US 20080314079A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2008/0314079 A1**

Brostow (43) **Pub. Date: Dec. 25, 2008**

(54) **NITROGEN REJECTION COLUMN REBOILER CONFIGURATION**

(75) Inventor: **Adam Adrian Brostow**, Emmaus, PA (US)

Correspondence Address:
AIR PRODUCTS AND CHEMICALS, INC.
PATENT DEPARTMENT
7201 HAMILTON BOULEVARD
ALLENTOWN, PA 181951501

(73) Assignee: **AIR PRODUCTS AND CHEMICALS, INC.**, Allentown, PA (US)

(21) Appl. No.: **11/764,975**

(22) Filed: **Jun. 19, 2007**

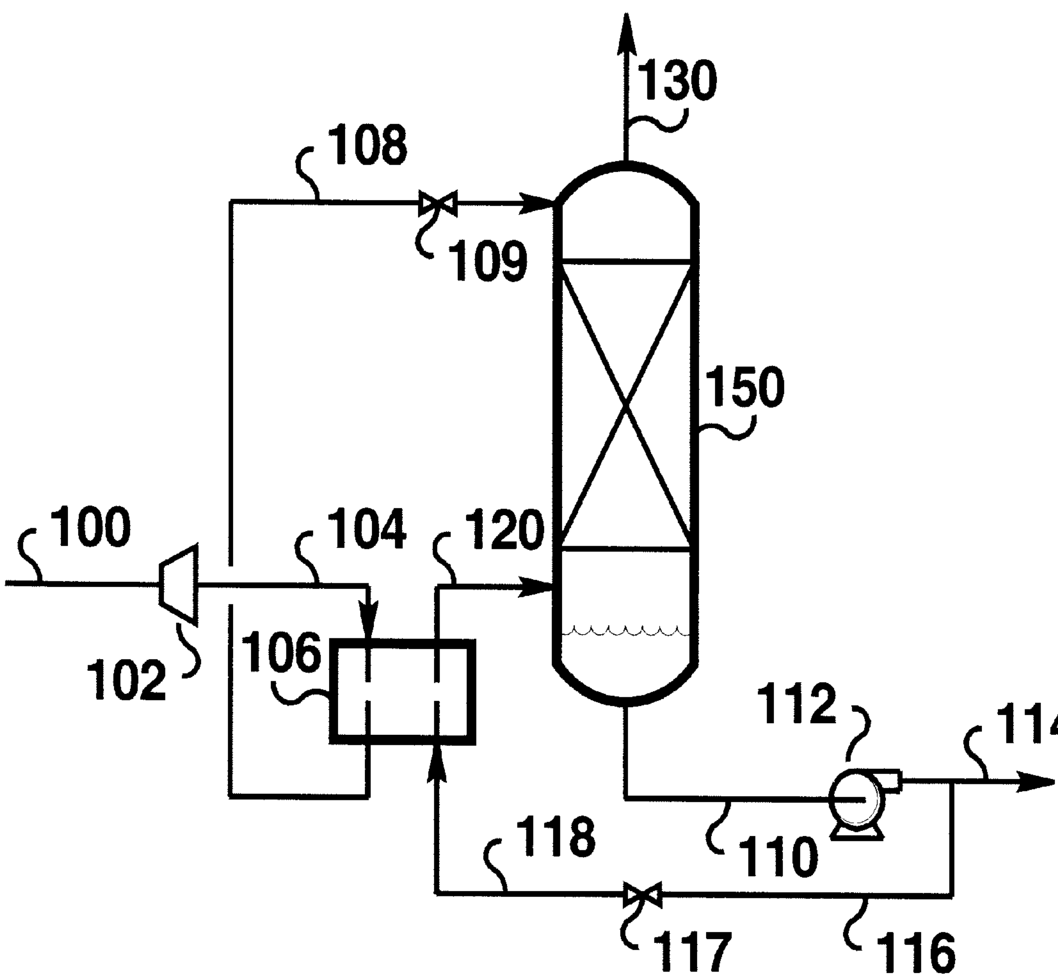
Publication Classification

(51) **Int. Cl.**
F25J 3/00 (2006.01)

(52) **U.S. Cl.** **62/620**; 62/634

(57) **ABSTRACT**

A process is provided for denitrogenation of a crude LNG stream. A crude LNG stream comprising between about 1% and 10% nitrogen, and the remainder methane and heavier hydrocarbons, is expanded in a means for expansion, and cooled. Resultant crude LNG stream is introduced into nitrogen rejection column, wherein nitrogen content of LNG is reduced. A nitrogen-enriched vapor stream is withdrawn from top of the column, and a nitrogen-diminished liquid stream is withdrawn from bottom of the column. The nitrogen-diminished bottoms LNG stream is pumped to higher pressure and then divided into two streams. The second stream is reduced in pressure and then passed through reboiler heat exchanger, thus cooling the crude LNG stream. Partially vaporized second stream is reinjected into column at a level above the level of withdrawal of nitrogen-diminished bottoms LNG stream and below the level of introduction of crude LNG feed stream to provide column boilup.



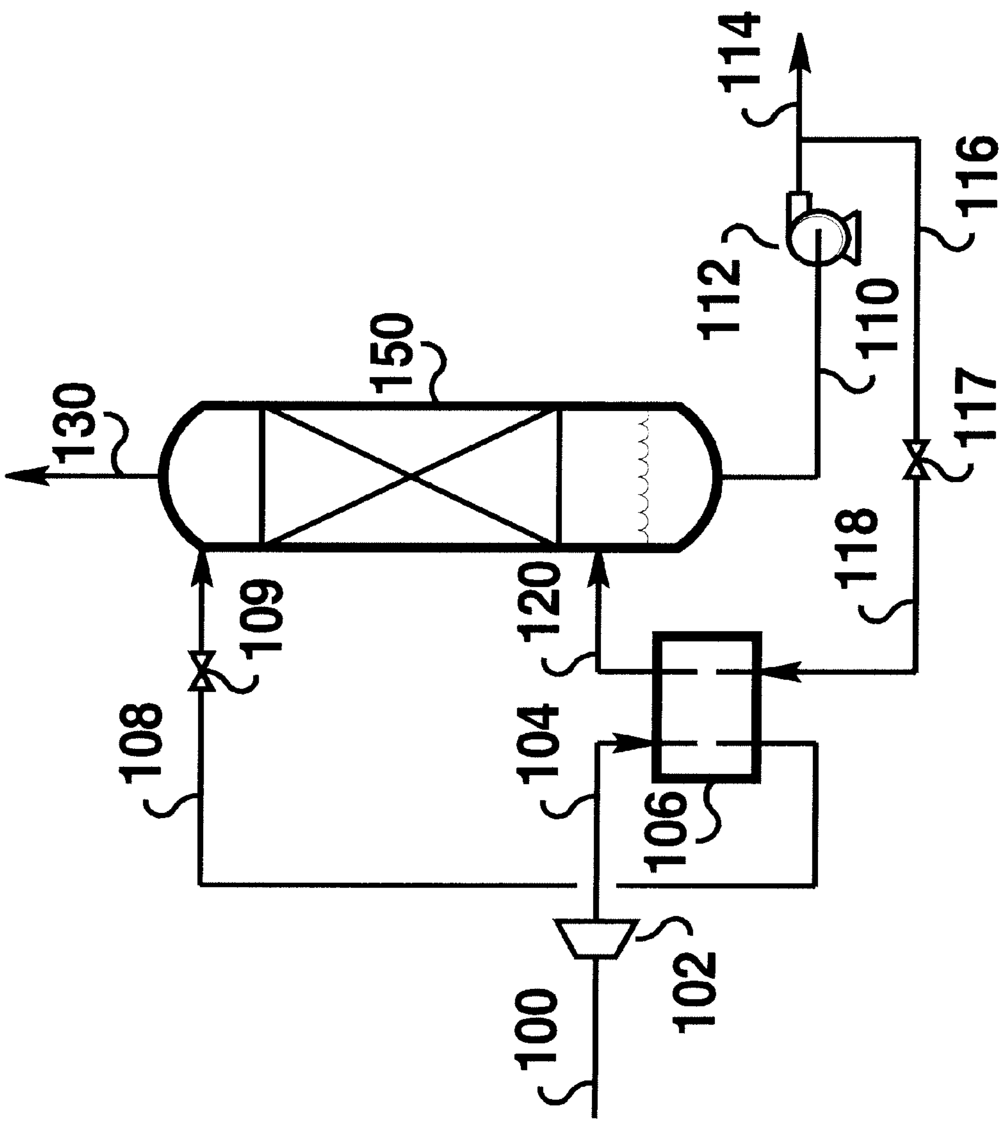


FIGURE 1

NITROGEN REJECTION COLUMN REBOILER CONFIGURATION

BACKGROUND OF THE INVENTION

[0001] This invention relates to a process for the separation of nitrogen from a liquid natural gas stream comprising nitrogen, methane, and possibly heavier hydrocarbons.

[0002] Crude natural gas is often liquefied to enable storage of larger quantities in the form of liquid natural gas (LNG). Because natural gas may be contaminated with nitrogen, nitrogen is advantageously removed from LNG to produce a nitrogen-diminished LNG product that will meet desired product specifications. Several methods of effectuating nitrogen removal from LNG have been disclosed in the prior art.

[0003] One simple method for separating nitrogen from a LNG stream is to isentropically expand the crude LNG stream in a turbine and then inject the stream into a flash separator. The liquid product removed from the flash separator will contain less nitrogen than the crude LNG stream, whereas the vapor product will contain a higher proportion of nitrogen.

[0004] A different method is disclosed in U.S. Pat. No. 5,421,165 ("the '165 patent"). A process is disclosed wherein crude LNG is isentropically expanded in a turbine and cooled in a reboiler heat exchanger. The cooled and expanded LNG stream is then passed through a valve, where it undergoes static decompression, prior to its injection into a denitrogenation column. Within the column, nitrogen is stripped from the falling liquid by the rising vapor, so that the vapor stream exiting the top of the column is enriched with nitrogen. A liquid LNG stream is withdrawn from the bottom of the column as a nitrogen-diminished product. Within the column, at a level below the level of injection of the LNG feed stream, a liquid stream is withdrawn and passed through the heat exchanger to cool the feed and then reinjected into the column at a level below that at which it had been withdrawn, to provide boilup to the column. In effect, the passage of the withdrawn stream through the heat exchanger provides an additional equilibrium stage of separation.

[0005] A similar method for separating nitrogen from an LNG stream replaces the turbine driven dynamic decompression with a valve for static decompression, such that the expansion takes place isenthalpically rather than isentropically. The use of the isentropic expansion in the process of the '165 patent allegedly permits greater methane recovery.

[0006] Another method for removing nitrogen from an LNG stream is described in U.S. Pat. No. 5,041,149 ("the '149 patent"). This patent discloses a method of removing nitrogen from a crude natural gas stream by first cooling the stream and then passing it through a phase separator, to produce a liquid stream and a vapor stream. The liquid stream is further cooled and injected into a denitrogenation column. The vapor stream is condensed and cooled further to produce a second liquid stream, prior to injection into the denitrogenation column at a higher level than that of the first liquid stream. Nitrogen-enriched vapor is removed from the top of the column and used to cool the incoming second liquid stream. The sump of the column is divided by a baffle, one side of which is filled with liquid from the lowest tray of the column. This bottoms liquid is withdrawn and at least partially vaporized in the heat exchanger, while condensing the vapor stream from the phase separator, and returned to the column as a reflux stream to provide boilup. The liquid remaining in the reflux stream falls to the other side of the baffle in the sump. This liquid reflux is then removed as a nitrogen-diminished product stream, pumped to a higher pressure, warmed and vaporized, and then dynamically expanded to reduce the temperature and pressure of the vapor product. Similar to the reboiler heat exchange of the '165 patent, the reflux of the bottoms liquid serves as an additional equilibrium stage of separation.

[0007] Another similar, but thermodynamically distinct method of nitrogen separation involves isentropically expanding the crude LNG stream in a turbine, cooling the expanded stream in a reboiler heat exchanger, and then injecting the cooled, expanded stream into a thermosiphon system. The liquid from the bottom of the column is withdrawn, and a portion of it is withdrawn and pumped away as the LNG product. A second portion is recycled through the reboiler heat exchanger where it is at least partially vaporized. The partially vaporized stream is then reinjected into the column, where the vapor portion of the stream provides boilup; the liquid portion of the stream mixes with the liquid coming off the bottom tray to provide the source of the withdrawn bottoms stream. This approach is thermodynamically different from that of the '**165** and '149 patents—in this case the liquid bottoms product is the result of the mixing of the liquid from the bottom tray of the column with the liquid from the reboiled stream, rather than of a pure additional equilibrium stage of separation. This difference leads to a thermodynamic mixing loss.

[0008] A disadvantage of these prior art nitrogen separation methods is that they are each dependent upon liquid head to drive the flow of the reboiler stream. This attribute has the adverse effect of limiting the flexibility of the overall process design. For example, the available head of the column will directly affect the design of the reboiler heat exchanger, wherein the pressure drop within the heat exchanger cannot be so great as to overcome the available flow. This design limitation tends to result in the implementation of larger, more expensive heat exchangers that will have a lower pressure drop, thus allowing the column's head to drive the reboiler flow. The large capital costs of the process equipment required to effectuate nitrogen removal can have a substantial effect on the profitability of the production of LNG.

[0009] Accordingly, it is an object of the present invention to provide a process which allows for greater flexibility in the design of the equipment necessary for nitrogen rejection from an LNG stream. This greater flexibility allows for the design of relatively inexpensive process equipment, thus lowering the capital costs associated with the process.

BRIEF SUMMARY OF THE INVENTION

[0010] The present invention provides an improved process for the denitrogenation of an LNG stream contaminated by nitrogen. This process allows for economic benefits by permitting a greater flexibility in the process design.

[0011] According to the invented process, a crude LNG stream comprising between about 1% and 10% nitrogen, and the remainder methane and heavier hydrocarbons, is expanded in a means for expansion, and cooled in a reboiler heat exchanger. The resultant crude LNG stream is introduced into a nitrogen rejection column, wherein the nitrogen content of the LNG is reduced as the liquid flows down the column. A nitrogen-enriched vapor stream is withdrawn from the top of the column, and a nitrogen-diminished liquid stream is withdrawn from the bottom of the column.

[0012] The nitrogen-diminished bottoms LNG stream is pumped to a higher pressure and then divided into two streams, and the first stream may be collected as an LNG product if desired. The second stream is reduced in pressure and then passed through the reboiler heat exchanger, thus cooling the crude LNG stream, the pressure reduction being to a level such that the second stream is at least partially vaporized in the reboiler heat exchanger. The partially vaporized second stream is reinjected into the column at a level above the level of withdrawal of the nitrogen-diminished bottoms LNG stream and below the level of introduction of the crude LNG feed stream to provide column boilup.

[0013] As will become apparent, several variations of this process are within the scope of the invention. For example, in one embodiment, the initial crude LNG stream is expanded in a dense fluid expander, which may be placed either upstream or downstream of the reboiler heat exchanger. In another embodiment, the reduction in pressure of the second stream may be accomplished through the use of a Joule-Thomson valve. A valve may also be placed immediately upstream of the nitrogen rejection column, such that the crude LNG stream is throttled through the valve prior to injection into the column.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0014] FIG. **1** is a schematic diagram illustrating a process for removing nitrogen from an LNG stream in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention achieves flexibility of design and process economic advantages in an LNG denitrogenation operation by using, in part, a pump to drive the reboiler stream, thus permitting a higher pressure drop within the reboiler heat exchanger. This, in turn, allows a higher velocity for the reboiler stream, and, consequently, higher heat transfer coefficients in the heat exchanger can be realized, permitting the use of a smaller heat exchanger.

[0016] As will be clarified in the following description, achieving this flexibility without the need for additional equipment, and maintaining output levels and energy requirements, involves the introduction of a small thermodynamic inefficiency. However, the initial capital savings afforded by the present invention more than compensates for this thermodynamic inefficiency, especially given the ease and low expense with which it may be remedied.

[0017] The term "nitrogen-enriched stream" is used herein to mean a stream containing a higher concentration of nitrogen when compared with an initial feed stream.

[0018] The term "nitrogen-diminished stream" is used herein to mean a stream containing a lower concentration of nitrogen when compared with an initial feed stream.

[0019] The term "below" is used herein to mean at a position of lesser height, i.e., closer to the ground.

[0020] The term "above" is used herein to mean at a position of greater height, i.e., farther from the ground.

[0021] The term "boilup" is used herein to mean vapor which rises up the column.

[0022] A preferred embodiment of the invention will now be described in detail with reference to FIG. **1**. The following embodiments are not intended to limit the scope of the invention, and it should be recognized by those skilled in the art that there are other embodiments within the scope of the claims.

[0023] As set forth in FIG. **1**, high-pressure LNG stream **100**, typically at a pressure of about 700 psi, containing from about 1 mol % to about 10 mol % nitrogen, and the remainder methane and possibly heavier hydrocarbons, is expanded via means for expanding the LNG stream **102** to produce lower-pressure LNG stream **104**. The expansion is preferably performed isentropically, and the means for expanding the LNG stream is preferably a dense fluid expander (also known as a hydraulic turbine), but may also be a valve or other known means for expanding a fluid. Lower-pressure LNG stream **104** is cooled in reboiler heat exchanger **106** to produce cooled, expanded LNG stream **108**. Reboiler heat-exchanger **106** is preferably a plate-fin heat exchanger, but may be a shell-and-tube design, or any other known means for bringing two fluid streams into a heat exchange relation with each other, without mixing the fluids. Cooled, expanded LNG stream **108** is then substantially isenthalpically expanded through valve **109** and injected into nitrogen rejection column **150**, this injection preferably taking place at the top of the column. Nitrogen rejection column **150** is preferably a tray column, but may be a packed column or any other mass transfer device suitable for fractionation. A nitrogen-enriched vapor stream **130** is withdrawn from the top of column **150**. By "nitrogen-enriched," it is herein understood to mean containing a higher concentration of nitrogen than that of high-pressure LNG stream **100**, and will typically contain more than about 30% N_2 and less than about 70% methane.

[0024] Nitrogen-diminished liquid stream **110** is withdrawn from the bottom of column **150** and pumped through pump **112** to a desired pressure. By "nitrogen-diminished," it is herein understood to mean containing a lower concentration of nitrogen than that of high-pressure LNG stream **100**. After bottoms liquid stream **110** is pumped, it is split into a first stream **114** and a second stream **116**. Stream **114** may be recovered as a product LNG stream. Stream **116** is substantially isenthalpically expanded through valve **117**, typically a Joule-Thomson valve, to produce low-pressure reboiler stream **118**. Valve **117** may be located at any position between the point of separation of streams **114** and **116** and the reboiler heat exchanger **106**. Low-pressure reboiler stream **118** is at least partially vaporized in reboiler heat exchanger **106** to produce partially vaporized reboiler stream **120**, which is then injected into the bottom of column **150**, below the lowest tray in the case of a tray column, or below the packing material in the case of a packed column, to provide boilup.

[0025] In an alternative embodiment, the means for expanding the LNG stream **102** may be placed downstream of reboiler heat exchanger **106**. In this manner, high-pressure stream **100** is cooled in reboiler heat exchanger **106** prior to undergoing expansion in the means for expanding the LNG stream **102**.

[0026] We note that in each of the described embodiments, valve **109** is optional, and, in the alternative, cooled LNG stream **108** can be directly injected into nitrogen rejection column **150**.

[0027] A particularly preferred embodiment is herein provided wherein a crude LNG stream **100** is substantially isentropically expanded in a dense fluid expander **102** and cooled in a reboiler heat exchanger **106**. This cooled, expanded LNG stream **108** is substantially isenthalpically expanded through valve **109** and injected into a nitrogen rejection column **150**. Within the column, rising vapor strips the nitrogen from the falling liquid, and a nitrogen-enriched stream **130** is withdrawn from the top of the column. A nitrogen-diminished liquid stream **110** is withdrawn from the bottom of the column and its pressure is increased by passage through a pump **112**. After pumping, the liquid stream is divided into a first stream **114** and a second stream **116**. The second stream **116** is reduced in pressure by passage through a valve **117** to a pressure that allows low-pressure reboiler stream **118** to at least partially vaporize during its subsequent passage through the reboiler heat exchanger **106**. After being at least partially vaporized in the reboiler heat exchanger, the reboiler stream **120** is reinjected into the nitrogen rejection column **150** to provide boilup.

[0028] The liquid portion of the reboiler stream mixes with the liquid from the lowest column stage upon reinjection such that the nitrogen-diminished liquid stream **110** is not exclusively the liquid from the bottom stage of the rejection column **150**, or from the reboiler **106**, but rather a mixture of both. There is a thermodynamic loss associated with the mixing of the liquid streams to provide the withdrawn nitrogen-diminished stream **110**. However, this can easily and cheaply be compensated for by the addition of a stage or stages to the nitrogen rejection column **150**.

[0029] By separating the second stream **116** from the first stream **114** after the pump **112**, the flow through the reboiler heat exchanger **106** is driven by a pump **112** that would already be available to pump the LNG product, first stream **114**. The reboiler heat exchanger **106** can be designed for a broad range of pressure drops based on considerations such as capital cost, and the appropriate pressure of the reboiler stream **118** can be attained by adjusting valve **117** upstream of the reboiler heat exchanger **106**.

[0030] The flow rate of the second stream **116** can be any amount up to the total flow of the nitrogen-diminished liquid stream **110**, but is preferably less than about 20% of the flow rate of the first stream **114**, and may be easily optimized for the particular process. This is in contrast with the process of the '165 patent, which requires 100% of the liquid flow off of a tray to be directed through the reboiler. The smaller flow rate of the reboiler stream compared with the prior art allows the reboiler heat exchanger **106** to be reduced in size.

[0031] Also, when compared with many of the prior art processes, the present invention has the additional advantage of eliminating the nozzle required for the withdrawal of the reboiler liquid stream from the column, since bottoms liquid that would be withdrawn anyway as LNG product is employed for column reboil.

[0032] The present invention provides a significant improvement in the adaptability and flexibility of a LNG denitrogenation process through the implementation of a hydraulically different process from those of the prior art. By permitting a pump **112** to drive the reboiler heat exchanger **106**, rather than relying on the column head, and including the valve **117** to control mass flow, the process may be designed to optimally perform in conjunction with a chosen reboiler heat exchanger **106** design. This flexibility can lead to a smaller capital expense at the remediable cost of a minor thermodynamic loss.

EXAMPLES

Example 1

[0033] To more particularly demonstrate some of the important differences between the process of the present invention and the prior art, process simulations were run, using an ASPEN process simulator, comparing an embodiment of the invention ("current process") with the process disclosed in the '165 patent. The comparison basis is an equal LNG production and a satisfied fuel balance (the amount of LNG product flash required to drive a gas turbine driving the process). The respective reference numerals used in this example refer to FIG. **1**, as described above, and the '165 patent (see, e.g., FIG. **1** therein).

The Current Process

[0034] With reference to FIG. **1**, following expansion in dense fluid expander **102**, low pressure LNG stream **104**, at a flow rate of 125,450 lbmol/hr, a pressure of 71.62 psi, a temperature of −243° F., and containing 2.96% N_2, 95.47% methane, 1.10% C_2 hydrocarbons, and 0.47% heavier hydrocarbons, is cooled in reboiler heat exchanger **106** to produce cooled, expanded LNG stream **108** at a temperature of −252.5° F. Cooled, expanded stream **108** is throttled through valve **109** and introduced into a denitrogenation column **150** comprising 6 trays, at a pressure of 18 psi. An overhead vapor stream **130** is withdrawn from the top of the column **150** at a flow rate of 8,123 lbmol/hr, and contains 31.06% N_2, 68.94% methane, and trace amounts of heavier hydrocarbons, at a pressure of 18 psi and a temperature of −261.9° F. Bottoms stream **110** is withdrawn from the column **150** at a flowrate of 136,071 lbmol/hr, a pressure of 19.45 psi, a temperature of −256.8° F., and contains 1.01% N_2, 97.31% methane, 1.17% C_2 hydrocarbons, and 0.51% heavier hydrocarbons. Bottoms stream **110** is pumped to a pressure of 75 psi and divided into a first stream **114** and a second stream **116**. The first stream **114**, at a flow rate of 117,327 lbmol/hr, a pressure of 75 psi, a temperature of −256.6° F., and containing 1.01% N_2, 97.31% methane, 1.17% C_2 hydrocarbons, and 0.51% heavier hydrocarbons, is recovered as the final LNG product. The second stream **116**, at a flow rate of 18,744 lbmol/hr is throttled through valve **117** to a pressure of 19.74 psi to produce low pressure reboiler stream **118**, which is then introduced to reboiler heat exchanger **106** at a temperature of −256.4° F., where it is partially vaporized to produce vaporized reboiler stream **120**. Vaporized reboiler stream **120**, which is at a temperature of −252.7° F., a pressure of 19.45 psi, and has a vapor fraction of 23.7%, is injected into the bottom of column **150** to provide boilup. This process requires approximately 229 MW of power.

Prior Art Process

[0035] With reference to FIG. **1** of the '165 patent, following expansion in turbine **21**, semidecompressed LNG stream **22**, at a flow rate of 125,451 lbmol/hr, a pressure of 71.76 psi, a temperature of −243° F., and containing 2.96% N_2, 95.47% methane, 1.10% C_2 hydrocarbons, and 0.47% heavier hydrocarbons, is cooled in indirect heat exchanger **2** to a temperature of −252.6° F. This cooled, expanded stream is throttled through valve **3** and introduced into denitrogenation column **5** comprising 6 trays, at a pressure of 18 psi. An overhead vapor stream **10** is withdrawn from the top of the column **5** at a flow rate of 8,122 lbmol/hr, and contains 31.17% N_2, 68.83% methane, and trace amounts of heavier hydrocarbons, at a pressure of 18 psi and a temperature of −261.9° F. Bottoms stream **11** is withdrawn from the column **5** at a flowrate of 117,329 lbmol/hr, a pressure of 19.45 psi, a temperature of −256.8° F., and contains 1.01% N2, 97.32% methane, 1.17% C_2 hydrocarbons, and 0.50% heavier hydrocarbons. First LNG fraction **6** is withdrawn from the lowest tray of the column at a flow rate of 121,047 lbmol/hr, a temperature of −259.7° F., a pressure of 19.74 psi, and contains 1.56% N_2, 96.81% methane, 1.14% C_2 hydrocarbons, and 0.49% heavier hydrocarbons. This first LNG fraction **6** is passed through indirect heat exchanger **2** to produce stream **7**, which is at a temperature of −256.8° F., a pressure of 19.45 psi, and has a vapor fraction of 3.1%. Stream **7** is returned to column **5** under the lowest tray to provide boilup. This process also requires approximately 229 MW of power.

[0036] Table 1 sets forth data of corresponding streams of these two processes in order to more clearly illustrate the comparison. We first note that the respective feed streams, **104** and **22**, and the respective product streams, **114** and **11**, and **130** and **10**, are substantially identical with respect to all relevant properties. This equivalency of feed streams and product streams enables a valid comparison of the two processes.

[0037] As demonstrated in Table 1, a significant difference between the two processes is that the reboiler stream of the current process **118** is at a flow rate of 18,744 lbmol/hr, which is only 15.5% of the flow rate of the reboiler stream **6** of the '165 patent process, 121,047 lbmol/hr. This difference is attributable to the fact that, while the '165 patent process requires that the entire liquid flow off of a column tray be recycled through the reboiler heat exchanger, the current process optimizes the amount of flow necessary to achieve the desired separation, and therefore only recycles the amount of bottoms liquid necessary to produce the required product. Another noteworthy difference between these processes is that, while the total fluid flow through the reboiler is substantially less for the current process than for the process of the '165 patent, because the same amount of heat is transferred in each reboiler, a greater percentage of the reboiler stream is vaporized in the current process, 23.7% versus 3.1%. The amount of vapor actually returned to the column for boilup is therefore greater for the current process (4442 lbmol/hr), than for the '165 patent process (3752 lbmol/hr).

[0038] There are several other important differences between these two processes. First, because the current process uses a portion of the withdrawn bottoms product for the reboiler stream rather than withdrawing an additional stream from the column as in the '165 patent process, the nozzles required by the '165 patent process are eliminated. This is a desirable improvement because nozzles add size to the column, require the use of additional equipment, and contribute to heat leak.

[0039] Another important difference is that the use of the pump to transfer the bottoms stream before dividing the two streams allows the reboiler heat exchanger to be driven by the pump rather than liquid head, as is the case in the '165 patent process. This provides an additional degree of freedom and allows for greater flexibility of design and implementation of the process. For example, valve **117** can be adjusted to compensate for a greater pressure drop in the heat exchanger. This additional flexibility may be reflected not only in the initial design of the heat exchanger, but also may be advantageously employed to compensate for unexpected process conditions.

[0040] We also note that although the overall power consumption for each of the processes is virtually identical—229.3 MW for the current process and 229.1 MW for the prior art process—in order to provide an LNG product stream at sufficient pressure for storage, pumping the bottoms liquid stream of the current process requires nearly 16% more power than pumping the bottoms liquid stream of the prior art process (293 kW for the current process and 253 kW for the prior art process). Because the pump in the current process not only provides the product LNG stream, but also drives the reboiler, 136,071 lbmol/hr of bottoms liquid must be pumped in the current process, while the prior art process need only pump the 117,329 lbmol/hr of product LNG. However, the increased flexibility permitted by the current process more than compensates for this minor increase in power consumption.

TABLE 1

comparison of the current process and the '165 patent process

Stream	Current Process					The '165 Patent Process				
and Ref. #	Flow (lbmol/hr)	N_2 mol %	CH_3 mol %	Temp. ° F.	Pres. psi	Flow (lbmol/hr)	N_2 mol %	CH_3 mol %	Temp. ° F.	Pres. psi
Feed 104/22	125,450	2.96	95.47	−243	71.62	125,451	2.96	95.47	−243	71.76
Vapor Product 130/10	8,123	31.06	68.94	−261.9	18	8,122	31.17	68.83	−261.9	18
LNG Product 114/11	117,327	1.01	97.31	−256.6	75	117,329	1.01	97.32	−256.8	19.45
Reboil Input Stream 118/6	18,744	1.01	97.31	−256.4	19.74	121,047	1.56	96.81	−259.7	19.74
Reboil Output Stream 120/7	18,744 (vapor fraction = 23.7%)	1.01	97.31	−252.7	19.45	121,047 (vapor fraction = 3.1%)	1.56	96.81	−256.8	19.45

[0041] Although the invention has been described in detail with reference to sertain embodiments, those skilled in the art will recognize that there are other embodiments within the scope of the claims.

1. A process for the denitrogenation of a liquid natural gas (LNG) feed stream, wherein said LNG stream comprises 1-10 mol % nitrogen, comprising:

(a) expanding the LNG feed stream via means provided to expand the LNG feed stream and cooling the LNG feed stream in a reboiler heat exchanger to form a cooled, expanded LNG stream, wherein the expansion is performed before the cooling or the cooling is performed before the expanding;

(b) introducing the cooled, expanded LNG stream into a nitrogen rejection column;

(c) withdrawing a nitrogen-enriched overhead vapor stream from the column;

(d) withdrawing a nitrogen-diminished bottoms liquid stream from the column;

(e) passing the bottoms stream from step (d) through a pump to increase the pressure of the nitrogen-diminished bottoms liquid stream of step (d);

(f) dividing the bottoms stream into a first stream and a second stream;

(g) at least partially vaporizing the second stream by reducing said second stream in pressure and then passing through the reboiler heat exchanger of step (a);

(h) injecting the partially vaporized second stream of step (g) into the column at a position of the column above that from which the bottoms stream of step (d) is withdrawn and below that which received the LNG feed stream of step (b), to provide boilup for the column.

2. The process of claim **1**, wherein the means provided to expand the LNG feed stream is a dense fluid expander.

3. The process of claim **1**, wherein the reduction in pressure of step (g) is achieved by passing through a Joule-Thomson valve.

4. The process of claim **1**, wherein the first stream of step (f) is collected as an LNG product.

5. The process of claim **1**, further comprising passing the cooled, expanded LNG stream of step (a) through a valve before introducing the cooled, expanded LNG stream into the nitrogen rejection column.

6. The process of claim **1**, wherein the expanding of step (a) is performed before the cooling of step (a).

7. The process of claim **1**, wherein the cooling of step (a) is performed before the expanding of step (a).

8. The process of claim **1**, wherein the reboiler heat exchanger of step (a) is a plate-fin heat exchanger.

9. The process of claim **1**, wherein the flow rate of the second stream of step (f) is less than about 20% of the flow rate of the first stream of step (f).

10. The process of claim **1**, wherein the cooled, expanded LNG stream of step (b) is introduced into the top of the nitrogen rejection column.

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