CLAIMS

~~*What is claimed is:*~~

1. A method of producing liquefied natural gas (LNG) from a natural gas stream, the method comprising:

cooling a portion of the natural gas stream in a first heat exchanger to generate a cooled natural gas stream;

combining the cooled natural gas stream and the natural gas stream to generate a combined natural gas stream;

removing heavy hydrocarbons from the combined natural gas stream in a separator to thereby generate a separated natural gas stream and a separator bottom stream;

separating liquids from the separator bottom stream to form an overhead stream;

cooling the overhead stream and separating liquids therefrom to form a recycle gas stream;

compressing the recycle gas stream in a recycle compressor to form a compressed recycle gas stream;

directing a first portion of the compressed recycle gas stream through the first heat exchanger to form a cooled compressed recycle stream therefrom;

directing the cooled compressed recycle stream to the separator as a column reflux stream;

using the separated natural gas stream as a coolant in the first heat exchanger to thereby generate a pretreated natural gas stream;

combining a second portion of the compressed recycle gas stream with the pretreated natural gas stream;

compressing the pretreated natural gas stream in at least one compressor to a pressure of at least 1,500 psia to form a compressed natural gas stream;

cooling the compressed natural gas stream to form a cooled compressed natural gas stream;

expanding, in at least one work producing natural gas expander, the cooled compressed natural gas stream to a pressure that is less than 2,000 psia and no greater than the pressure to which the at least one compressor compresses the pretreated natural gas stream, to thereby form a chilled pretreated gas stream;

recycling the chilled pretreated gas stream to exchange heat with one or more process streams comprising at least a portion of the natural gas stream, the separated natural gas stream,

and the first portion of the compressed recycle gas stream, thereby generating a warmed refrigerant stream; and

liquefying the warmed refrigerant stream to form LNG.

2. The method of claim 1, wherein liquefying the warmed refrigerant stream is performed in one of

one or more single mixed refrigerant (SMR) liquefaction units,

at least three parallel SMR liquefaction units, and

one or more expander-based liquefaction modules comprising

one or more nitrogen gas expander-based liquefaction modules or

one or more feed gas expander-based liquefaction modules.

3. The method of claim 1 or claim 2, wherein the at least one compressor comprises at least two serially arranged compressors, and wherein one of the at least two serially arranged compressors is driven by the natural gas expander.

4. An apparatus for the liquefaction of a natural gas stream, comprising:

a first heat exchanger that cools a portion of the natural gas stream to generate a cooled natural gas stream;

a first separation device configured to remove heavy hydrocarbons from the natural gas stream, combined with the cooled natural gas stream, to thereby generate a separated natural gas stream and a separator bottom stream, wherein the first heat exchanger partially condenses the separated natural gas stream to form a partially condensed natural gas stream;

a second separation device that separates liquids from the separator bottom stream to form an overhead stream;

a first cooling unit and a third separation device that cool and separate the overhead stream to form a recycle gas stream;

a recycle compressor that compresses the recycle gas stream to form a compressed recycle gas stream;

wherein a first portion of the compressed recycle gas stream is directed through the first heat exchanger to form a cooled compressed recycle stream therefrom, the cooled compressed recycle stream being directed to the first separator as a reflux stream, and wherein the separated natural gas stream is used as a coolant in the first heat exchanger to thereby generate a

pretreated natural gas stream;

at least one compressor that compresses the pretreated natural gas stream and a second portion of the compressed recycle gas stream to a pressure of at least 1,500 psia, to thereby form a compressed natural gas stream;

a second cooling unit that cools the compressed natural gas stream to form a cooled compressed natural gas stream;

at least one work producing natural gas expander that expands the cooled compressed natural gas stream to a pressure that is less than 2,000 psia and no greater than the pressure to which the at least one compressor compresses the pretreated natural gas stream, to thereby form a chilled pretreated gas stream;

wherein the chilled pretreated gas stream is recycled to the first heat exchanger to exchange heat with one or more process streams comprising at least the portion of the natural gas stream, the separated natural gas stream, and the first portion of the compressed recycle gas stream, thereby generating a warmed refrigerant stream; and

at least one liquefaction unit configured to liquefy the chilled pretreated gas stream.

5. The apparatus of claim 4, wherein the first separation device is a scrub column, and wherein a portion of the natural gas stream is directed into a lower portion of the scrub column as a stripping gas.

6. The apparatus of claim 4 or claim 5, wherein the portion of the natural gas stream cooled in the first heat exchanger is between 25% and 75% by weight of the natural gas stream.

7. The apparatus of any one of claims 4-6, wherein the at least one liquefaction unit comprises

one or more single mixed refrigerant (SMR) liquefaction units,

at least three parallel SMR liquefaction units, or

one or more expander-based liquefaction modules comprising

one or more nitrogen gas expander-based liquefaction modules or

one or more feed gas expander-based liquefaction modules.

8. The apparatus of any one of claims 4-7, wherein the at least one compressor comprises at least two serially arranged compressors, and wherein one of the at least two serially arranged

compressors is driven by the natural gas expander.

~~9. A method of producing liquefied natural gas (LNG) from a natural gas stream, the method comprising:~~

~~cooling a portion of the natural gas stream in a first heat exchanger to generate a cooled natural gas stream;~~

~~combining the cooled natural gas stream and the natural gas stream to generate a combined natural gas stream;~~

~~removing heavy hydrocarbons from the combined natural gas stream in a separator to thereby generate a separated natural gas stream and a separator bottom stream;~~

~~separating liquids from the separator bottom stream to form an overhead stream;~~

~~cooling and separating the overhead stream to form a recycle gas stream;~~

~~compressing the recycle gas stream in a recycle compressor to form a compressed recycle gas stream;~~

~~directing a first portion of the compressed recycle gas stream through the first heat exchanger to form a cooled compressed recycle stream therefrom;~~

~~directing the cooled compressed recycle stream to the separator as a column reflux stream;~~

~~reducing a pressure and a temperature of the separated natural gas stream in a pressure reducing device;~~

~~using the separated natural gas stream as a coolant in the first heat exchanger to thereby generate a pretreated natural gas stream;~~

~~combining a second portion of the compressed recycle gas stream with the pretreated natural gas stream;~~

~~compressing the pretreated natural gas stream in a feed compressor to a pressure of at least 1,500 psia to form a compressed natural gas stream;~~

~~cooling the compressed natural gas stream to form a cooled high pressure gas stream; and~~

~~liquefying the cooled high pressure gas stream to form LNG.~~

~~10. The method of claim 9, wherein the portion of the natural gas stream cooled in the first heat exchanger is between 25% and 75% by weight of the natural gas stream.~~

~~11. The method of claim 9 or claim 10, wherein liquefying the cooled high pressure natural~~

gas stream is performed in one of

one or more single mixed refrigerant (SMR) liquefaction units,

at least three parallel SMR liquefaction units, and

one or more expander-based liquefaction modules comprising

one or more nitrogen gas expander-based liquefaction modules or

one or more feed gas expander-based liquefaction modules.

12. The method of any one of claims 9-11, wherein the pressure reducing device is a Joule-Thomson valve.

13. The method of any one of claims 9-12, further comprising:

prior to liquefying the cooled high pressure gas stream, expanding the cooled high pressure gas stream in an expander.

14. The method of claim 13, further comprising:

prior to cooling the compressed natural gas stream, compressing the compressed natural gas stream in an additional compressor.

15. An apparatus for the liquefaction of a natural gas stream, comprising:

a first heat exchanger that cools a portion of the natural gas stream to generate a cooled natural gas stream;

a first separation device configured to remove heavy hydrocarbons from the natural gas stream, combined with the cooled natural gas stream, to thereby generate a separated natural gas stream and a separator bottom stream, wherein the first heat exchanger partially condenses the separated natural gas stream to form a partially condensed natural gas stream;

a second separation device that separates liquids from the separator bottom stream to form an overhead stream;

a first cooling unit and a third separation device that cool and separate the overhead stream, respectively, to form a recycle gas stream;

a recycle compressor that compresses the recycle gas stream to form a compressed recycle gas stream;

wherein a first portion of the compressed recycle gas stream is directed through the first heat exchanger to form a cooled compressed recycle stream therefrom, the cooled compressed recycle stream being directed to the first separator as a reflux stream;

a pressure reducing device that reduces a pressure and a temperature of the separated natural gas stream, wherein the separated natural gas stream is used as a coolant in the first heat exchanger to thereby generate a pretreated natural gas stream therefrom;

a feed compressor that compresses the pretreated natural gas stream and a second portion of the compressed recycle gas stream to a pressure of at least 1,500 psia, to thereby form a compressed natural gas stream;

a second cooling unit that cools the compressed natural gas stream to form a cooled high pressure gas stream; and

at least one liquefaction unit configured to liquefy the cooled high pressure gas stream.

16. The apparatus of claim 15, wherein the portion of the natural gas stream cooled in the first heat exchanger is between 25% and 75% by weight of the natural gas stream.

17. The apparatus of claim 15 or claim 16, wherein the at least one liquefaction unit comprises

one or more single mixed refrigerant (SMR) liquefaction units,

at least three parallel SMR liquefaction units, or

one or more expander-based liquefaction modules comprising

one or more nitrogen gas expander-based liquefaction modules or

one or more feed gas expander-based liquefaction modules.

18. The apparatus of any one of claims 15-17, wherein the pressure reducing device comprises a Joule-Thomson valve.

19. The apparatus of any one of claims 15-18, further comprising:

an expander configured to expand the cooled high pressure gas stream prior to liquefying the cooled high pressure gas stream in the at least one liquefaction unit.

20. The apparatus of claim 19, further comprising:

an additional compressor configured to compress the compressed natural gas stream prior to cooling the compressed natural gas stream in the second cooling unit.