

[54] MULTI-STAGE FLUIDIZED BED COAL GASIFICATION APPARATUS AND PROCESS

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[58] Field of Search..... 48/197 R, 202, 203, 206, 48/63, 64, 78, 101

[57] ABSTRACT

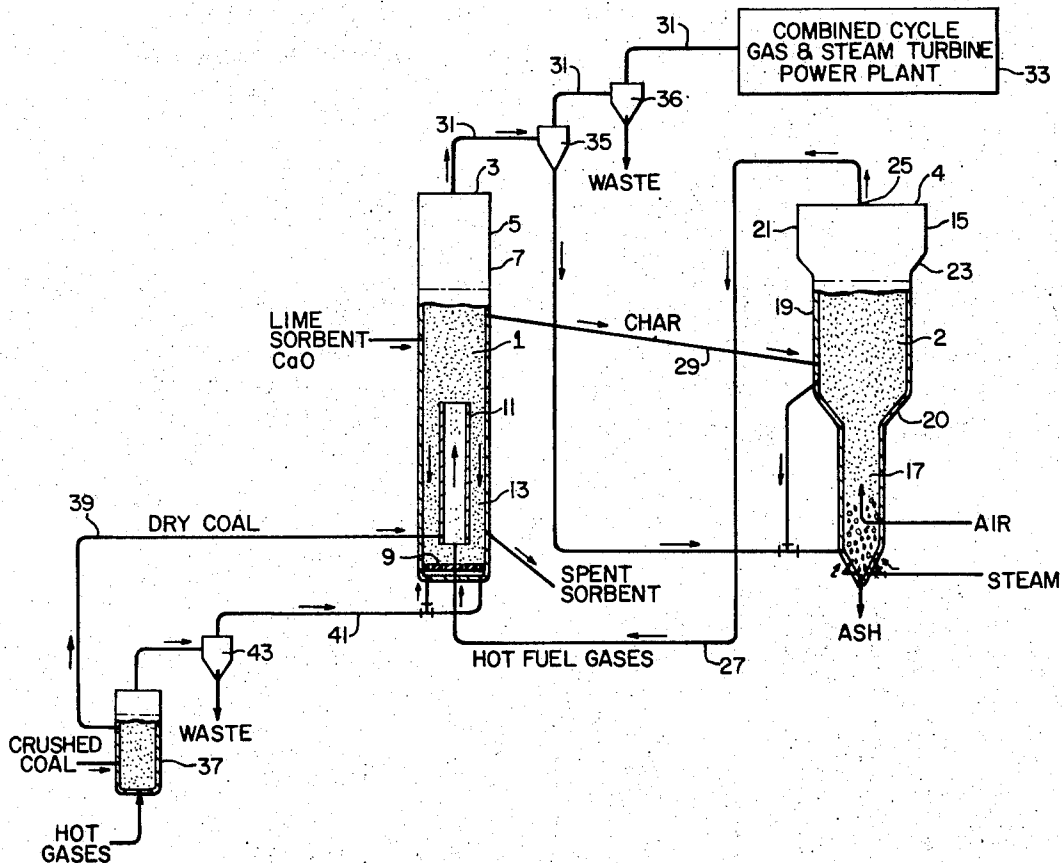
Apparatus and process for totally gasifying coal to form a gaseous fuel having a low sulfur content utilizing two fluidized beds, the first fluidized bed providing devolatilization and having a tubular member disposed therein in an upright position wherein coal is mixed with recirculated char and dolomite or lime to remove the sulfur and a second fluidized bed utilized to totally gasify the char from the first fluidized bed to produce a low BTU fuel gas low in sulfur content.

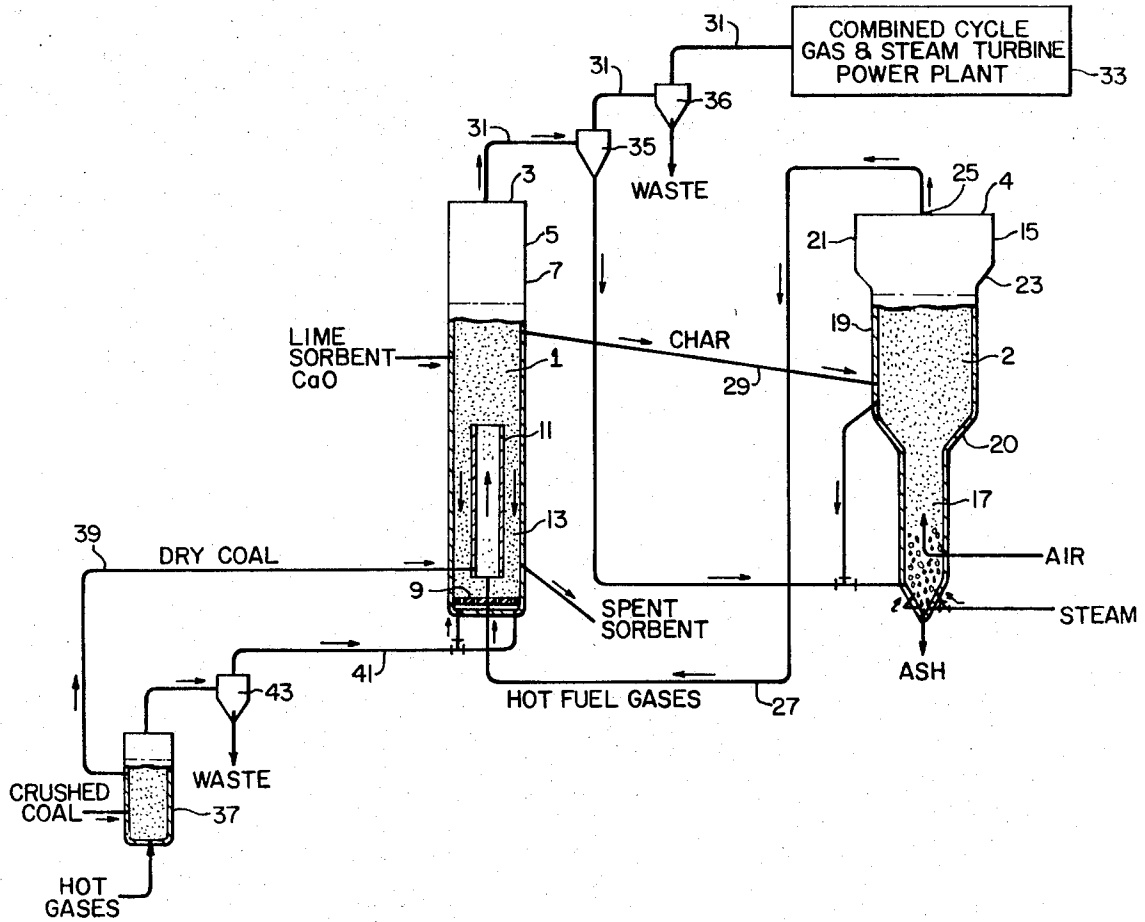
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11 Claims, 1 Drawing Figure





MULTI-STAGE FLUIDIZED BED COAL GASIFICATION APPARATUS AND PROCESS

BACKGROUND OF THE INVENTION

This invention relates to a system for desulfurizing and gasifying coal and more particularly to a system for producing a fuel gas having a low sulfur content.

Fossil fuel electrical power plants contribute approximately one-half of the sulfur dioxide, one-fourth of the nitrogen oxygen compounds, and one-half of the particulate pollutants to the environment of the United States. Thus, there have been several attempts to reduce the emission of such pollutants from the exhaust stacks of fossil fuel electrical power plants.

One approach has been to clean the exhaust gases utilizing electrostatic precipitators for particulate removal, catalytic converters to convert the sulfur dioxide to sulfur trioxide and then scrubbers to remove the sulfur trioxide. While this process does an excellent job of removing sulfur dioxide and particulate material it removes only a small portion of the nitrogen oxygen compounds. Since one of the by-products of this process is weak sulfuric acid, thus, the equipment utilized in such a process must be made of high alloy materials which result in an extremely high initial cost and high maintenance costs.

Another approach is to clean the gases during combustion by adding lime to the burning fuel in the combustion portion of the fire box of the boiler, however, this process does nothing to reduce the emission of particulate material.

Still another approach, which cleans the gases during the burning of the fuel includes adding lime to a fluidized bed of burning coal to remove sulfur and reduce the nitrogen oxygen compounds. These processes can be combined with partial gasification of coal. Char particles are produced in the gasification process and these are burned in a boiler to produce steam. For additional information on such a process, reference may be made to U.S. Pat. No. 3,481,834. The process described herein is an improvement on the process described in an earlier application by David H. Archer and Lee E. Brecher having the Ser. No. 216,950, filed Jan. 11, 1972 and now U.S. Pat. No. 3,804,606.

SUMMARY OF THE INVENTION

In general, a process and apparatus for completely gasifying coal to produce a fuel gas having a low sulfur content comprises utilizing apparatus having a first portion for devolatilizing coal resulting in the production of char, a second portion for totally gasifying the char and separating ash therefrom, the first and second portions having means disposed therein for fluidizing particulate matter supplied thereto, and conduit means connecting the first and second portions to transfer products therebetween. The first portion has a tubular portion generally disposed within the lower section thereof, means for supplying coal to the inside of the tubular portion and means for supplying hot gases from the second portion to the inside of the tubular portion. The tubular member is disposed above the lower end of the first portion whereby the influent coal flows upwardly in the tubular member becoming devolatilized to form char the char flows downwardly along the outside of the tubular member and is recirculated and mixed with the influent coal and again flows upwardly through the tubular member. A sulfur absorbing mate-

rial may be mixed with the char to remove sulfur from the fuel gas produced thereby.

BRIEF DESCRIPTION OF THE DRAWING

The objects and advantages of this invention will become more apparent from reading the following detailed description in connection with the accompanying drawing, in which the sole FIGURE is a flow diagram of a system for producing fuel gas having a low sulfur content from coal having a high sulfur content.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing in detail, there is shown a system and apparatus for producing a desulfurized gaseous fuel from coal having a high sulfur content utilizing two fluidized beds 1 and 2.

The fluidized beds 1 and 2 are disposed in vessels 3 and 4, respectively.

The first vessel or portion 3 of the system comprises a vertical shell 5 having a cylindrical wall 7. A grate or distribution plate 9 is disposed adjacent the lower end thereof. A tubular member or sleeve 11 is centrally disposed adjacent the lower portion of the vessel 3 and extends upwardly therefrom approximately one-half the height of the first fluidized bed 1. The tubular member 11 is generally cylindrical in shape, thus, forming an annular chamber or compartment 13 between the cylindrical wall 7 and the tubular member 11.

The second vessel 4 is formed from a shell 15 having a plurality of cylindrical wall sections which increase in diameter from bottom to top. A smaller diameter or lower section 17 has means disposed therein for removing ash. A central portion 19 is disposed above the lower portion 17 and a frustoconical portion 20 forms a transition member for the two sections. An upper section 21 is connected to the central portion 19 by a frustoconical transition member 23.

A hot fuel gas outlet nozzle 25 is centrally disposed in the upper section 21. A hot fuel gas conduit 27 extends from the nozzle 25 to the lower portion of the first vessel 3 where it supplies hot fuel gas to the lower end of the tubular member 11.

A char conduit 29 is disposed in fluid communication with the upper portion of the first fluidized bed 1 and the central portion 19 of the second vessel 4.

A fuel gas conduit 31 is disposed in fluid communication with the first vessel 3 and a combined cycle gas and steam turbine power generating unit 33 represented by a box. For more complete details of a process as described herein utilized with a combined cycle steam and gas turbine power plant, reference may be made to an earlier application assigned to the same assignee and given Ser. No. 216,950 when filed Jan. 11, 1972 and now U.S. Pat. No. 3,804,606. The aforementioned application is hereby incorporated by reference into this specification.

Two cyclone separators 35 and 36 are disposed in series in the conduit 31 to remove particulate material from the hot fuel gas being supplied to the combined cycling steam and gas turbine power plant 33.

Coal is crushed to a predetermined size by a coal crusher (not shown) and is fed to a dryer 37 wherein hot gases from some heat source, such as the exhaust of a gas turbine, are passed over the crushed coal to dry it. A dry coal conduit 39 is disposed in fluid communication with the dryer 37 and the inside of the tubular

member 11. An effluent drying gas conduit 41 is disposed in fluid communication with the dryer and the first fluidized bed 1 so as to supply a gaseous fluid to the annular chamber 13 surrounding the tubular member 11 to fluidize the particulate material disposed therein.

A cyclone separator 43 is disposed in the conduit 41 to remove particulate material therefrom.

The operation of the system or process is as follows:

Crushed coal is dried in the dryer 37 and transported by a conduit 39 to the first fluidized bed 1. Here devolatilization and desulfurization and partial hydrogasification functions are combined into a single recirculating fluidized bed reactor which operates at a temperature of between 1,300° to 1,700°F. The dried coal is supplied to the inside of the central tubular member 11 where it is mixed with large quantities of recirculated particulate matter, char and a sulfur absorbing material such as lime or dolomite. The mixture is carried upwardly through the tubular member 11 at velocities generally greater than 15 ft. per second. The recycle solids, char and sulfur absorbing material, are needed to dilute the coal supplied to the tubular member to temper the hot influent gases and prevent agglomeration of the coal as it is being devolatilized. In the central tubular member 11 the recycle solids flow at rates up to and above 100 times the rate at which coal is fed thereto in order to efficiently prevent and/or control agglomeration of the coal as it is devolatilized and passes through plastic and sticky phases. The sulfur absorbent is added to the fluidized bed to remove sulfur which is generally present in the process in the form of hydrogen sulfide H₂S. Alternately, separate desulfurization could be utilized, that is, the fuel gas could be cleaned at high temperature in a separate fluidized bed of calcium bearing materials such as lime or dolomite or by utilizing some other sulfur absorbing material.

However, in the process described herein, the sulfur absorbing material is added to the upper portion of the first fluidized bed and removed from the first fluidized bed at the lower portion in the form of calcium sulfide, CaS.

Char and devolatilized coal are withdrawn from the upper portion of the first fluidized bed 1 and transmitted to the second fluidized bed 2 via the conduit 29.

The second fluidized bed 2 performs the final gasification stages of the low sulfur char. In the lower portion 17 of the second vessel 4 air and steam are supplied to the char burning the char and producing a temperature of approximately 2,100°F and the heat for gasification in the other portions of the second fluidized bed 2. This lower portion of the second fluidized bed 2 may be referred to as the combustion zone. Heat produced in the combustion zone flows upwardly within the fluidized bed due to the upward flow of the combustion gases and solids which move upwardly with these gases. The ash being at an elevated temperature agglomerates and separates from the upwardly flowing particulate matter, thus settling to the bottom of the second vessel 4 and is removed therefrom.

Due to the heat flowing to the upper portion of the second fluidized bed, the temperature rises to approximately 1,800° to 2,000°F causing the char to react with air and steam to produce further gasification, resulting in the formation of a low BTU fuel gas. The hot fuel gas, and some particulate material, if necessary, are

transported via conduit 27 to the first fluidized bed to raise the temperature to approximately 1,300° to 1,700°F, thus providing the heat necessary for devolatilizing and desulfurizing the coal supplied to the first fluidized bed 1. The hot gases leaving the first fluidized bed are a low BTU fuel gas having a low sulfur content, the heating value, however, is sufficient to operate a combined cycle gas and steam turbine power plant.

The system hereinbefore described advantageously utilizes a wide variety of fuels as it will operate with caking coals or coals with high ash content without costly and inefficient pretreatment due to the fact that the high recirculation during the devolatilizing portion of the process prevents agglomeration of the coal.

The size of the coal particles is not critical as the fluidized beds enable the use of fines in the process.

The process produces high heat economy due to the countercurrent movement of gases and solids between the various stages. The long residence time in each stage or zone produces high carbon conversion with good temperature control in each of the fluidized beds.

The agglomerating of ash in the second fluidized bed results in ash with a low carbon content.

The use of lime or dolomite to remove sulfur produces a generally sulfur free fuel gas and by utilizing this hot fuel gas in a gas turbine, the heat energy in the hot fuel gas is efficiently changed to useful work.

What is claimed is:

1. Apparatus for completely gasifying coal to provide a gaseous fuel, said apparatus comprising means for devolatilizing coal resulting in the production of char, separate means for totally gasifying the char and separating ash therefrom, said devolatilizing and gasifying means having means disposed therein for fluidizing particulate materials supplied thereto, conduit means connecting said devolatilizing and gasifying means to transfer products therebetween, said devolatilizing means having a tubular member completely immersed in the fluidized particulate material therein, said tubular member being in a substantially upright position to form an annular chamber with said devolatilizing means means for supplying coal to the inside of said tubular member, means for supplying hot gases from said gasifying means to the inside of said tubular member, said tubular member being disposed above the lower end of the devolatilizing means, whereby the influent coal flows upwardly in said tubular member becoming devolatilized to form char, the char flowing downwardly along the outside of the tubular member in said annular chamber and being mixed with the influent coal as said coal flows upwardly within said tubular member to prevent agglomeration of the influent coal.

2. Apparatus as set forth in claim 1 and further comprising means for supplying a sulfur absorbing material to said devolatilizing means above said tubular members, whereby the sulfur absorbing material mixes with the char and flows downwardly with the char along the outside of said tubular member in said annular chamber and then with the char and coal flows upwardly through said tubular member.

3. Apparatus as set forth in claim 2, wherein the devolatilizing means has an outer cylindrical wall and the tubular member is a cylindrical sleeve centrally disposed within the cylindrical wall to form said annular

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chamber between the tubular member and the cylindrical wall.

4. Apparatus as set forth in claim 2, wherein the devolatilizing means has a grate disposed at the lower end thereof and the tubular member is disposed above the grate.

5. A process for totally gasifying coal to form a gaseous fuel utilizing a first and second fluidized bed the first fluidized bed having a tubular member completely immersed therein, said tubular member being in a substantially upright position to form an annular chamber within said first fluidized bed wherein influent coal is mixed with recirculated char, said process comprising the steps of:

- crushing the coal to a predetermined size,
- drying the crushed coal,
- supplying the coal to the tubular member,
- mixing said coal with a quantity of char sufficient to prevent the agglomeration of said coal in said tubular member,
- transferring char from said first fluidized bed to said second fluidized bed,
- supplying steam and oxygen to said second fluidized bed to totally gasify the char to produce a hot fuel gas.

6. A process as set forth in claim 5 and further comprising the step of adding a sulfur absorbing material to

the first fluidized bed above said tubular member so as to cause it to mix with said char.

7. A process as set forth in claim 6 and further comprising the step of transferring the hot fuel gas produced by the second fluidized bed to the tubular member of the first fluidized bed.

8. A process as set forth in claim 7 and further comprising the steps of utilizing hot gas to dry the coal and transferring effluent gas from the coal dryer to said annular portion of said first fluidized bed surrounding the tubular member.

9. A process as set forth in claim 8, wherein the step of mixing the coal with a quantity of char sufficient to prevent agglomerating the coal and sulfur absorbing material includes recirculating the char and said sulfur absorbing material at such a rate that it greatly exceeds the rate at which coal is supplied to the tubular member.

10. A process as set forth in claim 9 and further comprising the step of removing spent sulfur absorbing material from the lower portion of the first fluidized bed.

11. A process as set forth in claim 9 and further comprising the step of removing ash from the lower portion of the second fluidized bed.

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