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(54) COMBUSTION SYSTEM USING RECYCLED FLUE GAS TO BOOST OVERFIRE AIR

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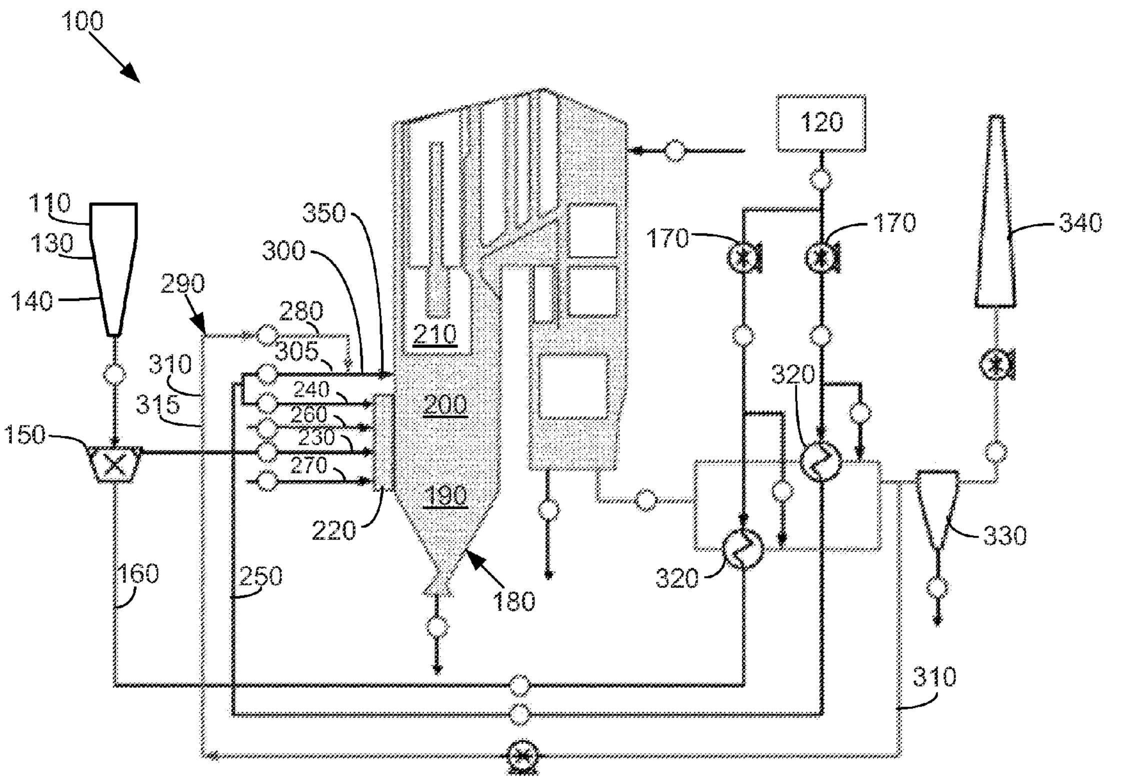
(57) ABSTRACT

The present application and the resultant patent provide a combustion system. The combustion system may include a combustion chamber for combusting a flow of fuel and a flow of air to a flow of flue gases, an overfire air system in communication with the combustion chamber, and a flue gas return line in communication with the overfire air system such that a recycled flue gas flow mixes with an overtire air flow before entry into the combustion chamber.



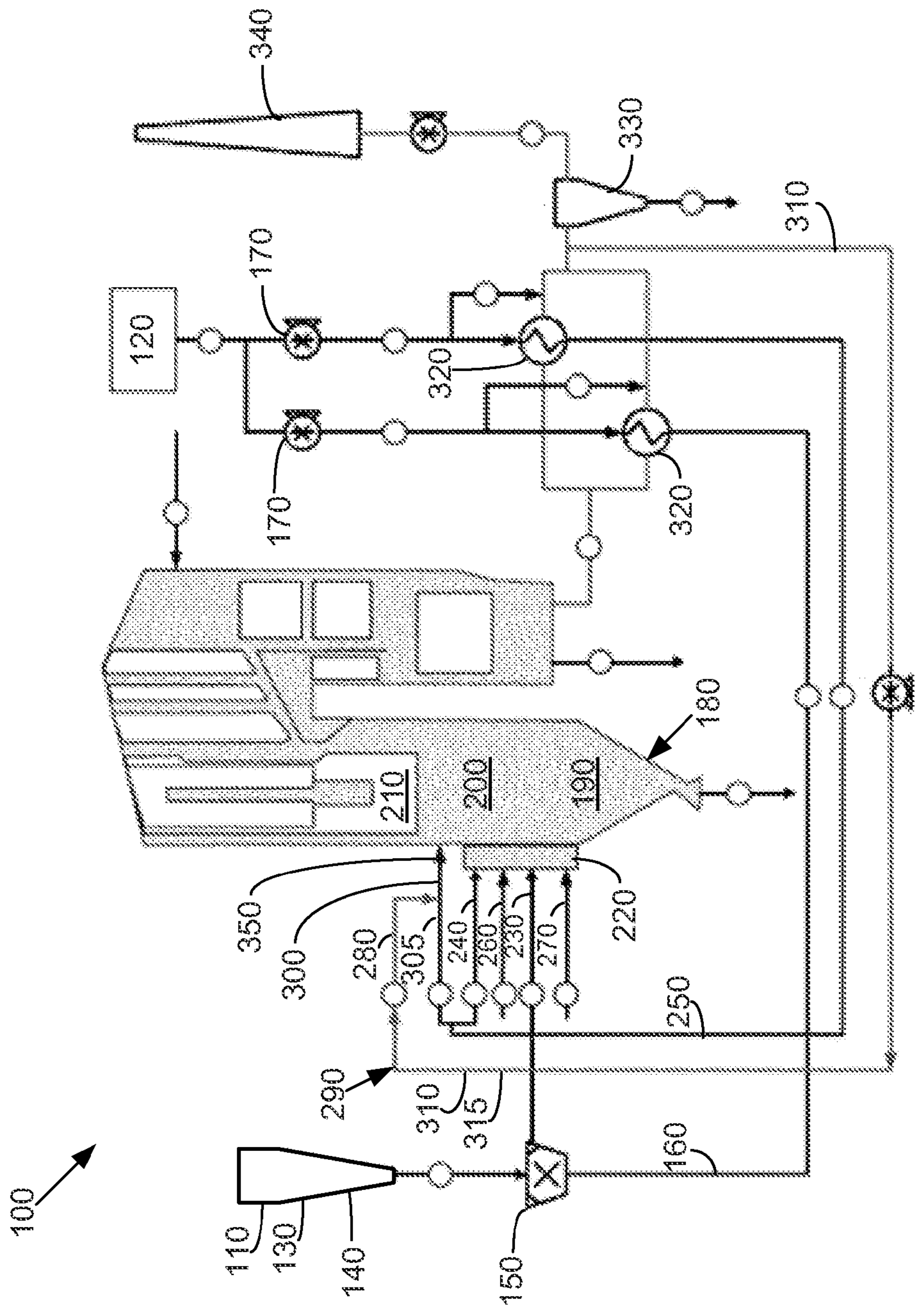

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Fig. 1

COMBUSTION SYSTEM USING RECYCLED FLUE GAS TO BOOST OVERFIRE AIR

TECHNICAL FIELD

[0001] The present application and the resultant patent relate generally to combustion systems and more particularly relates to combustion systems using a recycled flue gas flow to boost an overfire air flow for a reduction in emissions and an increase in efficiency.

BACKGROUND OF THE INVENTION

[0002] Combustion systems are used in numerous industrial environments to generate heat and hot gases. For example, boilers and furnaces typically burn hydrocarbon fuels such as oil and coal in stationary combustors to produce heat to raise the temperature of a fluid such as water. Industrial combustion systems typically employ various burner elements to combust the fuel and air injectors to provide combustion air to ensure complete combustion.

[0003] An industrial furnace or a utility furnace such as a boiler, whether gas or fossil fired, typically includes a lower combustion zone and a generally vertically extending flue gas passage. The air introduced into such a combustion system may be staged, i.e., the air may be introduced into the system in multiple stages to optimize combustion and minimize emissions. In air staging, the primary air is mixed with the fuel as both are injected into a combustion zone. Secondary air (air without fuel) may be injected in the primary combustion zone and also may be injected downstream of the primary combustion zone as in the case of overtire air.

[0004] Overfire air typically is injected into the flue gas at a location downstream of the primary combustion zone. Overtire air staging reduces the flow of combustion air provided to the primary combustion zone so as to suppress the formation of emissions such as nitrogen oxides. The reduced oxygen in the primary combustion zone increases the level of unburned hydrocarbons in the flue gas. The overtire air then completes combustion of the unhurried hydrocarbons, which are converted into carbon dioxide and water.

[0005] Although known overtire air systems generally are effective in reducing undesired emissions, such emissions control may come at an efficiency cost with respect to the overall combustion system. There is thus a desire for improved combustion systems using overtire air so as to provide adequate or increased emissions control with little or no impact on overall system efficiency.

SUMMARY OF THE INVENTION

[0006] The present application and the resultant patent thus provide a combustion system. The combustion system may include a combustion chamber for combusting a flow of fuel and a flow of air to a flow of flue gases, an overfire air system in communication with the combustion chamber, and a flue gas return line in communication with the overfire air system such that a recycled flue gas flow mixes with an overfire air flow before entry into the combustion chamber.

[0007] The present application and the resultant patent further provide a method of operating a combustion system. The method may include the steps of combusting a flow of air and a flow of fuel into a flue gas flow in a combustion zone of a combustion chamber, diverting a portion of the flow of air as an overtire air flow, recycling a portion of the flue gas flow, mixing the overfire air flow and the recycled portion of the flue gas flow, and injecting the overfire air flow and the recycled portion of the flue gas flow in the combustion chamber downstream of the combustion zone.

[0008] The present application and the resultant patent further provide a combustion system. The combustion system may include a combustion chamber for combusting a flow of fuel and a flow of combustion air to a flow of flue gases in a combustion zone, an overfire air system in communication with the combustion chamber downstream of the combustion zone for diverting a portion of the flow of combustion air as an overfire air flow, and a flue gas return line in communication with the overfire air system such that a recycled flue gas flow mixes with the overfire air flow before entry into the combustion chamber.

[0009] These and other features and improvements of the present application and the resultant patent will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the several drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWING

[0010] FIG. **1** is a schematic view of a combustion system as may be described herein using an overfire air system.

DETAILED DESCRIPTION

[0011] Referring now to the drawing, in which like numerals refer to like elements through out, FIG. **1** shows a combustion system as may be described herein. The combustion system **100** may be a fossil fuel fired boiler, furnace, and the like. The combustion system **100** combusts a flow of fuel **110** with one or more flows of air **120**. The fuel **110** may be a fossil fuel such as a supply of coal **130** and the like. The supply of coal **130** may be stored in a coal bunker **140** or other type of storage. The coal **130** may be pulverized as needed in a mill **150** or a similar type of device. The flow of air **120** may include a primary combustion air flow **160**. The primary combustion air flow **160** mixes with the pulverized coal **130** in the mill **150** for transport therewith. The one or more air flows **120** may have one or more fans **170** or other type of air movement devices associated therewith.

[0012] The combustion system **100** may include a combustion chamber **180**. The combustion chamber **180** may have a somewhat elongated shape although any desired size, shape, or configuration may be used herein. As will be described in more detail below, the combustion chamber **180** may include a combustion zone **190** for combusting the flow of fuel **110** and the flow of air **120**, a reburn zone **200** downstream thereof, and a burnout zone **210** further downstream. Other components and other configurations may be used herein.

[0013] The combustion chamber **180** may include one or more main burners **220** or other types of combustion devices. Although a coal fired main burner **220** is described herein, gas fired, oil fired, or other types of burners and the like also may be used herein. The main burner **220** includes a fuel input **230**. The fuel input **230** may be in communication with the pulverized coal **130** and the primary combustion air flow **160** from the mill **150**. The main burner **220** also may have an air input **240**. The air input **240** may be in communication with a combustion air flow **250** of the one or more air flows **120**. The one or more air flows **120** also may include a burner core air flow **260**, a furnace leakage flow **270**, and the like. The flow of fuel **110** and the flow of air **120** thus are ignited within the combustion chamber **180** by the main burner **220** to form a combustion flue gas flow **280**. The combustion flue gas **280** flows downstream towards the reburn zone **200**.

[0014] The combustion system **100** also includes an overfire air system **290**. The overtire air system **290** may include one or more overfire air injector **300**. The overfire air injectors **300** may be in communication with a portion of the combustion airflow **250**. The overfire air system **290** thus divers the portion of the combustion air flow **250** from the main burner **220** for combustion downstream of the combustion zone **190** as an overfire air flow **305**.

[0015] The overfire air system **290** also may include a flue gas return line **310** to provide a recycled flue gas flow **315**. The flue gas return line **310** may be in communication with the overtire air injector **300** and the combustion air flow **250**. The flue gas return line **310** also may be in communication with one or more flue gas heat exchangers **320** before reaching the overtire air injector **300**. The flue gas heat exchangers **320** may be in communication with the one or more incoming flows of air **120**. The flue gas heat exchangers **320** thus may cool the recycled flue gas flow **315** while heating the incoming flows of air **120**. The portion of the flue gas flow **280** not diverted to the overtire air system **290** as the recycled flue gas flow **315** may pass through an electrostatic precipitator **330** or a bag house and may exit the combustion system **100** via a stack **340** or other type of exhaust. Alternatively, the remainder of the flue gas **280** flow also may be used for other purposes in the overall combustion system **100** or otherwise.

[0016] In use, about ten percent (10%) of the overall flue gas flow **280** may be used as the recycled flue gas flow **315** and forwarded via the flue gas return line **310** to the overtire air injectors **300** of the overtire air system **290**. Other percentages and other types of flows also may be used herein. The recycled flue gas flow **315** thus mixes with the overfire air flow **305** diverted from the combustion air flow **250**. This mixture of the recycled flue gas flow **315** and the overfire air flow **305** may be injected into the combustion zone **190** at a speed higher than about sixty (60) meters per second or so. Other speeds may be used herein. The high speed of injection promotes good mixing of the overfire air flow **305** and the flue gas flow **280**. Good mixing thus may reduce effectively combustible emissions therein.

[0017] The use of the recycled flue gas flow **315** thus boosts the flow of the overfire air flow **305** to a higher mass, velocity, and momentum. Such an increase in momentum may control unburned hydrocarbons and carbon monoxide. Less overtire air **305** may be required for maintaining the combustible emissions level at a base line. Specifically, with a reduction of the overtire air flow rate, the oxygen level within the combustion zone **190** may be reduced so as to improve the efficiency of the overall combustion system **100**.

[0018] The combustion system **100** thus removes a portion of the combustion air flow **250** from the combustion zone **190** and injects the portion as the overfire air flow **305** at an upper elevation so as to complete combustion. Because the combustion air flow **250** is reduced, emissions of nitrogen oxides and the like may be lowered. Injecting the overfire air flow **305** at a higher velocity and momentum thus helps to reduce combustible emissions without impacting on boiler or overall system efficiency. Specifically, the increase velocity and momentum of the overtire air flow **305** may control effectively combustibles such that less air flow is needed. By reducing the total air flow, the overall efficiency of the combustion system **100** may be improved. Using the recycled flue gas flow **315** thus further reduced emissions while maintaining or improving overall system efficiency.

[0019] The overfire air system **290** with flue gas recycling may be used to modify existing combustion systems **100** given that modified wall openings may not be required. Moreover, such a modification may be relatively inexpensive to install and may require little downtime.

[0020] It should be apparent that the foregoing relates only to certain embodiments of the present application and the resultant patent. Numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the general spirit and scope of the invention as defined by the following claims and the equivalents thereof.

We claim:

1. A combustion system, comprising:

a combustion chamber for combusting a flow of fuel and a flow of air to a flow of flue gases;

an overfire air system in communication with the combustion chamber; and

a flue gas return line in communication with the overtire air system such that a recycled flue gas flow mixes with an overfire air flow before entry into the combustion chamber.

2. The combustion system of claim **1**, wherein the flow of fuel comprises a supply of coal.

3. The combustion system of claim **2**, further comprising a mill in communication with the supply of coal.

4. The combustion system of claim **1**, further comprising one or more main burners positioned about the combustion chamber and in communication with the flow of fuel and the flow of air.

5. The combustion system of claim **4**, wherein the combustion chamber comprises a combustion zone about the one or more main burners.

6. The combustion system of claim **5**, wherein the overtire system is positioned downstream of the combustion zone.

7. The combustion system of claim **1**, wherein the overtire system comprises one or more overfire air injectors.

8. The combustion system of claim **1**, wherein the flow of air comprises a flow of combustion air and wherein the overtire air flow comprises a portion of the flow of combustion air.

9. The combustion system of claim **8**, further comprising one or more flue gas heat exchangers in communication with the flue gas return line and the flow of combustion air.

10. The combustion system of claim **1**, wherein the recycled flue gas flow comprises about ten percent (10%) of the flue gas flow.

11. The combustion system of claim **1**, wherein the recycled flue gas flow and the overfire air flow comprise an entry speed into the combustion chamber of about sixty (60) meters per second or more.

12. A method of operating a combustion system, comprising:

combusting a flow of air and a flow of fuel into a flue gas flow in a combustion zone of a combustion chamber;

diverting a portion of the flow of air as an overtire air flow;

recycling a portion of the flue gas flow;

mixing the overfire air flow and the recycled portion of the flue gas flow; and

injecting the overfire air flow and the recycled portion of the flue gas flow in the combustion chamber downstream of the combustion zone.

13. The method of claim **12**, further comprising the step of exchanging heat between the flow of air and the recycled portion of the flue gas flow upstream of the combustion chamber.

14. The method of claim **12**, wherein the step of recycling a portion of the flue gas flow comprises recycling about ten percent (10%) of the flue gas flow.

15. The method of claim **12**, wherein the step of injecting the overtire air flow and the recycled portion of the flue gas flow comprises injecting the overtire air flow and the recycled portion of the flue gas flow at about sixty (60) meters per second or more.

16. A combustion system, comprising:

a combustion chamber for combusting a flow of fuel and a flow of combustion air to a flow of flue gases in a combustion zone;

an overfire air system in communication with the combustion chamber downstream of the combustion zone for diverting a portion of the flow of combustion air as an overfire air flow; and

a flue gas return line in communication with the overtire air system such that a recycled flue gas flow mixes with the overtire air flow before entry into the combustion chamber.

17. The combustion system of claim **16**, further comprising one or more main burners positioned about the combustion zone and in communication with the flow of fuel and the flow of combustion air.

18. The combustion system of claim **16**, wherein the overtire system comprises one or more overfire air injectors.

19. The combustion system of claim **16**, wherein the flow of fuel comprises a supply of coal.

20. The combustion system of claim **16**, further comprising one or more flue gas heat exchangers in communication with the flue gas return line and the flow of combustion air.

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