CLAIMS

What is claimed is:

1. An integrated CO_2 separation system, comprising:

a gas turbine system having a combustion chamber configured to stoichiometrically combust a compressed oxidant and a fuel in the presence of a compressed recycle stream in order generate a discharge stream, which is expanded in an expander, thereby generating a gaseous exhaust stream and at least partially driving a main compressor, wherein the compressed recycle stream acts as a diluent configured to moderate the temperature of the discharge stream;

an exhaust gas recirculation system having at least one of a boost compressor and one or more cooling units configured to increase the mass flow rate of the gaseous exhaust stream to provide a cooled recycle gas to the main compressor, wherein the main compressor compresses the cooled recycle gas and generates the compressed recycle stream, a portion of which is directed to the combustion chamber and a portion of which provides a purge stream; and

a CO_2 separator fluidly coupled to the purge stream, the CO_2 separator comprising:

an absorber column configured to receive the purge stream and circulate a potassium carbonate solvent therein to absorb CO_2 in the purge stream, wherein the absorber column discharges a nitrogen-rich residual stream and a bicarbonate solvent solution;

a first valve fluidly coupled to the absorber column and configured to flash the bicarbonate solvent solution to a near-atmospheric pressure; and

a regeneration column fluidly coupled to the first valve and configured to receive and boil the bicarbonate solvent solution to remove CO_2 and water therefrom, thereby producing a regenerated potassium carbonate solvent to be recirculated back to the absorber column.

2. The system of claim 1, wherein the temperature of the purge stream is about 800 °F, and the pressure of the purge stream is about 280 psia.

3. The system of claim 2, further comprising a heat exchanger associated with the purge stream, wherein the heat exchanger is a cross-exchange heat exchanger configured to reduce the temperature of the purge stream to between about 250 °F and about 300 °F.

4. The system of claim 1, wherein the regeneration column operates at a pressure of about 3 psig.

5. The system of claim 1, further comprising a reboiler fluidly coupled to the regeneration column and configured to receive and heat a portion of the regenerated potassium carbonate solvent and produce a heated regenerated potassium carbonate solvent.

6. The system of claim 5, wherein the reboiler is configured to recirculate the heated regenerated potassium carbonate solvent back into the regeneration column to produce steam for boiling the bicarbonate solvent solution.

7. The system of claim 1, further comprising a condenser fluidly coupled to the regeneration column and configured to receive and separate the CO_2 and water removed from the bicarbonate solvent solution, wherein the CO_2 is directed to a downstream compression system.

8. The system of claim 7, wherein a portion of the water separated from the CO_2 is pumped back into the regeneration column to create steam.

9. The system of claim 1, wherein a portion of the bicarbonate solvent solution is withdrawn from the regeneration column prior to complete solvent regeneration, and recirculated and fed low into the absorber column.

10. The system of claim 9, wherein about 50% or more of a total amount of bicarbonate solvent solution is withdrawn from the regeneration column prior to complete solvent regeneration.

11. An integrated CO_2 separation system, comprising:

a gas turbine system having a combustion chamber configured to stoichiometrically combust a compressed oxidant and a fuel in the presence of a compressed recycle stream in order to expand a discharge stream in an expander, thereby generating a gaseous exhaust stream and at least partially driving a main compressor, wherein the compressed recycle stream acts as a diluent configured to moderate the temperature of the discharge stream;

an exhaust gas recirculation system having a boost compressor and one or more cooling units fluidly coupled to the boost compressor, the boost compressor being configured to receive and boost the pressure of the gaseous exhaust stream and the one or more cooling units being configured to cool the gaseous exhaust stream and provide a cooled recycle gas to the main compressor, wherein the main compressor compresses the cooled recycle gas and generates the compressed recycle stream;

a purge stream fluidly coupled to the compressed recycle stream and having a heat exchanger configured to reduce the temperature of the purge stream and generate a cooled purge stream; and

a CO_2 separator fluidly coupled to the heat exchanger, the CO_2 separator comprising:

an absorber column configured to receive the cooled purge stream and circulate a potassium carbonate solvent therein to absorb CO_2 in the cooled purge stream, wherein the absorber column discharges a nitrogen-rich residual stream and a bicarbonate solvent solution;

a first valve fluidly coupled to the absorber column and configured to flash the bicarbonate solvent solution to a lower pressure, thereby generating a reduced-pressure solution;

a separator fluidly coupled to the first valve and configured to receive the reduced-pressure solution and remove a first portion of CO_2 therefrom to be injected into an inner stage of a downstream compression system;

a second valve fluidly coupled to the separator and configured to receive remaining portions of the reduced-pressure solution and flash the remaining portions to a near-atmospheric pressure, thereby generating a near-atmospheric bicarbonate solvent solution; and

a regeneration column fluidly coupled to the second valve and configured to receive and boil the near-atmospheric bicarbonate solvent solution to remove a second portion of CO_2 and water, thereby producing a regenerated potassium carbonate solvent to be recirculated back to the absorber column.

12. The system of claim 11, wherein the temperature of the purge stream is about 800 °F, and the pressure of the purge stream is about 280 psia.

13. The system of claim 12, wherein the heat exchanger is a cross-exchange heat exchanger configured to reduce the temperature of the purge stream to between about 250 °F and about 300 °F.

14. The system of claim 13, further comprising a high pressure cooling unit configured to cool the first portion of CO_2 prior to injection into the inner stage of the downstream compression system.

15. The system of claim 13, further comprising a condenser fluidly coupled to the regeneration column and configured to separate the second portion of CO_2 from the water and direct the second portion of CO_2 to a first stage of the downstream compression system.

16. A method of separating CO_2, comprising:

stoichiometrically combusting a compressed oxidant and a fuel in a combustion chamber and in the presence of a compressed recycle stream, thereby generating a discharge

stream to be expanded in an expander that drives a main compressor and generates a gaseous exhaust stream, wherein the compressed recycle stream moderates the temperature of the discharge stream;

increasing the pressure of the gaseous exhaust stream with a boost compressor and cooling the gaseous exhaust stream with one or more cooling units fluidly coupled to the boost compressor, whereby a cooled recycle gas is directed into the main compressor for compression, wherein the main compressor compresses the cooled recycle gas to generate the compressed recycle stream;

cooling a purge stream fluidly coupled to compressed recycle stream with a heat exchanger to generate a cooled purge stream;

directing the cooled purge stream into an absorber column having a potassium carbonate solvent circulating therein, the potassium carbonate solvent being configured to absorb CO_2 present in the cooled purge stream;

discharging a nitrogen-rich residual stream and a bicarbonate solvent solution from the absorber column;

flashing the bicarbonate solvent solution to a near-atmospheric pressure through a valve;

boiling the bicarbonate solvent solution in a regeneration column to remove CO_2 and water therefrom, thereby generating a regenerated potassium carbonate solvent; and

recirculating the regenerated potassium carbonate solvent back to the absorber column.

17. The method of claim 16, further comprising increasing the temperature of a portion of the regenerated potassium carbonate solvent in a reboiler to produce a heated regenerated potassium carbonate solvent.

18. The method of claim 17, further comprising recirculating the heated regenerated potassium carbonate solvent back into the regeneration column to produce steam for boiling the bicarbonate solvent solution.

19. The method of claim 16, further comprising separating the CO_2 from the water removed from the bicarbonate solvent solution in a condenser fluidly coupled to the regeneration column, and directing the CO_2 to a downstream compression system.

20. The method of claim 19, directing a portion of the water separated from the CO_2 in the separated back into the regeneration column to create steam.

21. The method of claim 16, further comprising withdrawing a portion of the bicarbonate solvent solution from the regeneration column prior to complete solvent regeneration, and feeding the withdrawn bicarbonate solvent solution low into the absorber column.

22. An integrated CO_2 separation system, comprising:

a gas turbine system having a combustion chamber configured to stoichiometrically combust a compressed oxidant and a fuel in the presence of a compressed recycle stream in order to expand a discharge stream in an expander, thereby generating a gaseous exhaust stream and at least partially driving a main compressor, wherein the compressed recycle stream acts as a diluent configured to moderate the temperature of the discharge stream;

an exhaust gas recirculation system having a boost compressor and one or more cooling units fluidly coupled to the boost compressor, the boost compressor being configured to receive and boost the pressure of the gaseous exhaust stream and the one or more cooling units being configured to cool the gaseous exhaust stream and provide a cooled recycle gas to the main compressor, wherein the main compressor compresses the cooled recycle gas and generates the compressed recycle stream;

a purge stream fluidly coupled to the compressed recycle stream and having a heat exchanger configured to reduce the temperature of the purge stream and generate a cooled purge stream and low pressure steam; and

a CO_2 separator fluidly coupled to the heat exchanger, the CO_2 separator comprising:

an absorber column configured to receive the cooled purge stream and circulate a potassium carbonate solvent therein to absorb CO_2 in the cooled purge stream, wherein the absorber column discharges a nitrogen-rich residual stream and a bicarbonate solvent solution;

a valve fluidly coupled to the absorber column and configured to flash the bicarbonate solvent solution to a near-atmospheric pressure;

a regeneration column fluidly coupled to the valve and configured to receive and boil the bicarbonate solvent solution to remove a first portion of CO_2 and water therefrom, thereby producing a regenerated potassium carbonate solvent;

one or more mixing chambers fluidly coupled to the regeneration column and corresponding one or more eductors, the one or more mixing chambers being configured to receive the regenerated potassium carbonate solvent, and the one or more eductors being configured to receive the low pressure steam from the heat exchanger and flash-boil the regenerated potassium carbonate solvent to extract a

second portion of CO_2 and water to be recirculated back to the regeneration column; and

a pump fluidly coupled to at least one of the one or more mixing chambers and configured to direct a remaining portion of regenerated potassium carbonate solvent back to the absorber column.

23. The system of claim 22, wherein the low pressure steam has a pressure of about 50 psig or higher.

24. The system of claim 22, further comprising a condenser fluidly coupled to the regeneration column and configured to separate the first portion of CO_2 from the water removed from the regeneration column and direct the first portion of CO_2 to a downstream compression system.

25. The system of claim 24, wherein a first portion of the water separated from the CO_2 is pumped back into the regeneration column to create steam.

26. The system of claim 25, wherein a second portion of the water separated from the CO_2 is directed to the heat exchanger to generate the low pressure steam.

27. The system of claim 22, further comprising a reboiler fluidly coupled to the regeneration column and configured to receive and heat a portion of the regenerated potassium carbonate solvent and produce a heated regenerated potassium carbonate solvent to be recirculated back into the regeneration column to produce steam for boiling the bicarbonate solvent solution.

28. A method of separating CO_2, comprising:

stoichiometrically combusting a compressed oxidant and a fuel in a combustion chamber and in the presence of a compressed recycle stream, thereby generating a discharge stream to be expanded in an expander that drives a main compressor and generates a gaseous exhaust stream, wherein the compressed recycle stream moderates the temperature of the discharge stream;

increasing the pressure of the gaseous exhaust stream with a boost compressor and cooling the gaseous exhaust stream with one or more cooling units fluidly coupled to the boost compressor, whereby a cooled recycle gas is directed into the main compressor for compression, wherein the main compressor compresses the cooled recycle gas to generate the compressed recycle stream;

cooling a purge stream fluidly coupled to compressed recycle stream with a heat exchanger to generate a cooled purge stream and a low pressure steam;

directing the cooled purge stream into an absorber column having a potassium carbonate solvent circulating therein, the potassium carbonate solvent being configured to absorb CO_2 present in the cooled purge stream;

discharging a nitrogen-rich residual stream and a bicarbonate solvent solution from the absorber column;

flashing the bicarbonate solvent solution to a near-atmospheric pressure through a valve;

boiling the bicarbonate solvent solution in a regeneration column to remove a first portion of CO_2 and water therefrom, thereby generating a regenerated potassium carbonate solvent;

injecting the low pressure steam into one or more eductors fluidly coupled to one or more mixing chambers, wherein the one or more mixing chambers are configured to receive the regenerated potassium carbonate solvent;

flash-boiling the regenerated potassium carbonate solvent from the regeneration column in one or more mixing chambers fluidly coupled to one or more eductors to produce an effluent comprising a second portion of CO_2 and water;

accelerating the low pressure steam through the one or more eductors to extract the effluent from the one or more mixing chambers, wherein the effluent is recirculated back to the regeneration column;

recirculating a remaining portion of regenerated potassium carbonate solvent back to the absorber column.

29. The method of claim 28, further comprising separating the first portion of CO_2 from the water removed from the bicarbonate solvent solution in a condenser fluidly coupled to the regeneration column, and directing the CO_2 to a downstream compression system.

30. The method of claim 29, further comprising directing a first portion of the water separated from the CO_2 in the condenser back into the regeneration column to create steam.

31. The method of claim 30, further comprising directing a second portion of the water separated from the CO_2 in the condenser to the heat exchanger to generate the low pressure steam.

CLAIMS

What is claimed is:

1. An integrated CO_2 separation system, comprising:

a gas turbine system having a combustion chamber configured to stoichiometrically combust a compressed oxidant and a fuel in the presence of a compressed recycle stream in order to expand a discharge stream in an expander, thereby generating a gaseous exhaust stream and at least partially driving a main compressor, wherein the compressed recycle stream acts as a diluent configured to moderate the temperature of the discharge stream;

an exhaust gas recirculation system having a boost compressor and one or more cooling units fluidly coupled to the boost compressor, the boost compressor being configured to receive and boost the pressure of the gaseous exhaust stream and the one or more cooling units being configured to cool the gaseous exhaust stream and provide a cooled recycle gas to the main compressor, wherein the main compressor compresses the cooled recycle gas and generates the compressed recycle stream;

a purge stream fluidly coupled to the compressed recycle stream and having a heat exchanger configured to reduce the temperature of the purge stream and generate a cooled purge stream and low pressure steam; and

a CO_2 separator fluidly coupled to the heat exchanger, the CO_2 separator comprising:

an absorber column configured to receive the cooled purge stream and circulate a potassium carbonate solvent therein to absorb CO_2 in the cooled purge stream, wherein the absorber column discharges a nitrogen-rich residual stream and a bicarbonate solvent solution;

a valve fluidly coupled to the absorber column and configured to flash the bicarbonate solvent solution to a near-atmospheric pressure;

a regeneration column fluidly coupled to the valve and configured to receive and boil the bicarbonate solvent solution to remove a first portion of CO_2 and water therefrom, thereby producing a regenerated potassium carbonate solvent;

one or more mixing chambers fluidly coupled to the regeneration column and corresponding one or more eductors, the one or more mixing chambers being configured to receive the regenerated potassium carbonate solvent, and the one or more eductors being configured to receive the low pressure steam from the heat exchanger and flash-boil the regenerated potassium carbonate solvent to extract a second portion of CO_2 and water to be recirculated back to the regeneration

column; and

a pump fluidly coupled to at least one of the one or more mixing chambers and configured to direct a remaining portion of regenerated potassium carbonate solvent back to the absorber column, wherein the low pressure steam has a pressure of about 50 psig or higher.