in handling the finely divided raw material, such as raw coal, as it comes from the cleaning plant. This material normally has a particle size suitable for fluidization i. e. about 8 mesh by zero or 3/8" by zero. When this type of coal is fed to storage hoppers, mechanical feed hoppers, aerated standpipes and the like handling equipment required in fluid solids operation considerable plugging, bridging and packing is experienced as a result of the sticky character of the moist coal which contains usually about 2–10% or more of free water.

One way of removing the moisture content of the coal is drying with air or other gases at elevated temperatures in conventional drying equipment. This adds materially to the investment and operating cost. In addition, the fine coal particles frequently agglomerate during such conventional dehydration treatment and have to be reground prior to fluidization. Furthermore, dehydration by mere heating requires a careful temperature control because effective dehydration temperatures may approach closely the plasticizing temperature of the coal. Thus, it may happen that the attempt to remove one cause of plugging creates another one in the form of a plastic sticky material.

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

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carried out will be fully understood from the following description thereof read with reference to the accompanying drawing.

It is, therefore, the principal object of my invention to provide improved means for handling finely divided carbonaceous solids.

Another object of my invention is to provide means for improving the utility of carbonaceous solids for fluid solids handling.

A further object of my invention is to provide means for drying finely divided carbonaceous solids without affecting their particle size.

A more specific object of my invention is to prepare a dry free-flowing carbonaceous charge for carbonization and gasification operations employing the fluid solids technique.

Other and more specific objects and advantages will appear hereinafter.

In accordance with the present invention the moisture content of finely divided carbonaceous solids is effectively reduced and their stickiness removed by mixing the mass of the moist carbonaceous solid with a moisture-free or "dry" moisture-absorbing solid of fluidizable particle size having a temperature substantially above the boiling point of water at the prevailing pressure.

The effect of this procedure is twofold. Mechanically adhering water is evaporated from the moist material by the transfer of sensible heat from the "dry" hot material. The "dry" material absorbs a substantial proportion of water mechanically adhering to the moist material to bring the average water content of the particles in the solids mixture below that causing stickiness.

The drying effect of the process of my invention is considerably aided and accelerated when applying fluid solids operation to the mixing of fresh feed and "dry" hot material by utilizing the ideal heat transfer and mixing speed in a turbulent ebullient mass of fluidized solids. In this case, relatively short contact times between moist and dry solids, of say about 0.1 to 10 minutes are sufficient to accomplish the desired effect.

My preferred "dry" high temperature solid is low temperature coke or char withdrawn from the fluidized solids bed of a low temperature carbonization process employing the fluid solids technique at temperatures of about 800°–1200° F. This material may be added to the moist fluidized carbonaceous solids substantially at the carbonization temperature without further treatment. For instance, when using a moist coal

of fluidizable particle size containing 5% free moisture at 60° F., about 20–100% by weight of char of a similar particle size having a temperature of about 800°–1200° F. or about 60% by weight of char having a temperature of about 850° F. is sufficient to establish a solids mixture having an average temperature of about 250° F. and being free-flowing.

When using char from the carbonization process substantially at the carbonization temperature as the "dry" solid, the heat balance of the system remains substantially unchanged. Furthermore, an external premixing step of this type leads to a more rapid uniform distribution of the fresh feed in the fluidized solids bed of the carbonizer, because a relatively high degree of premixing of fresh feed with dry nonplastic material having the average composition of the material undergoing carbonization has been accomplished prior to the entry of the fresh feed into the carbonization zone. This may permit a higher fresh feed rate to the carbonizer without the danger of plugging or agglomeration of the fresh feed while passing through the plasticization temperature range which normally lies between about 700° and 800° F.

Other suitable, though less desirable, "dry" solids include externally heated solid adsorbents such as clay, siliceous gels, iron oxides, etc. of fluidizable particle size.

My invention affords greatest advantages when applied to a system for treating fluidized carbonaceous solids wherein the treating conditions of temperature and residence time are maintained constant by maintaining a constant heat supply while controlling the fresh solids feed as a function of the treating temperature and the withdrawal of treated solids as a function of bed height, i. e. residence time as disclosed in my copending application Serial No. 716,408, filed December 14, 1946, for improvements in "Contacting Solids and Fluids." A system of this type requires highest mobility of the solids feed as it is accomplished by the present invention.

Having set forth the general nature and objects, the invention will be best understood from the subsequent more detailed description in which reference will be made to the accompanying drawing which shows a semi-diagrammatic illustration of equipment particularly adapted to carry out a preferred embodiment of my invention.

Referring now to the drawing, the system shown therein essentially comprises a fluidized feed standpipe **5** and a fluid solids treating chamber **20**, the functions and cooperation of which will be presently explained. In the following detailed description reference will be made to the carbonization in chamber **20** of coal supplied through standpipe **5**. It should be understood, however, that other carbonaceous materials and other treatments may be employed in the same or similar systems in a substantially analogous manner.

When applied to the carbonization of a bituminous carbonization coal having a free moisture content of about 2 to 10% and a softening point of about 700° to 800° F. the raw coal having a fluidizable particle size of less than 8 mesh, preferably about 50 to 200 mesh is supplied at atmospheric temperature, say about 60° F., to line **1** by any conventional conveying means. The finely divided raw coal enters line **3** wherein it meets hot dry coke or char supplied from carbonization chamber **20** as will become apparent hereinafter.

The mixture of raw moist coal and hot dry char drops into feed standpipe **5**. Small amounts of a preferably dry fluidizing gas such as dry steam, flue gas, nitrogen, make gas, or the like is supplied through line **7** to the bottom of standpipe **5** at a superficial velocity of about 0.2–10 ft. per second, preferably 0.3 to 2 ft. per second to convert the solids in standpipe **5** into a dense ebullient mass of fluidized solids having a well defined upper level L_5 and exerting a pseudo-hydrostatic pressure on the base of standpipe **5**. The apparent density of the fluidized mass in standpipe **5** may vary between about 10 and 50 lbs. per cu. ft.

The relative amount and temperature of the char are so controlled that the solids mixture in standpipe **5** assumes a temperature of about 150° to 300° F. and is kept in a free-flowing state. Depending on the above mentioned moisture content of the coal, about 0.4–0.9 lb. of char having a temperature of about 850° F. is sufficient for this purpose per lb. of feed coal. It may be desirable to preheat the fluidizing gas supplied through line **7** to a temperature of about 200°–600° F. by a suitable heat exchange with volatile and/or solid carbonization products in any conventional manner.

A free-flowing preheated fluidized mass of raw coal and char flows under the pseudo-hydrostatic pressure of standpipe **5** through a control valve **9** into carbonization chamber **20**. An oxidizing gas such as air and/or oxygen is supplied from line **11** by compressor **13** via a knock-out and surge drum **15** and a flow controller **17** through line **19** to the lower conical portion of carbonizer **20**.

The oxidizing gas enters carbonization zone **23** through a distributing grid **21**. The amount of oxygen supplied should be sufficient to cause a limited combustion of coal constituents adequate to generate at least the major proportion of the heat required for carbonization in zone **23**. About 0.1 to 0.8 lb. of air or a corresponding amount of oxygen per lb. of raw coal is generally sufficient to establish carbonization temperatures of about 800°–1400° F. within zone **23**.

The finely divided coal and coke in zone **23** are fluidized by the flue gases and volatile carbonization products to form a dense turbulent mass of solids resembling a boiling liquid forming a well defined upper level L_{20}. Linear gas velocities within the approximate limits of about 0.3 to 10 ft. per second, preferably 0.3–3 ft. per second are generally suitable to establish a fluidized mass of an apparent density of about 10–60 lbs. per cu. ft. in zone **23** at the particle sizes here involved.

Volatile carbonization products such as coal gas, light oils, tar, etc. pass overhead from level L_{20} through a conventional gas-solids separator such as cyclone **25**. Carbonaceous solids fines separated in cyclone **25** may be returned to zone **23** through pipe **27**. Product vapors and gases substantially free of solids are passed through line **29** to a conventional product recovery system (not shown).

Carbonized solids consisting essentially of "dry" hot char are withdrawn downwardly under the pseudo-hydrostatic pressure of the fluidized bed in zone **23** through a bottom drawoff **31** which may be aerated through one or more taps **33**. The speed of solids withdrawal through pipe **31** is regulated by a slide valve **35**. "Dry" char substantially at the temperature of carbonization zone **23** drops into a conveying means such as a screw conveyor **37** from which it may be passed to cooling means and storage (not shown).

A substantial portion of the hot dry char, which may amount to about 20 to 100% by weight of

fresh coal to be carbonized is diverted from conveyor 37 to a suitable pick-up means such as elevator 39 and hoisted above the upper end of standpipe 5. This hot char then flows into line 3 and from there to standpipe 5 to perform the functions of drying and preheating the raw coal as described above.

In accordance with the preferred modification of this embodiment of my invention, the solids flow through standpipe 5 is controlled by temperature responsive means such as thermocouple 41 arranged in zone 23 and the solids flow through pipe 31 is regulated by level responsive means 43 actuated by level L_{20} while the supply of oxidizing gas through line 19 is maintained substantially constant, as described in greater detail in my copending application mentioned above. In this manner, a perfect automatic control of the operating conditions may be accomplished, no irregularities in the raw coal feed being encountered.

It will be understood that the heat required for carbonization may be supplied by other means than partial combustion within zone 23. For example, the sensible heat of a heating gas heated above carbonization temperature in a separate heater may be employed for this purpose. Heat may also be generated by burning char withdrawn from zone 23 in a separate fluid combustion zone and recirculating hot solid combustion residue to zone 23. Details of these heating methods are disclosed in my copending application identified above.

The process of my present invention may be applied with greatest advantage to a system of the type illustrated in the drawing. Other means of controlling the operating conditions and of conveying the subdivided solids may be used without deviating from the spirit of the invention.

Chamber 20 may serve as a coal preheating or gasification zone by a suitable change of the treating temperatures and the gas supplied through line 19. Preheating may be carried out by merely lowering the temperature within zone 23 to a level below incipient carbonization and coal softening. Water gas may be produced by raising the temperature of zone 23 to about 1500° F.–2500° F. and introducing an amount of steam through line 19 sufficient to support the desired conversion of carbon into CO and H_2. Other modifications of my invention will occur to those skilled in the art.

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

Example

Operating conditions for the carbonization of Pittsburgh seam-bituminous coal containing 5% free moisture without plugging of the carbonizer and feeding device in a system of the type illustrated in the drawing may be chosen as given below:

Carbonizer temperature ____ °F__	900
Raw coal rate to feed standpipe___lbs./hr__	2000
Raw coal temperature ____°F__	60
Raw coal particle size:	
On 8 mesh ____per cent__	0.2
On 14 mesh ____do____	22.2
On 48 mesh ____do____	77.2
On 100 mesh ____do____	88.8
On 200 mesh ____do____	96.2
Through 200 mesh ____do____	3.8
Air to carbonizer (at 150° F.)___S. C. F. M__	175
Superficial gas velocity in carbonizer ft./sec__	3

Solids concentration in carbonizer bed lbs./cu. ft__	13
Char withdrawn through bottom drawoff lbs./hr__	2640
Char to feed standpipe (at 875° F.) lbs./hr__	1200
Temperature in feed standpipe____° F__	250
Superficial velocity of flue gas (at 250° F.) in standpipe ____ft./sec__	1
Solids concentration in feed standpipe lbs./cu. ft__	30
Average solids residence time in feed standpipe ____min__	1
Average moisture content of solids supplied to carbonizer ____per cent__	0.7

The foregoing description and exemplary operations have served to illustrate specific applications and results of my invention. However, 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.

I claim:

1. In the low temperature carbonization of subdivided bituminous coal at carbonization temperatures of about 800°–1200° F. in the form of a dense turbulent fluidized mass maintained at said carbonization temperatures in a carbonization zone by burning a portion of said coal in said carbonization zone, the improvement which comprises maintaining the bituminous coal to be carbonized as a dense turbulent fluidized mass of solids having a fluidizable particle size in a drying zone at a drying temperature, withdrawing substantially dry moisture-absorbing fluidizable char having a particle size similar to that of said bituminous coal downwardly from said carbonization zone, adding said withdrawn char to said drying zone substantially at said carbonization temperature, said added char supplying in the form of sensible heat of solids substantially all the heat required for drying, and supplying a fluidized mixture of bituminous coal and char from said drying zone to said carbonization zone.

2. The process of claim 1 wherein said mixture is supplied from said drying zone to said carbonization zone under the pseudo-hydrostatic pressure of said fluidized mass in said drying zone.

3. The process of claim 1 wherein the temperature of said char added to said drying zone is about 800°–1200° F., the amount of dry char added to said drying zone is about 20–100% by weight of said subdivided bitminous coal, and the time of contact between the solids charged to said drying zone is about 0.5 to 60 minutes.

4. The process of claim 1 wherein the supply of solids from said drying zone to said carbonization zone is controlled by the temperature of said carbonization zone.

KARL J. NELSON.

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