The present invention relates generally to the cleaning of a flue gas and, in one embodiment, to a device, system and method that mitigates and/or prevents slurry deposition at the flue inlet to a wet flue gas desulfurization (WFGD) unit in order to keep the inlet dry and minimize deposition (e.g., deposition scale) at the flue inlet to the WFGD tower. In one embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising a plenum air device and/or forced-air box located proximate the inlet transition zone. In another embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising at least one chill plate located proximate the inlet transition zone.
FIG. 6
SYSTEM AND METHOD FOR CONTROLLING SCALE BUILD-UP IN A WFGD

RELATED APPLICATION DATA


FIELD AND BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to the cleaning of a flue gas and, in one embodiment, to a device, system and method that mitigates and/or prevents slurry deposition at the flue inlet to a wet flue gas desulfurization (WFGD) unit in order to keep the inlet dry and minimize deposition (e.g., deposition scale) at the flue inlet to the WFGD tower. In one embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising a plenum air device and/or forced-air box located proximate the inlet transition zone. In another embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising at least one chill plate located proximate the inlet transition zone. In still another embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising a plenum air device and/or forced-air box and at least one chill plate, where both devices are located proximate the inlet transition zone.

[0004] 2. Description of the Related Art

[0005] FIG. 1 is an illustration of a typical wet flue gas desulfurization (WFGD) unit and the various parts and features contained therein. As illustrated in FIG. 1, the SO$_2$-laden flue gas that enters via the inlet shown in FIG. 1 in various WFGD towers comes into contact with the slurry utilized in the WFGD tower. Due to the hot flue gas entering the tower, the flue gas temperature and the gas flow path around the inlet can cause the slurry to deposit on the walls/roof of the inlet nozzle. The slurry can then “flash-dry” onto this surface thereby leaving one or more deposits extremely hard scale. This scale has the potential to break off in service during tower load swings and plant outages thereby causing one or more pieces of hard and abrasive material to fall into the WFGD tank and make its way through the process streams.

[0006] While not wishing to be bound to any one theory, it is believed that the formation of the scale starts in the two lower corners of the WFGD inlet with the lowest gas flow, and thus, the highest possibility of stagnation and highest potential of liquid to gas in the inlet. One non-limiting theory is that in the specific case of tile-lined WFGD towers allow for more adhesion of the scale due to the porous nature of the grout and/or tile utilized therein. This allows for large pieces of scale to form and shed at one time.

[0007] Given this, one potential solution to the above problem is disclosed in U.S. Pat. No. 5,403,523 where a deflection system is utilized to maintain a cleaner WFGD inlet. Given this, an exemplary prior art solution is illustrated in FIGS. 2 through 5.

[0008] Turning to Figures, FIG. 1 is an overall view of an exemplary wet flue gas desulfurization (WFGD) unit, while FIG. 2 is a cross-sectional illustration of a portion of a known wet flue gas desulfurization (WFGD) system 10, wherein a wet scrubber module 12 having a cylindrical housing 14 receives a flue gas 16 at a transition between an inlet flue 18 and the housing. Inlet flue 18 typically approaches cylindrical housing 14 at a downward angle ranging from 0° to 90° from the horizontal. Inlet flue 18 is typically rectangular in cross-section, having a width W that is approximately 2.5 times greater than its height H (i.e., an aspect ratio of width to height W/H of approximately 2.5). At locations 20, 22 near an intersection of upper and lower surfaces 24, 26, respectively of inlet flue 18 and cylindrical housing 14, inlet flue 18 is mitered so that it intersects and attaches to cylindrical housing 14 at a 90° angle; i.e., inlet flue 18 is substantially perpendicular to cylindrical housing 14. This perpendicular orientation simplifies the transition, structural design and fabrication of the wet scrubber module 12. Prior to inlet flue 18, other portions (not shown) of the flue system upstream of inlet flue 18 may include cross-section transitions, elbows, fans, and/or other hydraulic devices to supply the flue gas 16 to the inlet flue 18.

[0009] As illustrated in FIGS. 3A and 3B, within the cylindrical housing 14, an inlet awning 28 is used to direct part of the hot flue gas 16, typically provided to the wet scrubber module 12 at a temperature of approximately 300°F, downwardly at a 45° angle with respect to horizontal. Liquid slurry 30 that is sprayed within the wet scrubber module 12 and/or which drains from packing, trays, or other surfaces within the wet scrubber module 12, flows downwardly onto an upper surface 32 of the inlet awning 28. A weir plate 34 located above a tip 36 of the inlet awning 28 provides a gap 38 through which the liquid slurry 30 passes, and thus regulates and improves the uniformity of a liquid slurry curtain 40 that is discharged down into the hot flue gas stream 16. As the hot flue gas 16 enters the wet scrubber module 12, it is quenched and humidified by the liquid slurry curtain 40, evaporating a fraction of the water present in the liquid slurry curtain 40.

[0010] In the absence of an inlet awning 28, a thin liquid film of liquid slurry 30 flowing downwardly along the walls of the wet scrubber module 12 contacts the hot flue gas 16. However, the amount of water present in the thin liquid film of slurry 30 falling across the inlet opening to the wet scrubber module 12 is not sufficient to completely quench and humidify the hot flue gas 16. The inlet awning 28 collects all the liquid slurry 30 that falls on top of it and channels the liquid slurry 30 to the gap 38 to form the thick liquid slurry curtain 40. This larger amount of water diverted by the inlet awning 28 and forming the liquid slurry curtain 40 exceeds what is needed for complete and instantaneous quenching and humidification of the hot flue gas 16. This complete and sudden quench and humidification reduces the wet/dry interface and the possibility of solid deposition.

[0011] In the absence of an inlet awning 28, if the liquid slurry 30 and hot flue gas 16 combination contacts any surface of the inlet flue 18 or housing 14, solid deposits will form as the liquid slurry 30 evaporates. Solids form at the wet/dry interface because the water present is not sufficient to continuously and fully humidify the incoming gas. These solid deposits build up over time, which requires the wet scrubber...
module 12 to be shut down so that maintenance personnel can enter the wet scrubber module 12 and remove the deposits. Shut down of a wet scrubber module 12 requires that either spare wet scrubber modules 12 be available to clean the flue gas 16, that the boiler load is reduced so that the amount of flue gas produced does not exceed the capacity of the remaining on-line wet scrubber modules 12, or that there is a discharge of partially or untreated flue gas 16 directly into the atmosphere. All of these alternatives are undesirable and not accepted by the industry. It is thus preferable to maintain the wet/dry interface of the liquid slurry 30 with the hot flue gas 16 away from these surfaces, and the inlet awning 28 accomplishes this result by creating the liquid slurry curtain 40. The liquid slurry curtain 40 is maintained away from these surfaces because the inlet awning 28 extends downwardly and into the cylindrical housing 14 of wet scrubber module 12. The liquid slurry curtain 40 also provides more water than required for humidification.

[0012] As shown in FIGS. 4 and 5, at the side ends 42 of the inlet awning 28, sidewalls 44 extend from the inlet awning 28 into the housing 14 and downwardly to a point below the lower surface 26 of inlet flue 18. These sidewalls 44 prevent liquid slurry 30 from flowing off the side ends 42 of the inlet awning 28 or along an inner surface 46 of the housing 14 from entering inlet flue 18. These sidewalls 44 are necessary to maintain an acceptable wet/dry interface away from these surfaces to avoid the deposition problems discussed earlier. In addition, the inlet awning 28 is provided with stiffeners 48 which, in conjunction with the sidewalls 44, further distribute the slurry flow 30 evenly about these surfaces.

[0013] Hydraulic testing of the known inlet flue 18 and inlet awning 28 devices described above revealed a significant flue gas side total pressure drop. High flue gas side pressure drops require increased fan pressure capability, resulting in increased fan and motor capacity and increased operating costs for the life of the unit. This is very undesirable because even a 1.0 inch H₂O gas side pressure drop can be assessed at values which can reach one million dollars. Therefore, reducing the flue gas side pressure drop in the scrubber equipment is an effective way to reduce costs. However, such reductions must still be achieved in a manner which prevents unwanted deposition of dried slurry material at the transition interface and/or zone.

[0014] Given the above, a need exists in the art for a device, system and/or method by which to reduce the amount of slurry material that deposits in the transition interface and/or zone where the flue gas inlet meets the WFGD tower.

SUMMARY OF THE INVENTION

[0015] The present invention relates generally to the cleaning of a flue gas and, in one embodiment, to a device, system and method that mitigates and/or prevents slurry deposition at the flue inlet to a wet flue gas desulfurization (WFGD) unit in order to keep the inlet dry and minimize deposition (e.g., deposition scale) at the flue inlet to the WFGD tower. In one embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising a plenum air device and/or forced-air box located proximate the inlet transition zone. In another embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising at least one chill plate located proximate the inlet transition zone. In still another embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising a plenum air device and/or forced-air box and at least one chill plate, where both devices are located proximate the inlet transition zone.

[0016] Accordingly, one aspect of the present invention is drawn to a scale prevention system for a wet flue gas desulfurization unit (WFGD), the system comprising: a flue structure, wherein the flue structure is connected to the inlet of an wet flue gas desulfurization unit; at least two air nozzles, each air nozzle having a respective air supply line, wherein at least two air nozzles are positioned on the interior of the flue so as to provide air coverage across the horizontal width of the flue inlet to the wet flue gas desulfurization unit; and at least one inlet awning designed to deflect a slurry from the wet flue gas desulfurization unit, the at least one inlet awning being position above the flue inlet to the wet flue gas desulfurization unit.

[0017] In yet another aspect of the present invention, there is provided a scale prevention system for a wet flue gas desulfurization unit (WFGD), the system comprising: a flue structure, wherein the flue structure is connected to the inlet of a wet flue gas desulfurization unit; at least two air nozzles, each air nozzle having a respective air supply line, wherein at least one air nozzle is positioned on each opposite vertical interior wall of the flue so as to provide air coverage across the horizontal width of the flue inlet to the wet flue gas desulfurization unit; and at least two lateral air nozzles, each lateral air nozzle having a respective air supply line, wherein each lateral air nozzle is positioned internally of each of the at least two air nozzles and are positioned at the top edge of the flue inlet to the wet flue gas desulfurization unit so as to provide air coverage across the horizontal width of the flue inlet to the wet flue gas desulfurization unit.

[0018] In yet another aspect of the present invention, there is provided a scale prevention system for a wet flue gas desulfurization unit (WFGD), the system comprising: a flue structure, wherein the flue structure is connected to the inlet of an wet flue gas desulfurization unit; and at least two chill plates, each chill plate having a respective supply line, wherein at least two chill plates are positioned on the interior of the flue so as to provide temperature control across the horizontal width of the flue inlet to the wet flue gas desulfurization unit.

[0019] The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific benefits attained by its uses, reference is made to the accompanying drawings and descriptive matter in which exemplary embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is an illustration of a typical wet flue gas desulfurization (WFGD) unit;

[0021] FIG. 2 is a cross-sectional illustration of the wet flue gas desulfurization (WFGD) unit of FIG. 1;

[0022] FIG. 3A is a sectional side view of the transition between the inlet flue and the wet scrubber module of FIG. 2;

[0023] FIG. 3B is a sectional view illustrating a portion of FIG. 3A;

[0024] FIG. 4 is a sectional plan view taken in the direction of the 4-4 arrows of FIG. 2.
FIG. 5 is a sectional side view illustrating a side wall for the inlet awning of FIG. 2;

FIG. 6 is an illustration of one embodiment of a scale prevention system for a WFGD flue inlet;

FIG. 7 is a cross-sectional illustration of the scale prevention system of FIG. 6;

FIG. 8 is an illustration of another embodiment of a scale prevention system for a WFGD flue inlet;

FIG. 9 is a cross-sectional illustration of the scale prevention system of FIG. 8;

FIG. 10 is an illustration of still another embodiment of a scale prevention system for a WFGD flue inlet;

FIG. 11 is a cross-sectional illustration of the scale prevention system of FIG. 10;

FIG. 12 is a cross-sectional illustration of still another embodiment of a scale prevention system for a WFGD flue inlet;

FIG. 13 is a cross-sectional illustration of still another embodiment of a scale prevention system for a WFGD flue inlet; and

FIG. 14 is a cross-sectional illustration of still another embodiment of a scale prevention system for a WFGD flue inlet.

DESCRIPTION OF THE INVENTION

The present invention relates generally to the cleaning of a flue gas and, in one embodiment, to a device, system and method that mitigates and/or prevents slurry deposition at the flue inlet to a wet flue gas desulfurization (WFGD) unit in order to keep the inlet dry and minimize deposition (e.g., deposition scale) at the flue inlet to the WFGD tower. In one embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising a plenum air device and/or forced-air box located proximate the inlet transition zone. In another embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising at least one chill plate located proximate the inlet transition zone. In still another embodiment, a wet flue gas desulfurization (WFGD) unit, system and/or method according to the present invention comprises, among other features, a scale prevention system comprising a plenum air device and/or forced-air box and at least one chill plate, where both devices are located proximate the inlet transition zone.

As used herein, “inlet transition zone” is defined to mean the area in the WFGD inlet and/or, to the device where the temperature gradient is changing from “hot” to “cold” and/or the flue gas is experiencing a change in the amount of water saturation in the flue gas due to contact of the flue gas with the slurry from the WFGD. As would be apparent to those of skill in the art, the “inlet transition zone” is not located in one specific area. Rather, the “inlet transition zone” varies from one WFGD unit to another, or can even vary within the same WFGD depending upon operating conditions.

Regarding the air utilized in the various scale mitigation and/or prevention systems of the present invention, the air supplied to the various air lines and/or piping of any one or more embodiments of the present invention can be supplied from temperature controlled air from any suitable source (e.g., from any suitable air pump, compressor, etc.), or can be supplied from any surplus oxidation air that might be available from the oxidation air being supplied to the WFGD. In another embodiment, the air supplied to the various air lines and/or piping of any one or more embodiments of the present invention can be supplied from any combination of temperature controlled air from any suitable source (e.g., from any suitable air pump, compressor, etc.) and any surplus oxidation air that might be available from the oxidation air being supplied to the WFGD.

Furthermore, the temperature of the air supplied to the various air lines and/or piping of any one or more embodiments of the present invention should be within a range of about −25°F to about +25°F of the WFGD slurry temperature. In another embodiment, the temperature of the air supplied to the various air lines and/or piping of any one or more embodiments of the present invention should be within a range of about −20°F to about +20°F, or about −15°F to about +15°F, or about −10°F to about +10°F, or about −5°F to about +5°F, or even about −2.5°F to about +2.5°F of the WFGD slurry temperature. Here, as well as elsewhere in the specification and claims, individual range values and/or limits can be combined to form additional non-disclosed ranges.

Turning to the Figures, FIG. 6 illustrates one embodiment of an inlet scale mitigation and/or prevention system (hereinafter solely referred to as a “scale prevention system” for the sake of brevity). In the embodiment of FIG. 6, a scale prevention system 100 is disclosed. As illustrated in FIG. 6, flue 102 is shown as entering the tower portion 104 of a WFGD unit. It should be noted that although the tower portion 104 of the WFGD is shown as having a circular cross-sectional shape, the present invention is not limited thereto. Accordingly, any geometric shape can be utilized for the tower portion 104 of a WFGD unit. Turning to the remaining portions of scale prevention system 100, flue 102 is formed so as to have at least one expansion joint 106 that traverses the width of flue 102. Additionally, scale prevention system 100 also includes left and right air lines and/or piping 108 that supply air to left and right side clean-out nozzles 110. Side clean-out nozzles 110 direct clean-out air supplied via each clean-out nozzle’s respective air line and/or piping 108 in the same general direction as the flue gas flow direction (denoted by arrow 112). In some embodiments, scale prevention system 100 can further include an inlet awning and/or sidewalls like those disclosed and discussed in FIG. 5 so as to provide additional coverage and/or protection to the top and/or side portions of flue 102 so as to prevent WFGD slurry “raining” down from above and then entering flue 102. Accordingly, the combination of left and right air lines and/or piping 108, left and right side clean-out nozzles 110 and, if so present, inlet awning and/or sidewalls (see FIG. 5) act together to prevent WFGD slurry from entering into flue 102 and causing scale to build-up on the WFGD-end of flue 102.

FIG. 7 is a cross-sectional illustration of the open end of flue 102 as it enters the tower portion 104 of the WFGD illustrating the orientation of left and right clean-out nozzles 110. In another embodiment, if so desired an inlet awning and/or sidewalls according to the embodiment of FIG. 5 can be placed over the top and side edges of flue 102 (above the upper edges of left and right clean-out nozzles 110) to provide further protection against the WFGD slurry “raining” down from above and then entering flue 102. In still another embodiment, left and right clean-out nozzles 110 can be any desired height so long as left and right clean-out nozzles start at the bottom edge of flue 102 and proceed substantially vertically up toward the top edge of flue 102.
Turning to FIG. 8, FIG. 8 illustrates another embodiment of a scale prevention system 200. As illustrated in FIG. 8, flue 202 is shown as entering the tower portion 204 of a WFGD unit. It should be noted that although the tower portion 204 of the WFGD is shown as having a circular cross-sectional shape, the present invention is not limited thereto. Accordingly, any geometric shape can be utilized for the tower portion 204 of a WFGD unit. Turning to the remaining portions of scale prevention system 200, flue 202 is formed so as to have at least one expansion joint 206 that traverses the width of flue 202. In another embodiment, the expansion joint can have one or more expansion joint drip zones and/or drains 232 represented by the left and right rectangular shapes. In one embodiment, expansion joint drip zones and/or drains 232 are located on the underside of the expansion joint section of flue 202. Additionally, scale prevention system 200 also includes left and right air lines and/or piping 234 that supply air to left and right side clean-out nozzles 236 as well as lateral clean-out nozzles 238. Lateral clean-out nozzles 238 are located toward the center line of flue 202 and are separated by baffle plate 240.

In one embodiment, lateral clean-out nozzles 238 and baffle plate 240 are located along the bottom edge of flue 202 as it enters into tower 204. In another embodiment, lateral clean-out nozzles 238 and baffle plate 240 are located along the top edge of flue 202 as it enters into tower 204. For the purposes of the present invention, the bottom edge of flue 202 is located closest to the bottom of tower 204. Baffle plate 240 is placed between lateral clean-out nozzles 238 in order to create multiple air zones due to the presence of at least two lateral clean-out nozzles. In one embodiment, the existence of baffle plate 240 permits each of the left and right lateral clean-out nozzles 238 to be operated independently of one another thereby permitting customized control of the air provided to the left and right portions of flue 202 as it enters tower 204. In another embodiment, left and right clean-out nozzles 238 can be operated in tandem rather than independently.

Given the above, the combination of side clean-out nozzles 236 and lateral clean-out nozzles 238 directs clean-out air supplied via each clean-out nozzle’s respective air line and/or piping 234 in the same general direction as the flue gas flow direction (denoted by arrow 212). In another embodiment, although not illustrated, scale prevention system 200 can further include an inlet awning and/or sidewalls that cover/surround the top and/or side portions of flue 202 so as to prevent WFGD slurry “raining” down from above and then entering flue 202. Accordingly, the combination of left and right air lines and/or piping 234, left and right side clean-out nozzles 236, left and right lateral clean-out nozzles 238, and baffle plate 240 set together to prevent WFGD slurry from entering into flue 202 and causing scale to build-up on the WFGD-end of flue 202.

FIG. 9 is a cross-sectional illustration of the open end of flue 202 as it enters the tower portion 204 of the WFGD illustrating the orientation of left and right clean-out nozzles 236, left and right lateral clean-out nozzles 238, and baffle plate 240. In another embodiment, if so desired an inlet awning and/or sidewalls can be placed over/around the top and/or side edges of flue 202 (above left and right lateral clean-out nozzles 238 and baffle plate 240) to provide further protection against the WFGD slurry “raining” down from above and then entering flue 202.

Turning to FIG. 10, FIG. 10 illustrates another embodiment of a scale prevention system 300. As illustrated in FIG. 10, flue 302 is shown as entering the tower portion 304 of a WFGD unit. It should be noted that although the tower portion 304 of the WFGD is shown as having a circular cross-sectional shape, the present invention is not limited thereto. Accordingly, any geometric shape can be utilized for the tower portion 304 of a WFGD unit. Turning to the remaining portions of scale prevention system 300, flue 302 is formed so as to have at least one expansion joint 306 that traverses the width of flue 302. In another embodiment, the expansion joint can have one or more expansion joint drains (not shown) located on the underside of the expansion joint section of flue 302. Additionally, scale prevention system 300 also includes left and right lines and/or piping 320 that supply temperature controlled air and/or temperature controlled liquid to left and right chill plates 322. The combination of left and right lines and/or piping 320 and left and right chill plates 322 seek to reduce the temperature at the inlet of WFGD tower 304 so as to mitigate and/or prevent scale build-up due to a large temperature change between the flue gas entering the WFGD and the WFGD’s slurry that is “raining” down from above. It should be noted that in another embodiment of the present invention the embodiment of FIG. 10 can be combined with either of the embodiments of FIG. 6 or FIG. 8.

In still another embodiment, although not illustrated, scale prevention system 300 can further include an inlet awning and/or sidewalls that cover/surround the top and/or side portions of flue 302 so as to prevent WFGD slurry “raining” down from above and then entering flue 302.

FIG. 11 is a cross-sectional illustration of the open end of flue 302 as it enters the tower portion 304 of the WFGD illustrating the orientation of left and right chill plates 322. In another embodiment, if so desired an inlet awning can be placed over the top edge of flue 302 to provide further protection against the WFGD slurry “raining” down from above and then entering flue 302.

Turning to FIGS. 12 through 14, FIGS. 12 through 14 are cross-sectional illustrations of various alternative embodiments of the present invention. In the embodiment of FIG. 12, a flue 402 and partial WFGD tower 404 are illustrated. As shown in the embodiment of FIG. 12, the scale prevention system disclosed therein contains both left and right side clean-out nozzles 236 and left and right chill plates 322. In the embodiment of FIG. 13, the scale prevention system disclosed therein contains left and right clean-out nozzles 236, left and right lateral clean-out nozzles 238, baffle plate 240, and left and right chill plates 322 located as shown at the end of flue 502 as it enters the tower 504. In the embodiment of FIG. 14, the scale prevention system disclosed therein contains left and right clean-out nozzles 236, left and right lateral clean-out nozzles 238, baffle plate 240, and left and right chill plates 322, with the left and right clean-out nozzles 236 being located vertically above the respective left and right chill plates 322 located as shown at the end of flue 602 as it enters the tower 604.

It should be noted that the size, height and/or width of any of the nozzles, chill plates and/or baffle plates of the present invention can be varied as needed and/or desired. Accordingly, the present invention is not limited to just one geometric shape, layout, and or design orientation. Further-
more, the various nozzles, chill plates, and/or baffle plates can be operated in combination, various sub-combinations, or even each item independently.

[0050] While not wishing to be bound to any one advantage, or set of advantages, a scale prevention system according to the present invention prevents scale from forming and then falling into the WFGD tank. Alternatively, if scale forms the scale that forms is smaller in size and is able to break up into smaller pieces by the agitators and pump (absorber recycle pumps and/or bleed pumps). Given this, in the bleed pump stream, the scale pieces are able to be pumped into the primary hydroclones. The one or more systems of the present invention prevent larger scale pieces from forming and thereby prevents such scale pieces from entering into the one or more hydroclones were such pieces are not able to be removed in the underflow stream. This reduces plugging of the one or more hydroclones and thus reduces the frequency of maintenance intervals.

[0051] The present invention is also advantageous over those systems that utilize some type of water-based system to prevent scale formation at the tower end of a flue entering a WFGD. Such water-based systems are subject to a number of drawbacks including, but not limited to, undesirable variations in the WFGD tower water/aqueous balance, corrosion at the tower end of the flue entering the WFGD; and/or water supply problems that might actually end up causing an increase in scale formation.

[0052] Another potential advantage attributable to the present invention is the reduction in scale size and frequency reduces the amount and size of scale pieces that are forced through the Absorber Recycle (AR) pumps. This has the potential of reducing the amount of abrasive particles in the pump stream. Furthermore, scale pieces are typically pushed into the AR headers and into the slurry nozzles in the upper portion of the towers. These nozzles have small openings and if enough scale pieces become wedged together, there is a high likelihood of plugging AR nozzles and/or headers. Such plugging leads to a drop in SO₂ removal as well as the risk of lower limestone utilization by the system. Accordingly, the one or more embodiments of the present invention can reduce the severity and/or occurrence of this phenomena thereby resulting in better SO₂ removal rates as well as less damage to the one or more AR nozzles.

[0053] Given the above, the embodiments of the present invention utilize two different principles to reduce the amount of scale that forms at the flue inlet of a WFGD. The embodiments of FIGS. 6 through 8 utilize pressurized and/or forced air via various nozzles and/or a plenum structure to keep the inlet area clean by two means: (i) by higher pressure air forcing any slurry and/or eddy current gas flow out of the inlet and into the tower; and (ii) by supplying air that serves to create an insulating zone between the hot flue gas and cooler slurry. In one embodiment, the air supplied to the flue inlet can be humidified down to an acceptable temperature. This colder plenum should be kept at a temperature equal to or less than the operating temperature of the WFGD fluid in order to prevent the slurry from flash-drying to the plenum and forming scale.

[0054] In still another embodiment, the air source for the various embodiments of the present invention is provided from the WFGD’s oxidation air flow into the tower, then an added benefit is realized in that WFGD sites are designed and are operating with (due to tower loading turn-down) excess oxidation air. This excess oxidation air leads to adverse chemistry effects in some plants including but not limited to: (a) strong oxidizer formation with downstream impacts; (b) tower corrosion from manganese deposition forming a galvanic bridge to drive fluoride induced under-deposit corrosion; (c) adverse selenium speciation; and (d) mercury reemission. Accordingly, the use of such excess oxidation air can help to reduce, mitigate and/or eliminate one or more of the above noted negative effects.

[0055] The embodiments of FIGS. 9 and 10 that utilize left and right chill plates, with or without the use of pressurized/oxidation air, can decrease the formation of the scale at the flue inlet to the WFGD. The chill plates help to maintain a cooler inlet surface which helps to prevent the thermal shock the slurry experiences at the flue inlet. This thermal shock can lead to the “flash drying” that is linked to scale formation at the flue inlet. The chill plates also permit the use flowing liquid/or gas at a predetermined temperature so as to keep the contact surface of the inlet at a lower temperature than the flue gas inlet temperature.

[0056] While specific embodiments of the present invention have been shown and described in detail to illustrate the application and principles of the invention, it will be understood that it is not intended that the present invention be limited thereto and that the invention may be embodied otherwise without departing from such principles. In some embodiments of the invention, certain features of the invention may sometimes be used to advantage without a corresponding use of the other features. Accordingly, all such changes and embodiments properly fall within the scope of the following claims.

What is claimed is:

1. A scale prevention system for a wet flue gas desulfurization unit, the system comprising:
   a flue structure, wherein the flue structure is connected to a flue inlet of a wet flue gas desulfurization unit;
   at least two air nozzles, each air nozzle having a respective air supply line, wherein the at least two air nozzles are positioned on the interior of the flue structure so as to provide air coverage across the horizontal width of a flue inlet to the wet flue gas desulfurization unit; and
   at least one air nozzle having a respective air supply line, wherein at least one air nozzle is positioned above the flue inlet to the wet flue gas desulfurization unit.

2. The system of claim 1, wherein the flue structure has a rectangular or square cross-sectional shape and the at least two air nozzles are positioned on opposite interior walls of the flue.

3. The system of claim 2, wherein the at least two air nozzles are positioned on opposite vertical interior walls of the flue.

4. The system of claim 1, wherein the at least two air nozzles receive temperature controlled air that is within a range of about -25°C F. to about +25°C F. of the wet flue gas desulfurization unit slurry temperature.

5. A scale prevention system for a wet flue gas desulfurization unit, the system comprising:
   a flue structure, wherein the flue structure is connected to a flue inlet of a wet flue gas desulfurization unit and the flue structure has a cross-sectional shape selected from a rectangle or a square;
   at least two air nozzles, each air nozzle having a respective air supply line, wherein at least one air nozzle is positioned on each opposite vertical interior wall of the flue.
structure so as to provide air coverage across the horizontal width of a flue inlet to the wet flue gas desulfurization unit; and
at least two lateral air nozzles, each lateral air nozzle having a respective air supply line, wherein each lateral air nozzle is positioned internally of each of the at least two air nozzles and are positioned at the top edge of the flue inlet to the wet flue gas desulfurization unit so as to provide air coverage across the horizontal width of the flue inlet to the wet flue gas desulfurization unit.
6. The system of claim 5, wherein the at least two lateral air nozzles are separated by a baffle plate.
7. The system of claim 5, wherein the system further comprises at least one inlet awning designed to deflect a slurry from the wet flue gas desulfurization unit, the at least one inlet awning being position above the flue inlet to the wet flue gas desulfurization unit.
8. The system of claim 5 wherein the at least two air nozzles receive temperature controlled air that is within a range of about −25° F. to about +25° F. of the wet flue gas desulfurization unit slurry temperature.
9. A scale prevention system for a wet flue gas desulfurization unit, the system comprising:
a flue structure, wherein the flue structure is connected to a flue inlet of a wet flue gas desulfurization unit; and
at least two chill plates, each chill plate having a respective supply line, wherein the at least two chill plates are positioned on the interior of the flue structure so as to provide temperature control across the horizontal width of a flue inlet to the wet flue gas desulfurization unit.
10. The system of claim 9, wherein each chill plate receives temperature controlled gas.
11. The system of claim 9, wherein each chill plate receives temperature controlled liquid.
12. The system of claim 9, wherein the at least two chill plates receive a temperature controlled gas that is within a range of about −25° F. to about +25° F. of the wet flue gas desulfurization unit slurry temperature.
13. The system of claim 9, wherein the at least two chill plates receive a temperature controlled liquid that is within a range of about −25° F. to about +25° F. of the wet flue gas desulfurization unit slurry temperature.
14. The system of claim 9, wherein the system further comprises at least one inlet awning designed to deflect a slurry from the wet flue gas desulfurization unit, the at least one inlet awning being position above the flue inlet to the wet flue gas desulfurization unit.
15. The system of claim 9, wherein the flue structure has a rectangular or square cross-sectional shape and at least one chill plate is positioned on each of the opposite vertical interior walls of the flue structure.
16. The system of claim 9, wherein the flue structure has a cross-sectional shape selected from a rectangle or a square and at least one chill plate is positioned on each of the opposite bottom interior corners of the flue structure.
17. A scale prevention system for a wet flue gas desulfurization unit, the system comprising:
a flue structure, wherein the flue structure is connected to a flue inlet of a wet flue gas desulfurization unit;
at least two air nozzles, each air nozzle having a respective air supply line; and
at least two chill plates, each chill plate having a respective supply line,
wherein the combination of the at least two air nozzles and the at least two chill plates are positioned on the interior of the flue structure so as to provide temperature control across the horizontal width of a flue inlet to the wet flue gas desulfurization unit.
18. The system of claim 17, wherein the system further comprises at least one inlet awning designed to deflect a slurry from the wet flue gas desulfurization unit, the at least one inlet awning being position above the flue inlet to the wet flue gas desulfurization unit.
19. The system of claim 17, wherein the flue structure has a rectangular or square cross-sectional shape and the at least two air nozzles are positioned on opposite vertical interior walls of the flue.
20. The system of claim 17, wherein the flue structure has a rectangular or square cross-sectional shape and at least one chill plate is positioned on each of the opposite vertical interior walls of the flue structure.
21. The system of claim 17, wherein the flue structure has a cross-sectional shape selected from a rectangle or a square and at least one chill plate is positioned on each of the opposite bottom interior corners of the flue structure.
22. The system of claim 17, wherein the at least two air nozzles receive temperature controlled air that is within a range of about −25° F. to about +25° F. of the wet flue gas desulfurization unit slurry temperature.
23. The system of claim 17, wherein the at least two chill plates receive a temperature controlled gas that is within a range of about −25° F. to about +25° F. of the wet flue gas desulfurization unit slurry temperature.
24. The system of claim 17, wherein the at least two chill plates receive a temperature controlled liquid that is within a range of about −25° F. to about +25° F. of the wet flue gas desulfurization unit slurry temperature.
25. A scale prevention system for a wet flue gas desulfurization unit, the system comprising:
a flue structure, wherein the flue structure is connected to a flue inlet of a wet flue gas desulfurization unit;
at least two air nozzles, each air nozzle having a respective air supply line, wherein at least one air nozzle is positioned on each opposite vertical interior wall of the flue;
at least two lateral air nozzles, each lateral air nozzle having a respective air supply line, wherein each lateral air nozzle is positioned internally of each of the at least two air nozzles and are positioned at the top edge of the flue inlet to the wet flue gas desulfurization unit; and
at least two chill plates, each chill plate having a respective supply line, wherein the at least two chill plates are positioned on the interior of the flue, wherein the combination of the at least two air nozzles, the at least two lateral air nozzles and the at least two chill plates are positioned on the internal surfaces of the flue structure so as to provide temperature control across the horizontal width of a flue inlet to the wet flue gas desulfurization unit.
26. The system of claim 25, wherein the at least two lateral air nozzles are separated by a baffle plate.
27. The system of claim 25, wherein the system further comprises at least one inlet awning designed to deflect a slurry from the wet flue gas desulfurization unit, the at least one inlet awning being position above the flue inlet to the wet flue gas desulfurization unit.
28. The system of claim 25, wherein the flue structure has a rectangular or square cross-sectional shape and the at least two air nozzles are positioned on opposite vertical interior walls of the flue.

29. The system of claim 25, wherein the at least two lateral air nozzles are separated by a baffle plate.

30. The system of claim 25, wherein the flue structure has a rectangular or square cross-sectional shape and at least one chill plate is positioned on each of the opposite vertical interior walls of the flue structure.

31. The system of claim 25, wherein the flue structure has a cross-sectional shape selected from a rectangle or a square and at least one chill plate is positioned on each of the opposite bottom interior corners of the flue structure.

32. The system of claim 25, wherein the at least two air nozzles receive temperature controlled air that is within a range of about -25°F to about +25°F of the wet flue gas desulfurization unit slurry temperature.

33. The system of claim 25, wherein the at least two chill plates receive a temperature controlled gas that is within a range of about -25°F to about +25°F of the wet flue gas desulfurization unit slurry temperature.

34. The system of claim 25, wherein the at least two chill plates receive a temperature controlled liquid that is within a range of about -25°F to about +25°F of the wet flue gas desulfurization unit slurry temperature.

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