SYSTEM AND METHOD FOR IMPROVED HEAT RECOVERY FROM FLUE GASES WITH HIGH SO3 CONCENTRATIONS

Inventors: Joel Charles MacMurray, Allentown, PA (US); Galip Hakan Guvelioğlu, Macungie, PA (US)

Assignee: AIR PRODUCTS AND CHEMICALS, INC., Allentown, PA (US)

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ABSTRACT
Disclosed is a power generation system for high sulfur fuel combustion and a method of generating power from high sulfur fuel. The system includes a boiler for combusting a sulfur containing fuel to form a sulfur containing flue gas, a heat exchanger arranged and disposed to transfer heat from the sulfur containing flue gas to combustion air, a sorbent injector arranged and disposed to inject sorbent into the sulfur containing flue gas, and a second stage heat recovery mechanism arranged and disposed to transfer heat from the sulfur containing flue gas.
SYSTEM AND METHOD FOR IMPROVED HEAT RECOVERY FROM FLUE GASES WITH HIGH SO\textsubscript{3} CONCENTRATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This Application claims the benefit of U.S. Provisional Application No. 61/356,765, filed on Jun. 21, 2010. The disclosure of this Application is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention is directed to systems and methods of power generation. More particularly, the present invention is directed to systems and methods of power generation having neutralizing sorbent injection and second stage heat recovery.

[0003] Energy demand is constantly increasing. As the energy demand increases, efficiency for fossil fuel energy sources increases in importance. Generally, the efficiency of fossil fuel powered plants can be impacted by the amount of heat that can be recovered from flue gas.

[0004] In some fossil fuel powered plants, flue gas may be cooled by transferring heat to combustion air, thereby improving efficiency of combustion in a boiler. For example Swedish patent SE 448117 B, which is hereby incorporated by reference in its entirety, discloses cooling flue gas below an acid dew point, thereby condensing sulfuric acid. The sulfuric acid can cause heat exchangers and other process elements to foul. To prevent fouling, expensive alloys and corrosion resistant materials are used.

[0005] EP 0102770 A2, which is hereby incorporated by reference in its entirety, discloses condensing sulfuric acid by cooling flue gas below an acid dew point. To prevent fouling, heat exchangers include special designs and protective coatings, both of which may be expensive.

[0006] International patent application WO 2006/087416 A1, which is hereby incorporated by reference in its entirety, discloses heat recovery from flue gas through a fluidized bed boiler combusting sulfurous fuel. The process results in flue gas being cooled below the acid and water dew points. To prevent fouling, heat exchanger tubes are made of plastics and other acid resistant materials, which may be expensive.

[0007] Japanese patent application JP 2002162020 A, which is hereby incorporated by reference in its entirety, discloses two stage heat recovery with the second stage heating the flue gas directed to a stack, thereby mitigating visual plume concerns. The additional heat from the flue gas in the second stage is not converted into power and is only used to reheat the flue gas leaving the stack. Thus, the second stage does not improve the efficiency of the power plant.

[0008] What is needed is a system and method for improving efficiency in a fossil fuel power plant by increasing the low level heat recovery from the flue gas without relying upon expensive alloys and corrosion resistant materials to prevent fouling of heat exchangers and other process elements.

BRIEF SUMMARY OF THE INVENTION

[0009] The instant invention solves problems associated with conventional practices by providing a system and method for controlling and removing SO\textsubscript{3} in a sulfur containing flue gas.

[0010] In an exemplary embodiment, a power generation system for high sulfur fuel combustion includes a boiler for combusting a sulfur containing fuel to form a sulfur containing flue gas, a heat exchanger arranged and disposed to transfer heat from the sulfur containing flue gas to combustion air, a sorbent injector arranged and disposed to inject sorbent into the sulfur containing flue gas, and a second stage heat recovery mechanism arranged and disposed to transfer heat from the sulfur containing flue gas. The heat exchanger maintains a temperature of the sulfur containing flue gas above a predetermined temperature, the predetermined temperature relating to the acid condensation temperature. The sorbent reduces concentration of sulfur in the sulfur containing flue gas, thereby reducing the acid condensation temperature of the sulfur containing flue gas.

[0011] In another exemplary embodiment, a power generation system for high sulfur fuel combustion includes a boiler for combusting a sulfur containing fuel to form a sulfur containing flue gas, a heat exchanger arranged and disposed to transfer heat from the sulfur containing flue gas to combustion air, a sorbent injector arranged and disposed to inject sorbent into the sulfur containing flue gas, and a second stage heat recovery mechanism arranged and disposed to transfer heat from the sulfur containing flue gas to a directed to the heat exchanger. In the embodiment, the heat exchanger maintains a temperature of the flue gas above a predetermined temperature, the predetermined temperature relating to the acid condensation temperature. The predetermined temperature corresponds to a sulfuric acid dew point or is based upon a correlation, the sorbent comprises at least one sorbent selected from the group consisting of limestone, lime, trona, sodium bisulfate, magnesium hydroxide, and combinations thereof, the application of the sorbent results in the sulfur containing flue gas having a SO\textsubscript{3} concentration of less than about 50 ppm volume, and the application of the sorbent lowers SO\textsubscript{3} concentration in the sulfur containing flue gas by at least 80%.

[0012] In another exemplary embodiment, a method of generating power includes combusting a sulfur containing fuel to form a sulfur containing flue gas, in a heat exchanger, transferring heat from the sulfur containing flue gas to combustion air, maintaining a temperature of the sulfur containing flue gas leaving the heat exchanger above a predetermined temperature, the predetermined temperature relating to the acid condensation temperature. The predetermined temperature relates to the acid condensation temperature, injecting sorbent into the sulfur containing flue gas, wherein the sorbent reduces concentration of sulfur in the sulfur containing flue gas, thereby reducing the acid condensation temperature of the sulfur containing flue gas, and transferring heat from the sulfur containing flue gas in a second stage heat recovery mechanism.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0013] FIG. 1 shows an exemplary power generation system according to the disclosure.

[0014] FIG. 2 shows the sulfuric acid dew point as a function of the SO\textsubscript{3} and water vapor concentrations in flue gas.

[0015] FIG. 3 shows another exemplary power generation system according to the disclosure.

[0016] Wherever possible, the same reference numbers will be used throughout the drawings to represent the same parts.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Provided is a system and method of power generation having neutralizing sorbent injection and heat recovery.
Embodiments of the disclosure may improve efficiency in fossil fuel power plants by recovering the low level heat in flue gas without relying upon expensive alloys and corrosion resistant materials to prevent fouling of heat exchangers and other process elements.

[0018] An exemplary power generation system 100 may include a boiler 102, a selective catalytic reduction unit 112, a first air preheater 116, a sorbent injection location 124, a particulate removal mechanism 120, a second stage heat recovery mechanism (for example, a second air preheater 128), a flue gas desulfurization unit 134, a wet electrostatic precipitator 142, and a stack 146.

[0019] Referring to FIG. 1, boiler 102 is arranged and disposed to receive a fuel (for example, provided by a fuel stream 104) to generate steam (for example, transported by steam stream 106) and convert the steam into power. Fuel may be a fossil fuel (for example, coal, oil, and/or pet coke, etc.). Any suitable system for converting steam into power may be used. For example, boiler 102 converts water (for example, provided by a water stream 108) into the steam, and the steam is converted into mechanical energy to power a steam turbine or generator 109. Any suitable steam turbine or generator 109 may be used in conjunction with boiler 102. Generally, steam turbine or generator 109 receives the steam from boiler 102 via steam stream 106, the steam heats an element such as a liquid-filled heat exchanger (not shown), and water is formed and returned via water stream 108 to boiler 102 to be converted into steam. The process is repeated with the introduction of more fuel. In the conversion of the steam into mechanical energy, boiler 102 produces a flue gas that is transported to further processing equipment via a flue gas conduit 103.

[0020] The amount of heat energy transferred to the steam may be controlled by the design of boiler 102 and/or by environmental emission control equipment located down-stream of boiler 102. In one embodiment, boiler 102 may use preheated air (from any suitable source) at a temperature of about 300 °F to about 600 °F (about 149 °C to about 316 °C). The heat may be transferred to water to generate the steam used to produce power. In one embodiment, the flue gas generated by boiler 102 may be at about 550 °F to 800 °F (about 288 °C to about 427 °C).

[0021] The flue gas leaving boiler 102 may include nitrogen oxides (NOx), sulfur oxides (SOx), H2O, and/or particulate. The amount of the SOx generated in boiler 102 may depend upon various factors including, but not limited to, the sulfur content of the fuel, combustion process conditions, and other process characteristics. For combusting high sulfur containing fuels, the concentration of SOx in the flue gas present in flue gas conduit 103 can be as high as 300-400 parts per million (ppm) by volume in the flue gas and the acid dew point can be as high as about 340 °F (about 171 °C). System 100 may include environmental control equipment for reducing or eliminating NOx, SOx, and/or particulate. Pre-combustion, combustion and/or post combustion emission control technologies may form environmental control equipment.

[0022] Flue gas is provided to selective catalytic reduction (SCR) unit 112 via flue gas conduit 103 as part of the environmental control equipment. SCR unit 112 is in fluid communication with boiler 102 and is arranged and disposed to apply a reductant (for example, from reductant stream 114) to flue gas. SCR unit 112 may reduce NOx in the flue gas generated during combustion into N2 and H2O. The reduction may be performed by applying the reductant (for example, anhydrous ammonia, aqueous ammonia, urea, cyanuric acid, and/or ammonium sulfate) in the presence of a catalyst (for example, ceramic carriers including active catalytic components, such as, oxides of base metals, zeolites, and/or precious metals) to the flue gas within SCR unit 112. In embodiments using urea as the reductant, additional mechanisms for removing CO2 may be included. In one embodiment, SCR unit 112 may reduce NOx by about 60% to about 95%. In the embodiment, the flue gas leaving SCR unit 112 via a flue gas conduit 113 includes about 5% to about 40% of the NOx in the flue gas leaving boiler 102 via flue gas conduit 103 and the concentration of the SOx may be increased due to SO2 oxidizing to SO3 in the presence of SCR catalyst. Thus, flue gas leaving SCR unit 112 may include particulate, H2O, an increased concentration of SO2, and a decreased concentration of NOx.

[0023] The efficiency of system 100 may relate to the amount of heat that can be recovered from the flue gas to form the steam. Including air preheater 116 in system 100 may provide such heat recovery. Generally, including air preheater 116 may transfer heat to combustion air in boiler 102. By heating the combustion air in boiler 102, more heat energy from the combustion of fuel in boiler 102 can be used to form the steam, thereby improving combustion efficiency.

[0024] As also shown in FIG. 1, air preheater 116 is arranged and disposed to transfer heat from the flue gas to combustion air provided by air inlet 132. The flue gas may transfer heat to the combustion air in air preheater 116. Upon transferring heat in air preheater 116, the air in combustion air inlet line 118 is heated. The heated combustion air may be provided to boiler 102 for increasing efficiency of combustion. In one embodiment, the air in combustion air inlet line 132 may be pre-heated prior to reaching air preheater 116.

[0025] The flue gas entering air preheater 116 may contain particulate. Particulate may include fly ash and/or other solid or semi-solid combustion products carried by the flue gas. The heat exchanger may be configured to operate in the presence of particulate (or other high-solids conditions). For example, the heat exchanger may be configured to operate despite fouling that may be caused by particulate. In one embodiment, the heat exchanger may be a rotating regenerative heat exchanger (for example, Ljungstrom type heat exchangers or other suitable regenerative heat exchangers). In the rotating regenerative heat exchanger, the flue gas and the air may flow counter-currently, thereby permitting the heat exchanger to have a flue gas side and an air side. The heat exchangers may include a round basket having corrugated sheet metal plates that rotate inside a round housing between the flue gas and the air provided to air preheater 116. The corrugated sheet metal plates may be heated by flue gas. The corrugated sheet metal plates may then rotate and transfer heat to the air in the air side of the heat exchanger.

[0026] Flue gas entering air preheater 116 via flue gas conduit 113 may be cooled by the exchange of heat in the air preheater 116 but is maintained above a predetermined temperature. The predetermined temperature corresponds to an acid dew point (for example, a sulfuric acid dew point), thereby reducing or eliminating corrosion and fouling within air preheater 116. The acid dew point is a temperature at which acid condensation begins. The sulfuric acid dew point is the temperature at which sulfuric acid begins to condense. As shown in FIG. 2, the sulfuric acid dew point depends upon the concentration of SO2 and H2O. In addition, the sulfuric acid dew point may depend upon the pressure of flue gas. FIG.
2 specifically shows H$_2$SO$_4$ dew point as a function of SO$_3$ concentration in the flue gas at three different concentrations of H$_2$O in flue gas at a flue gas pressure of 14.3 psia. The acid dew point increases as SO$_3$ and H$_2$O concentrations increase.

[0027] As used herein, the term “corresponds,” “corresponding,” and grammatical variations thereof refer to a relationship of the predetermined temperature and preselected operating conditions. The predetermined temperature corresponds to the acid dew point of preselected operating conditions. The flue gas may be maintained above the predetermined temperature independent of whether the preselected operating conditions are present. Thus, the predetermined temperature may correspond to an acid dew point but not be the actual acid dew point.

[0028] In one embodiment, the predetermined temperature may be based upon a dew point correlation. The dew point correlation may be any suitable dew point correlation, including but not limited to, the Kiang correlation. As used herein, the “Kiang correlation” is a mathematic formula for predicting the dew point of an acid. For example, the Kiang correlation for sulfuric acid is the following: 1,000/\(T_{DP}\) - 2.276 - 0.0294 \(\ln(P_{H2SO4})\) - 0.0858 \(\ln(P_{H2SO4})\) + 0.0062 \(\ln(P_{H2O})\) \(\ln(P_{H2SO4})\). In the Kiang correlation, \(T_{DP}\) is the acid dew point (in Kelvin), and \(P\) is the partial pressure (in units mm Hg).

[0029] In maintaining the flue gas above the predetermined temperature (for example, the sulfuric acid dew point), corrosion and fouling may be reduced or eliminated, despite the sulfur in fuel oxidizing into SO$_3$ and SO$_2$ in boiler 102. In one embodiment, maintaining the predetermined temperature may prevent the decrease in temperature of the flue gas (for example, in air preheater 116) from condensing gaseous H$_2$SO$_4$ at the sulfuric acid dew point. For example, maintaining the predetermined temperature above about 500° F. (about 260° C.) may prevent the SO$_3$ in the flue gas from reacting with H$_2$O in the flue gas to form H$_2$SO$_4$.

[0030] Maintaining the predetermined temperature may control the amount of heat recovered from the flue gas based upon the sulfuric acid dew point. In one embodiment, maintaining the temperature of the flue gas above the predetermined temperature may prevent sulfuric acid condensate from reacting with the reductant introduced in SCR unit 112. For example, maintaining the predetermined temperature may prevent ammonia from reacting with the sulfuric acid condensate to form ammonium bisulfate, which may foul the heat exchanger. In the embodiment, preventing the fouling of the heat exchanger may prevent a reduction in heat transfer, may prevent drops in pressure, may reduce or eliminate use of expensive anti-fouling and/or anti-corrosion materials (for example, in ducts for flue gas, air preheater 116, particulate removal mechanism 120, and/or air preheater 128), and/or may prevent shutdown of boiler 102 for cleaning and/or repair of air preheater 116.

[0031] In one embodiment, maintaining the temperature of the flue gas above the predetermined temperature may permit the formation of a small amount of sulfuric acid condensate on the heat exchange surface. In the embodiment, which may rely upon the 1-jogstrom type heat exchanger, the basket element of the heat exchanger rotates from air inlet 132 to the flue gas, thereby contacting the flue gas with cold metal plates in the heat exchanger. The temperature of the cold metal plates in the heat exchanger may be below the sulfuric acid dew point, thereby forming some sulfuric acid condensate.

[0032] As shown in FIG. 1, the flue gas may exit air preheater 116 via flue gas conduit 119 having been cooled to the predetermined temperature. A sorbent 126 is applied to flue gas at sorbent injection location 124 or any other suitable location. In one embodiment, sorbent injection location 124 may be positioned along flue gas conduit 119. Sorbent injection location 124 may include or be part of vessels and/or equipment for enhanced contact between sorbent 126 and the flue gas. Additionally or alternatively, sorbent injection location 124 may be positioned to increase the residence time to allow sufficient time for the reactions.

[0033] Sorbent 126 may be any suitable neutralizing agent (s). For example, sorbent 126 may comprise at least one member selected from the group consisting of limestone, lime, trona, sodium bisulfate, and/or magnesium hydroxide.

The amount of sorbent 126 applied to the flue gas, the specific sorbent to be applied, the method of applying sorbent 126 may be adjusted to correspond to the selected sorbent.

[0034] With the addition of sorbent 126, the amount of SO$_3$ in the flue gas may be reduced. For example, if trona is used as sorbent 126, trona is calcined with the following reaction and then the resultant Na$_2$CO$_3$ reacts with SO$_3$ to form Na$_2$SO$_4$:

Calcination: 2Na$_2$CO$_3$ + CaHCO$_3$ + H$_2$O → 2Na$_2$CO$_3$ + CO$_2$ + 3H$_2$O

SO$_3$ Removal: Na$_2$CO$_3$ + SO$_3$ → Na$_2$SO$_4$ + CO$_2$ + H$_2$O

[0035] As shown in FIG. 2, reducing the amount of SO$_3$ in the flue gas reduces the sulfuric acid dew point. By reducing the sulfuric acid dew point, a lower temperature may be maintained in the flue gas without (or substantially devoid of) formation (precipitation) of sulfuric acid, thereby increasing heat transfer and increasing efficiency by increasing the temperature of combustion air inlet line 118. In one embodiment, sorbent 126 may be applied at an amount resulting in SO$_3$ concentration being less than about 50 ppm volume, reduced from 150-200 ppm volume in the flue gas present in flue gas conduit 103 and 300-400 ppm volume in the flue gas present in flue gas conduit 113 (for example, about 84% to 80% reduction in SO$_3$, or above 84% reduction in SO$_3$.)

The amount of sorbent 126 used may be based upon economic and efficiency considerations. In one embodiment, the cost of sorbent 126 may be balanced with the cost savings associated with increased efficiency resulting from the amount of SO$_3$. For example, as the SO$_3$ concentration decreases, more contact time and more sorbent may be used. The increased contact time and increased sorbent increase operating costs. The return based upon the heat recovered may be balanced with the increased operating costs.

[0036] Referring again to FIG. 1, an additional optional sorbent injection location 117 may be included in system 100. Optional sorbent injection location 117 along flue gas conduit 113 may apply the same sorbent as sorbent injection location 124 or any other suitable sorbent(s) for sulfuric acid dew point reduction. In one embodiment, optional sorbent injection location 117 applies sorbent 127 configured for reducing fouling in air preheater 116 and preventing slagging and/or corrosive material being included in combustion air inlet line 118 with carry over. For example, in the embodiment, sorbent 127 may be a magnesium based sorbent. In one embodiment, sorbent(s) 127 may be selectively applied by sorbent injection location 117 and/or sorbent injection location 124. Such selective application of sorbent(s) 127 may permit additional control of system 100. For example, increased application of sorbent(s) 127 in sor-
bent injection location 117 may reduce slagging in boiler 102 in conjunction with a decreased application of sorbent(s) 126 in sorbent injection location 124 to achieve the desired sulfuric acid dew point and/or corresponding/related temperature. Other suitable modifications to the amount or type of sorbent(s) being applied to sorbent injection location 117 and/or sorbent injection location 124 may include increased SO_{2} reduction as the flue gas cools in air preheater 116 and prevent fouling.

[0037] Particulate removal mechanism 120 is arranged and disposed to receive the flue gas from air preheater 116. A portion or all of a SO_{2} neutralization product resulting from the application of sorbent(s) 126, any excess sorbent 126, and/or particulate may be removed by any suitable mechanism. For example, the SO_{2} neutralization product, sorbent(s) 126, and/or particulate may form particulate waste 122, which may be removed by particulate removal mechanism 120. In one embodiment, particulate removal mechanism 120 may include particulate material collection equipment (not shown) such as, an electro-static precipitator (ESP) and/OR a filter medium (bag house). The flue gas may be treated by the particulate material collection equipment to remove a predetermined amount of particulate waste 122 in the flue gas. For example, in one embodiment, about 99% of particulate is removed from the flue gas as particulate waste 122. In another embodiment, all particulate above a predetermined size (for example, about 10 microns) is removed from the flue gas as particulate waste 122.

[0038] The flue gas with reduced or eliminated particulate may travel from particulate removal mechanism 120 to a second air preheater 128 for second stage heat recovery. Air preheater 128 may be any suitable preheater. Air preheater 128 may be the same type of air preheater as air preheater 116. Air preheater 128 is arranged and disposed to directly or indirectly receive the flue gas via flue gas conduit 121 from particulate removal mechanism 120 and to receive air 130.

[0039] Referring to FIG. 1, air preheater 128 may be arranged and disposed for cooling flue gas provided by particulate removal mechanism 120. Although the temperature of the flue gas may be reduced by air preheater 128 transferring heat from the flue gas to air 130, the temperature of the flue gas is maintained above the sulfuric acid dew point and/or corresponding/related temperature. Upon heating air 130, a stream of preheated air may be provided via combustion air inlet line 132 to any suitable component. For example, all or a portion of the preheated air may be provided to air preheater 116 and/or boiler 102, thereby increasing efficiency of combustion. In one embodiment, air 130 may be pre-heated prior to reaching air preheater 128. In one embodiment, air 130 may be provided to air preheater 128 at a temperature above the sulfuric acid dew point, thereby preventing condensation of any remaining SO_{2} and sharing similar benefits identified with reference to air preheater 116. In one embodiment, air preheater 128 may be configured for low solids. For example, air preheater 128 may include a tubular heat exchanger.

[0040] As shown in FIG. 3, prior to the flue gas traveling to flue gas desulfurization unit 134, wet electrostatic precipitator 142, and/or stack 146, in one embodiment, the flue gas may travel through one or more flue gas heat exchangers 306 operably connected to air preheater 128 and forming the second stage heat recovery. The second stage heat recovery may be performed indirectly by drawing a heat transfer medium (for example, water) circulated within heat transfer medium circulation loop 302 with a pump 304 from the one or more flue gas heat exchangers 306 to air preheater 128. The one or more flue gas heat exchangers 306 may reduce the temperature of the flue gas prior to providing the flue gas to further processing. Heat transfer medium in circulation loop 302 may heat air 130 in air preheater 128 and provide air for use as described above via combustion air inlet line 132. Upon the heat transfer medium cooling, the cooled heat transfer medium may recirculate back to the one or more flue gas heat exchangers 306.

[0041] As shown in FIG. 1 or 3, the flue gas may be provided to flue gas desulfurization (FGD) unit 134 via flue gas conduit 110. FGD unit 134 is arranged and disposed to receive the flue gas from the second stage heat recovery mechanism (for example, from air preheater 128 in FIG. 1 or from flue gas heat exchangers 306 in FIG. 3). Within FGD unit 134, the SO_{2} in the flue gas may react with oxidation air 136 and reagent 138 (for example, a limestone slurry) to form waste product 140 (for example, gypsum). In an exemplary embodiment, the limestone forced oxidation process is used. In one embodiment, FGD unit 134 may remove over 90% of the SO_{2} in the flue gas. In one embodiment, FGD unit 134 may include corrosion resistant material at the flue gas entrance where reagent 138 is applied to the flue gas and neutralizes the acid in the flue gas.

[0042] Within FGD unit 134, cooling of the flue gas may remove a portion of the remaining SO_{2} in the flue gas by condensing as sulfuric acid. In one embodiment, a portion of SO_{2} is removed with waste product 140. The flue gas may then be optionally provided for further processing via flue gas conduit 135. For example, if SO_{2} in the flue gas is below a predetermined concentration and/or amount, the flue gas may be released via flue gas conduit 143 to the atmosphere through stack 146. If SO_{2} in flue gas is above a predetermined amount, the flue gas may be provided to wet electrostatic precipitator 142.

[0043] Wet electrostatic precipitator (WESP) 142 is arranged and disposed to receive wash water 144 and to provide the flue gas to stack 146 via flue gas conduit 143. WESP 142 may treat remaining SO_{2} (for example, a sulfuric acid mist) and remaining particulate (for example, very fine particulate, such as particulate smaller than about 10 micrometers). WESP 142 may remove the remaining SO_{2} and the remaining particulate by charged electrodes. The electrodes attract the remaining SO_{2} and the remaining particulate. The remaining SO_{2} and the remaining particulate are washed substantially continuously from the charged electrodes with wash water 144 to dilute and remove the remaining SO_{2} and the remaining particulate.

[0044] While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

1. A power generation system for high sulfur fuel combustion, the system comprising:

a boiler for combusting a sulfur containing fuel to form a sulfur containing flue gas;
a heat exchanger arranged and disposed to transfer heat from the sulfur containing flue gas to combustion air; a sorbent injector arranged and disposed to inject sorbent into the sulfur containing flue gas; a second stage heat recovery mechanism arranged and disposed to transfer heat from the sulfur containing flue gas; wherein the heat exchanger maintains a temperature of the sulfur containing flue gas above a predetermined temperature, the predetermined temperature relating to the acid condensation temperature, and wherein the sorbent reduces concentration of sulfur in the sulfur containing flue gas, thereby reducing the acid condensation temperature of the sulfur containing flue gas.

2. The system of claim 1, wherein the second stage heat recovery mechanism is arranged and disposed to transfer heat from the sulfur containing flue gas to air directed to the heat exchanger.

3. The system of claim 1, wherein the predetermined temperature is a sulfuric acid dew point in the sulfur containing flue gas.

4. The system of claim 1, wherein the predetermined temperature corresponds to a sulfuric acid dew point.

5. The system of claim 1, wherein the predetermined temperature is correlated to a sulfuric acid dew point.

6. The system of claim 1, wherein the predetermined temperature is correlated to a sulfuric acid dew point based upon a Kiang correlation.

7. The system of claim 1, further comprising a selective catalytic reduction unit arranged and disposed to receive the sulfur containing flue gas from the boiler and to apply a reductant to the sulfur containing flue gas.

8. The system of claim 5, further comprising an additional sorbent injection location positioned between the selective catalytic reduction unit and the heat exchanger.

9. The system of claim 6, wherein the additional sorbent injection location applies a second sorbent, the second sorbent being configured for reducing fouling.

10. The system of claim 1, further comprising a particulate removal mechanism arranged and disposed to remove particulate from the sulfur containing flue gas.

11. The system of claim 1, further comprising a flue gas desulfurization unit arranged and disposed to apply oxidation air and reagent to the sulfur containing flue gas to remove SO2 and form a waste product, and to release the waste product.

12. The system of claim 1, wherein the heat exchanger is configured to operate in the presence of particulate.

13. The system of claim 1, wherein the sorbent is selected from the group consisting of limestone, lime, trona, sodium bisulfate, magnesium hydroxide, and combinations thereof.

14. The system of claim 1, wherein the application of the sorbent results in the sulfur containing flue gas having a SO3 concentration of less than about 50 ppm volume.

15. The system of claim 1, wherein the application of the sorbent lowers SO3 concentration in the sulfur containing flue gas by at least 80%.

16. A power generation system for high sulfur fuel combustion, the system comprising:

- a boiler for combusting a sulfur containing fuel to form a sulfur containing flue gas;
- a heat exchanger arranged and disposed to transfer heat from the sulfur containing flue gas to combustion air;
- a sorbent injector arranged and disposed to inject sorbent into the sulfur containing flue gas; and
- a second stage heat recovery mechanism arranged and disposed to transfer heat from the sulfur containing flue gas to air directed to the heat exchanger;

wherein the heat exchanger maintains a temperature of the flue gas above a predetermined temperature, the predetermined temperature relating to the acid condensation temperature, and wherein the predetermined temperature corresponds to a sulfuric acid dew point or is based upon a correlation, wherein the sorbent is selected from the group consisting of limestone, lime, trona, sodium bisulfate, magnesium hydroxide, and combinations thereof.

wherein the application of the sorbent results in the sulfur containing flue gas having a SO3 concentration of less than about 50 ppm volume, and wherein the application of the sorbent lowers SO3 concentration in the sulfur containing flue gas by at least 80%.

17. A method of generating power, the method comprising:

- combusting a sulfur containing fuel to form a sulfur containing flue gas;
- in a heat exchanger, transferring heat from the sulfur containing flue gas to combustion air;
- maintaining a temperature of the sulfur containing flue gas leaving the heat exchanger above a predetermined temperature, the predetermined temperature relating to the acid condensation temperature;
- injecting sorbent into the sulfur containing flue gas, wherein the sorbent reduces concentration of sulfur in the sulfur containing flue gas, thereby reducing the acid condensation temperature of the sulfur containing flue gas; and
- transferring heat from the sulfur containing flue gas in a second stage heat recovery mechanism.

18. The method of claim 17, further comprising directing the air in the second stage heat recovery mechanism to the heat exchanger.

19. The method of claim 17, further comprising reducing fouling by applying an additional sorbent.

20. The method of claim 17, wherein the predetermined temperature corresponds to a sulfuric acid dew point.

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