

[72] Inventor **John W. Bishop**
Alexandria, Va.
 [21] Appl. No. **860,563**
 [22] Filed **Sept. 24, 1969**
 [45] Patented **Feb. 23, 1971**
 [73] Assignee **the United States of America as represented**
by the Secretary of the Interior

[56]

References Cited

UNITED STATES PATENTS

2,871,004	1/1959	Gorin	110/28X
2,976,853	3/1961	Hunter et al.	122/4
3,397,657	8/1968	Tada	110/28X

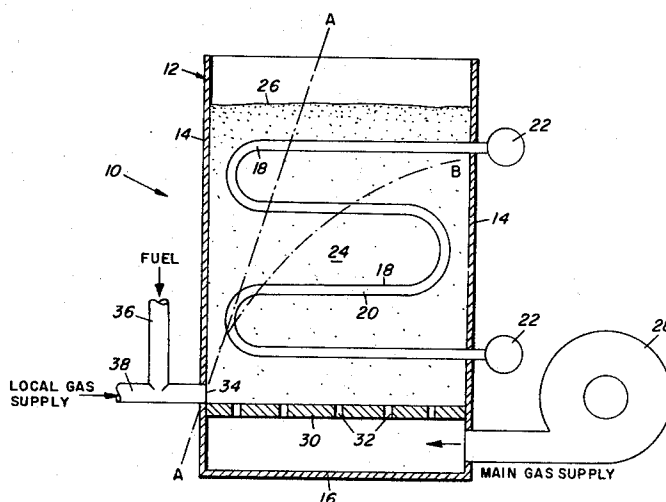
Primary Examiner—Edward G. Favors

Attorneys—Ernest S. Cohen and Albert A. Kashinski

[54] METHOD FOR REGULATING HEAT OUTPUT FROM AN OXIDIZING FLUIDIZED BED 11 Claims, 1 Drawing Fig.

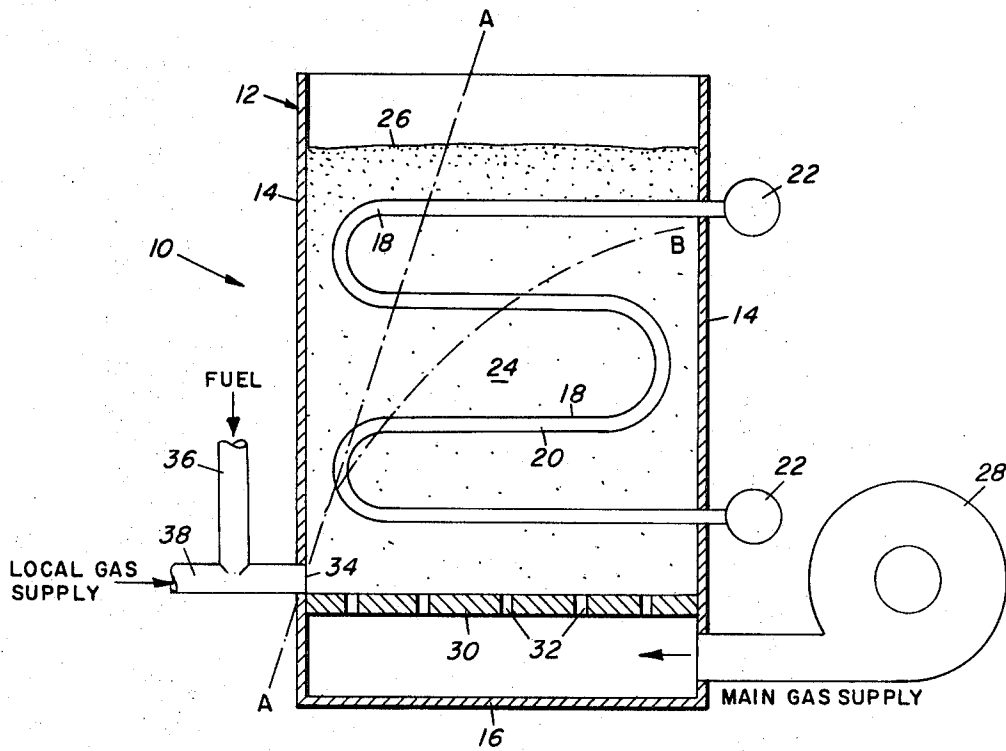
[52] U.S. Cl. **110/28,**
122/4
 [51] Int. Cl. **F23d 19/02**
 [50] Field of Search. **110/28;**
122/4

ABSTRACT: Gas is injected into a localized area in an oxidizing fluidized bed boiler to fluidize a portion of the bed. By varying the relative pressures and flow rates of the locally injected gas supply and the main fluidizing gas supply a selected portion of the bed is fluidized, while the remainder of the bed remains in a static condition. Fuel distribution and combustion are restricted to the fluidized portion of the bed, making possible a wide range of thermal output variation.



PATENTED FEB 23 1971

3,565,022



INVENTOR
JOHN W. BISHOP

BY *Ernest S. Cohen*

ATTORNEYS

METHOD FOR REGULATING HEAT OUTPUT FROM AN OXIDIZING FLUIDIZED BED

BACKGROUND OF THE INVENTION

This invention relates generally to fluidized beds, and more particularly to a method for regulating the rate of fuel consumption and heat output from oxidizing fluidized beds.

Simply stated, a fluidized bed consists of a mass of discrete particles suspended within a walled enclosure by a flowing stream of fluid, which enters the enclosure through a porous bottom surface. As the fluid, which may be a liquid or gas, passes upward through the bed, individual particles are suspended in the stream and disengaged from one another. Mobility of the particles within the bed is enhanced, so that the mass of fluidized particles resembles a high viscosity liquid. The fluidized particulate suspension obtained by this process is useful in a wide variety of chemical and industrial processes.

Recently developed fluidized bed boilers employ oxidizing fluidized beds for heat generation. A bed of inert granular material is supported in contact with heat exchange surfaces by a stream of air within the boiler. When the fluidized bed is heated above a critical ignition temperature and is supplied with a mixture of air and coal, intense combustion occurs within the bed. High heat releases, and heat transfer direct from the bed material to the heat exchange surfaces enhance the efficiency of the boiler, reducing the boiler dimensions required for a specified thermal output, in comparison with more conventional boiler designs.

Although heat exchange efficiency is inherent in the operation of oxidizing fluidized bed boilers, a relatively narrow range for variation of fuel consumption and heat output in each individual boiler has impeded their general commercial acceptance. Previously, it was necessary to operate the oxidizing fluidized bed near the maximum output, or, alternatively, to completely shut the bed down. This all-or-nothing operation made inefficient use of fuel and lacked the output flexibility available from conventional boilers. Partitioned beds, the sections of which were operable individually or in groups, were investigated in attempts to provide additional discrete steps in the operation of fluidized bed boilers. However, the turndown ratio continued to be limited by the operational limits of each individual bed section.

SUMMARY OF THE INVENTION

This invention is a method for improving the turndown ratio of oxidizing fluidized beds. It is based upon the determination that selective fluidization of a portion of a bed can be achieved under carefully controlled operating conditions. By varying the size of the fluidized portion, the amount of combustion within the bed can be regulated over a wide range.

When a fluidizing gas, such as air, is directed upward from a distribution grid and through a particulate bed, the bed remains in a static condition until the gas velocity is sufficient to fluidize the smallest, lightest fraction of the particulate. At this gas velocity the smaller particles rise to the top of the bed in a fluidized state, while the larger particles remain in static condition below them. If a localized stream of gas, such as air or fluegas, is injected in combination with the main fluidizing gas supply at a point within the static lower portion of the bed, with sufficient pressure and flow rate to overcome the static resistance of the bed, fluidization of the larger particles results in the area of localized gas injection. Solid fuel particles injected into the bed at a point near the localized gas stream can then penetrate the fluidized upper and lower portions of the bed to provide discrete areas of combustion, regardless of the overall extent of bed fluidity. The fuel particles penetrate only the fluidized portion, and not the static portion of the bed. By maintaining the bed between the minimum ignition temperature of the fuel and the agglomeration temperature of the bed, continuing combustion within the locally fluidized portion is possible.

Combination of a localized gas injection with a main fluidizing gas supply may be used in this way to obtain a wide variation in the heat output from the bed. In addition, with sufficient pressure and flow rate the localized gas supply alone is sufficient, in itself, to fluidize a small portion of the particulate bed, so that the boiler output is continuously variable between the minimum limit imposed by local fluidization and the maximum limit.

Three distinct fluidization conditions represent the possible range of operation in a fluidized bed regulated by the method of this invention. During minimum load, only that portion of the bed fluidized by the localized gas supply is available for active heat production and transmission to imbedded heat exchange surfaces. During an intermediate load condition, the portion of the bed which is locally fluidized interacts with the upper portion of the bed which is fluidized by the main fluidizing gas supply. In this condition, fuel particles transported into the bed near the local injection point readily diffuse through the combined fluidized portions of the bed, but do not penetrate the static portion of the bed. Oxidizing bed temperature is reached only in the fluidized portions of the bed. Under full load condition, the entire bed is fluidized by the main gas supply, and the injected fuel is distributed uniformly and oxidized throughout the bed. This latter condition is the state of bed operation achieved by the prior art.

Therefore, one object of this invention is a method for obtaining a wide range of thermal output variation in an oxidizing fluidized bed.

Another object of this invention is increased operating efficiency and flexibility in oxidizing fluidized bed boilers by enabling their operation over a wide range of thermal output.

Still another object of this invention is to increase the turndown ratio of oxidizing fluidized bed boilers.

These and other objects of the invention will become more apparent with reference to the following specification and drawing.

BRIEF DESCRIPTION OF THE DRAWING

The sole FIG. is a partial section of an oxidizing fluidized bed boiler.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the sole FIG. an oxidizing fluidized bed boiler 10 is shown. The boiler 10 incorporates design details which are well known in the prior art and includes an enclosure 12 with vertical sidewalls 14 and a horizontal base 16. Within the enclosure 12, fuel is mixed with air and burned. Heat generated by this process is transferred through heat exchange surfaces 18 to a working fluid, flowing in a conduit 20 within the boiler. Working fluid enters and leaves the conduit 20 through supply pipes 22 on the exterior of the boiler, passing to its ultimate use in a heated state.

The combustion zone 24 of the boiler 10 is a bed 26 of different sized inert particles which can be suspended in a fluidized state by a stream of gas from a blower 28. Gas, such as air or a mixture of air and other gases, from the blower 28 enters the boiler 10 near the base 16 of the enclosure 12. This main fluidizing gas supply flows upward into the bed 26 through a perforated distribution grid 30, which is spaced upward from the base 16. In the distribution grid 30 there is an array of spaced perforations 32 which distribute the main gas supply in an even stream throughout the horizontal cross section of the bed 26. When the gas is injected into the bed with sufficient pressure and flow rate, individual particles in the bed are disengaged from one another and suspended in a fluidized state.

Depending upon their relative sizes, particles in the bed 26 are fluidized by different pressures and flow rates of the fluidizing gas. Smaller particles are fluidized by lesser pressures and flow rates than larger particles, and so the smaller particles drift to the top of the bed. When the pressure and flow rate is insufficient to fluidize large particles the lower part

of the bed, the large particles remain in a static condition while the smaller particles may form a fluidized layer on the top. In this way it is possible to fluidize a fractional portion of the bed with the main fluidizing gas supply.

Fuel enters the boiler 10 through an injection port 34 adjacent to the distribution grid 30 at the bottom of the bed 26. The fuel is preferably a particulate solid, such as crushed coal, which is mechanically or pneumatically injected into the bed. For pneumatic injection the fuel is mixed with a local gas supply, such as air or fluegas, at the junction of a fuel supply pipe 36 and a gas supply pipe 38. When the entire bed is in a fluidized state, the injected fuel spreads throughout the volume of the bed with relatively uniform distribution. By maintaining the bed temperature above the ignition temperature of the fuel, reaction of the fuel and air mixture results in uniform combustion.

It has been found that if sufficient pressure and flow rate are maintained, the local gas supply acting alone is sufficient to fluidize a fractional portion of the bed 26. The required pressures and flow rate depend upon design characteristics of the bed and boiler, and are easily determined experimentally by increasing the input volume of the local gas supply until partial fluidization occurs. When the localized supply is injected with sufficient pressure and flow rate, fluidization in the area immediately above the injection port 34 results, as depicted by the line A-A in the FIG. Incoming fuel particles penetrate only the fluidized portion of the bed, and active oxidation is limited to the portion of the bed to the left of line A-A. The only direct heat transfer from the bed 26 to the heat exchange surface 18 takes place in the fluidized portion. The balance of the bed, to the right of line A-A remains relatively cool and in static condition, with little heat transfer into the heat exchange surfaces. By designing the heat exchange surfaces, so that they occupy only the space to the right of line A-A, operation of the bed can be maintained without substantial heat transfer to the working fluid.

The effects of the main fluidizing gas supply can be combined with those of the local gas supply to achieve varying states of fluidization within the bed 26. By increasing gas flow through the distribution grid 30, a fractional upper portion of the bed can be fluidized, as explained above. The fractional portions affected by each gas supply combine to form a larger area of fluidization than occurs with either gas supply acting alone, as shown by the area above and to the left of line A-B in the FIG. The active area for heat transfer from the bed to the heat exchange surface 18 is thus increased.

By varying the relative pressures and flow rates of the main and local gas supplies, other states of partial fluidization are possible. Either gas supply may be reduced to a pressure which is insufficient alone to produce fluidization, but in combination with the other gas supply is sufficient for partial fluidization. It is only necessary that the combined pressures and flow rates be sufficient to fluidize a portion of the bed adjacent to the fuel injection port so that there is a path for injection of fuel into the active area of the bed. When these conditions exist, the static portion of the bed remains relatively impervious to incursions by the fuel and localized gas stream.

For full load operation the pressure and flow rate of the main gas supply from blower 28 are increased in an amount sufficient to fluidize the entire bed, as practiced by the prior art. Additional temperature control at this and lesser load conditions may be achieved by combining air and recirculated fluegas in the main fluidizing gas supply to regulate the oxidation rate within the bed 26.

While the sizes of the bed particles and the type and size of fuel employed will vary according to well known fluidized bed design parameters, experiment has shown that a bed of coal ash particles in the range of $\frac{1}{8}$ inch by 20 mesh is suitable for the method of this invention. Coal in the range of $\frac{1}{8}$ inch to $\frac{1}{4}$ inch by 0 mesh is an appropriate fuel. For optimum results, the bed particles should be of nonuniform size distribution, and the fuel particles should be generally larger than the bed particles. These and other specific parameters for practice of this

invention will easily be verified by the skilled worker in the art in accord with known design and operational characteristics of fluidized beds.

While this invention has been described in relation to a specific oxidizing fluidized bed boiler configuration, it may be practiced in any suitable fluidized bed boiler. Furthermore, practice of the invention is not limited to an oxidizing fluidized bed, but will find application for a variety of reactions and reactants in fluidized beds in general. The invention is therefore to be limited only by the scope of the following claims.

I claim:

1. A method for controlling a reaction within a fluidized bed comprising:

injecting a localized stream of fluid into the bed at a point near the base of the bed;

injecting a stream of reactant into the bed near the point at which the localized stream of fluid is injected;

injecting a distributed stream of fluid into the bed from points spaced about the lower surface area of the bed;

regulating the relative pressures and flow rates of the localized and distributed fluid streams so that a selected fractional portion of the bed is fluidized, with at least some part of the fractional portion in contact with the stream of reactant;

maintaining the fluidized portion of the bed in a state conducive to a desired reaction; and

whereby localized reaction takes place in the fluidized fractional portion of the bed, and the static portion of the bed remains substantially impervious to incursions by the fuel and localized fluid stream.

2. A method for controlling the thermal output of an oxidizing fluidized bed comprising:

injecting a localized stream of gas into the bed at a point near the base of the bed;

injecting a stream of fuel into the bed near the point at which the localized stream of gas is injected;

injecting a distributed stream of gas into the bed from points spaced about the lower surface area of the bed;

regulating the relative pressures and flow rates of the localized and distributed gas streams so that a selected fractional portion of the bed is fluidized, with at least some part of the fractional portion in contact with the stream of fuel;

maintaining the fluidized portion of the bed above the minimum ignition temperature of the fuel; and

whereby localized combustion takes place in the fluidized fractional portion of the bed, and the static portion of the bed remains substantially impervious to incursions by the fuel and localized gas stream.

3. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 2, in which the step of regulating further comprises:

regulating the pressure and flow rate of the localized stream of gas so that the localized stream of gas is sufficient alone to fluidize a fractional portion of the bed; and

regulating the pressure and flow rate of the distributed stream of gas so that the distributed stream has a minimal effect upon fluidization of the bed.

4. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 2, in which the step of regulating further comprises:

regulating the pressure and flow rate of the localized stream of gas so that the localized stream of gas is insufficient alone to fluidize any fractional portion of the bed; and

regulating the pressure and flow rate of the distributed stream of gas so that the distributed stream of gas alone is insufficient to fluidize any portion of the bed, but in combination with the localized stream of gas is sufficient to fluidize a fractional portion of the bed.

5. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 2, in which the step of regulating further comprises:

5

regulating the pressure and flow rate of the localized stream of gas so that the localized stream of gas is sufficient alone to fluidize a fractional portion of the bed; and

regulating the pressure and flow rate of the distributed stream of gas so that the distributed stream of gas alone is insufficient to fluidize any portion of the bed, but in combination with the localized stream of gas is sufficient to fluidize a larger fractional portion of the bed than the localized stream of gas acting alone.

6. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 2, in which the step of regulating further comprises:

regulating the pressure and flow rate of the localized stream of gas so that the localized stream of gas is insufficient alone to fluidize any fractional portion of the bed; and

regulating the pressure and flow rate of the distributed stream of gas so that the distributed stream of gas alone is sufficient to fluidize only a fractional portion of the bed, and in combination with the localized stream of gas is sufficient to fluidize a larger fractional portion of the bed.

7. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 2, in which:

the steps of injecting a localized stream of gas and injecting a stream of fuel are performed by injecting a mixture of gas, such as air or fluegas, and particulate fuel, such as coal, into the bed; and

the step of injecting a distributed stream of gas into the bed comprises injecting a distributed stream of oxygen laden air into the bed to promote combustion within the bed.

8. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 3 in which:

the steps of injecting a localized stream of gas and injecting a stream of fuel are performed by injecting a mixture of

6

gas, such as air or fluegas, and particulate fuel, such as coal, into the bed; and

the step of injecting a distributed stream of gas into the bed comprises injecting a distributed stream of oxygen laden air into the bed to promote combustion within the bed.

9. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 4 in which:

The steps of injecting a localized stream of gas and injecting a stream of fuel are performed by injecting a mixture of gas, such as air or fluegas, and particulate fuel, such as coal, into the bed; and

the step of injecting a distributed stream of gas into the bed comprises injecting a distributed stream of oxygen laden air into the bed to promote combustion within the bed.

10. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 5 in which:

the steps of injecting a localized stream of gas and injecting a stream of fuel are performed by injecting a mixture of gas, such as air or fluegas, and particulate fuel, such as coal, into the bed; and

the step of injecting a distributed stream of gas into the bed comprises injecting a distributed stream of oxygen laden air into the bed to promote combustion within the bed.

11. A method for controlling the thermal output of an oxidizing fluidized bed as claimed in claim 6 which:

the steps of injecting a localized stream of gas and injecting a stream of fuel are performed by injecting a mixture of gas, such as air or fluegas, and particulate fuel, such as coal, into the bed; and

the step of injecting a distributed stream of gas into the bed comprises injecting a distributed stream of oxygen laden air into the bed to promote combustion within the bed.

35

40

45

50

55

60

65

70

75