

Description

The present invention relates to a process for the recovery of $C_2 +$ or $C_3 +$ hydrocarbons from a hydrocarbon containing stream using the sequential steps of cooling, phase separating, rectifying and stripping wherein the refrigeration necessary for such processing is derived predominantly from a single loop vapor recompression refrigerator employing a mixed refrigerant.

BACKGROUND OF THE INVENTION

A process for the recovery of a heavy hydrocarbon product (i.e., $C_2 +$ or $C_3 +$ hydrocarbons) from a hydrocarbon containing stream using the sequential steps of cooling, phase separating, rectifying and stripping is taught in the art. Specifically, U.S. Patent No. 4,622,053 by Tomlinson, et al. discloses such a process. Tomlinson further discloses that the refrigeration for the process can be provided by a two-stage (two loop) cascade refrigerator (the preferred embodiment) or a single loop vapor recompression refrigerator employing a mixed refrigerant. It has now been found, however, that the efficiency of Tomlinson's cycle incorporating the sequential steps of cooling, phase separating, rectifying and stripping wherein the predominant amount of refrigeration is provided by a single loop vapor recompression refrigerator employing a mixed refrigerant can be significantly improved.

Other prior art of general relevance showing various individual steps that are relevant to the technical field of the present invention, including phase separating, rectifying via low temperature dephlegmation and stripping include: U.S. Patent Nos. 4,002,042; 4,272,270; 4,356,014; 4,526,596; 4,507,133; 4,608,068; 4,664,687; 4,675,036; 4,707,170; 4,714,487 and 4,718,927.

SUMMARY OF THE INVENTION

The present invention claims an improvement to the prior art separation process for the recovery of a heavy hydrocarbon product from a hydrocarbon containing gas stream. The prior art separation process comprises:

- (a) cooling the gas stream to effect the partial condensation thereof;
- (b) phase separating the partially condensed gas stream into its vapor and liquid components in a phase separator;
- (c) rectifying the vapor component from step (b) by low temperature dephlegmation to produce a light gas stream and a heavy liquid stream; and
- (d) stripping the liquid component from step (b) and the heavy liquid stream from step (c) in a stripping column containing a reboiler wherein the bottoms stream from the stripping column is the heavy hydrocarbon product;
- (e) providing the predominant amount of the refrigeration for the process from a single loop vapor recompression refrigerator employing a mixed refrigerant;

The present invention claims an improvement to increase the energy efficiency of the above described prior art process. The improvement comprises:

- (i) passing the liquid component from step (b) and the heavy liquid stream from step (c) directly to the stripping column of step (d);
- (ii) operating the stripping column at below ambient temperature;
- (iii) passing the overhead vapor from the stripping column directly to the phase separator of step (b) to be rectified with the vapor component from step (b); and
- (iv) using the mixed refrigerant employed in step (e) as a heating medium for the reboiler of the stripping column in order to provide at least a portion of the heat duty for the reboiler.

The present invention allows the feed gas stream to be processed at low pressure, for example, 2,76 to 13,8 bar (40 to 200 psia), where the high relative volatility between the light and heavy components provides easier separations resulting in a lower energy of separation. Another major advantage of the present invention is that only one compressor (the single loop mixed refrigerant compressor) is required in most applications, resulting in significant capital savings.

BRIEF DESCRIPTION OF THE DRAWINGS

The Figure is a flow diagram of one embodiment of the process of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides an efficient process for the recovery of $C_2 +$ or $C_3 +$ hydrocarbons from a hydrocarbon containing stream such as a refinery off-gas stream. The hydrocarbon containing stream can contain any number of non-hydrocarbon components such as hydrogen, nitrogen, carbon monoxide and carbon dioxide. The hydrocarbon components can include saturated and unsaturated hydrocarbons including methane, ethane, ethylene, propane, propylene, butane, butene, isobutane, pentane, pentene, hexane and potentially residual amounts of even heavier hydrocarbons. Throughout the text of this patent, saturated and unsaturated hydrocarbons are symbolically referenced as the $C_x +$ designate of the carbon number of the hydrocarbon. The "+" symbol is utilized to indicate that the carbon atom count constitutes the designated number placed in the "x" subscript and higher molecular weight compounds.

In the present invention, feed gas at relatively low pressure is cooled to an intermediate temperature, for example, -1°C to -101°C ($+30^\circ\text{F}$ to -150°F). The condensed liquid is removed in a phase separator and the uncondensed vapor is further cooled and rectified in a dephlegmator to recover the remaining $C_2 +$ or $C_3 +$ hydrocarbons. The condensed liquids are fractionated in a stripping column operating at below ambient temperature to remove residual light components and increase the purity of the $C_2 +$ or $C_3 +$ hydrocarbon product. The purified hydrocarbons may be recovered as a liquid product or revaporized for refrigeration recovery.

The overhead vapor from the stripping column is returned to the phase separator and then to the dephlegmator to recover residual $C_2 +$ or $C_3 +$ hydrocarbons. The mixed refrigerant employed in the single loop vapor recompression refrigerator acts as a heating medium for the reboiler of the stripping column in order to provide at least a portion of the heat duty for the reboiler. If necessary, other streams, such as the feed and product streams, can be used to supply supplemental heat duty for the reboiler.

This process reduces both the power requirements and the capital cost for the separation and recovery of $C_2 +$ or $C_3 +$ hydrocarbons. It allows the feed gas stream to be processed at low pressure, for example, 2,76 bar to 13,8 bar (40 to 200 psia), where the high relative volatility between the light and heavy components provides easier separations resulting in a lower energy of separation.

A major advantage of the process is that only one compressor, the single loop mixed refrigerant compressor, is required in most applications. Feed compression is not necessary; two separate compressors for a two-stage (two loop) cascade refrigerator are not required. The compression requirements for the process are consolidated into one machine, the mixed refrigerant compressor, resulting in significant capital savings. In addition, the rectification achieved in the dephlegmator minimizes the quantity of light components entering the stripping column, resulting in a smaller column and more efficient fractionation.

The present invention is an improvement to the prior art cycle for recovering heavy hydrocarbons (i.e., $C_2 +$ or $C_3 +$ hydrocarbons) from a hydrocarbon containing stream. The prior art cycle is shown in FIG. 2 of U.S. Patent No. 4,622,053 by Tomlinson, et al. and comprises the sequential steps of cooling, phase separating, rectifying and stripping. Refrigeration for the preferred embodiment of the prior art cycle is provided by a two-stage (two loop) cascade refrigerator. However, the Tomlinson patent recites in column 6, lines 38 thru 43, that, "The two-stage cascade refrigerator employed in the process described in FIG. 2 may be replaced by some other form of external refrigeration, if desired. For example, a single loop vapour compression refrigerator employing a mixed refrigerant may be employed [as in the present invention] but the power savings will not be so great."

The significant and unexpected increase in efficiency of the present invention over the prior art cycle is derived from the following improvements to the prior art cycle:

1. In the prior art cycle, the liquid component from the phase separating step and the liquid component from the rectification step are mixed and warmed by indirect heat exchange with the feed gas mixture prior to sending such liquid components to the stripping column; in the present invention, these liquid components are passed directly to the stripping column, without warming.
2. In the prior art cycle, the stripping column is operated at or above ambient temperature; in the present invention the stripping column is operated below ambient temperature.
3. In the prior art cycle, the overhead vapor from the stripping column is mixed with the incoming feed and cooled prior to being directed to the phase separator; in the present invention, this vapor component is passed directly to the phase separator, without cooling.

4. In the prior art cycle, hot oil or low pressure steam is used as a heating medium for the reboiler of the stripping column; in the present invention, the mixed refrigerant is used as the heating medium for the reboiler of the stripping column in order to provide at least a portion of the heat duty for the reboiler.

Implementation of the above improvements to the prior art cycle significantly increases the efficiency of the separation process. As shown in the following Table 1, the present invention requires 19% less power than the preferred embodiment of the prior art cycle for recovering the C₃ + hydrocarbons from a typical refinery off gas stream. These power savings are even more impressive considering that the Tomlinson patent, as noted above, stated a power penalty would be incurred when substituting a single loop vapor recompression refrigerator employing a mixed refrigerant (as in the present invention) in place of the preferred embodiment's two-stage (two loop) cascade refrigerator. Both the present invention and the prior art cycle achieve 95% recovery of propane and 100% recovery of C₄ + components.

TABLE

RELATIVE PERFORMANCE OF PRESENT INVENTION vs. TOMLINSON PROCESS*		
	Present Invention	Tomlinson Process*
Feed (lb moles/hr)**	1654	1654
Propane Recovery	95%	95%
C ₄ + Recovery	100%	100%
Total Power (HP)	1660	2050

* As shown in FIG 2 of U.S. Patent No. 4,622,053 by Tomlinson, et al.

** The feed is at 26,6°C and 7,25 bar (80°F and 105 psia) and contains 54.1% hydrogen, 0.2% carbon dioxide, 14.2% methane, 11.7% ethane, 0.8% propylene, 10.9% propane, 3.2% isobutane, 3.2% butane, 1.4% pentane and 0.3% hexane.

One embodiment of the present invention will now be described in detail as it relates to the recovery of C₃ + hydrocarbons from a typical refinery off-gas stream. Referring to the Figure, a feed gas is introduced in line 10 at 26,6°C and 7,25 bar (80°F and 105 psia) containing 54.1% hydrogen, 0.2% carbon dioxide, 14.2% methane, 11.7% ethane, 0.8% propylene, 10.9% propane, 3.2% isobutane, 3.2% butane, 1.4% pentane and 0.3% hexane. The feed gas in line 10 is cooled in heat exchanger 1. The feed gas is partially condensed as it exits in line 11 at a temperature of -23,3° (-10°F) and a pressure of 6,7 bar (100 psia). It is introduced into a phase separator vessel 3 to produce a heavy liquid stream containing heavy hydrocarbons in line 12 and a vapor stream containing light feed gas components in line 21. The vapor stream in line 21 ascends a refluxing heat exchanger, or dephlegmator 2, wherein it is partially condensed and the heavy condensed portion of the stream descends the heat exchange passageways to act as a reflux to rectify the vapor stream in line 21. The condensed portion of the stream is returned to phase separator vessel 3 to be combined with the stream initially phase separated as the heavy liquid stream in line 12. The light components which exit overhead from the dephlegmator 2 are removed in line 22 at -80,5°C and 6,83 bar (-113°F and 99 psia). This stream in line 22 is returned thru dephlegmator 2 and heat exchanger 1 and, after being rewarmd, is removed as a fuel stream in line 23 at 43,3°C and 6,2 bar (110°F and 90 psia) containing 67.0% hydrogen, 0.3% carbon dioxide, 17.5% methane, 14.2% ethane, 0.3% propylene, and 0.7% propane.

The heavy liquid stream is passed thru line 12 into stripping column 4. The stripping column is operated with a reboiler 8 in its bottom. The heavy hydrocarbon product containing C₃ + hydrocarbons is derived from the bottom of the stripping column in line 13 at 26,7°C and 6,96 bar (80°F and 101 psia) containing 1.0% ethane, 2.9% propylene, 54.0% propane, 16.4% isobutane, 16.6% butane, 7.5% pentane and 1.6% hexane. The overhead vapor from the stripping column is removed in line 14 and returned to phase separator 3 to be rectified in dephlegmator 2 to recover residual C₃ + hydrocarbons.

The refrigeration necessary to operate the process described and illustrated in the Figure is derived from a single loop vapor recompression refrigerator employing a mixed refrigerant. The mixed refrigerant can be derived from any number of components but is generally selected from the components comprising the feed gas. In FIG. 1, the mixed refrigerant consists of 5.8% methane, 50.4% ethane and 43.8% butane. Referring to the Figure, the mixed refrigerant in line 30 is at a temperature of 43,3°C (110°F) and a pressure of 1,2 bar (17 psia). It is recompressed in compressor 6 to 27,2 bar (395 psia) and partially condensed in air cooler 5 and in the reboiler of the stripping column. The partially condensed, high pressure mixed refrigerant stream exits the reboiler in line 31 at 46,1°C (115°F) and is further condensed

and cooled to $-83,3^{\circ}\text{C}$ (-118°F) in heat exchanger 1 and dephlegmator 2, flashed to 1,38 bar (20 psia) in valve 7 and partially revaporized in dephlegmator 2 to provide low temperature refrigeration. The low pressure mixed refrigerant is then further warmed and vaporized in heat exchanger 1 and returned to compressor 6 in line 30 at $43,3^{\circ}\text{C}$ and 1,2 bar (110°F and 17 psia).

Although not shown in the Figure, it is also possible to obtain supplemental refrigeration for the process through expansion of the feed gas stream. For example, the light components exiting the top of the dephlegmator in line 22 could be expanded prior to rewarming in the dephlegmator or after rewarming in the dephlegmator.

Another source of supplemental refrigeration which may be utilized is revaporization of the heavy hydrocarbon product in line 13. When the heavy hydrocarbon product is not required as a liquid stream, the heavy hydrocarbon product could be revaporized in the dephlegmator 2 or in the heat exchanger 1 to provide supplemental refrigeration.

The single loop vapor recompression refrigerator employs a mixed refrigerant to provide the predominant amount of refrigeration for the process. The mixed refrigerant can be made up from relatively pure components, if available, or from a suitable mixture of components obtained from the processing of the feed gas. For example, a suitable mixed refrigerant composition might be obtained by mixing vapor obtained from line 14 or line 21 with liquid obtained from line 12 or line 13 in appropriate proportions.

The composition of the mixed refrigerant and its condensing and vaporizing pressure levels are selected to provide thermodynamically efficient temperature differences between the process streams and the mixed refrigerant streams in the heat exchangers and in the dephlegmator. The mixed refrigerant is compressed to a sufficiently high pressure that it can be at least partially condensed with a combination of refrigeration sources available from cooling water or air coolers, from the reboiler of the stripping column and from rewarming of the process streams. The mixed refrigerant may be partially condensed or it may be totally condensed and subcooled prior to flashing and vaporizing at lower pressure for refrigeration supply.

For convenience, the vapor and liquid portions of the single loop mixed refrigerant stream may be condensed and cooled separately or vaporized and warmed separately in any of the heat exchangers or in the dephlegmator. The mixed refrigerant may also be vaporized and warmed at more than one pressure level for refrigeration supply to reduce recompression energy.

Claims

1. In a low temperature separation process for the recovery of C_2 + hydrocarbons or C_3 + hydrocarbons from a hydrocarbon containing gas stream, comprising:

(a) cooling the gas stream to effect the partial condensation thereof;

(b) phase separating the partially condensed gas stream into its vapor and liquid components in a phase separator (3);

(c) rectifying the vapor component from step (b) by low temperature dephlegmation to produce a light gas stream and a heavy liquid stream; and

(d) stripping the liquid component from step (b) and the heavy liquid stream from step (c) in a stripping column (4) containing a reboiler (8), wherein the bottoms stream from the stripping column (4) is the heavy hydrocarbon product;

(e) providing the predominant amount of the refrigeration for the process from a single loop vapor recompression refrigerator employing a mixed refrigerant;

the improvement for increasing the efficiency of said separation process comprising:

(i) passing the liquid component from step (b) and the heavy liquid stream from step (c) directly to the stripping column (4) of step (d);

(ii) operating the stripping column (4) at below ambient temperature;

(iii) passing the overhead vapor from the stripping column (4) directly to the phase separator (3) of step (b) to be rectified with the vapor component from step (b); and

(iv) using the mixed refrigerant employed in step (e) as a heating medium for the reboiler (8) of the stripping column (4) in order to provide at least a portion of the heat duty for the reboiler (8).

2. The separation process in accordance with Claim 1 wherein the hydrocarbon containing gas stream contains hydrogen, nitrogen, carbon monoxide, carbon dioxide, methane and C_2 + hydrocarbons.

3. The separation process in accordance with Claim 1 or 2, wherein the hydrocarbon containing gas stream is at a pressure between 2,76 and 13,8 bar (40 and 200 psia) and wherein said separation process involves no compression of said gas stream.



and cooled to $-83,3^{\circ}\text{C}$ (-118°F) in heat exchanger 1 and dephlegmator 2, flashed to 1,38 bar (20 psia) in valve 7 and partially revaporized in dephlegmator 2 to provide low temperature refrigeration. The low pressure mixed refrigerant is then further warmed and vaporized in heat exchanger 1 and returned to compressor 6 in line 30 at $43,3^{\circ}\text{C}$ and 1,2 bar (110°F and 17 psia).

Although not shown in the Figure, it is also possible to obtain supplemental refrigeration for the process through expansion of the feed gas stream. For example, the light components exiting the top of the dephlegmator in line 22 could be expanded prior to rewarming in the dephlegmator or after rewarming in the dephlegmator.

Another source of supplemental refrigeration which may be utilized is revaporization of the heavy hydrocarbon product in line 13. When the heavy hydrocarbon product is not required as a liquid stream, the heavy hydrocarbon product could be revaporized in the dephlegmator 2 or in the heat exchanger 1 to provide supplemental refrigeration.

The single loop vapor recompression refrigerator employs a mixed refrigerant to provide the predominant amount of refrigeration for the process. The mixed refrigerant can be made up from relatively pure components, if available, or from a suitable mixture of components obtained from the processing of the feed gas. For example, a suitable mixed refrigerant composition might be obtained by mixing vapor obtained from line 14 or line 21 with liquid obtained from line 12 or line 13 in appropriate proportions.

The composition of the mixed refrigerant and its condensing and vaporizing pressure levels are selected to provide thermodynamically efficient temperature differences between the process streams and the mixed refrigerant streams in the heat exchangers and in the dephlegmator. The mixed refrigerant is compressed to a sufficiently high pressure that it can be at least partially condensed with a combination of refrigeration sources available from cooling water or air coolers, from the reboiler of the stripping column and from rewarming of the process streams. The mixed refrigerant may be partially condensed or it may be totally condensed and subcooled prior to flashing and vaporizing at lower pressure for refrigeration supply.

For convenience, the vapor and liquid portions of the single loop mixed refrigerant stream may be condensed and cooled separately or vaporized and warmed separately in any of the heat exchangers or in the dephlegmator. The mixed refrigerant may also be vaporized and warmed at more than one pressure level for refrigeration supply to reduce recompression energy.

Claims

1. In a low temperature separation process for the recovery of C_2 + hydrocarbons or C_3 + hydrocarbons from a hydrocarbon containing gas stream, comprising:

- (a) cooling the gas stream to effect the partial condensation thereof;

- (b) phase separating the partially condensed gas stream into its vapor and liquid components in a phase separator (3);

- (c) rectifying the vapor component from step (b) by low temperature dephlegmation to produce a light gas stream and a heavy liquid stream; and

- (d) stripping the liquid component from step (b) and the heavy liquid stream from step (c) in a stripping column (4) containing a reboiler (8), wherein the bottoms stream from the stripping column (4) is the heavy hydrocarbon product;

- (e) providing the predominant amount of the refrigeration for the process from a single loop vapor recompression refrigerator employing a mixed refrigerant;

the improvement for increasing the efficiency of said separation process comprising:

- (i) passing the liquid component from step (b) and the heavy liquid stream from step (c) directly to the stripping column (4) of step (d);

- (ii) operating the stripping column (4) at below ambient temperature;

- (iii) passing the overhead vapor from the stripping column (4) directly to the phase separator (3) of step (b) to be rectified with the vapor component from step (b); and

- (iv) using the mixed refrigerant employed in step (e) as a heating medium for the reboiler (8) of the stripping column (4) in order to provide at least a portion of the heat duty for the reboiler (8).

2. The separation process in accordance with Claim 1 wherein the hydrocarbon containing gas stream contains hydrogen, nitrogen, carbon monoxide, carbon dioxide, methane and C_2 + hydrocarbons.

3. The separation process in accordance with Claim 1 or 2, wherein the hydrocarbon containing gas stream is at a pressure between 2,76 and 13,8 bar (40 and 200 psia) and wherein said separation process involves no compression of said gas stream.



4. The separation process in accordance with Claims 1 to 3, wherein the components of the mixed refrigerant are obtained from the hydrocarbon containing gas stream.
5. The separation process in accordance with Claims 1 to 4, wherein supplemental refrigeration for the process is derived from expansion of the feed gas.
6. The separation process in accordance with Claims 1 to 5, wherein supplemental refrigeration for the process is derived from vaporization of the heavy hydrocarbon product.
7. The separation process according to one of the Claims 1 to 6, wherein, in addition to the mixed refrigerant stream, heat duty is supplied to the reboiler (8) only by feed or product streams and wherein no source of external heat duty, such as steam, is utilized.

Patentansprüche

1. Bei einem Niedertemperatur-Zerlegungsverfahren zur Wiedergewinnung von C_2 + -Kohlenwasserstoffen oder C_3 + -Kohlenwasserstoffen aus einem Kohlenwasserstoff enthaltenden Gasstrom, mit
 - (a) dem Kühlen des Gasstroms zum Bewirken seiner teilweisen Kondensation;
 - (b) der Phasentrennung des teilweise kondensierten Gasstroms in seine Dampf- und Flüssigkeitskomponenten in einer Phasentrenneinrichtung (3);
 - (c) der Rektifizierung der Dampfkomponente des Schritts (b) durch Niedertemperatur-Dephlegmierung zur Herstellung eines leichten Gasstroms und eines schweren Flüssigkeitsstroms; und
 - (d) dem Strippen der flüssigen Komponente des Schritts (b) und des schweren flüssigen Stroms aus Schritt (c) in einer Strippkolonne (4), die einen Aufkocher (8) enthält, wobei der Bodenstrom aus der Strippkolonne (4) das schwere Kohlenwasserstoffprodukt ist;
 - (e) wobei die überwiegende Menge der Kälte für das Verfahren von einem Einzelschleifen-Dampf-Rückkompressionskühler zur Verfügung gestellt wird, der ein gemischtes Kältemittel verwendet;
 die Verbesserung zur Steigerung der Effizienz des Zerlegungsverfahrens, welche umfaßt:
 - (i) Das Führen der flüssigen Komponente aus Schritt (b) und der schweren flüssigen Komponente aus Schritt (c) direkt zur Strippkolonne (4) des Schritts (d);
 - (ii) das Betreiben der Strippkolonne (4) unterhalb der Umgebungstemperatur;
 - (iii) das Führen des Kopfdampfes aus der Strippkolonne (4) direkt zur Phasentrenneinrichtung (3) des Schritts (b) zur Rektifizierung mit der Dampfkomponente aus Schritt (b); und
 - (iv) die Verwendung des im Schritt (e) eingesetzten Kältemittels als Heizmedium für den Aufkocher (8) der Strippkolonne (4), um mindestens einen Anteil des Wärmebedarfs für den Aufkocher (8) zur Verfügung zu stellen.
2. Das Zerlegungsverfahren gemäß Anspruch 1, bei dem der Kohlenwasserstoff enthaltende Gasstrom Wasserstoff, Stickstoff, Kohlenmonoxid, Kohlendioxid, Methan und C_2 + -Kohlenwasserstoffe enthält.
3. Zerlegungsverfahren gemäß Anspruch 1 oder 2, bei dem der Kohlenwasserstoff enthaltende Gasstrom bei einem Druck zwischen 2,76 und 13,8 bar (40 und 200 psia) ist, und bei dem das Zerlegungsverfahren nicht mit einer Kompression des Gasstroms verbunden ist.
4. Zerlegungsverfahren gemäß den Ansprüchen 1 bis 3, bei dem die Komponenten des gemischten Kältemittels aus dem Kohlenwasserstoff enthaltenden Gasstrom erhalten werden.
5. Zerlegungsverfahren gemäß Anspruch 1 bis 4, bei dem zusätzliche Kälte für das Verfahren aus der Expansion des Zufuhrgases stammt.
6. Zerlegungsverfahren nach einem der Ansprüche 1 bis 5, bei dem zusätzliche Kälte für das Verfahren aus der Verdampfung des schweren Kohlenwasserstoffproduktes stammt.
7. Zerlegungsverfahren nach einem der Ansprüche 1 bis 6, bei dem, zusätzlich zum Strom des gemischten Kältemittels, Wärmebedarf für den Aufkocher (8) nur durch Zufuhr- oder Produktströme zur Verfügung gestellt wird, und bei dem keine externe Wärmebedarfsquelle, wie zum Beispiel Dampf, verwendet wird.

**Revendications**

1. Dans un procédé de séparation à basse température en vue de la récupération d'hydrocarbures en $C_2 +$ ou d'hydrocarbures en $C_3 +$ d'un flux de gaz contenant des hydrocarbures, comportant les étapes consistant à:
- (a) refroidir le flux de gaz pour en réaliser la condensation partielle;
 - (b) séparer les phases des composants vapeur et liquide du flux de gaz partiellement condensé, dans un séparateur de phases (3);
 - (c) rectifier le composant vapeur provenant de l'étape (b) par déphlegmation à basse température, pour produire un flux gazeux léger et un flux liquide lourd; et
 - (d) séparer le composant liquide provenant de l'étape (b) et le flux de liquide lourd provenant de l'étape (c) dans une colonne de séparation (4) contenant un bouilleur (8), dans lequel le flux de fond de colonne provenant de la colonne de séparation (4) est le produit d'hydrocarbures lourds;
 - (e) fournir la partie principale de la réfrigération nécessaire pour le procédé à partir d'une machine frigorifique à recompression de vapeur en boucle unique utilisant un réfrigérant mixte;
- l'amélioration en vue d'augmenter le rendement dudit procédé de séparation, comportant les étapes consistant à:
- (i) faire passer le composant liquide provenant de l'étape (b) et le flux de liquide lourd provenant de l'étape (c) directement dans la colonne de séparation (4) de l'étape (d);
 - (ii) faire fonctionner la colonne de séparation (4) à une température inférieure à l'ambiante;
 - (iii) faire passer directement la vapeur de tête provenant de la colonne de séparation (4) dans le séparateur de phases (3) de l'étape (b), pour la rectifier avec le composant vapeur provenant de l'étape (b); et
 - (iv) utiliser le réfrigérant mixte utilisé dans l'étape (e) comme fluide chauffant pour le bouilleur (8) de la colonne de séparation (4), pour fournir au moins une partie des besoins thermiques du bouilleur (8).
2. Procédé de séparation selon la revendication 1, dans lequel le flux de gaz contenant des hydrocarbures contient de l'hydrogène, de l'azote, du monoxyde de carbone, du dioxyde de carbone, du méthane et des hydrocarbures en $C_2 +$.
3. Procédé de séparation selon la revendication 1 ou 2, dans lequel le flux de gaz contenant des hydrocarbures se trouve à une pression située entre 2,76 et 13,8 bars (40 et 200 psia), et dans lequel ledit procédé de séparation n'implique pas la compression dudit flux de gaz.
4. Procédé de séparation selon les revendications 1 à 3, dans lequel les composants du réfrigérant mixte sont obtenus à partir du flux de gaz contenant des hydrocarbures.
5. Procédé de séparation selon les revendications 1 à 4, dans lequel une réfrigération supplémentaire pour le procédé est dérivée de la détente du gaz d'alimentation.
6. Procédé de séparation selon les revendications 1 à 5, dans lequel une réfrigération supplémentaire pour le procédé est dérivée de la vaporisation du produit d'hydrocarbures lourds.
7. Procédé de séparation selon l'une des revendications 1 à 6, dans lequel, en plus du flux de réfrigérant mixte, la chaleur nécessaire est fournie au bouilleur (8) uniquement par les flux d'alimentation ou des produits, et dans lequel on n'utilise aucune source de chaleur externe telle que de la vapeur.