CLAIMS

1. A method for removing a solidifiable gas component from a process gas stream, the method comprising:

a) contacting in a countercurrent manner in two or more stages in a contacting assembly a process gas stream containing a solidifiable gas component with a cold liquid at a contacting temperature and a contacting pressure to form a liquid-solid slurry containing the cold liquid and solids formed by solidifying at least a portion of the solidifiable component in the process gas stream;

wherein:

the contacting further forms a treated gas stream containing a portion of the process gas stream that was not solidified by the contacting with the cold liquid;

the cold liquid is at a temperature at which the solidifiable gas component within the process gas stream will transition to a solid phase;

the cold liquid has a different composition than the solidifiable gas component; and

the process gas stream includes at least one gas component that remains in a gas phase at the contacting temperature and the contacting pressure; and

b) removing at least a portion of the solids from the slurry;

wherein the removing step is performed mechanically and wherein removal occurs between at least one set of adjacent stages.

2. The method of claim 1, wherein the solidifiable gas component is selected from the group consisting of carbon dioxide, hydrogen sulfide, sulfur dioxide, or carbonyl sulfide.

3. The method of claim 1, wherein the process gas stream includes water at a concentration equal to a water saturation at a temperature above the freezing point of water.

4. The method of claim 3, wherein the method includes removing at least a portion of the water from the process gas stream prior to the contacting.

5. The method of claim 1, wherein the process gas stream includes an exhaust stream from a combustion process.

6. The method claim 1, wherein the cold liquid has a solidifiable gas component solubility of less than 10 mol% at the contacting pressure and the contacting temperature.

7. The method of claim 1, wherein the cold liquid has a different composition than the process gas stream.

8. The method of claim 1, wherein the cold liquid is a liquid at a temperature of 20°C and a pressure of 1 atmosphere, and further wherein the cold liquid has a freezing point of less than -100°C.

9. The method of claim 1, wherein the cold liquid comprises an isoalkane, an isoalkene, an alcohol, or combinations thereof.

10. The method of claim 1, wherein the cold liquid comprises a mixture of two or more components.

11. The method of claim 1, wherein the contacting pressure is less than 100 psia, and further wherein the contacting temperature is less than -80°C.

12. The method of claim 1, wherein the contacting comprises spraying the process gas stream with the cold liquid or bubbling the process gas stream through the cold liquid.

13. The method of claim 1, wherein the method includes repeating the contacting with the cold liquid at a different contacting temperature.

14. The method of claim 1, wherein the cold liquid is a first cold liquid, and further wherein the method includes repeating the contacting with a second cold liquid having a different composition than the first cold liquid.

15. The method of claim 1, wherein the method includes repeating the contacting with a second cold liquid at a different contacting temperature.

16. The method of claim 1, wherein the removing includes heating the slurry to a temperature at which at least a portion of the solids are no longer in a solid phase.

17. The method of claim 1, wherein prior to the removing, the method includes pressurizing the slurry to a pressure that is greater than the contacting pressure, the pressurization being achieved by heating the solid in a sealed container.

18. The method of claim 1, wherein the removing produces a resultant liquid stream from which the solids were removed, and further wherein the method includes recycling the resultant liquid to form at least a portion of the cold liquid, by heat exchange with at least a portion of the treated gas stream.

19. The method of claim 1, wherein the contacting is performed using a filter.

20. A system for removing a solidifiable gas component from a process gas stream by direct contact with a cold liquid, the system comprising:

a cold liquid supply containing cold liquid having a cold liquid temperature;

a process gas source containing process gas containing gases that include a solidifiable gas component having a freezing point and at least one other gas component having a freezing point that is lower than the freezing point of the solidifiable gas component;

a contacting assembly adapted to receive a cold liquid stream containing cold liquid from the cold liquid supply, a process gas stream containing process gas from the process gas source, and to directly contact the cold liquid with the process gas at a contacting temperature and a contacting pressure to produce a

liquid-solid slurry and a treated gas stream, wherein the slurry contains the cold liquid and solids formed from the solidifiable gas component, wherein the treated gas stream contains the at least one other gas component, and wherein the contacting occurs in a counter-current manner in two or more stages in a contacting assembly; and

a separation assembly adapted to remove the solids from the slurry to produce a removed stream containing the solidifiable gas component that was removed from the process gas stream, wherein the removing step is performed mechanically and where the removing occurs between at least one set of adjacent stages.

21. The system of claim 20, wherein the contacting assembly includes a plurality of contacting assemblies, wherein the cold liquid supply is a first cold liquid supply, the cold liquid stream is a first cold liquid stream, the cold liquid is a first cold liquid, and further wherein the system includes a second cold liquid supply that is adapted to deliver a second cold liquid stream containing a second cold liquid into direct contact with the process gas stream.

22. The system of claim 21, wherein the first cold liquid and the second cold liquid have at least one of different compositions and different temperatures.

23. The system of claim 20, wherein the separation assembly includes a heat source adapted to heat the slurry to a temperature that is above the freezing point of the solidifiable gas component.

24. The system of claim 20, wherein the system includes a solid-liquid separator that is adapted to receive a slurry stream containing the slurry from the contacting assembly and to separate the slurry stream into a concentrated slurry stream and a resultant cold liquid stream, wherein the concentrated slurry stream contains a greater concentration of the solids than the slurry stream, and further wherein the resultant cold liquid stream does not include all of the cold liquid present in the slurry stream.

25. The system of claim 24, wherein the solid-liquid separator comprises a filter.

26. The system of claim 24, wherein the solid-liquid separator comprises a mechanical moving scraper.

27. The system of claim 24, wherein the contacting pressure is less than 100 psia, preferably less than 35 psia, and the contacting temperature is less than -80°C.

28. The system of claim 20, wherein the cold liquid has a freezing point that is less than -100°C, and further wherein the cold liquid is a liquid at a temperature of 20°C and a pressure of 1 atm.

29. The system of claim 20, wherein the contacting assembly includes at least one spray tower, bubble column, bubble contactor, tank, or combination thereof.