CLAIMS

What is claimed is:

1. A vertically oriented co-current contacting system, including:

a vertically oriented co-current contactor located in-line within a pipe, the vertically oriented co-current contactor including:

a vertically oriented mixer, including:

an annular support ring configured to maintain the vertically oriented mixer within the pipe;

a number of radial blades configured to allow a liquid stream to flow into the vertically oriented mixer; and

a central gas entry cone configured to allow a gas stream to flow through a hollow section within the vertically oriented mixer; and

a vertically oriented mass transfer section downstream of the vertically oriented mixer;

wherein the vertically oriented mixer and the vertically oriented mass transfer section provide for efficient incorporation of liquid droplets formed from the liquid stream into the gas stream, and wherein the liquid droplets include impurities from the gas stream; and

a separation system configured to remove the liquid droplets including the impurities from the gas stream.

2. The vertically oriented co-current contacting system of claim 1, wherein the separation system is vertically oriented.

3. The vertically oriented co-current contacting system of any of claims 1 and 2, wherein the separation system is horizontally oriented.

4. The vertically oriented co-current contacting system of any of claims 1-3, wherein the vertically oriented co-current contacting system includes a first vertically oriented co-current contactor and a second vertically oriented co-current contactor upstream of the separation system.

5. The vertically oriented co-current contacting system of claim 4, wherein the liquid stream that is flowed into the vertically oriented mixer of the first vertically oriented co-

current contactor includes a semi-lean solvent stream, and wherein the liquid stream that is flowed into the vertically oriented mixer of the second vertically oriented co-current contactor includes a lean solvent stream.

6. The vertically oriented co-current contacting system of any of claims 1-4, wherein the gas stream includes a natural gas stream, and wherein the impurities include water.

7. The vertically oriented co-current contacting system of any of claims 1-4 and 6, wherein the gas stream includes a natural gas stream, and wherein the impurities include an acid gas.

8. The vertically oriented co-current contacting system of any of claims 1-4, 6, and 7, wherein the separation system includes a cyclonic separator.

9. The vertically oriented co-current contacting system of any of claims 1-4 and 6-8, wherein the separation system includes a distillation column.

10. The vertically oriented co-current contacting system of any of claims 1-4 and 6-9, wherein a downstream portion of the central gas entry cone includes a blunt ended cone.

11. The vertically oriented co-current contacting system of any of claims 1-4 and 6-10, wherein a downstream portion of the central gas entry cone includes a tapered ended cone.

12. The vertically oriented co-current contacting system of any of claims 1-4 and 6-11, wherein the liquid stream includes an absorbent liquid stream.

13. The vertically oriented co-current contacting system of any of claims 1-4 and 6-12, including a number of vertically oriented co-current contacting systems connected in series within the pipe.

14. The vertically oriented co-current contacting system of any of claims 1-4 and 6-13, wherein the vertically oriented co-current contacting system is implemented within a gas processing system.

15. The vertically oriented co-current contacting system of any of claims 1-4 and 6-14, wherein the vertically oriented co-current contacting system is used for quench applications.

16. The vertically oriented co-current contacting system of any of claims 1-4 and 6-15, wherein the vertically oriented co-current contacting system is used for water wash applications.

17. A method for separating impurities from a gas stream, including:

flowing a liquid stream into a vertically oriented mixer of a vertically oriented co-current contactor via an annular support ring and a number of radial blades extending from the annular support ring, wherein the annular support ring secures the vertically oriented mixer in-line within a pipe;

flowing a gas stream into the vertically oriented mixer via a central gas entry cone that is supported by the number of radial blades, wherein a first portion of the gas stream flows through the central gas entry cone and a second portion of the gas stream flows around the central gas entry cone between the number of radial blades;

contacting the gas stream with the liquid stream within the vertically oriented mixer and a vertically oriented mass transfer section of the vertically oriented co-current contactor to provide for incorporation of liquid droplets formed from the liquid stream into the gas stream, wherein the liquid droplets include impurities from the gas stream; and

separating the liquid droplets including the impurities from the gas stream within a separation system.

18. The method of claim 17, including flowing the gas stream through a number of vertically oriented co-current contactors upstream of the separation system.

19. The method of any of claims 17 and 18, including flowing the gas stream through a number of vertically oriented co-current contactors and corresponding separation systems connected in series within the pipe.

20. The method of any of claims 17-19, wherein the gas stream includes a natural gas stream, and wherein the impurities include water.

21. The method of claim 20, including generating a dehydrated natural gas stream by removing liquid droplets including incorporated water from the natural gas stream.

22. The method of any of claims 17-20, wherein the gas stream includes a natural gas stream, and wherein the impurities include acid gas.

23. The method of claim 22, including generating a sweetened natural gas stream by removing liquid droplets including incorporated acid gas from the natural gas stream.

24. A method for separating impurities from a natural gas stream, including:

flowing a semi-lean solvent stream into a first vertically oriented co-current contactor of a vertically oriented co-current contacting system;

flowing a natural gas stream into the first vertically oriented co-current contactor;

contacting the natural gas stream with the semi-lean solvent stream within the first vertically oriented co-current contactor to provide a first multi-phase stream, wherein the first multi-phase stream includes the natural gas stream with incorporated liquid droplets formed from the semi-lean solvent stream that include impurities from the natural gas stream;

flowing the first multi-phase stream into a second vertically oriented co-current contactor of the vertically oriented co-current contacting system;

flowing a lean solvent stream into the second vertically oriented co-current contactor;

contacting the first multi-phase stream with the lean solvent stream within the second vertically oriented co-current contactor to provide a second multi-phase stream, wherein the second multi-phase stream includes the natural gas stream with additional incorporated liquid droplets formed from the lean solvent stream that include residual impurities from the natural gas stream; and

separating the second multi-phase stream into a purified natural gas stream and a rich solvent stream within a separation system of the vertically oriented co-current contacting system.

25. The method of claim 24, wherein the natural gas stream and the semi-lean solvent stream are flowed into a vertically oriented mixer of the first vertically oriented co-current contactor, and wherein the natural gas stream is contacted with the semi-lean solvent stream within the vertically oriented mixer and a vertically oriented mass transfer section of the first vertically oriented co-current contactor.

26. The method of any of claims 24 and 25, wherein the first multi-phase stream and the lean solvent stream are flowed into a vertically oriented mixer of the second vertically oriented co-current contactor, and wherein the first multi-phase stream is contacted with the lean solvent stream within the vertically oriented mixer and a vertically oriented mass transfer section of the second vertically oriented co-current contactor.

27. The method of any of claims 24-26, wherein the impurities include water, and wherein a dehydrated natural gas stream is generated by removing liquid droplets including incorporated water from the natural gas stream.

28. The method of any of claims 24-27, wherein the impurities include acid gas, and wherein a sweetened natural gas stream is generated by removing liquid droplets including

incorporated acid gas from the natural gas stream.

29. The method of any of claims 24-28, including:

regenerating the semi-lean solvent stream and the lean solvent stream from the rich solvent stream within a second vertically oriented co-current contacting system;

recirculating the semi-lean solvent stream to the first vertically oriented co-current contactor; and

recirculating the lean solvent stream to the second vertically oriented co-current contactor.

CLAIMS

1. A vertically oriented co-current contacting system, including:

a vertically oriented co-current contactor located in-line within a pipe, the vertically oriented co-current contactor including:

a vertically oriented mixer, including:

an annular support ring configured to maintain the vertically oriented mixer within the pipe;

a number of radial blades extending from the annular support ring, the annular support ring securing the mixer in-line within a pipe, the number of radial blades having injection orifices disposed thereon, the annular support ring having a plurality of liquid channels connected to the injection orifices and providing a flow path for a liquid stream to flow through the number of radial blades and out of the injection orifices; and

a central gas entry cone that is supported by the number of radial blades, the central gas entry cone having a hollow section connected to gas exit slots included in the number of radial blades such that a first portion of a gas stream flows through the hollow section of the central gas entry cone and through the gas exit slots, while a second portion of the gas stream flows around the central gas entry cone and between the number of radial blades; and

a vertically oriented mass transfer section downstream of the vertically oriented mixer;

wherein the vertically oriented mixer and the vertically oriented mass transfer section provide for efficient incorporation of liquid droplets formed from the liquid stream into the gas stream, and wherein the liquid droplets include impurities from the gas stream; and

a separation system configured to remove the liquid droplets including the impurities from the gas stream.

2. The vertically oriented co-current contacting system of claim 1, wherein the separation system is vertically oriented.

3. The vertically oriented co-current contacting system of any of claims 1 and 2, wherein the separation system is horizontally oriented.

4. The vertically oriented co-current contacting system of any of claims 1-3, wherein the vertically oriented co-current contacting system includes a first vertically oriented co-current contactor and a second vertically oriented co-current contactor upstream of the separation system.

5. The vertically oriented co-current contacting system of any of claims 1-4, wherein the separation system includes a cyclonic separator.

6. The vertically oriented co-current contacting system of any of claims 1-5, wherein the separation system includes a distillation column.

7. The vertically oriented co-current contacting system of any of claims 1-6, wherein a downstream portion of the central gas entry cone includes a blunt ended cone.

8. The vertically oriented co-current contacting system of any of claims 1-7, wherein a downstream portion of the central gas entry cone includes a tapered ended cone.

9. The vertically oriented co-current contacting system of any of claims 1-8, including a number of vertically oriented co-current contacting systems connected in series within the pipe.

10. The vertically oriented co-current contacting system of any of claims 1-9, wherein the vertically oriented co-current contacting system is implemented within a gas processing system.

11. A method for separating impurities from a gas stream, including:

flowing a liquid stream into a vertically oriented mixer of a vertically oriented co-current contactor via an annular support ring and a number of radial blades extending from the annular support ring, wherein the liquid stream flows through the number of radial blades and out of injection orifices disposed on the number of radial blades, and wherein the annular support ring secures the vertically oriented mixer in-line within a pipe;

flowing a gas stream into the vertically oriented mixer via a central gas entry cone

that is supported by the number of radial blades, wherein a first portion of the gas stream flows through a hollow section of the central gas entry cone and through exit slots included in the number of radial blades, and wherein a second portion of the gas stream flows around the central gas entry cone and between the number of radial blades;

contacting the gas stream with the liquid stream within the vertically oriented mixer and a vertically oriented mass transfer section of the vertically oriented co-current contactor to provide for incorporation of liquid droplets formed from the liquid stream into the gas stream, wherein the liquid droplets include impurities from the gas stream; and

separating the liquid droplets including the impurities from the gas stream within a separation system.

12. The method of claim 11, including flowing the gas stream through a number of vertically oriented co-current contactors upstream of the separation system.

13. The method of any of claims 11 and 12, including flowing the gas stream through a number of vertically oriented co-current contactors and corresponding separation systems connected in series within the pipe.

14. The method of any of claims 11-13, wherein the gas stream includes a natural gas stream, and wherein the impurities include water.

15. The method of claim 14, including generating a dehydrated natural gas stream by removing liquid droplets including incorporated water from the natural gas stream.

16. The method of any of claims 11-14, wherein the gas stream includes a natural gas stream, and wherein the impurities include acid gas.

17. The method of claim 16, including generating a sweetened natural gas stream by removing liquid droplets including incorporated acid gas from the natural gas stream.

18. A method for separating impurities from a natural gas stream, including:

flowing a semi-lean solvent stream into a first vertically oriented co-current contactor of a vertically oriented co-current contacting system;

flowing a natural gas stream into the first vertically oriented co-current contactor;

contacting the natural gas stream with the semi-lean solvent stream within the first vertically oriented co-current contactor to provide a first multi-phase stream, wherein the first

multi-phase stream includes the natural gas stream with incorporated liquid droplets formed from the semi-lean solvent stream that include impurities from the natural gas stream;

flowing the first multi-phase stream into a second vertically oriented co-current contactor of the vertically oriented co-current contacting system;

flowing a lean solvent stream into the second vertically oriented co-current contactor;

contacting the first multi-phase stream with the lean solvent stream within the second vertically oriented co-current contactor to provide a second multi-phase stream, wherein the second multi-phase stream includes the natural gas stream with additional incorporated liquid droplets formed from the lean solvent stream that include residual impurities from the natural gas stream; and

separating the second multi-phase stream into a purified natural gas stream and a rich solvent stream within a separation system of the vertically oriented co-current contacting system; wherein each of the first co-current contactor and the second co-current contactor includes

a mixer, including:

an annular support ring configured to maintain the mixer within the pipe;

a number of radial blades extending from the annular support ring, the annular support ring securing the mixer in-line within a pipe, the number of radial blades having injection orifices disposed thereon, the annular support ring having a plurality of liquid channels connected to the injection orifices and providing a flow path for a liquid stream to flow through the number of radial blades and out of the injection orifices; and

a central gas entry cone that is supported by the number of radial blades, the central gas entry cone having a hollow section connected to gas exit clots included in the number of radial blades such that a first portion of a gas stream flows through the hollow section of the central gas entry cone and through the gas exit slots, while a second portion of the gas stream flows around the central gas entry cone and between the number of radial blades.

19. The method of claim 18, wherein the natural gas stream and the semi-lean solvent stream are flowed into a vertically oriented mixer of the first vertically oriented co-current contactor, and wherein the natural gas stream is contacted with the semi-lean solvent stream within the vertically oriented mixer and a vertically oriented mass transfer section of the first vertically oriented co-current contactor.

20. The method of any of claims 18 and 19, wherein the first multi-phase stream and the lean solvent stream are flowed into a vertically oriented mixer of the second vertically oriented co-current contactor, and wherein the first multi-phase stream is contacted with the lean solvent stream within the vertically oriented mixer and a vertically oriented mass transfer section of the second vertically oriented co-current contactor.

21. The method of any of claims 18-20, wherein the impurities include water, and wherein a dehydrated natural gas stream is generated by removing liquid droplets including incorporated water from the natural gas stream.

22. The method of any of claims 18-21, wherein the impurities include acid gas, and wherein a sweetened natural gas stream is generated by removing liquid droplets including incorporated acid gas from the natural gas stream.

23. The method of any of claims 18-22, including:

regenerating the semi-lean solvent stream and the lean solvent stream from the rich solvent stream within a second vertically oriented co-current contacting system;

recirculating the semi-lean solvent stream to the first vertically oriented co-current contactor; and

recirculating the lean solvent stream to the second vertically oriented co-current contactor.