APPARATUS AND METHOD FOR GENERATING HEAT

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References Cited
UNITED STATES PATENTS
2,818,049 12/1957 Blaskowski .................. 122/4 X
3,717,700 2/1973 Robinson et al. .............. 110/1 X

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ABSTRACT

An apparatus and method for generating heat in which a particulate fossil fuel material and a solid absorbent material are passed into a chamber and are fluidized by passing air through the chamber. The portion of fuel material entrained in the air passing through the material is directed to, and is fluidized in, a second chamber. The sulphated sorbent from the first chamber is passed to the second chamber and is desulphated therein before being passed back to the first chamber.

3 Claims, 1 Drawing Figure
APPARATUS AND METHOD FOR GENERATING HEAT

BACKGROUND OF THE INVENTION

This invention relates to an apparatus and method for generating heat and, more particularly, to such an apparatus and method utilizing a plurality of stacked fluidized beds to form a heat exchanger.

The use of fluidized beds has long been recognized as an advantageous way of generating heat, such as in the use of heat exchangers or the like in which steam is generated from water passing in a heat exchange relation to the fluidized beds. The bed usually consists of particulate fuel, such as coal, and is fluidized by passing air through the fuel to promote the combustion thereof. The advantages of this type of arrangement include an improved heat transfer rate, a reduction in corrosion, a reduction in boiler fouling, an increase in combustion efficiency, a lower combustion temperature and a reduction in boiler size.

In U.S. patent application Ser. No. 324,041, filed Jan. 16, 1973, and assigned to the same assignee of the present application, with a co-inventor of the instant application being a co-inventor of the above application, a vapor generator is disclosed in which a plurality of fluidized beds are arranged in a stacked manner which enables a relatively large range of heat transfer to be obtained, yet otherwise enjoys the other advantages of the fluidized beds set forth above. The disclosure of this application is hereby incorporated by reference.

In some of the prior art arrangements mentioned above, as well as in the above-mentioned application, a sorbent, such as limestone or dolomite, is added to the particulate fuel in the fluidized beds to absorb the sulphur released during combustion in the beds for the purpose of minimizing the polluting effect of the sulphur. The sulphated sorbent thus formed is passed to an external sorbent regenerator in which the sulphur is recovered, with the regenerated sorbent formed in the regenerator being passed back into the fluidized beds for further use. Although these type arrangements are successful in reducing the polluting effect of the sulphur, it can be appreciated that the provision of a separate sorbent regenerator located externally of the main heat exchanger is relatively expensive and considerably adds to the costs of the overall system.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a heat generating apparatus and method in which the necessity of a separate sorbent regenerator is eliminated, yet which enables the sulphur to be absorbed from the combustion gases and recovered separately.

It is a further object of the present invention to provide an apparatus and method of the above type in which the sulphated sorbent is desulphated in a fluidized bed disposed in the main heat exchanger housing adjacent the other fluidized beds.

Toward the fulfillment of these and other objects, the apparatus of the present invention comprises means defining a first chamber, means for passing a particulate solid fuel material and a sorbent material for the sulphur dioxide produced upon combustion of said fuel material into said first chamber, means for passing air through said first chamber to fluidize said materials and promote the combustion of said fuel material, a portion of said fuel material being entrained in the air passing through said chamber, means for separating said portion of fuel material from said air and directing said portion of fuel material to a second chamber, means for passing air through said second chamber to fluidize said portion of fuel material, means for passing the sulphated sorbent from said first chamber to said second chamber to regenerate said sulphated sorbent, and means for passing said regenerated sorbent to said first chamber.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a partial schematic, partial sectional, view depicting the apparatus and method of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring specifically to the drawing, the reference numeral 10 refers in general to a housing having several openings for the passage of air therethrough and for receiving pipes as will be described in detail later. An enclosure 12 is defined within the housing and comprises a front wall 14 and a rear wall 16 shown in cross section, with each wall being formed by a plurality of finned tubes welded together in a conventional manner and extending for the entire length of the wall. A pair of side walls are also provided but are not shown in the drawings for the convenience of presentation.

A plurality of air distribution plates 20 are disposed in a spaced relationship in the enclosure 12 to divide the enclosure into a plurality of vertically stacked chambers, or compartments. Since the five upper compartments are identical, they are each referred to by the reference numeral 22, with the lowermost compartment being slightly different from the compartments 22 and being referred to by the reference numeral 24.

A mixture of particulate fuel and sorbent is injected into each compartment 22 via a feed line 26 extending through suitable openings provided in the housing 10 and the wall 16, and passing through the distributor plate 20 associated with each compartment 22. The lines 26 are adapted to receive the particulate fuel and sorbent from a source, such as a pneumatic feeder, which has not been shown in the drawing for the sake of simplicity.

The fuel material is preferably in the form of a fossil fuel, such as high sulphur bituminous coal, while the particulate sorbent material is preferably in the form of limestone or dolomite.

Air from an external source is passed into the housing 10 via an inlet 30 and is passed in a direction shown by the dashed arrows to the area defined between the front wall 14 of the enclosure 12 and the corresponding wall of the housing 10, whereby it is separated into six separate streams and passed through a damper 32 into an air plenum chamber 34 extending below each distribution plate 20.

As a result, the bed of particulate material in each compartment 22 is fluidized, with the velocity and rate of flow of the air passing through the beds being regulated so that it is high enough to fluidize the particulate fuel and to obtain economical burning or heat release rates per unit of area bed, yet is low enough to avoid the loss of too many fine fuel particles from the bed and
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3 to allow sufficient residence time of gases for sulphur removal by the sorbent material.

The heated air, after passing through the fluidized beds, discharges as combustion gases through outlets 36 provided in the rear wall 16, as shown by the dashed arrows, where it flows into a duct 38 disposed to the rear of the wall 16 and extending for substantially the entire length thereof. The gases are directed from the chamber 38 through a duct 40 and to a cyclone type dust collector 42 which removes the fine coal particles entrained in the gases. It is understood that the gases with the fines thus removed are then passed, via a duct, through an air heater (not shown) which is adapted to pass the relatively warm air and gas in a heat exchange relationship with the air entering the system to preheat the latter air before it is passed into the housing 10 through the inlet 30, as disclosed and described in detail in the above-mentioned patent application.

After being separated out of the combustion air stream by the dust collector 42, the fine particles, which largely consist of fragments of the unburned fuel material and sorbent material, are directed to a dust hopper 44 and then into an injector 46 which injects the particles back into the compartment 24. The fine particles in the compartment 24 are fluidized by air passing into this compartment through a damper 32 and an air plenum chamber 34 associated therewith to promote combustion of the fuel material in a similar manner to that described in connection with the fuel material in the compartments 22. The combustion gases exit from the compartment 24 through its outlet 36 and into a duct 50 adjacent the chamber 38 whereby they are directed to a separate cyclone 43 for removal of particulates entrained in the air and combustion gases leaving compartment 24. The air and combustion gases are then directed to a treatment facility (not shown) for removal of sulphur pollutants therefrom.

A tube bundle 52 is disposed in each fluidized bed in the compartments 22. Although each tube bundle 52 is represented by only a single tube in the drawing, it is understood that each tube bundle consists of a plurality of juxtaposed tubes extending across the entire width of the enclosure 12. Although not shown in the drawing, it is understood that the tube bundles are connected by means of feeder tubes, downcomers, etc., in a manner to direct the fluid to be heated through the respective beds in a sequence determined by their respective connections. For example, the tube bundle 52 disposed in the lower two compartments 22 could be connected in series, with one of same adapted to receive the heat exchange fluid at a predetermined temperature, and the other adapted to discharge the fluid to another stage of the system after it is heated further in the tube bundles. The other tube bundles 52 in the remaining compartments 22 could be individually connected to a steam turbine or adapted for use for reheating, all in accordance with the specific disclosure of the above-identified application.

Although also not shown in the drawing, it is understood that an additional series of tubes can be provided in the enclosure 12 that extend for the entire length thereof in a serpentine relationship to form a plurality of banks respectively disposed in the compartments 22 above each tube bundle 56 to enable the water passing into the system to be preheated before being passed through the fin tube walls and the tube bundles 52, as also disclosed in the above-identified application.

As stated above, a sorbent, in particulate form, is added to the fuel material in each bed to absorb the sulphur from the combustion gases. With limestone, or calcium oxide being taken as an example of one type of sorbent, the calcium oxide would react with the sulphur in the combustion process to produce calcium sulphate. According to one of the main features of the present invention, the calcium sulphate is transferred from each bed via a plurality of pipes 54 extending from the compartments 22 to a vertically extending distribution pipe 56 connected to the pipes 54. From the pipe 56, the calcium sulphate is transferred, via a pipe 58, to the particulate bed disposed in the compartment 24. In the compartment 24, the coal particles supplied to the bed via the injector 46 are combusted to provide reducing gas to convert the calcium sulphate in accordance with the following reaction:

\[
\text{CaSO}_4 + \left( \frac{\text{CO}_2}{\text{H}_2} \right) \rightarrow \text{CaO} + \text{SO}_2 + \left( \frac{\text{CO}_2}{\text{H}_2O} \right)
\]

The sulphur dioxide gas thus generated in the compartment in accordance with the above is passed, via a flue 50, out of the enclosure 12 for further processing, whereby it can be converted to pure sulphur, or to sulphuric acid, or the like, in accordance with known processes.

The regenerated calcium oxide formed in the compartment 24 is passed, via a pipe 60, to a vertical distributor pipe 62 and, from the latter, through a plurality of individual pipes 64 into each fluidized bed disposed in the compartments 22. As a result, the calcium oxide can again be utilized to absorb the sulphur dioxide particles from the combustion gases in each bed, as described above.

It is understood that the above transfers of material to and from the various beds can be done in accordance with conventional methods, such as pneumatic injection, etc., using standard equipment such as overflow pipes with level controls, etc.

As a result of the foregoing, separate units for combusting the particles from the cyclone separator 42 and for regenerating the sorbent are eliminated since both of these functions are carried out in the compartment 24.

Although the present invention has been described in connection with a system in which the beds are fluidized by atmospheric air, it is understood that it also is applicable to a system in which the beds are fluidized by pressurized air. As an example of the latter system, reference is made to U.S. patent application Ser. No. 382,404, filed July 25, 1973, now U.S. Pat. No. 3,863,606 and assigned to the same assignee as the present invention. A co-inventor of this application is a co-inventor of the instant application, and the application is hereby incorporated by reference.

Of course, variations of the specific construction and arrangement of the apparatus and method disclosed above can be made by those skilled in the art without departing from the invention as defined in the appended claims.

What is claimed is:

1. An apparatus for generating heat, comprising a housing, means for establishing a series of vertically aligned fluidized beds of particulate material in said housing, said material including a sulfur containing fuel
and a sorbent for said sulfur, said fuel being combusted and said sorbent being sulfated in said beds, means for establishing an additional fluidized bed of particulate fuel material in said housing in vertical alignment with said series of fluidized beds, means for receiving the combustion gases from said series of beds and separating the gases from any of said particulate material entrained therein, first conduit means for passing said separated particulate material to said additional fluidized bed, second conduit means connecting each of said series of fluidized beds to said additional bed for passing the sulfated sorbent from said series of beds to said additional bed, said sulfated sorbent being desulfated in said additional bed to form a sulfur enriched gas, and means for passing said gas from said housing.

2. The apparatus of claim 1 further comprising means for passing the desulfated sorbent from said additional bed to said series of beds.

3. The apparatus of claim 1 further comprising means for passing a heat exchange medium successively through said chambers in a heat exchange relation thereto to gradually raise the temperature of said medium.

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