WHAT IS CLAIMED IS

1. Apparatus for absorption of sulfur dioxide from a flue gas, the apparatus comprising:

a reactor configured to receive the flue gas;

a spraying layer that is disposed in the reactor and is configured to contact the flue gas with an ammonia-bearing liquid that that contains ammonium sulfite and absorbs, at a temperature, sulfur from the flue gas;

a control that is configured to:

limit oxygen content of material entering the reactor to a content that is in the range 3 to 9% by volume; and

lower the temperature in response to an excess aerosol content in effluent from the reactor;

an oxidation system configured to oxidize the liquid; and

an auxiliary system that is configured to derive ammonium sulfate solid from the liquid, the absorption reaction temperature is be controlled at 30-60 °C and the water content of the flue gas is 4-15%.

2. The apparatus of claim 1 wherein the auxiliary system comprises:

an ammonium sulfate post-treatment system;

an ammonia supply system; and

a process water system.

3. The apparatus of claim 1 wherein:

the reactor includes an absorption tower in which is defined:

a pre-wash zone;

an absorption zone; and

a fine particle control zone;

wherein:

each of the zones includes one or more spraying layer;

a first gas-liquid separator is disposed between the absorption zone and the pre-wash zone; and

a second gas-liquid separator is disposed between the absorption zone and the fine particle control zone.

4. The apparatus of claim 3 wherein:

a third gas-liquid separator is disposed within the absorption zone; and

a fourth gas-liquid separator is disposed within the fine particle zone.

5. The apparatus of claim 3 wherein:

in the absorption zone, in each layer:

a liquid-gas ratio is not less than 0.4L/Nm3; and

an average spray coverage rate is not less than 200%; and,

in the fine particle control zone, in each layer:

a liquid-gas ratio is not less than 0.42L/Nm3; and

an average spray coverage rate is not less than 150%.

6. The apparatus of claim 3 wherein the oxidation system includes an oxidation tank configured to:

receive used absorption liquid;

flow:

a first fraction of the used absorption liquid through a first path; and

a second fraction of the absorption liquid through a second path; and

provide:

from the first path, a first output to the fine particle control zone; and,

from the second path, a second output to the absorption zone;

wherein the first output is more oxidized than is the second output.

7. The apparatus of claim 6 wherein the oxidation tank includes:

an array of gas-liquid dispersion intensifiers;

a first output port that is:

disposed at a first location along the array; and

configured to provide the first output;

a second output port that is:

disposed at a second location along the array; and

configured to provide the second output; and

an ammonia chamber that defines perforations for passage of:

ammonia from the chamber to the first path; and

used absorption liquid into the chamber;

wherein the second location causes less oxidation of the used absorption liquid than does the first location.

8. The apparatus of claim 6 wherein the oxidation tank includes:

a separator; and,

in the first path, an oxidized air source;

wherein the second path passes outside the separator.

wherein:

no oxidized air is provided along the second path; and

the used absorption liquid at the first output is fully oxidized.

9. The apparatus of claim 3 wherein the tower is configured to:

flow the flue gas at a superficial gas flow rate of 0.8 m/s-4m/s; and

receive flue gas having an SO_2 concentration of up to 30,000 mg/Nm^3.

10. The apparatus of claim 3 wherein the effluent has an SO_2 content that is not more than 100 mg/Nm^3.

11. The apparatus of claim 10 wherein the effluent has an SO_2 content that is not more than 35 mg/Nm^3.

12. The apparatus of claim 9 wherein the total dust content is not more than 20mg/Nm^3.

13. The apparatus of claim 12 wherein the total dust content is not more than 5 mg/Nm^3.

14. The apparatus of claim 3 wherein the tower is configured to emit effluent having an ammonia escape that is no more than 8 mg/Nm^3.

15. The apparatus of claim 14 wherein the tower is configured to emit effluent having an ammonia escape that is no more than 2 mg/Nm^3.

16. The apparatus of claim 3 further comprising:

an additive gas source that is configured to flow additive gas into the flue gas before the flue gas enters the tower, a mixture of the additive gas and the flue gas being process gas and having, at an inlet of the tower, a water content that exceeds 15%; and

an evaporative crystallization system configured to crystallize ammonium sulfate from absorbed SO_2 after absorption of SO_2 in the ammonia-bearing liquid.

17. The apparatus of claim 16 further comprising a steam jet pump that is part of a dual-effect evaporative crystallization process.

18. The apparatus of claim 16 wherein the evaporative crystallization system is configured to perform an MVR evaporative crystallization process.

19. The apparatus of claim 3 further comprising:

an additive gas source that is configured to flow additive gas into the flue gas before the flue gas enters the tower, a mixture of the additive gas and the flue gas being process gas having, at an inlet of the tower, a water content that exceeds 15%;

a heat exchanger configured to exchange heat with the ammonia-bearing liquid before the ammonia-bearing liquid is sprayed in the absorption zone; and

an evaporative crystallization system configured to crystallize ammonium sulfate from absorbed SO_2 after absorption of SO_2 in the ammonia-bearing liquid.

20. The apparatus of claim 3 further comprising:

an additive gas source that is configured to flow additive gas into the flue gas before the flue gas enters the tower, a mixture of the additive gas and the flue gas being process gas having, at an inlet of the tower, a water content that exceeds 15%;

a heat exchanger configured to exchange heat with the ammonia-bearing liquid before the ammonia-bearing liquid is sprayed in the absorption zone;

a heat exchanger configured to exchange heat with pre-wash fluid before the pre-wash fluid is sprayed in the pre-wash zone; and

an evaporative crystallization system configured to crystallize ammonium sulfate from absorbed SO_2 after absorption of SO_2 in the ammonia-bearing liquid.

21. The apparatus of claim 3 further comprising an air distribution device configured to:

flow air into the flue gas, to form process gas, before the flue gas enters the tower; and

limit an oxygen content of the process gas, downstream of the air distribution device and upstream of the tower, to no greater than 12% by volume;

wherein the flue gas, prior to mixing with the air, has a water content that exceeds 15% by volume.

22. The apparatus of claim 21 wherein the oxygen content is in the range 3-9%.

23. The apparatus of claim 22 further comprising a condensation device that is configured to:

cool the process gas; and

reduce a humidity of the process gas.

24. The apparatus of claim 3 further comprising:

an air distributor in fluid communication with the flue gas; and

a pre-wash zone heat exchanger configured to cool pre-wash circulating liquid entering the tower;

wherein the air distributor is configured to maintain a water content of the process gas at no more than 10% by volume when the flue gas has a water content that exceeds 18% by volume.

25. The apparatus of claim 24 further comprising:

an absorption zone heat exchanger configured to cool absorption liquid entering the tower;

wherein the air distributor is configured to maintain a water content of the process gas at no more than 10% by volume when the flue gas has a water content that exceeds 18% by volume.

26. A method for absorption of sulfur dioxide from a flue gas, the method comprising:

flowing the flue gas through a reactor;

in the reactor, absorbing at a temperature, in an ammonia-bearing, circulating liquid that contains ammonium sulfite, sulfur from the flue gas;

collecting the liquid; and

limiting oxygen content of material entering the reactor to a content that is in the range 3 to 9% by volume;

responsive to an excess aerosol content in effluent from the reactor, lowering the temperature, the absorption reaction temperature is be controlled at 30-60 ℃ and the water content of the flue gas is 4-15%.

27. The method of claim 26 further comprising, before the flowing, mixing air with the flue gas to form process gas;

wherein the lowering includes lowering a temperature of the air.

28. The method of claim 26 wherein:

the lowering includes lowering a temperature of the liquid; and

the lowering a temperature of the liquid includes passing the liquid through a circulating water cooler.

29. The method of claim 26 further comprising:

providing cooling water to a water cooler; and,

in response to an excess ion condition in the cooling water, replacing a fraction of the cooling water with process water;

wherein the lowering a temperature of the liquid includes passing the liquid through the circulating water cooler.

30. The method of claim 29 wherein the replacing includes obtaining process water from a steam condensate treatment system that is configured to derive steam from an ammonium sulfate slurry.

31. The method of claim 26 further comprising crystalizing ammonium sulfate in the liquid by transferring heat from the flue gas to the liquid;

wherein the lowering a temperature of the liquid includes:

increasing a flow rate of the air; and

reducing a humidity of the air.

32. The method of claim 26 wherein the lowering lowers the temperature to a value that is within the range is 45-53 °C.

33. The method of claim 26 wherein the limiting limits the oxygen content to a content that is no greater than 8%

34. The method of claim 26 wherein:

the absorbing includes providing the ammonia-bearing liquid in stages having different compositions; and

the absorbing has:

an absorption temperature; and

an absorption oxygen content

that are controlled such that:

no less than 90% of the sulfur dioxide is removed from the flue gas; and

dust content of effluent from the reactor is no greater than 50 mg/Nm^3.

35. The method of claim 27 wherein the process gas includes a water content that is in the range 4 to 15%.

36. The method according to claim 34 further comprising:

using the stages, controlling a gradient of a species selected from the group consisting of:

ammonium sulfite;

ammonium bisulfite; and

ammonium sulfate;

prior to the absorbing:

mixing air with the flue gas to form process gas; and

cooling and purifying the process gas;

contacting the process gas with:

the ammonia-bearing liquid, in one or more of the stages that includes ammonium sulfite and ammonium sulfate; and,

then, a fine particle washing circulating liquid, in one or more of the stages that includes ammonium sulfite and ammonium sulfate,

whereby:

the stages;

the cooling and purifying; and

the contacting act together to absorb the no less than 90% of the sulfur dioxide.

37. The method of claim 36 further comprising adjusting a ratio of flue gas to air to control oxygen content of the process gas to a level no greater than 12%.

38. The method of claim 36 wherein:

the providing includes selecting, based on:

a measured sulfur dioxide concentration of the flue gas; and

an export emission index;

a number of the stages;

the number is greater than two;

the composition of a one of the stages includes:

0.15-4.95% ammonium sulfite; and

5-38% ammonium sulfate; and

the stages include:

an upper absorption circulating liquid; and

a lower absorption circulating liquid; and

the upper absorption circulating liquid has an ammonium sulfite content that is lower than that of the lower absorption circulating liquid.

39. The method of claim 36 wherein:

the providing includes selecting, based on:

a measured sulfur dioxide concentration of the flue gas; and

an export emission index;

a number of the stages;

the number is greater than two;

the composition of a one of the stages includes:

0.15-4.95% ammonium sulfite; and

5-38% ammonium sulfate; and

the stages include:

an upper absorption circulating liquid; and

a lower absorption circulating liquid; and

the upper absorption circulating liquid has a pH value that is lower than that of the lower absorption circulating liquid.

40. The method of claim 36 wherein a stage of the stages includes a fine particle washing circulating liquid having:

a composition that includes:

0.003-1% ammonium sulfite; and

0.3-38% ammonium sulfate; and

a pH value in the range 1-6.

41. The method of claim 31 further comprising, when the flue gas has a water content greater than 15%:

reducing the water content to a water content in the range 8 to 13% by adding to the flue gas a dry gas having a water vapor volume content no greater than 5%; and

limiting the oxygen content to be no more than 12%.

42. The method of claim 41 wherein the dry gas includes air.